


Productivity, Innovation and Competitiveness in Small Open Economies

Final Report

Study on Productivity, Innovation and Competitiveness

in Small Open Economies

February 2011

Bradford University School of Management

Manchester Institute of Innovation Research, Manchester Business School

Department of Economics, University College Cork

Preface

Productivity, Innovation and Competitiveness in Small Open Economies is the final report of the project on Productivity, Innovation and Competitiveness in Small Open Economies (PICSOE). The PICSOE project is a research study commissioned by the Department of Enterprise, Trade and Investment (DETI) in 2009 to investigate approaches and strategies for advancing productivity, innovation and competitiveness in the three leading small open economies of Singapore, New Zealand, and the Republic of Ireland so as to draw insights for Northern Ireland.

The PICSOE project has undertaken performance, industry, and policy analyses of these small open economies and of key sectors within them, including emerging technology industries, chemicals, processed food, and advanced services. Three prior technical reports have been delivered: 1. *A Comparison of Northern Ireland's Productivity and Efficiency across Services and Manufacturing*; 2. *Mapping Organizational Capabilities for Innovation and Competitiveness: Research Performance and Patenting in Small Open Economies*; and 3. *Competitiveness and Innovation Profiles of Three Small Open Economies: New Zealand, Singapore, and Republic of Ireland.* This final report, *Productivity, Innovation and Competitiveness in Small Open Economies*, provides an overview of the findings of these earlier reports and assesses the applicability, comparability, and significance of the findings for policy development in Northern Ireland to support the region's prosperity, innovativeness, and industrial productivity. Some of the information and analyses included in the technical reports have been updated prior to use in the PIC SOE final study report.

The study team comprised: Dr. Adrian T.H. Kuah, (University of Bradford, UK); Prof. Philip Shapira (Manchester Institute of Innovation Research, Manchester Business School, University of Manchester, UK); Dr. Eleanor Doyle (Institute for Business Development and Competitiveness, Department of Economics, University College Cork, Republic of Ireland); and Dr. Damian R. Ward (University of Bradford, UK). Additional research assistance was provided by Lasandahasi Ranmuthumalie de Silva, Fergal O'Connor, Gary Marsh and Luciano Kay. This final report was completed by Philip Shapira, Eleanor Doyle, and Damian Ward. Any opinions, findings, and recommendations expressed in this report are those of the authors and do not necessarily reflect the views of DETI.

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Executive Summary

Northern Ireland has many economic strengths and dynamic businesses. However, the region lags not only many other UK regions but also other competing countries in productivity, innovation and competitiveness. Such overall lags in productivity and innovation impair the ability of Northern Ireland to compete at a high-level (and with high wages) in an era of globalisation. At the same time, current pressures to reduce public spending are intensifying needs to rethink how policies and programmes to foster productivity and innovation can be more effective and efficient.

The project on **Productivity, Innovation and Competitiveness in Small Open Economies** (PICSOE) examines three open economies - Singapore, New Zealand, and the Republic of Ireland - to develop comparisons and contrasts with Northern Ireland. An assessment of policy lessons and best practices for advancing productivity, innovation and competitiveness in Northern Ireland is provided. This process of comparison identifies challenges and opportunities for Northern Ireland, and develops insights that can advance innovative policymaking.

The report summarises results from three technical reports already prepared for DETI and presents case studies and discussions of best practices in fostering productivity, innovation and competitiveness in the three benchmark economies. These analyses use econometric and bibliometric methods, as well as drawing on the Global Competitiveness Report and other secondary documentation. Within the cases, performance in productivity, innovation and competitiveness in Singapore, New Zealand, and the Republic of Ireland are probed. For each country, we examine the four pillars of (1) macro-frameworks, (2) targets and strategies, (3) organisational design, and (4) policy and governance. These cases draw on field research conducted in the four countries between September 2009 and February 2010. Based on our analyses, cases, and assessments of practices in Singapore, New Zealand, and the Republic of Ireland, we consider policy areas where opportunities for improvement are potentially available for Northern Ireland.

Northern Ireland, as in the other benchmark economies, is targeting support to grow advanced technology sectors (including through university research and incubation) in biotechnology, nanotechnology, and medicine. Such efforts need to be sustained. Additionally, our research identified sectoral and clustering opportunities that appear, by comparison with benchmark economies, to be under-exploited in Northern Ireland at present. These include opportunities to **develop innovative capabilities in the agri-food value-chain**, **build up the financial services technology cluster**, and **retain and upgrade capabilities in engineering innovation**.

The small open economies we studied are focusing additional efforts on indigenous firms, particularly small and medium sized enterprises (SMEs). In the Republic of Ireland, but most particularly in New Zealand, there is evidence of the growth of exports by indigenous companies, in agri-food, manufacturing and advanced services. In Singapore, there are dedicated agencies supporting productivity and technological innovation in SMEs and the internationalisation of Singaporean firms. As there are different varieties of indigenous firms, ranging from new high-tech start-ups to existing and mature companies, this leads to different needs and strategies. Northern Ireland has devoted attention in recent years to fostering high-tech start-ups and assisting them to access export markets. Such efforts are worthwhile and should be intensified. We suggest additional attention to identifying, mentoring and supporting **"born global" firms** – enterprises

with innovative product offerings in advanced services as well as high-tech products that have the potential to grow rapidly through sales in international markets. Additionally, there are opportunities to **bolster initiatives to upgrade innovation capabilities in indigenous existing firms** – including through greater support for technology deployment, enterprise networking, and customized applied research and innovation**.**

In the Republic of Ireland, foreign-owned electronics and pharmaceuticals companies remain among the most productive and export-oriented parts of the economy. The Republic remains the most intensive economy in Europe for foreign direct investment (FDI). Similar FDI-intensive production is a feature in Singapore, with leadership from foreign-owned chemicals and electronics companies. Singapore is notable for its on-going partnering and close contact with foreign direct investors, seeking to stimulate them to upgrade their in situ capabilities and activities. Northern Ireland, through Invest NI, has also targeted foreign direct investment and business expansion of such plants as one of the key elements of its economic development policy. We believe there is also an opportunity for Northern Ireland to increase its distinctiveness, capability and innovativeness in attracting foreign-owned companies through **supply-chain improvements**. The emerging model in Singapore and New Zealand show us that these countries work with companies on a strategic basis, with **long-term and mutual private and public investment in complementary capabilities**, rather than on a project-by-project basis.

All three benchmark economies have seen reorientation and enhancement in their institutions and organisations for applied research. New Zealand has transformed its public research institutes into privatised commercial corporations (albeit still with public core and competitive support). In Singapore, a model has evolved of powerful government agencies collaborating with universities in research, led by Singapore's Agency for Science, Technology and Research (A*STAR). The Republic of Ireland lags in this regard having identified it as a weakness requiring greater focus. In the UK, recent attention has focused on the need to develop the landscape of applied technology and innovation centres throughout the country to expand translational capabilities to bridge research and technology commercialisation. There may be specific opportunities for Northern Ireland to seek one of the limited numbers of new Technology and Innovation Centres being planned in 2011 by the UK government. However, Northern Ireland needs to go beyond this particular bid to strategically consider its institutional landscape for applied commercial research and innovation. It would be timely to establish a mechanism to consider the various options, leading us to recommend the **tasking of a design team to explore and recommend options to substantially develop commercially-oriented applied research** in Northern Ireland. Such a design team would involve expertise from the private, academic, applied international research, and public sectors, and would consider options that could start to be put into place within 2 years as part of a longer term strategy e.g. to 2025 and beyond.

There has been a long-running debate in Northern Ireland about the concessionary 12.5% level of corporate tax in the Republic of Ireland whereas in the UK (including Northern Ireland) the corporate tax rate is 28% (in 2010). By comparison, for 2010 the corporate tax rate in Singapore was 17% while for New Zealand the rate was 30%. The UK government has announced a lowering of corporate tax rates from 28% to 24% for large companies over the four years to 2014, with the rate for SMEs to be lowered from 21% to 20% by 2011. However, we did not find from our analysis of other countries that corporation tax has a major impact on fostering innovation and productivity in particular. The ability for Northern Ireland to lower its corporate tax further than the already declining UK rate would place it closer to the Republic of Ireland on this measure, although at potentially considerable cost in lost tax revenues. This may be viewed as desirable by some business advocates, and it may marginally help in specific business attraction projects. But,

corporate tax rates are only one of many factors that come into play in business attraction and it is not necessarily a major factor in encouraging or discouraging innovation.

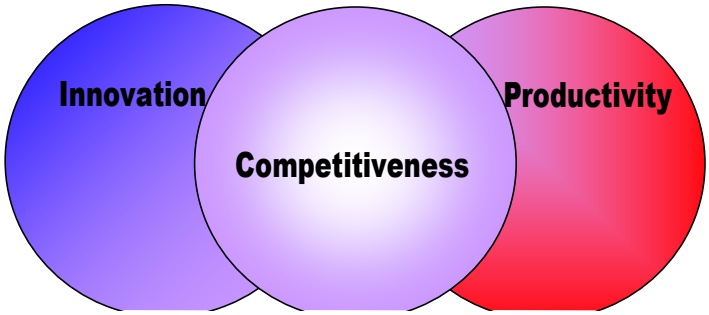
A key issue in achieving competitiveness is the robustness of the economic policy environment. Our study revealed that businesses in Singapore valued the stability and consistency of economic policies. In New Zealand, while much less interventionist than Singapore, there are also clear policy principles. Policies in New Zealand appear to be more open with explicit consultations when policy changes are considered. In our discussions with businesses in Northern Ireland, despite having Invest NI as a non-governmental public body, we received consistent feedback about the fragmentation of policymaking for economic development and innovation in Northern Ireland, with multiple agencies subject to numerous layers of executive and legislative oversight, and marked differences in perspectives among policymakers. The transaction costs involved in these processes are high, potentially turning the devolved powers over economic development and innovation (which should be an advantage to Northern Ireland) into a disadvantage. More fundamental organisational reforms and adjustments are necessary to ensure a situation where there is a competent, but lean and flexible, departmental structure with capabilities for policy development, assessment analysis, and foresight arms, as evident in the case of Singapore. For Northern Ireland, we advise that the key **government departments and agencies increase their focus on innovation, industry growth and new business formation**. This will be facilitated by **improvements in inter-agency integration and vision sharing**, **devolving the implementation of productivity, innovation and competitiveness functions** to organizations outside of civil service government departments, **fostering public demand-driven innovation**, and shifting from project to **programme and system evaluation.**

1. Introduction

Increasing globalisation pushes and pulls companies and economies to raise their engagement with international markets to sustain innovation and growth. Small open economies, which by definition lack the high levels of domestic demand and scale available to larger countries, must consider how their firms and economy can meet the challenges of international competitiveness - a task made even tougher by the current global economic crisis and constraints on public expenditure. In an environment characterized by continuing uncertainty across the global economy, with new demands to refocus policies at home, it is an opportune moment to rethink strategies for building competitiveness and to refine assumptions about the roles of government and how markets should be regulated to support innovation and industrial development.

There are a number of successful small economies that have managed to compete against - and in some cases outperform – larger competitors, such as the US or Japan, as well as hold their position in the face of rising competition from China and other emerging economies.

Figure 1. Productivity, Innovation and Competitiveness



The interfaces and relationships between productivity, innovation and competitiveness (Figure 1) are central to understanding national and regional economic performance, as well as providing the framework for addressing broader societal challenges.[1] The project on Productivity, Innovation and Competitiveness in Small Open Economies (PICSOE) examines policy-relevant insights from the performance of three highly competitive small open economies**.** The economies studied by the project are: New Zealand, Singapore and the Republic of Ireland. We probe their approaches and strategies for advancing productivity, innovation and competitiveness, with a view to seeking insights and recommendations for Northern Ireland.

In addition to reviewing the broad policy framework within each of the three study economies, the PICSOE project examined a set of sectors in each country. The study surveyed the new technology and advanced manufacturing sectors (including biotechnology, nanotechnology, and chemical processing), traditional sectors (including food processing and established manufacturing sectors such as engineering), and sectors in internationally traded advanced services (e.g. financial services). Additionally, econometric studies of productivity were pursued for the banking, chemicals and food processing sectors. These sectors are economically significant in all the three reference economies as well as in Northern Ireland.

Against the backdrop of differences and similarities in the economic structure and performance of New Zealand, Singapore, the Republic of Ireland and Northern Ireland, the PICSOE project investigated benchmark, analytical and policy questions in three background reports that inform this final report.[2] Among key questions addressed are**:**

[1] The OECD Innovation Strategy: Getting a Head Start on Tomorrow, Paris, 2010.

[2] Ward, D.R., Doyle, E., Shapira, P., and Kuah, A.T.H. *A Comparison of Northern Ireland's Productivity and Efficiency across Services and Manufacturing*. Report submitted to the Department of Enterprise, Trade and Investment, Northern

1. What are the key indicators of productivity and how do they compare against each other? How productive are the leading firms, relative to other similar firms, in the economies of New Zealand, Singapore, the Republic of Ireland and Northern Ireland?

2. What are the innovation indicators and how do they compare against each other? What characterises the firms and national institutions of innovation operating in key sectors? Who are key corporate and scientific actors leading knowledge-driven innovation in each economy? What are the new areas of knowledge generation and growth in each economy?

3. What are the competitiveness indicators? What are the main determinants of innovative capacity of small open economies? What roles do institutions for collaboration and government play in improving industry competitiveness? How are productivity and knowledge creation supported and constrained in each economy? What is the substance and experience of policies and programmes at national and regional levels to foster enterprise productivity, innovation and competitiveness?

The project team completed a series of meetings with policymakers, business representatives, and academic experts in the three reference economies and in Northern Ireland.[3] We also reviewed available documentation on Northern Ireland's economic performance and policy strategies. By integrating the key findings from the three earlier reports, and complementing these with information gained from the meetings and secondary sources, this final report provides a strategic perspective to assess the applicability, comparability, and significance of findings and to learn what lessons and best practice insights can be garnered for policy development.

The next section (chapter 2) of the report presents the rationale for country selection and sets the stage for our investigation of competitiveness in small open economies. Chapter 3 offers a review and summary of the findings of the technical analyses (in the earlier reports) of productivity and efficiency, innovation and knowledge performance, and competitiveness and innovative capacity. This is followed, in chapter 4, by case studies of the three benchmark economies. Four pillars of comparative performance and best practice in productivity, innovation and competitiveness are identified: (1) macro foundations; (2) targets and strategies; (3) organisation and design; and (4) policy and governance. Chapter 5 concludes by using these four pillars of comparison to identify insights and findings significant for further policy development in Northern Ireland.

Ireland. Project on Productivity, Innovation and Competitiveness in Small Open Economies. Bradford University School of Management, UK; Manchester Business School, UK; and University College Cork, Ireland. August 2009; Shapira, P., and Kay, L. *Mapping Organizational Capabilities for Innovation and Competitiveness: Research Performance and Patenting in Small Open Economies*. Report submitted to the Department of Enterprise, Trade and Investment, Northern Ireland. Project on Productivity, Innovation and Competitiveness in Small Open Economies. Bradford University School of Management, UK; Manchester Business School, UK; and University College Cork, Ireland. August 2009; Doyle, E., Shapira, P., and Kuah, A.T.H. *Competitiveness and Innovation Profiles of Three Small Open Economies: New Zealand, Singapore, and Republic of Ireland*. Report submitted to the Department of Enterprise, Trade and Investment, Northern Ireland. Project on Productivity, Innovation and Competitiveness in Small Open Economies. Bradford University School of Management, UK; Manchester Business School, UK; and University College Cork, Ireland. February 2010.

[3] Field research interviews were conducted during the period September 2009 through to February 2010 with business representatives, policy makers, universities and research organisations, academic experts, and other stakeholders. We undertook more than 30 interviews in New Zealand, 25 interviews in Singapore, 22 interviews in the Republic of Ireland, and more than 20 interviews in Northern Ireland.

2. Identification of Best Practice Economies

2.1 Rationale for Country Selection

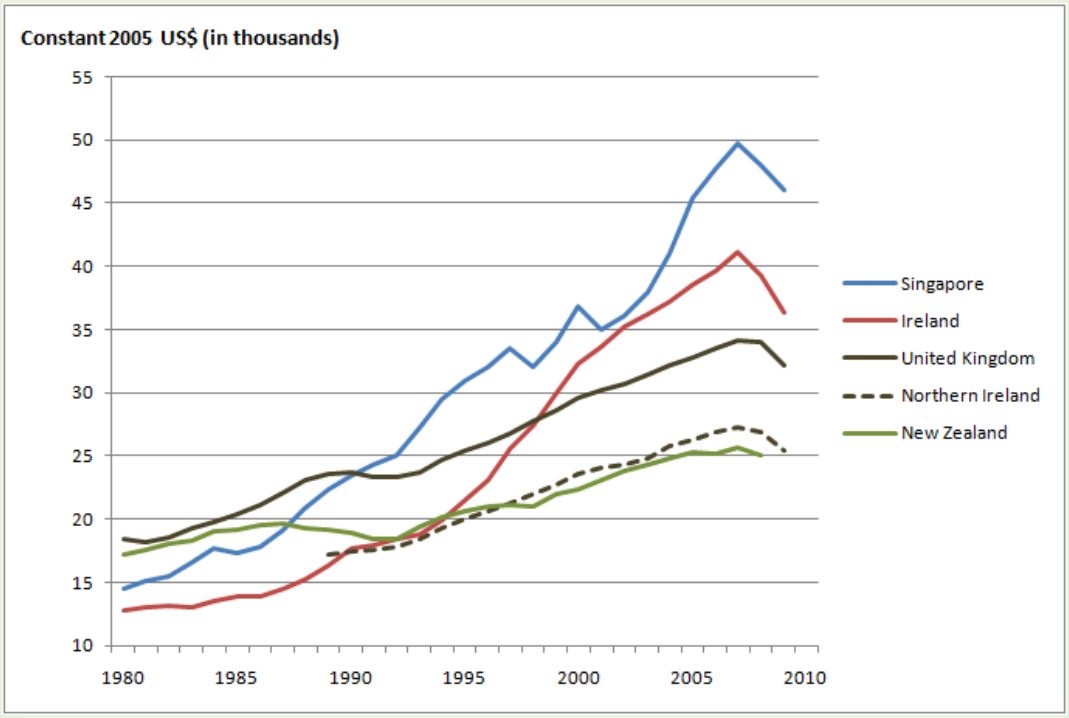
The PICSOE project examines three prominent small open economies - Singapore, New Zealand, and the Republic of Ireland – to understand their socio-economic contexts and to detail significant features of these economies which contribute to fostering productivity, innovation, high-wage/ value-added employment and competitiveness. The study develops comparisons and contrasts with Northern Ireland.

Each of the three benchmark economies is in the top quintile of 133 countries ranked in the Global Competitiveness Index.[4] Nonetheless, significant variations are evident among the three countries particularly in the composition of their ranking by sub-factors in the three main elements of the index (a) Basic Requirements, (b) Efficiency, and (c) Business Sophistication and Innovation. Each country is identified by the Global Competitiveness Index to be in the "innovation-driven" stage of development, based on levels of income per capita.[5] In 2010, Singapore, New Zealand, and the Republic of Ireland are ranked 3rd, 20th, and 25th respectively, out of 133 countries based on 12 main competitiveness pillars (see section 2.4 for details) in the Global Competitiveness Index. The three countries all have high per capita levels of Gross Domestic Product (GDP) – or value added through the production of goods and services in the economy. However, there have been noticeable differences in per capita GDP growth over the last three decades (based on constant 2005 US$ GDP per capita estimates using purchasing power parity or PPP).[6] Singapore shows the strongest growth in per capita GDP over the long run, followed by the Republic of Ireland. Conversely, New Zealand has seen slower growth in per capita GDP, taking it from the highest among the three benchmark economies in the 1980s to the lowest among the group towards the end of the 2000s. In the 1990s, Singapore, followed by the Republic of Ireland, overtook the United Kingdom in terms of GDP per head of population. Northern Ireland's estimated 2005 US$ GDP PPP per capita[7] was comparable to the Republic of Ireland's in the early 1990s, but has grown more slowly than the Republic on this measure from the mid-1990s through to the mid-2000s. Northern Ireland also lags the UK average (at about four-fifths of the overall UK per capita GDP), although it did narrow the gap with the UK through to 2006 (with some slight widening in the years since then). With the onset of the global economic downturn, all economies saw declines in per capita GDP from 2008 onwards, with the Republic of Ireland seeing the sharpest drop.

Our research design allows for a range of comparison and contrasts. We focus on two proximate economies within the European Union - the Republic of Ireland and Northern Ireland - and two economies in the fast-growing Asia Pacific region - Singapore and New Zealand. In interpreting the cases, care needs to be given to the specific policy contexts and differences in the economic and innovation landscapes of the respective countries. Moreover, the country cases exhibit a variety of policy approaches: Singapore and the Republic of Ireland pursued explicit, targeted innovation and

[4] The Global Competitiveness Project of the World Economic Forum is outlined at http://www.weforum.org/
[5] Global Competitiveness Report, 2009-10, at http://www.weforum.org/documents/GCR09/index.html
[6] World Bank, International Comparison Program database, GDP per capita, PPP, constant 2005 international dollars (equivalent to US$), http://data.worldbank.org/.
[7] For Northern Ireland, the annual ratio of Gross Value Added (GVA) per capita relative to the UK GVA is used to approximate GDP per capita (Source: Northern Ireland Statistics and Research Agency (NISRA), GVA, residence based, data for 1989-2009). This GVA ratio closely tracks the ratio for Northern Ireland compared with the UK for the series on regional gross domestic product (PPS per inhabitant) published by Eurostat. The Eurostat data is available only for 1996-2007, so the NISRA series with its longer time availability is used as a basis for the estimates graphed in Figure 2.1.

Figure 2. Gross Domestic Product Per Capita (Constant US$)



Source: World Bank, International Comparison Program database, GDP per capita, PPP, constant 2005 international dollars (equivalent to US$). For Northern Ireland, the annual ratio of Gross Value Added (GVA) per capita relative to the UK GVA per capita * UK $ GDP per capita is used to approximate Northern Ireland's $ GDP per capita (See Footnote 5).

development strategies, albeit delivered through different systems of national governance. New Zealand has focused on re-orienting policy frameworks and pursuing a strong emphasis on privatisation and deregulation. Both Northern Ireland and the Republic of Ireland operate within the framework of the European Union, although as part of the UK, Northern Ireland remains outside of the Eurozone. Additionally, Northern Ireland operates under the broad fiscal, taxation and trade policy regime established by the UK, although Northern Ireland possesses significant devolved powers for innovation, economic development and associated elements such as universities and training.

Although differences exist between Northern Ireland (as a region) and the other three national economies, we judge that our selected economies in the Asia Pacific region and the neighbouring Republic of Ireland represent a strong yet diverse set that – with appropriate care, as already noted – can offer useful comparisons for policy development. For Northern Ireland, the three benchmark economies offer intriguing insights on approaches to maintaining national competitiveness for firms and industries and on strategies for innovation. However, before discussing lessons for Northern Ireland, we first analyse each of the benchmark economies. The following sections of this chapter provide overviews of economic performance, sectoral strengths, and competitive performance for the Republic of Ireland, Singapore, and New Zealand.

2.2 Routes to Economic Success

The Republic of Ireland has a strong external orientation underpinning economic development and providing the stimulus for industrialisation. The Republic has attracted high-end foreign direct investment (FDI) and has seen considerable growth in internationally traded services (see Section 4.3). The export sector, dominated by foreign multinationals, has remained a key component of Ireland's economy. The development of new comparative advantages in traditionally absent industries was explicitly targeted and encouraged. Recent policy has been future-oriented, emphasising science, technology and innovation, with the development of public and private investments in improving the national innovation system.

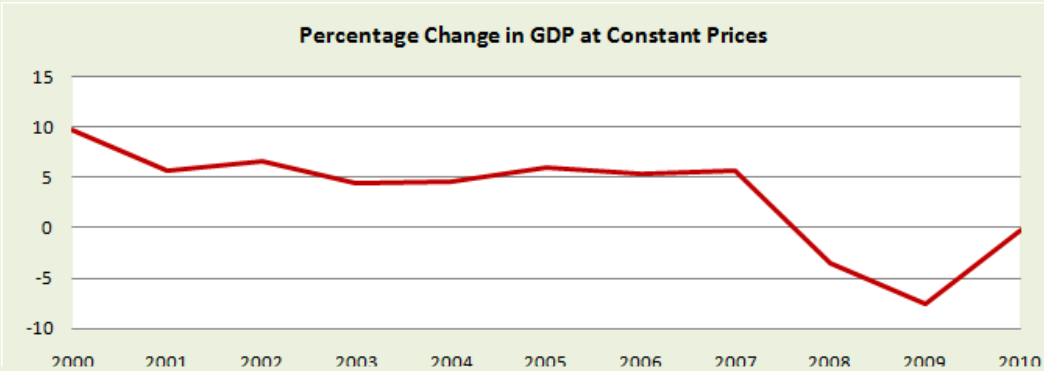
The recent financial crisis has deeply hit the Republic of Ireland. After strong GDP growth from 2000 through to 2007, Ireland saw negative growth in eight consecutive quarters from 2008 through to the end of 2009. After some positive growth in 2010 Q1, growth was negative to flat for the next two quarters of 2010. (Recent data is illustrated in Table 1 and Figure 3). The immense fiscal problems now facing the Republic of Ireland do not take away from its significant achievements in education, industrial development and enterprise innovation over the last two decades (the focus of this study). Indeed, the continued development of innovation, productivity, and export competitiveness will be critical in rebalancing and rebuilding the Republic of Ireland's economy over the next period of time.

Table 1. GDP Growth in the Republic of Ireland

Year	Mar	Jun	Sep	Dec
2010	2.14	-1.01	0.54	
2009	-2.55	-0.29	-0.60	-2.31
2008	-2.51	-1.89	-0.25	-4.77

Percentage quarterly change at annualized rates. Source: World Bank; Trading Economics (http://www.tradingeconomics.com)

Figure 3. GDP trends in the Republic of Ireland, 2000-2010



Source: International Monetary Fund, national currency basis (estimated for 2010).

Singapore has a highly developed and successful free-market economy. It enjoys per capita GDP higher than that of most developed countries (see Figure 2). The economy depends heavily on exports, particularly in consumer electronics, information technology

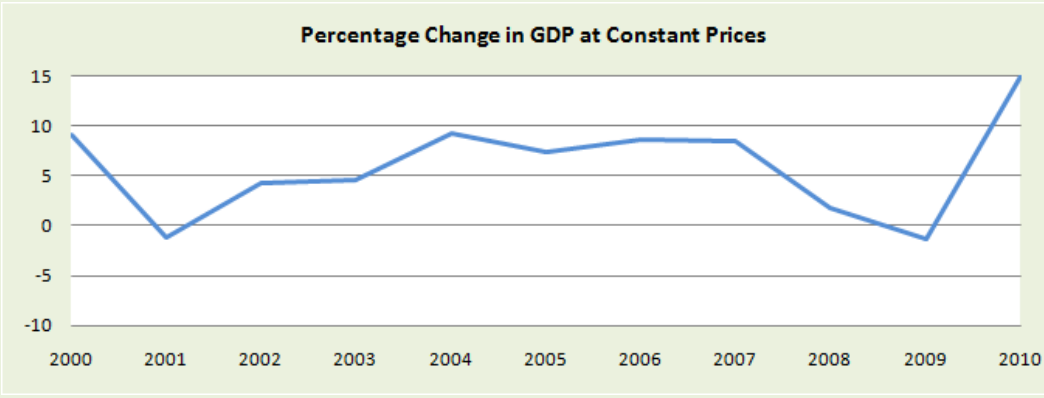
Table 2. GDP Growth in Singapore

Year	Mar	Jun	Sep	Dec
2010	45.90	27.90	-18.90	6.90
2009	-11.00	18.50	11.10	-1.00
2008	17.60	-12.50	-3.00	-9.00

Percentage quarterly change at annualized rates. Source: World Bank; Trading Economics (http://www.tradingeconomics.com)

products, pharmaceuticals, and on a growing services sector. Singapore recovered quickly from a 2001 recession to grow rapidly through to 2007. (For recent and historical data on GDP growth for Singapore, see Table 2 and Figure 4.) There was a slowdown in 2008-2009, but Singapore was not deeply affected by banking problems and has suffered far less than the Republic of Ireland in the current economic downtown. Indeed, average quarterly GDP growth was 7.6% between 2007 and 2010, a very strong performance, despite large quarterly fluctuations (positive and negative) on a quarterly basis between 2008 and 2010 (Table 2).

Figure 4. GDP trends in Singapore, 2000-2010



Source: Source: International Monetary Fund, national currency basis (estimated for 2010).

Singapore has moved from being a follower nation in innovation to a position at the frontier and is now searching for a new model for continued economic success. It has experienced a sustained period of significant investment in infrastructure and education, supplemented by the attraction of talented people and foreign direct investment by the Singaporean government (see Section 4.2). R&D expenditures, patents and publications remain significantly higher in Singapore than in the other benchmark economies with the current focus on investment and creation of a new R&D framework to supplement further value creation.

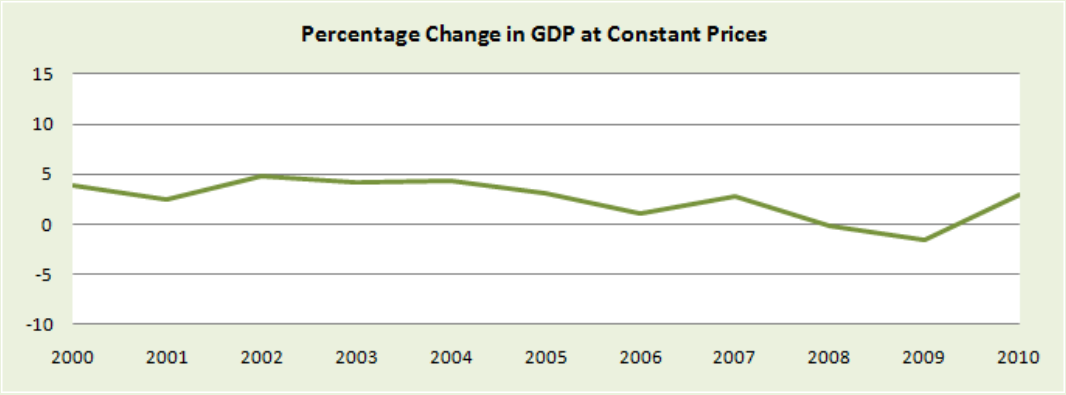
Table 3. GDP Growth in New Zealand

Year	Mar	Jun	Sep	Dec
2010	0.50	0.20	-0.20	
2009	-0.90	0.10	0.20	1.00
2008	-0.30	-0.60	-0.60	-1.10

Percentage quarterly change at annualized rates. Source: World Bank; Trading Economics http://www.tradingeconomics.com)

From 1987 until 2010, **New Zealand's** average quarterly GDP growth was 0.6%. While there has been a slowdown in the economy in 2008 through 2010 due to the global economic crisis, New Zealand has been modestly affected, without major problems in the finance sector. (For recent and historical data on GDP growth for New Zealand, see Table 2.3 and Figure 2.3.) Export volume growth has remained strong over the recent crisis but was met by a large run-down in inventories rather than by production. Over a period of over 20 years, the government has supported transformation of New Zealand from an agrarian economy dependent on concessionary British market access to a more industrialized, free market economy competing globally. This dynamic growth has boosted real incomes - but left behind some at the bottom of the ladder - and both broadened and deepened the technological capabilities of the industrial sector.

Figure 5. GDP trends, New Zealand, 2000-2010



Source: Source: International Monetary Fund, national currency basis (estimated for 2010).

New Zealand has invested in overhauling its public sector, restructured its research institutes towards a commercialisation of activities, fostered new public-private knowledge-exchange relationships, and liberalized its markets through deregulation (see Section 4.1). Although New Zealand has lagged in overall per capita GDP growth, it offers specific insights for productivity, innovation and competitive improvement. These include New Zealand's sustained support of innovation in the agri-food sector, the re-orientation of research institutes to more closely address business requirements, and new public-private innovation partnerships in traditional sectors. The open-to-competition attitude of the government has spurred collaboration among institutions, small company spinouts, public-private partnerships, and support for internationalisation.

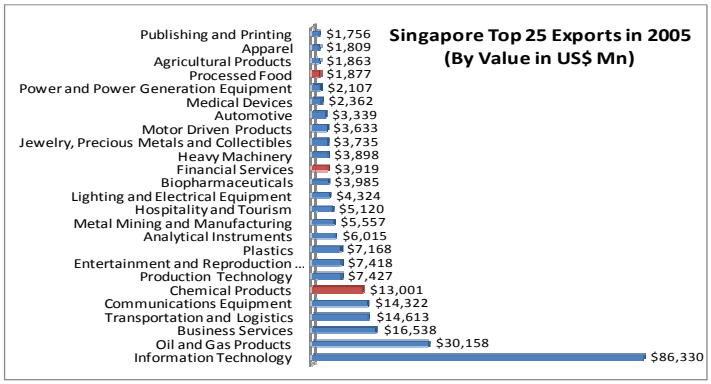
The Republic of Ireland, Singapore and New Zealand have all sought to compete through an open market orientation, the promotion of high value-added industries, and specific policies and programmes to accelerate productivity and innovation. Yet, as subsequent sections of this report will show, there are important differences in macro-economic foundations, strategies, institutional arrangements, and policy design and implementation. As our case studies demonstrate, there are different routes to achieving economic success and to addressing productivity, innovation and competitiveness challenges and opportunities.

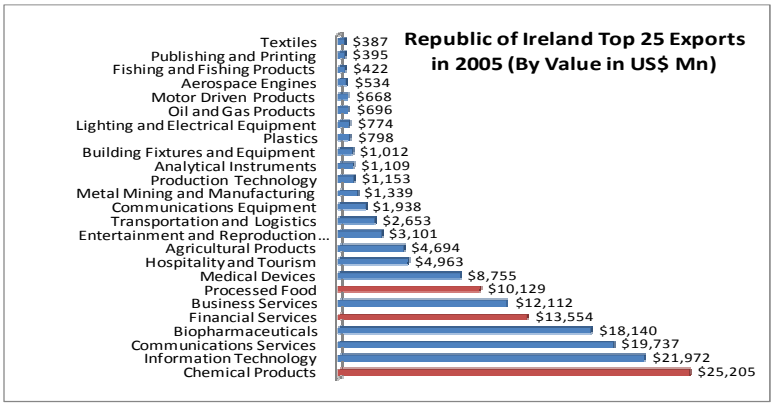
2.3 Revealed Sectoral Strengths across Economies

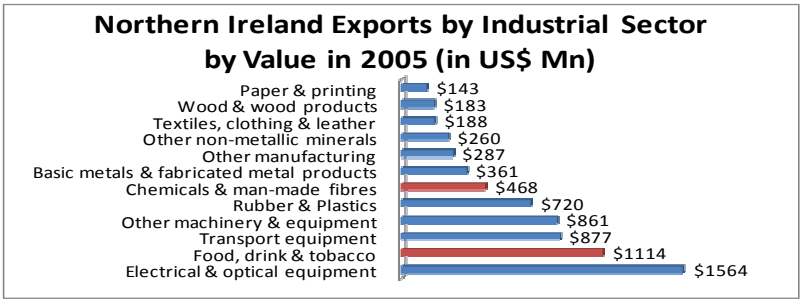
Leading export-intensive firms must be competitive to produce goods and services that have a propensity to be internationally traded. As competitive export-oriented sectors sell to overseas customers, wealth is transferred into the economy through revenue receipts creating positive trade balance impacts. Successful exports by high-income economies are a strong indicator of high value-added output, which is associated with higher returns, higher wages and improved economic prosperity.[8] The Republic of Ireland, Singapore and New Zealand each exhibit strengths in a range of export sectors, as does Northern Ireland. The leading export sectors for our reference economies are indicated in Error! Reference source not found.

[8] M.E. Porter, *The Competitive Advantage of Nations*, Free Press, New York, 1990.

Figure 6. Leading Export Sectors for Selected Economies







Source: Institute for Strategy and Competitiveness of Harvard Business School (New Zealand, Singapore and the Republic of Ireland); DETI Manufacturing Sales & Exports Survey 2005/06 (Northern Ireland).

The PICSOE project examined selected common sectors from the four economies, with a focus on agri-food processing, new technology and manufacturing (e.g. biotechnology, nanotechnology, chemicals, and traditional manufacturing), and internationally traded advanced services (e.g. financial services and banking). The selected sectors are economically significant in all of the economies of interest.

Agricultural products and processed foods are key export sectors in New Zealand, while chemical products are the eighth largest export sector in the economy.[9] In terms of global export value, New Zealand ranks as the 13th largest exporter of processed food, 42nd in chemical products and 61st in financial services. In Singapore, chemical products rank 6th, financial services, 15th; and processed food, 22nd by national export share. In terms of global market shares, Singapore is the 11th largest exporter of chemical products, 11th in financial services and 23rd in processed food. Chemical products represent the largest export sector in the Republic of Ireland. Financial services ranks 5thand processed food is 7th in the economy. By global market share, the Republic of Ireland is the 4th largest global exporter of chemical products, 5th in financial services and 7th in processed food.

In Northern Ireland, the main manufacturing export sector is electrical and optical equipment (23%), followed by food (18%), and transport equipment (12%). Chemicals is ranked 6th.[10] Sales and export in these goods producing activities are important for the economy, yet over 80% of employment is engaged in services, hence it is also vital to consider service-based economic activities.[11] The most economically significant services activities in Northern Ireland are real estate, renting and business activities – contributing 25% to total services GVA, with wholesale and retail trade and the repair of motor vehicles contributing the second highest percentage at 17%, and financial intermediation producing 6% of total services GVA.[12]

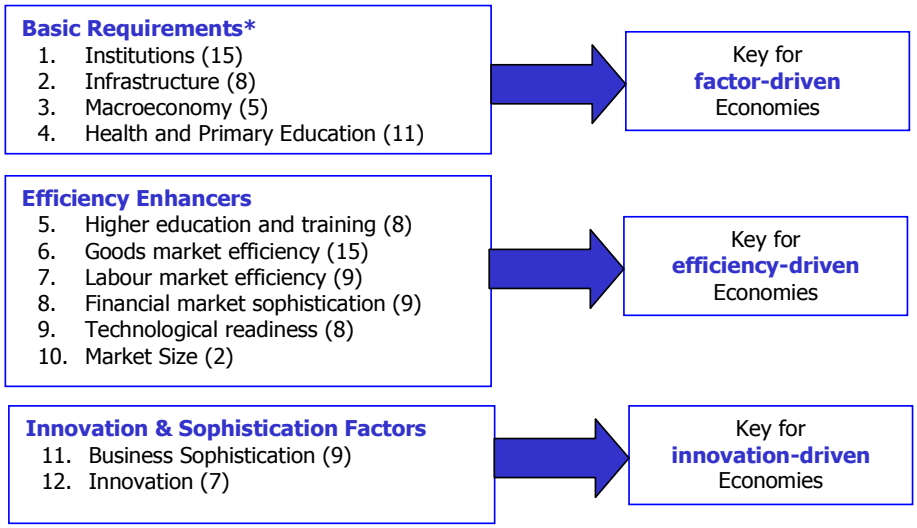
2.4 Competitive Performance

The analysis of competitiveness used in the study builds on twelve pillars of competitiveness as identified by the Global Competitiveness Project of the World Economic Forum. The approach of the Forum's Global Competitiveness Index (GCI) rests on an explicit conceptual framework. This framework, illustrated in Figure 7, is founded on the view that the most important drivers of productivity vary with the stage of development of an economy.

While all competitiveness pillars matter for competitiveness, the weighting towards innovation rises with income. The three countries examined in this project plus Northern Ireland all have high levels of income per capita and find themselves among the group of economies defined as producing and trading in an innovation-driven stage of development. Given their per capita income, these economies have the weighting of 50% on Efficiency Enhancers, 30% on Innovation and Sophistication Factors and 20% on Basic Requirements.[13] The implication is that while all twelve competitiveness pillars matter for competitiveness, the role of innovation becomes increasingly more important (and that of Basic Requirements and Efficiency Enhancers less important) as income rises.

[9] Data on exports for New Zealand, Singapore and the Republic of Ireland from the Institute for Strategy and Competitiveness of Harvard Business School. Export data for Northern Ireland from DETI Manufacturing Sales & Exports Survey 2005/06.
[10] DETI, Northern Ireland Manufacturing Sales and Exports Survey 2008/09.
[11] DETI, Quarterly Employment Survey, June 2010.
[12] ONS, Regional GVA, 2008.
[13] See Chapter 1.1 in the Global Competitiveness Report 2009-10.

Figure 7. The Twelve Pillars of Competitiveness



Note: * Figures in parentheses indicate the number of measures used in measuring each pillar.

Source: Adapted from Figure 1, Chapter 1.1 in the Global Competitiveness Report 2007-8, Palgrave Macmillan

Comparable data on the pillars of competitiveness allow us to draw some comparisons across our benchmark economies of New Zealand, Singapore and the Republic of Ireland to understand the competitiveness drivers. To generate some comparable data for Northern Ireland, available national and GCI statistics were complemented with a limited survey of fifteen business executives who were interviewed using a comprehensive survey instrument[14] similar to that for the GCI. The analysis provided an indication of opinions, as opposed to statistically significant findings, of both foreign-owned and locally-owned businesses in Northern Ireland. The results for Northern Ireland are presented in Table 4, alongside the other three benchmark economies. As with the other countries, Northern Ireland's competitive position is compiled relative to 133 economies.

From our survey feedback, Northern Ireland performs relatively poorly in terms of **Basic Requirements,** ranking 59th among the 133 economies. Within this category, Infrastructure is generally considered weak (79), particularly air transport. The ranking for Macroeconomic Stability at 68 is driven by UK-wide factors (including budget deficit, national savings, inflation, interest rate spread and government debt). Institutions are ranked 59th with worse rankings for the burden of government regulation and the efficacy of corporate boards. There is considerable scope for catch-up here, as well as an opportunity for local political processes as they become more established and effective in the Northern Ireland economy. Health and primary education ranked best (29), again driven largely by UK-wide measures.

In terms of **Efficiency Enhancers,** these are found to be comparable to the other benchmark economies.[15] Investments in developing Northern Ireland's production processes and improving product quality are reflected in its score and ranking here. Northern Ireland rates highly for expenditure on employee training and development and on the quality of the education system generally. Competition from imports is high as trade barriers are not perceived by local business to

[14] The authors are grateful to the WEF for permission to adapt their *Executive Opinion Survey* for this purpose.

[15] Several of the detailed measures in this category are influenced by UK-wide performance (such as tariff barriers, ranked 5th, legal rights ranked 5th, and internet use ranked 6th).

be significant. It is easy to set up a new business and the time taken is not onerous. Access locally to latest the international technologies is considered good. Identified weaknesses remain including, perceived local limitations on the availability of high-quality specialized training services (ranked 117), and the limited intensity of competition in most industries (81).

Table 4. Global Competitiveness Index (GCI) and its Components: 2009-2010

	GCI Score (Rank)	Basic Requirements Score (Rank)	Efficiency Enhancers Score (Rank)	Innovation & Sophistication Score (Rank)
Singapore	5.55 (3)	5.99 (2)	5.61 (2)	5.15 (10)
New Zealand	4.98 (20)	5.58 (16)	5.11 (15)	4.37 (27)
Republic of Ireland	4.84 (25)	5.06 (37)	4.87 (22)	4.63 (20)
Northern Ireland	4.47 (43*)	4.47 (59)	4.69 (27)	4.11 (36)
Weighting in GCI		20%	50%	30%

Source: Data for Singapore, New Zealand and Republic of Ireland are taken from *Global Competitiveness Report*, 2009-2010, World Economic Forum, Palgrave Macmillan. *The ranking for Northern Ireland is based on authors' calculations, with an overall GCI that would place Northern Ireland in 43rd position in the 2009-10 rankings (below Puerto Rico and above Portugal).

In terms of **Business Sophistication,** Northern Ireland's best ranking is for competitive advantage (25), indicative of the presence of unique manufactured products/processes in Northern Ireland. The score for companies' presence across the value chain is strong (33). Control of international distribution is good (27). The weakest scores are observed for local supplier quantity (106), marketing capabilities (88) and a perceived lack of willingness to delegate authority (70). For **Innovation**, the weakest performances are for government procurement of advanced technological products (69) and the availability of scientists and engineers (52). Northern Ireland scored relatively better, compared with the 133 economies, in terms of university-industry collaboration in R&D (12); the capacity for innovation (31); the quality of scientific research institutions (17); and company R&D (24). These results appear to show that business ranks relatively highly the *quality* of Northern Ireland's universities and research institutions and its corporate research and capability for innovation where that occurs. However, low rankings are given to the *quantity* of scientists and engineers available. This is consistent with the traditionally low overall levels of R&D spending in Northern Ireland, and hints that there are issues related to the breadth and scale of R&D and innovation in the region.

Further details of this technical analysis, as well as the innovative capacity modelling to understand the determinants of innovation, are presented in the following chapter (see Section 3.3). The next chapter also details the performance of Northern Ireland against the benchmark economies in terms of productivity, innovative capacity and competitiveness.

3. Summary of Technical Analyses

This chapter summarises the technical analyses of the benchmark economies in comparison with Northern Ireland. The analyses were undertaken at the initiation of the study, examining three complementary aspects of productivity and efficiency; innovation and knowledge performance; and competitiveness and innovative capacity. These three aspects are discussed in Sections 3.1, 3.2 and 3.3 respectively. They provide the context for understanding the performance of Northern Ireland, and situate the New Zealand, Singapore and the Republic of Ireland case studies discussed in chapter 4.

We have developed a broad picture of the types of firms, industries, and the economic and competitiveness landscape in each economy using the following methodologies and sources:

1) Productivity data are modelled using stochastic frontier and data envelopment techniques for selected industries in the small open economies;

2) Bibliometric and patent data are examined to reveal key research performers and innovative patent producers, as well as the linkages and emerging topics in knowledge production in each economy; and

3) Competitiveness data are collected and collated to generate descriptive statistics and enable comparison across each economy and its institutions.

Full details of these analyses are contained in three earlier reports submitted to the Department of Enterprise, Trade and Investment in 2009-2010 (see Footnote 2). Although we do not make specific recommendations from the technical analyses, the findings emphasise the importance of assessing and enhancing overall frameworks and capabilities for R&D, innovation and productivity enhancement, developing strategic innovation themes and targets, creating effective institutional forms and support instruments, and building appropriate governance mechanisms.

3.1 Productivity and Efficiency

A macro-level examination of selected sectors across the benchmark economies of New Zealand, Singapore and the Republic of Ireland reveals a range of efficiencies and total factor productivities at firm and industry levels. Our micro-level technical analysis focused on three sectors - banking, chemicals and food processing –to represent key sectors of advanced services and manufacturing and other export intensive industries relevant to the economic structure of each economy. The continued development of productivity and efficiency in these sectors underpins continued growth in value added, international competitiveness and the economic prosperity of the countries within which such sectors locate and operate.

We measure productivity and efficiency in the selected sectors using data envelopment analysis (DEA).[16] This technique was chosen because i) of its long established use and development both

[16] When using DEA it is important to understand that firm level efficiency is a comparative concept. A firm is more efficient than another if it uses less input for a given level of output (or when the firm produces more output for a fixed amount of input). When firms use multiple inputs to create multiple outputs, efficiency cannot be easily measured. Instead, statistical techniques, such as data envelopment analysis, are more appropriate. DEA identifies the most efficient firms within a sample. These firms define an efficient frontier against which all other firms can be measured. The further a firm is from the frontier, the more inefficient it is. For more details on DEA see PICSOE Report 1.

within the academic and business community, ii) as a non-parametric technique, DEA can cope with small samples of observations; and iii) statistical routines for DEA are well developed for examining levels and changes in efficiency, including both improvements and deteriorations in efficiency over time.

Inefficiency arises from technical or scale sources. A firm can reduce technical inefficiency by improving its processes and optimizing the conversion of inputs into outputs. Scale inefficiency is reduced by a firm altering its size to exploit economies of scale. Overall efficiency improvements over time are referred to as changes in Total Factor Productivity. Total Factor Productivity comprises improvements in technical efficiency, improvements in scale efficiency and improvements in the productivity frontier of the most efficient firms. Such a change in the frontier of efficient firms is denoted as technological improvement.

A comprehensive range of secondary data sources were used in assessing productivity and efficiency across three sectors in our four economies. Data limitations need to be borne in mind when considering the results. [17] The main findings are summarised as follows:

Banking: when measuring efficiency within Northern Ireland only, banks display strong efficiency characteristics with high degrees of technical and scale efficiency. When compared with leading banks in the benchmark economies, Northern Ireland's banking sector displays a level of technical efficiency that is comparable to New Zealand, but significantly lags that of Singapore and the Republic of Ireland. Northern Ireland's banking sector average for technical efficiency is between 40% and 50%, suggesting that on average firms perform to within 50% to 60% of best practice. In contrast, the scale efficiency of Northern Ireland's banks dominates that of the other banking sectors, with a sector average approaching 80% of best practice. Despite technical efficiency being comparatively low in Northern Ireland's banking sector, improvements in productivity over time have been strong at around 4% per annum.

Chemicals: When compared with New Zealand and Singapore, the Chemicals sector in Northern Ireland is comparably efficient. The pooled technical efficiency average for the sector is within 80% of best practice. Scale efficiency is also strong for Northern Ireland, which consistently achieves average scale efficiency exceeding 90% of best practice. Improvements in efficiency over time averaged 2% per annum, achieved by improved best practice, improved scale economies, and by a slowing of technical inefficiencies.

Food: When compared with the other selected economies, technical efficiency in Northern Ireland's processed food sector averages around 75% of best practice. Scale efficiency in Northern Ireland also outperformed that of the other economies with an average of around 80% of best practice. Throughout the sample period, Northern Ireland's processed food sector improved

[17] Banking data were sourced from the global banking database Bankscope. The banking data period of analysis was constrained to 2000 – 2006 to avoid any impact of the financial crisis on measured efficiency. Data on the Chemicals and Food sectors within the Northern Ireland region were obtained from the Northern Ireland Annual Business Inquiry, whilst data for the other economies was obtained from Datastream. As two databases are used, there are some differences in the treatment and operationalisation of the data. Specifically, Revenue is taken as the net revenue line in Datastream. Capital is taken as net property, plant and equipment. All other cash expenses are taken as the difference between net revenue and earnings before interest, tax and depreciation. All data was converted into UK Pounds sterling using Purchasing Power Parity exchange rates published by the International Monetary Fund. From the Northern Ireland Annual Business Inquiry, Revenue is Total Turnover (399); all other cash expenses are Employment Costs (450) + Total purchases of energy, goods, materials and services (499). Net Capital Expenditure is Acquisitions (600)-Disposals (699). Importantly, the Northern Ireland data on capital is a flow, not a stock measure, as in the Datastream data. This is due to data limitations and the working assumption is that net capital expenditures act as a positive proxy for net capital stock (i.e. the more capital stock a company has, the more capital expenditure it will undertake to replace, repair and maintain).

productivity by an average 4.4% per annum. Most of these gains came from improvements in best practice, rather than improvements in technical and scale efficiency.

Productivity and efficiency: Key observations

There is evidence that Northern Ireland's industrial sector has a capacity to further improve its productivity. The banking sector reflects genuine technical efficiency inferiority and may also represent differences in the nature of value-added services provided in the sense that the cost of serving rural economies in Northern Ireland may hamper technical efficiency in this sector. It is recognized that a large proportion of the staff employed in local banks in Northern Ireland provide local rather than tradable services. However, lags in efficiency even at the local level may raise costs and constrain overall productivity growth. Opportunities to foster improved performance may be generated through such means as training and ICT enhancement and through encouraging new market entrants. The scale efficiency of chemicals firms in Northern Ireland, relative to the benchmark countries, indicates they are operating at a relatively more efficient scale than in the other economies. However, our results indicate potential opportunities for improvement for the food processing sector in terms of technical and scale efficiency. The food processing sector is important for Northern Ireland, and could add more value with improvements in productivity and innovation. In Chapter 5, after further examination of insights from the three country cases, we consider a series of possible measures aimed at developing productivity, innovation and competitiveness in Northern Ireland at regional and sectoral levels.

3.2 Innovation and Knowledge

The second macro-level examination reveals the profiles of research, development, and innovation and identifies key scientific and corporate actors engaged in knowledge-driven innovation in each economy. The innovativeness of an economy is influenced to a significant extent by its institutions' ability to generate and acquire new knowledge through scientific research, the development of intellectual property, the encouragement of new scientific and technological fields, and the formation of collaborative research and knowledge sharing relationships. In this section, we examine the creation of new scientific knowledge within each economy and characterise research and corporate organisations and their interactions. We also explore new knowledge creation in the social sciences, focusing on management, economics and finance (since these provide a knowledge base for advanced services). Lastly, we assess the performance of the economies in applying knowledge to secure protectable intellectual property in inventions and innovations.[18] The major findings are outlined below.

Research Concentration and Performance

In Singapore, R&D investment has grown more rapidly than in the other three economies, with Gross Expenditure on R&D (GERD) reaching 2.2% of Gross Domestic Product (GDP) in 2006 and 2.8% in 2009. The aspiration is to achieve 3% in the near future.[19]

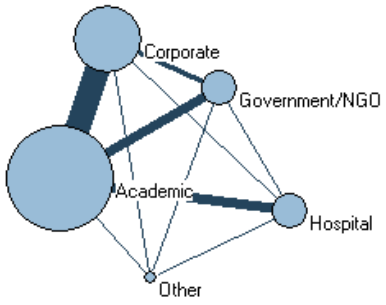
Scientific publication is concentrated in universities and other public research institutes such as hospitals and government agencies/institutions in many of the economies. The top-3 research

[18] This chapter, published earlier in PICSOE Report 2, is based on the bibliometric analysis of 119,000 Science Citation Index and 6,800 Social Science Citation Index records (Web of Science) for publications and on 50,200Patstat records of patent grants for inventions in Northern Ireland, the Republic of Ireland, New Zealand, and Singapore, for the period from 1999 through to mid-2008.

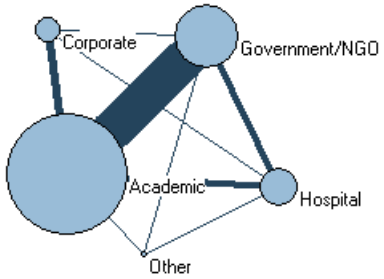
[19] Based on interviews with ASTAR and MTI in November 2009.

organisations of each country are mainly universities, except for a third-placed research hospital in Northern Ireland and a similarly-placed government research agency in Singapore.

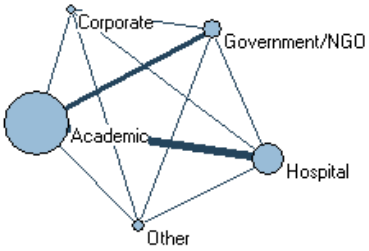
Figure 8. Nodes of Collaboration and Linkages



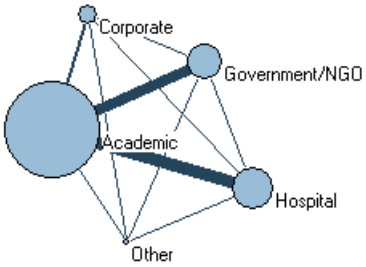
New Zealand



Singapore



Northern Ireland



Republic of Ireland

Source: ISI-WoS database, Science Citation Index Expanded (SCI-EXPANDED). *Note:* Size of circles is proportion to number of publications (1999-mid-2008); width of lines is proportional to number of co-authorships associated with these publications.

A significant share of research is undertaken in collaborations and networks, usually centred on the large universities. While the number of collaborations is signified by the thickness of the lines connecting nodes in Figure 8, we can clearly see less extensive collaboration for universities in Northern Ireland. Interestingly, we find that Northern Ireland's researchers generate more publications per million inhabitants than R&D workers in Singapore, the Republic of Ireland and New Zealand.

Table 5 illustrates that scientific research targets in all four countries are generally diversified, more so in Northern Ireland, the Republic of Ireland, and New Zealand. The exception is Singapore, with a strong concentration in engineering-related areas. The growth areas can be seen as representing newer and important targets in small economies. The areas of decline reflect relative diminutions in research paper output, possibly driven by reductions in research sponsorship and industry interest.

Table 5. Scientific Research Target Areas in Selected Economies

	New Zealand	Singapore	Republic of Ireland	Northern Ireland
Top Areas	Chemistry 7.5%; Engineering 6.3%; Ecology 4.8%; Biochemistry & Molecular Biology 4.4%; Marine & Freshwater Bio 4.4%	Engineering 28.7%; Physics 15.9%; Materials Science 11.8%; Chemistry 11.0%; Computer Science 8.7%	Chemistry 10.2%; Physics 9.7%; Engineering 9.4%; Food Science & Technology 5.3%; Biochemistry & Molecular Bio 5.1%	Physics 9.9%; Engineering 9.8%; Chemistry 9.3%; Astronomy & Astrophysics5.4%; Medicine 4.1%
Fastest Growth Areas	Environmental Sciences; Physics; Engineering; Food Science & Technology; Ecology	Nanoscience & nanotechnology; Biotechnology & Applied Microbiology; Oncology; Cell Biology; Medicine;	Genetics & Heredity; Computer Science; Optics; Astronomy & Astrophysics; Materials Science	Oncology; Biochemistry & Molecular Biology; Engineering; Materials Science; Computer Science
Fastest Decline Areas	Medicine; Fisheries; Plant Sciences; Oceanography; Marine & Freshwater Bio	Automation & Control Systems; Mathematics; Mechanics; Polymer Science; Engineering	Medicine; Pharmacology & Pharmacy; Food Science & Tech; Immunology; Agriculture	Medicine; Veterinary Sciences; Optics; Microbiology; Clinical Neurology

Source: ISI-WoS database, Science Citation Index Expanded (SCI-EXPANDED), 1999-mid-2008.

Table 6. Research Inputs and Outputs in Selected Economies

	New Zealand	Singapore	Republic of Ireland	Northern Ireland
Total Publications (1999-2008)	37,639	42,832	27,473	12,395
All Publications Growth Rate	2.6%	9.0%	9.4%	3.3%
Corporate Publications	10,594	1,705	916	189
Corporate Publication Growth Rate	-0.2%	10.2%	13.5%	9.8%
Number of Corporate Participants	643	497	407	91
Gross Domestic Expenditure on R&D, $US millions, 2006	1,826[b]	4,582	2,030	602
Publications per million population, 2006[a]	9,087	9,732	6,460	7,115
Publications per $US million 2006 GERD[a]	20.6[b]	9.3	13.5	20.6

GDP = Gross Domestic Product. GERD = Gross Expenditures on Research and Development.
Sources: ISI-WoS database, Science Citation Index Expanded (SCI-EXPANDED), 1999-mid-2008. [a]Population, GDP, GERD from OECD data, for 2006, except where indicated by [b] as of 2005.

Corporate Research

The Republic of Ireland and Singapore exhibit the fastest expansions in corporate and commercial research, with 50% or higher rates of increase in the number of companies producing research papers between 1999-2003 and 2004-2008 (see also Table 6). The equivalent rate is about 26% in Northern Ireland. Engineering and materials science are well-represented in corporate research in Singapore, the Republic of Ireland and Northern Ireland, but less so in New Zealand. In Northern Ireland, corporate research is also significant in chemistry and veterinary sciences; in the Republic of Ireland, in chemistry, biotechnology, and computer science; and, in Singapore, in physics and nanotechnology. At least 62% of the companies undertaking scientific research in these countries do so in collaboration with other organisations. In Singapore and New Zealand, the share reaches to about 70%, indicating denser corporate collaboration networks.

International Research Collaboration

International research collaborations are significant for both university and commercial research. At least 40% of scientific publications in the four economies are published in collaboration with organisations outside the home country. For the period 1999-2008, the USA was a primary partner for all countries. Specifically, for Northern Ireland, other leading research partners were England, the Republic of Ireland, and Scotland.

Social Science Research

Finance and business-related research areas in the social sciences are of special interest. Such categories, however, represent a minor share of all publications in Northern Ireland, the Republic of Ireland, New Zealand, and Singapore. These research areas are growing in significance for New Zealand and Singapore, where they contributed about 4% of the overall publication output in more recent years (about 50% growth in 10 years). The relative scale of these areas for Northern Ireland and the Republic of Ireland is lower, with less than a 3% share of all papers. Singapore leads in business/management and New Zealand in economics/finance. Social science research is performed primarily by universities, with few government or corporate contributions.

Scientific Application and Patents

Singapore is the leader in terms of granted patents in the last decade, followed by New Zealand and the Republic of Ireland, and then Northern Ireland. While patent ownership and licensing do not guarantee successful commercialisation, it is often required to exploit new technologies and conquer high-technology markets. Some technology concentrations are evident from our analysis. At least one-fourth of the technologies patented by Northern Ireland, the Republic of Ireland, and New Zealand are related to medical or veterinary science and organic chemistry. Singapore's patents are more strongly related to electric, electronic, and communications engineering.

Special interest is usually given to collaborations between companies and universities, which can highlight capabilities to commercialise new technologies arising from public research. However, we find little evidence of significant co-assigned patenting between companies and universities. It is low in these economies, and especially low in Northern Ireland.

Although technologies may be created and developed by local inventors, the capability to exploit or commercialise such technologies may be situated in other countries if the patent has foreign assignees. Our analysis shows that at least one-third of the patents granted to these countries

between 1999 and 2008 are owned by foreign assignees. In Northern Ireland that share is even higher. The findings may have important implications that deserve further investigation.

Organisational Patterns and Capabilities

While Northern Ireland and the Republic of Ireland display university-centred research systems, New Zealand is pursuing a strategy of strong involvement of privatised companies in scientific research. Meanwhile, Singapore is characterised by the central roles not only for its two large universities but more recently for its growing networks of government research labs. Commercial companies, in general, play a secondary role in scientific research in our findings, although their patterns of collaboration with other research organisations can be important markers of knowledge-driven innovation.

Two universities - Queen's University and the University of Ulster - dominate scientific research and scientific collaborations in Northern Ireland. These universities are dynamic and well integrated in global scientific collaboration networks, yet they maintain a regional focus.

Privatising Public Research – Balancing Short and Long-Term Needs

In March 2010, the New Zealand Ministry of Research, Science and Technology issued a panel study: "Report of the Crown Research Institute Taskforce: How to enhance the value of New Zealand's investment in Crown Research Institutes." This assessment found that New Zealand's privatised Crown Research Institutes (CRIs) were helping New Zealand to address key economic, scientific, sustainability, and risk issues. The report did not argue for changing the number of CRIs, but suggested that a greater emphasis should be placed on the CRIs generating value for the country rather than for each CRI company itself. The study also raised concerns that a too-high commercial orientation in the CRIs could lead to a short-term focus, with insufficient attention to longer-term strategic R&D missions. The government was recommended to ensure that a simplified but strategic framework was in place to ensure a longer-run strategic orientation among the CRIs and to employ more balanced performance indicators (to avoid an overreliance on rates of return).

Innovation and knowledge: Key observations

A series of policy-relevant findings and observations emerge from our comparative analysis of the different research landscapes. Northern Ireland's relatively weak spending on R&D and its low share of R&D workers likely places the economy at a significant competitive disadvantage compared with leading R&D intensive economies like Singapore. In addition, the lag in private R&D investment is a particular concern in Northern Ireland. There is also a high orientation of Northern Ireland's R&D workforce towards publication, but not towards patenting. Simply investing more R&D funds in Northern Ireland without other changes in structures or incentives therefore may not generate desired results.

Evidence shows that New Zealand has successfully transformed its public research institutes into privatised commercial corporations, while Singapore has demonstrated a model of powerful government agencies collaborating with universities and research laboratories. In this respect, Northern Ireland has two important types of non-university research organisations that can be leveraged upon. Nine of Northern Ireland's top scientific research performers are in fact hospitals, perhaps raising opportunities to accelerate the translation of medical research into more health-related innovations that can be commercialised. In the food and agricultural sector, AFBI (the Agri-

Food and Biosciences Institute) is Northern Ireland's seventh most productive scientific research organisation.

Finally, Northern Ireland is a traditional centre of excellence in engineering, and retains capabilities in engineering research and corporate engineering innovation. Northern Ireland may wish to consider options to bolster these capabilities and to enhance partnerships in corporate R&D in areas where the region continues to have relative strengths, such as medical, veterinary science, and organic chemistry research.

3.3 Competitiveness and Innovative Capacity

The purpose of the micro-analysis is to investigate the microeconomics of competitiveness of the benchmark economies and their innovation capacity.[20] To generate an indication of comparable data for Northern Ireland, survey responses from fifteen business executives of both foreign owned and locally-owned businesses were employed based on a comprehensive survey instrument similar to that for the GCI (see Section 2.4), coupled with available regional (or relevant UK) statistics.

Competitiveness

From Table 7, Singapore ranks highest of the benchmark economies in third place across the 133 countries surveyed in 2009-10. New Zealand and the Republic of Ireland were quite similarly ranked initially in 2005-06 - at 22 and 21 respectively - and their performances remained in the high to mid-twenties over the period. Most recently, the Republic's performance declined and its most recent ranking is 25, while New Zealand's most recent ranking of 20 was an improvement of 4 positions on the previous year.[21]

Table 7. Competitiveness Measures, Selected Countries: 2005-6 to 2009-10

CGI	2009-2010		2008-2009		2007-2008		2006-2007		2005-2006	
Country	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**
Singapore	3	5.55	5	5.53	7	5.45	5	5.63	5	5.67
UK	13	5.19	12	5.30	9	5.41	10	5.54	13	5.11
N. Zealand	20	4.98	24	4.93	24	4.98	23	5.15	22	5.22
R. Ireland	25	4.84	22	4.99	22	5.03	21	5.21	21	5.22
Top Score		5.60		5.74		5.67		5.81		5.85
Countries		133		134		131		125		117

Source: Global Competitiveness Report, various editions, World Economic Forum, Palgrave Macmillan. UK measures included for comparative purposes.

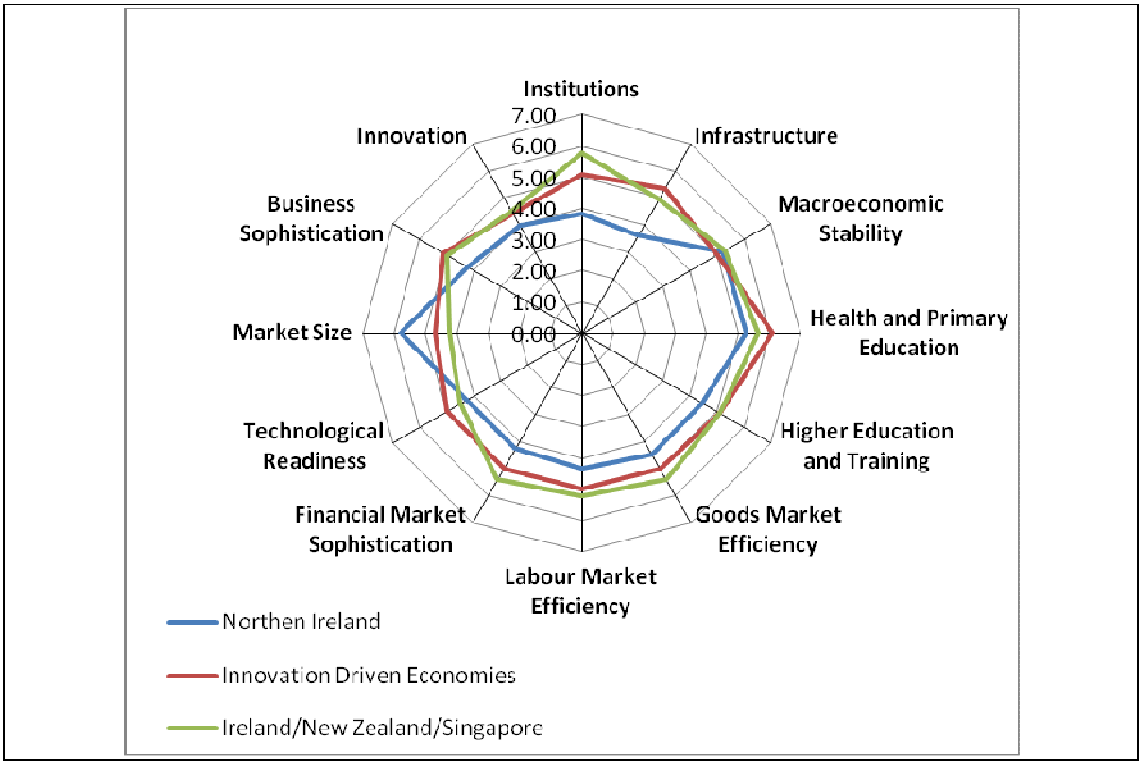
[20] This section draws on Competitiveness and Innovation Profiles of Three Small Open Economies: New Zealand, Singapore, and Republic of Ireland, 2010 (see Footnote 2).

[21] The most recent rankings can be interpreted in the light of the international recession. A measurable decline in average scores for 2009-2010 is been observed for countries in the GCI (Global Competitiveness Index), with those most adversely affected by financial crises (such as the Republic of Ireland) displaying greater declines in their rankings. This emphasises the importance of viewing trends over multiple years rather than focusing on specific points in time.

Competitiveness of Northern Ireland

Following the methodology of the Global Competitiveness Project of the World Economic Forum, and survey responses by fifteen business executives in Northern Ireland, measures corresponding to the twelve pillars of competitiveness were compiled. These were compared with the outcomes for other innovation-driven economies in the world (thirty three countries in total) and with our benchmark economies of New Zealand, Singapore and the Republic of Ireland. We chart our findings in Figure 9.

Figure 9. Competitiveness Pillars – Northern Ireland and Selected Other Economies



Source: Global Competitiveness Report, various editions, World Economic Forum, Palgrave Macmillan.; Northern Ireland data based on survey of 15 business executives.

Our three benchmark economies perform consistently better than the average innovation-driven economy in six pillars – Institutions, Macroeconomic Stability, Goods Market Efficiency, Labour Market Efficiency, Financial Market Sophistication, and Innovation (this may be driven by Singapore's performance). Relatively weaker scores are observed for the pillars of Infrastructure (driven by the Republic of Ireland's poor performance), Health and Primary Education (where both Singapore and the Republic of Ireland are weaker), Technological Readiness, and Business Sophistication (despite above average performance by Singapore).

For the pillar of Higher Education and Training, the averages coincide, although the Republic of Ireland's performance is weak here. In the case of Market Size, given their small economy status it is no surprise that our benchmark economies are relatively weaker on this measure: Northern Ireland's home market is considered as the UK, hence its strong performance. In the remaining pillars, Northern Ireland's performance is weaker than for the average innovation-driven economy. The pillars where Northern Ireland's best relative performance is observed are: Innovation, Goods Market efficiency, Higher Education and Training and Labour Market Efficiency.

As noted previously, the high rankings offered by business related to innovation may reflect the high quality attached to Northern Ireland's universities and corporate R&D activities where they occur. Issues of the breadth and scale of R&D and innovation across the region's economy are nonetheless present, as other evidence cited in this report indicates. Northern Ireland's weakest pillars are identified as Infrastructure and Institutions, according to the feedback of the business executives in Northern Ireland.

Determinants of Innovation Capacity in Advanced Small Economies

In additional analyses, we have examined the relationships of innovation and competitiveness with other variables of interest. Three complementary approaches to analysing the determinants of innovative capacity were employed for 23 modern developed economies from 1993-2005, including a selection of small open economies. Northern Ireland could not be included due to a lack of data for Patent Stock, Property Rights Protection and Openness.[22] However, the findings are still instructive, since other small open economies are included. We use a National Innovative Capacity framework.[23] Modelling generates robust results. The percentage of variation in patenting activity explained by applying this approach is over 92%, indicative of the comprehensive explanatory power of the statistical model applied in estimating the relationship between patenting activity (a proxy for innovative capacity) and selected variables.

Our analyses show that small open economies in general use the same basic principles as the "average" advanced economy to generate innovative activity. Accumulated Patent Stock was identified as a major factor in determining both current and future patent output. A 10% increase in Patent Stock resulted in approximately a 2% increase in patent production consistent across our entire sample and for the economies examined. We identify R&D expenditure as a very significant determinant of innovative activity in small open economies: a 10% increase generates a 4.8% increase in patenting for the whole sample but a larger 6.7% increase in patenting in the case of small open economies.

Our results indicate that the variable "persons employed in R&D" (significant in earlier studies applying this method) is consistently insignificant once R&D expenditure is included. It is possible that a structural break may be evident in the way patents are produced in more recent years, with R&D expenditures spread more broadly across companies and associated organizations (rather than in units with dedicated R&D workers).

Two further variables Legal Structure & Security of Property Rights and Openness generated results of particular interest from the perspective of their impact in small economies. Both variables are significant explanatory factors with a 10% increase in the perceived level of Property Rights resulting in approximately a 1% increase in patents for the full sample and over 3% for our small economies. For Openness, the respective impacts are 1.4% for the full sample and 2% for small economies.

Competiveness and Innovation Capacity: Key Observations

Over 45% of total sales from Northern Ireland are destined for Great Britain, with a further 10% to the Republic of Ireland.[24] About 7% of Northern Ireland's sales occur in other European countries,

[22] A further variable *Expenditure on 2nd & 3rd level education as % GDP* is included to reflect policy decisions on behalf of government regarding the extent to which such expenditure is prioritised. In the NI context, such a variable would not be reflective of such policy making over the period considered here 1993-2005.
[23] This approach began with the creation of an Innovation Index in Porter and Stern (1999) and developed into the National Innovative Capacity Framework underlying our approach here presented in Furman, Porter and Stern (2002).
[24] Northern Ireland's Manufacturing Sales & Exports Survey 2009/10, DETI.

with about 17% of sales to other countries outside of Europe (led by the USA). Large companies (with 250 or more employees) account for the majority of Northern Ireland's external and export sales. The challenge of increasing exports, particularly for SMEs, is closely related to Northern Ireland's current policy target of closing the productivity gap (with the UK) and improving competitiveness. Research on the relationship between exporting firms and productivity reveals that the causation runs from productivity to increased innovation, in other words, the most productive firms are more likely to engage in and be successful in innovation and exports. Hence rather than treating the goal of increasing exports as separate to the productivity and innovation imperatives, these are related aspects which need to be addressed together to improve economic performance.

Innovative capacity is important to competitiveness particularly for advanced small economies, since they are likely to have limited ability to generate increased output from further investments in capital (the predominant productivity driver in the efficiency-driven stage). Being a small open economy neither strengthens nor weakens potential ability to produce innovation and patents. Small open economies that appear to have reached high levels of critical mass in terms of inputs to and outputs from expenditure on innovation include Denmark (with expenditure at twice that of Northern Ireland and the Republic of Ireland), Finland and Israel (with expenditure levels three times that of Northern Ireland and the Republic of Ireland). Our findings indicate that the level of patent stock accumulated over time was an important factor in explaining patenting activity. However, it is possible to override this path dependency and to rapidly accumulate patents even from a historically low level, as the case of Singapore illustrates.

We find that R&D spending is a significant determining factor for patenting activity, and that the relationship between R&D and patenting is even more important in small open economies. This raises a number of issues in terms of innovation policy and strategy. As an economy with a large base of small and medium sized businesses, many of which cannot afford in-house R&D, Northern Ireland requires creative thinking in supporting partnerships across related companies for innovation purposes. For example, an initiative to pool innovation vouchers (as undertaken in Singapore) could offer a mechanism that would serve the dual purposes of initially increasing networking and, thereafter, allow fruitful projects to be identified across firms committed to innovation. The development of industry-led innovation communities, as recommended by DETI's MATRIX panel of business experts, offers a further strategy to use business networks to leverage innovation performance in Northern Ireland.

4. Case Studies and Best Practices

This chapter summarises our country case studies of productivity, innovation and competitiveness (PIC) in New Zealand, Singapore and the Republic of Ireland, including their socio-economic conditions.[25] It includes discussion of policy process and organization in the country and a description of key programmes supporting PIC. We conclude each section with key "takeaways" from each economy that are based on observations and interviews carried out with practitioners and policy makers. The three cases - New Zealand, Singapore and the Republic of Ireland – offer a range of insights for improving productivity, innovation and competitiveness. These are reported in the conclusion to each country case. Subsequently, in Chapter 5, we draw on the benchmark country cases to identify issues and options for Northern Ireland.

4.1 New Zealand

The New Zealand case reveals that good government and efficient markets do not necessarily lead to high competitiveness if there are lags in infrastructure, R&D and innovation investment. Despite strong performance in agricultural, food and selected high technology sectors, its overall per capita income and productivity growth has lagged. No easy local access to large markets exists: its domestic economy is small with the next closest market 1,200 miles away. Recently New Zealand overhauled its public sector, restructured its research institutes, fostered public-private new knowledge-exchange relationships, and liberalized its markets. Insights for productivity, innovation and competitive improvement are demonstrated in its sustained support of innovation in the agri-food sector, the re-orientation of research institutes towards business, and new public-private innovation partnerships in traditional sectors.

4.1.1 Underlying Trends

From a population of under 2 million in 1950, New Zealand experienced consistent population growth to reach 4 million in 2003, with recent estimates (September 2009) at 4.33 million generated largely through net in-migration.[26] New Zealand's economy depends significantly on services, which account for about 70% of GDP. Key service sectors include financial services, transport, tourism, and communications. Agriculture, hunting, forestry and fishing contribute a further 6% of GDP. This is relatively high for an advanced economy (for example, these primary sectors contribute just 0.9% of the UK's GDP). New Zealand's industrial sector (including energy) comprises about 25% of GDP, down from about 30% in 1980. Within the industrial sector, manufacturing accounts for nearly 14% of GDP.[27]

The Global Competitiveness Index ranks New Zealand in the top 11 among all countries for institutions, health and primary education, higher education, and market efficiency (see Table 8).[28] It scores lower for infrastructure and macro-economic policy (ranked mid-30s), technology readiness and innovation (ranked 23rd), and business sophistication (ranked 34).

[25] This chapter is based on our third background report, Competitiveness and Innovation Profiles of Three Small Open Economies: New Zealand, Singapore, and Republic of Ireland (see Footnote 2).
[26] New Zealand ranks 4th among reporting OECD countries in its share of foreign-born population (21.2% in 2006).
[27] GDP shares from OECD StatExtracts (for 2004). Manufacturing GDP share from Statistics New Zealand (for 2007).
[28] Rankings are based on the method applied in the annual Global Competitiveness Reports of the World Economic Forum, available from http://www.weforum.org/en/initiatives/gcp/Global%20Competitiveness%20Report/index.htm

Table 8. Competitiveness Index Measures: New Zealand

	Competitiveness Pillars	2007-2008		2008-2009		2009-2010	
		Score	Rank	Score	Rank	Score	Rank
A	**Basic Requirements**	5.33	17	5.58	19	5.58	16
	Institutions	5.80	9	5.81	8	6.03	5
	Infrastructure	4.52	33	4.37	42	4.64	35
	Macro-Stability	5.36	36	5.72	25	5.24	33
	Health & Primary Education	6.45	4	6.42	5	6.43	4
B	**Efficiency Enhancers**	5.10	18	5.07	17	5.11	15
	Higher Education &Training	5.53	12	5.40	15	5.49	11
	Goods Market Efficiency	5.35	9	5.17	17	5.20	8
	Labour Market Efficiency	5.17	9	5.10	10	5.12	11
	Financial Market Sophistication	6.02	4	5.87	3	5.69	3
	Technological Readiness	4.82	23	5.09	22	5.24	23
	Market Size	3.69	59	3.78	60	3.89	59
C	**Innovation & Sophistication**	4.42	25	4.26	28	4.37	27
	Business Sophistication	4.75	29	4.57	37	4.64	34
	Innovation	4.09	25	3.95	26	4.10	23

Source: *Global Competitiveness Report*, annual editions 2007-2009, World Economic Forum, Palgrave Macmillan

A recent OECD innovation review highlights the economic reforms undertaken over the last two decades and notes strengths in the innovation system.[29] These include positive basic conditions for entrepreneurship and innovation, competent public administration, public research institutional capabilities, competitive nature-resource based sectors, and pockets of excellence in software, creative industries and other new sectors. The OECD also highlights weaknesses, including physical infrastructure, broadband Internet availability and cost, weak business R&D investment, barriers to business growth including distance to markets, lack of public support for innovation-related investments, the "lifestyle" orientation of some entrepreneurs, and lack of management skills and limitations in technology diffusion. The OECD particularly flags New Zealand's overreliance on maintaining "policy principles" at the expense of "efficacious implementation" which leads to high transaction costs through the separation of customer and contractor functions in public R&D funding.

New Zealand's annual labour productivity growth was at an all-time high of 3.1% between 1997 and 2000 but fell to 1.3% between 2000 and 2006, and subsequently to -0.3% between 2006 and 2009. Overall, annual growth in labour productivity between 1978 and 2009 averaged 1.9% per annum.[30] Tax reform continues in New Zealand, with key issues being business taxes and the effect on productivity and competitiveness of New Zealand companies.[31] The top marginal rate of income tax was reduced from 66% gradually to reach 33% (on amounts over NZ$70,000) in 2010 and the corporate income tax rate from 33% in the mid-1990s and early 2000s to 30% in 2010.[32]

[29] OECD Reviews of Innovation Policy – New Zealand, 2007, Organisation for Economic Cooperation and Development, Paris, 2007.
[30] Statistics New Zealand, http://www.stats.govt.nz/
[31] See: Business Tax Review, Inland Revenue Department, Wellington, New Zealand, 2006, http://taxpolicy.ird.govt.nz/sites/default/files/2006-dd-btr.pdf; Briefing for the Incoming Minister of Revenue – 2008, Inland Revenue Department, Wellington, New Zealand, 2008, http://www.ird.govt.nz/aboutir/reports/briefing/briefing-2008/bim-08/.
[32] OECD Tax Database, Corporate and capital income taxes, Part II. Taxation of Corporate and Capital Income (2010), http://www.oecd.org/dataoecd/26/56/33717459.xls, accessed January 23, 2011.

Agricultural and horticultural production contributes about 5% to New Zealand's GDP, with food and beverage manufacturing contributing a further 2.9% of GDP.[33] Additional GDP contributions are made by downstream transportation, retail, and other associated activities. In 1984, there was a landmark change when New Zealand eliminated almost all subsidies to agriculture. New Zealand is now regarded as having one of the world's least subsidized and most open agricultural markets. Agricultural subsidies are about 1% of agricultural production value in New Zealand, comprised mainly of public support for scientific research, notable by comparison with subsidies of 25% and 7% in the EU and US respectively.[34] The sector has changed significantly over the past four decades, with an increase in productivity and innovation and a shift from predominantly supplying the UK (prior to EU entry in 1973) to exporting globally including to the USA, Japan, China, the EU and Australia. New Zealand's leading products include dairy produce, beef, lamb, fruit (including apples and kiwifruit), wine, processed vegetables, seeds and agricultural services. About 55% of New Zealand's merchandise export earnings derive from agricultural and horticultural production.[35] About 337,000 people – or nearly one in five of all those employed in New Zealand – work in the agricultural and food value chain, including primary agriculture, food processing, wholesaling, and retail and food service. Of these, about nearly 74,000 (22%) are employed in food processing.[36]

Relative Earnings in Agriculture in New Zealand

Agricultural employment is relatively higher paid in New Zealand than in Northern Ireland. Mean and median weekly earnings for all jobs (full-time and part-time) in New Zealand's agricultural sector were 86.3% and 89.7% respectively when compared with the equivalent national weekly wages in New Zealand in 2010. In Northern Ireland, mean and median weekly agricultural wages (full and part-time workers) were 62.6% and 74.5% respectively of the weekly wages for all employees. For only full-time workers in agriculture in Northern Ireland, there is a similar picture: mean and median full-time agricultural wages were 68.5% and 69.6% of weekly wages for all workers in Northern Ireland in 2010. Comparable data for full-time New Zealand agricultural employees was not available.

Sources: Statistics New Zealand, Earnings from wage and salary jobs by industry, 2010, http://www.stats.govt.nz/tools_and_services/tools/TableBuilder/income-tables.aspx; Department of Enterprise, Trade and Investment, Annual Survey of Hours and Earnings (ASHE) 2010, by Industry, Table 2.1, http://www.detini.gov.uk/deti-stats-index/stats-surveys/stats-hours-and-earnings.htm.

Anticipated challenges facing the sector include reorganizing a domestic co-operative-based industry structure to compete internationally on a larger scale, enhancing productivity and innovation, and dealing with issues of sustainability, food security and bio-safety, animal welfare, water availability and climate change. Long-term demand for New Zealand agricultural and food exports is expected to expand. In the meantime, some commodity prices have fallen - particularly for dairy products.[37] To face these challenges, the agricultural and food-sector can draw on well-developed capabilities for productivity improvement, innovation and product development. The

[33] Industrial Structure and Principal Economic Sectors, New Zealand Economic and Financial Overview 2010, The Treasury, Wellington, New Zealand. http://www.treasury.govt.nz/economy/overview/2010/09.htm.
[34] OECD, Agricultural Policies in OECD Countries: Monitoring and Evaluation. Paris, 2009.
[35] Exports of agriculture and forestry from New Zealand, 2009. Ministry of Agriculture and Forestry, Wellington, New Zealand. Analysis of data available at http://www.maf.govt.nz/agriculture/statistics-forecasting/international-trade.aspx.
[36] Food and Beverage Skills Working Group, *Skills Action Plan for the Food and Beverage Sector*. Food and Beverage Taskforce, Department of Labour. Wellington, July 2006.
[37] Ministry of Agriculture and Forestry, *Briefing for Incoming Ministers*. Wellington, November 2008.

government invests more than NZ$100 million (£45 million) a year in agricultural research, while the private sector invests about NZ$174 million (£79.6 million) in R&D in the primary and food processing sectors.[38]

New Zealand's manufacturing sector is comprised of a large number of small enterprises, with relatively few larger firms – although the larger firms account for a disproportionately high share of manufacturing jobs. In 2009, there were 21,827 manufacturing enterprises – 4.6% of all of New Zealand's 478,569 enterprises in NZ. These manufacturing enterprises employed nearly 240,000 people, or 12.4% of all enterprise employment in New Zealand.[39] Only 2% of New Zealand manufacturing enterprises (or about 340 enterprises) employ more than 100 employees, although these firms account for over 50% of the manufacturing workforce.[40] Food-related industries take a major role in New Zealand's manufacturing sector: dairy and meat products manufacturing and other food and beverage goods accounted for 48% of all manufacturing sales in New Zealand in 2009. Metal-working, engineering, and resource-related firms are also significant. In 2009, metal products, machinery and equipment, and transportation equipment accounted for 21% of sales of manufacturing goods and services; resource-based industries, including wood and paper products, petroleum and coal products, chemicals, and non-metallic mineral products, generated 18% of manufacturing sales; and other diversified industries such as textiles, furniture, and printing accounted 13% of manufacturing sales.[41]

In the financial sector, there are issues of scale and the lack of large domestic institutions. After a period of openness, the New Zealand financial sector has seen recent significant merger, acquisition and consolidation activity, resulting in the ascendancy of four Australian-owned banks. While there are no large domestic banks, there are more than 29,000 enterprises in New Zealand's financial and insurance services sector. Yet, more than three-quarters of employees work in about 60 main enterprises.[42] The local insurance market is relatively unregulated, with no insurance regulatory commission. An industry group, the Insurance Council of New Zealand, pursues a "self-regulatory" approach.[43]

Despite the small size of New Zealand's financial markets and the dominance of large financial companies, there are still opportunities for innovation in the sector, including for smaller enterprises. An example of an innovative financial services company in New Zealand is Pinnacle. In 2007, Pinnacle became the first life insurance company to offer life insurance directly through the Internet, using a customized intelligent approach developed by a New Zealand software company Intelligentlife. The company's paperless process and focus on simple, straightforward products means that Pinnacle is able to offer life insurance at a relatively low price. Pinnacle Life has won international awards for the design of its website and for innovation that directly benefits customers (as opposed to just cutting costs for the insurer).[44] Revenues have grown to NZ$5 million (£2 million) annually.[45] As yet, this is just a small share of New Zealand's NZ$1.4 billion

[38] Statistics New Zealand, *Research and Development Survey: 2008*. Wellington, April 2008.
[39] Calculated from data available at Statistics New Zealand, *Detailed Industry for Enterprises, ANZSIC 06*. http://www.stats.govt.nz/tools_and_services/tools/tablebuilder/business-statistics.aspx.
[40] Calculated from data available at: Statistics New Zealand, *Employment Size by Enterprise Groups, ANZSIC 06*. (See previous footnote for web link.)
[41] Analysis of data for four quarters of 2009 from Statistics New Zealand, *Economic Survey of Manufacturing, ANZSIC96* Industry by variable, http://www.stats.govt.nz/infoshare/.
[42] Financial and insurance sector enterprise and employment data for 2009 from Statistics New Zealand *Employment Size by Enterprise Groups, ANZSIC 06*. (See earlier footnote above for web link.)
[43] http://www.icnz.org.nz/about/environment.php
[44] "2008 Innovator of the Year, *Scoop Business*, September 16, 2008. http://www.scoop.co.nz/stories/BU0809/S00329.htm
[45] Interview with management at Pinnacle Life, Auckland, New Zealand, November 18, 2009.

(£0.7 billion) life insurance market,[46] although Pinnacle seeks to expand its revenues five-fold over the next few years. Pinnacle's entry as a small start-up in a market dominated by large well-established players is significant. It has been facilitated by New Zealand's liberal financial regulation rules. Also important in Pinnacle's rise is the role of a seasoned industry executive, the willingness of private investors to provide risk capital, and the deployment of innovative marketing approaches pioneering the use of the Internet to sell life insurance directly.

Orion Health is another example of an innovative New Zealand services company, in this case in the area of health IT systems. Orion was founded in 1993 to address early efforts in New Zealand to build a national health records system.[47] It is an example of an innovative services-sector firm that started as a small start-up but which has aggressively entered foreign markets in order to grow and maintain leadership, building upon New Zealand's base of specialized advanced services (See Section 4.1.3).

4.1.2 Policymaking and Implementation

New Zealand's policies and institutions for Science, Technology and Innovation (STI) have undergone major restructuring over the past two decades. Ranked low among developed economies by the relative share of funds allocated to R&D, New Zealand's reforms have sought to improve the effectiveness of R&D by better prioritizing R&D expenditures, corporatizing public research organizations, and focusing more on commercially-oriented R&D. Institutional reorganization was a key focus with respect to separating responsibilities for policy advice, funding and policy implementation.

Policy advice is located in government ministries, with the Ministry of Research, Science and Technology (MoRST) responsible for science and technology advice. For universities, policy advice occurs in the Ministry of Education (MED). Economic development advice is located in the Ministry of Economic Development. MoRST is the lead agency for the cross-cutting area of innovation policy, working with the MED. Non-governmental organizations such as the Royal Society of New Zealand are also influential in policy development. Funding decisions are located in a separate set of agencies, with R&D funding allocations being the responsibility of the Foundation for Research, Science and Technology. Higher education funding (including for research) is allocated through the Tertiary Education Commission, with the Health Research Council funding medical research. Implementation lies with a third set of organizations. Public research is performed primarily in Crown Research Institutes, universities, and research hospitals. Multiple organizations have roles in innovation, including regional agencies, non-profits, and industry associations.

For productivity issues, the New Zealand Department of Labour provides policy advice related to workplace productivity and provides information to business. An independent Productivity Commission was launched in 2010, which aims to promote public and private sector productivity, including through inquiries and regulatory review. New Zealand Trade and Enterprise[48] assists the country's businesses to sell and expand internationally, working overseas with the New Zealand Ministry of Foreign Affairs and Trade.

[46] 2007-2008 data, from "Transforming the insurance industry," *Te Ara: The Encyclopedia of New Zealand,* http://www.teara.govt.nz/en/insurance/6 (retrieved January 21, 2011).
[47] Interview with management at Orion Health, Auckland, New Zealand, November 20, 2009.
[48] Formed in 2003 by merging Trade New Zealand (trade promotion) and Industry New Zealand (economic development).

4.1.3 PIC Policy and Programmes

University engagement with small business. New Zealand's universities and leading technical institutes have increased efforts to collaborate with small and medium-sized enterprises - the country lacks large-scale manufacturers.[49] Universities have traditionally focused on academic curiosity-driven research, so an underlying challenge has been to gain recognition for, and increase the role of, applied industry-focused research, a shift the government has been keen to encourage. For example, the Plastics Centre of Excellence, established in 2008, builds on an alliance between the University of Auckland and Plastics New Zealand. The latter is a trade association with over 180 member companies – 75% of all New Zealand companies engaged in plastics manufacturing, design, machinery, and associated sectors.[50] The Centre was initially funded through a government grant of NZ$5 million (£2.25 million) matched by Plastics New Zealand. This policy intervention focuses on traditional industries and seeks to engage researchers in applied work. Importantly, the model encourages industry leadership, and generates on-going private sector contributions to applied collaborative R&D.

What's Your Problem New Zealand? Industrial Research Limited (IRL) is the Crown Research Institute tasked with supporting New Zealand industry. With 320 researchers and staff, IRL is organized in 3 major clusters: advanced manufacturing technologies (including energy and materials, engineering and applied physics, and high temperature superconductors); industrial biotechnologies; and measurement standards. Formerly part of the Department of Scientific and Industrial Research, IRL continues to transition from a researcher-led to a client-led orientation. In 2009, 72% of its revenues of $NZ60.5 million (£27.2 million) were provided by government, with 26% from commercial sources and it secured 10 New Zealand patents, 20 overseas patents, 8 licensing agreements, 5 joint ventures and developed close strategic linkages with 5 high-potential companies.[51] The relatively low share of commercial funding for IRL's research effort reflects some lack of R&D awareness and investment among New Zealand manufacturers. To counter this, in 2009, IRL launched the "What's Your Problem New Zealand?" programme – a nationwide competition to select a company to receive $NZ1.0 million (£450,000) of IRL R&D services. A major marketing and publicity effort was initiated, the idea for which initially came from a group of IRL staff.[52] Companies were asked to submit R&D project requests. Of 100 applications received, 10 were selected for review by an independent panel. The winning company, Resene, was awarded the prize to develop water-based paints made from resins using ingredients comprised of up to 80% sustainable materials.[53]

Access to finance. New Zealand ranked 2nd overall in a recent international study of business conditions for providing credit compared to good practice and selected economies.[54] Although New Zealand's capital markets are relatively shallow, the banking system in New Zealand has not suffered major stress during the current global economic crisis. New Zealand avoids large-scale subsidies to enterprise. Where it invests public resources, the government typically seeks to leverage those funds. Examples of programmes include:

[49] There are 8 research universities in New Zealand, and over 20 institutes of technology, polytechnics and other tertiary-sector colleges.
[50] http://www.plastics.org.nz/
[51] Industrial Research Limited, *Annual Report 2009*.
[52] "'Eureka Moment' Leads To Development of $1 Million R&D Competition," *Scoop*, March 17, 2009, http://www.scoop.co.nz/stories/SC0903/S00034.htm
[53] http://www.resene.co.nz/comn/whtsnew/eco_winner.htm
[54] International Finance Corporation and the World Bank, *Doing Business 2011: Making a Difference for Entrepreneurs*. http://www.doingbusiness.org/reports/doing-business/doing-business-2011 (access February 22, 2011).

- NZ Venture Investment Fund (NZVIF) – established by the New Zealand government in 2002, but drawing on private equity funds and managed by a private sector board. NZVIF manages a $NZ160 million (£72 million) Venture Capital Fund, which invests in other private venture capital funds to expand the resource base for start-up companies. NZVIF invests up to NZ$25 million (£10.6 million) into other funds. NZVIF also manages a NZ$40 million (£17 million) Seed Co-investment Fund, which invests on a 1:1 matching basis in other private funds targeted to early-stage high-growth small businesses.[55]

- NZ Trade and Enterprise's Escalator Service, which provides information, training, and brokerage assistance to SMEs with have the potential for growth and exporting, including targeted assistance and networking to access private funding sources.[56]

To ensure stability during the global financial crisis, New Zealand lowered its Reserve Bank interest rate and introduced facilities to ensure liquidity in the banking sector. Existing SME support programmes continued without special expansion.

Partnering for innovation in the agri-food sector. Fonterra is the largest agricultural and food processing business in New Zealand. The group is a co-operative, formed in 2001 with the merger of two preceding cooperatives and New Zealand's Dairy Board, and is owned by more than 10,500 dairy farmers.[57] It is New Zealand's largest exporter and the world's leading exporter of dairy products, with some 15,600 employees, sales in over 140 countries, and annual revenues of NZ$16 billion (£7.3billion).[58] Fonterra has a strategic emphasis on innovation, including through reducing processing time, improving texture and flavour bases and enhancing protein-based diary ingredients for functional foods, sports and medical foods. Fonterra participates in a new programme established in 2009 by six leading New Zealand food R&D organizations to market New Zealand food R&D expertise globally and to attract other global companies to undertake food research domestically.[59] While Fonterra has research and technical centres in major international markets, it maintains a strong commitment to research in New Zealand. Fonterra puts ideas forward to, and competes for research support from, New Zealand's Foundation for Science and Research (FORST). With government supports (50%), Fonterra takes on about 40 undergraduate student interns each year and provides them with 3 months of project experience in food science and related food-manufacturing areas. In short, there is an intensive and supporting set of public and public-private relationships, capabilities, and mechanisms which Fonterra is able to engage with and build upon as it implements its own R&D and innovation strategies.

Innovating through new SMEs in the agri-food value chain. At the other end of the size scale is Flavorjen[60] employing 6 people. Flavorjen provides natural food flavours, sourcing key ingredients from Jeneil Biotech, Inc., based in Wisconsin, USA.[61] The company draws on the local research infrastructure through links with Massey University on various projects (including development a new food innovation centre in Auckland), with Otago University on food technology research, and with the Plant and Food Crown Research Institute in food biotech and flavour research. Flavorjen has also benefited from grants and services provided by TechNZ, the business investment and commercialization programme of the Foundation for Research, Science and Technology. This infrastructure, and the cluster of food sector companies and organizations in Auckland, is

[55] http://www.nzvif.com/about-nzvif.html (accessed February 22, 2011).
[56] http://www.nzte.govt.nz/develop-knowledge-expertise/Investment-Ready-Guide/Investment-resources/Pages/The-Escalator-service.aspx (Accessed February 22, 2011).
[57] Interview with management, Fonterra Co-operative Group Limited, Auckland, New Zealand, November 18, 2009.
[58] Fonterra Co-operative Group Limited, *Fonterra Annual Report*, 2009.
[59] http://www.foodinnovationnz.co.nz/
[60] http://flavorjen.com/
[61] Interview with management, Flavorjen, Limited, Auckland, New Zealand, November 17, 2009.

important to Flavorjen. The company is a positive example of the role and potential of small yet highly capable intermediary players in product enhancement and value-added services in fostering innovation in the food industry.

Re-orienting research institutes towards the business sector. New Zealand's Crown Research Institutes (CRIs) are corporatized organizations, formed in the 1990s from government scientific and industrial research units and labs, to undertake research and to transfer it to industry and other users.[62] While each CRI receives some public funding to maintain and develop capabilities, they are required to operate as commercial entities, seeking private funds and competing for available public research programs and projects. In 2009, the combined revenues of all CRIs (from public and private sources) totalled NZ$625 million (£286 million) and they employed about 4,400 researchers and staff. One of the leading CRIs in the food sector is Plant & Food Research (PFR) – created in 2008, from the merger of two prior horticultural and crop and food CRIs. Today, PFR employs about 900 researchers and staff, with 2009 revenues of NZ$92.3 million (£42.2 million). Within PFR, there is an on-going effort to adjust from an investigator-led public research orientation to a client-led focus engaging interdisciplinary teams. The strategic commercially-oriented areas targeted by PFR include efforts to foster choice cultivars - fruits, vegetables and crops with special qualities, sustainable production systems, and new functional foods. PFR maintains several research centres, with three larger facilities in Auckland, Palmerston North (co-located with Fonterra's R&D centre), and Christchurch. PFR works with export-oriented companies and sector organizations on customized research projects. Such sector organizations can draw on levies from individual farmers and growers to sponsor research projects with PFR. The institute developed 105 new and improved processes in 2009, secured 13 New Zealand patents and 10 overseas patents, entered into 8 licensing agreements and 5 joint ventures/associations, and spun-out one company.

Beacheading into international markets. Innovative companies find that they rapidly need to enter foreign markets in order to grow and maintain competitiveness, and they often draw on New Zealand's specialized trade services. Orion Health is an innovative company in health IT systems. Based in Auckland, Orion provides clinical workflow and information technology for medical providers and health care managers, including access to and integration of electronic healthcare records.[63] Orion received R&D support from FoRST on a 50:50 matching basis to develop new software technologies and has been provided with salary assistance to support summer interns. Company managers also work with local universities in developing software training and education programmes. After projects with New Zealand agencies as lead users, Orion expanded internationally with a branch in the US, and offices in Australia, Canada, the UK and Spain. The company employs about 250 people worldwide, with 150 people in New Zealand.

[62] The eight current Crown Research Institutes (CRIs) are: the New Zealand Pastoral Agriculture Research Institute (AgResearch); the New Zealand Institute for Plant and Food Research (Plant & Food Research); the Institute of Environmental Science and Research (ESR); Scion (New Zealand Forest Research Institute Limited); GNS Science, the Institute of Geological and Nuclear Sciences; Industrial Research Limited (IRL); Landcare Research; and the National Institute of Water and Atmospheric Research (NIWA). The CRIs are monitored by the Crown Ownership Monitoring Unit of the New Zealand Treasury (http://www.comu.govt.nz/crown-research-institutes.html). Science New Zealand (http://www.sciencenewzealand.org/) is the organization that represents the 8 CRIs.

[63] Interview with management at Orion Health, Auckland, New Zealand, November 20, 2009.

Orion Health in Northern Ireland

In December 2009, New Zealand-based Orion Health, which operates worldwide, won a contract in Northern Ireland to pilot a province-wide electronic care record (ECR) system. The project, worth just under £100,000, will see hospitals and GP practices across two of the five Health and Social Care Trusts begin to share medical records and basic social care information using the Concerto Portal – a system developed by Orion Health. It will allow clinicians in Northern Ireland's acute and primary care services to access a summary of information collected during previous hospital and GP visits and will allow clinicians to present data to patients in order to better explain, inform and share health records securely and reliably. This improved access to information will allow staff to make better clinical decisions leading to improved healthcare and better health outcomes.

Source: Invest NI

Orion has longstanding relationships with New Zealand Trade and Enterprise (NZTE), a government agency which helps domestic firms to export and access international markets. Orion used NZTE's Beachhead programme to set up operations in California. The programme targets companies with aggressive international growth plans (e.g. at least NZ$5million (£2.3m) in annual revenues and plans to expand to $NZ100 million (£46m)) and provides support through specialist advisors in international markets, business development assistance and introductions to potential customers, branding and (in Dubai and Tokyo) access to office space. The Ministry of Foreign Affairs and Trade (MFAT) also has supported the company, with New Zealand Ambassadors opening up high-level access to senior decision makers abroad.

4.1.4 New Zealand Lessons

Market liberalization is a necessary but insufficient condition for success in globalized competition. Faced with a long-run decline in productivity and income per capita relative to other reference countries, New Zealand embarked two decades ago on major economic reforms, including privatization and opening up of markets. There is now an increasing realization that additional innovation system and governance elements are needed to boost productivity and competitive performance. These include investments in key components of the innovation system (outlined below), active public-private sector engagement in developing policies and strategies, actions to support access to finance for enterprise, and efforts to encourage knowledge exchange, networks, and linkages internationally as well as domestically.

Investments in human capital, R&D, and infrastructure are critical in building the foundation for high-value economic growth. While the human capital base is strong, aided by inward migration, weaknesses in R&D investment and infrastructure have limited high-value economic growth and innovation in New Zealand. One notable exception is in the agricultural sector. Rather than providing agricultural or export subsidies, the government invests more than NZ$100 million (£45 million) a year in agricultural research, while the private sector invests almost double that figure in R&D in the primary and food processing sectors.[64]

Primary and food-processing sectors have significant potential for innovation and export-led growth. Opportunities presented by primary and food processing sectors have not been overlooked in New Zealand. Recently, increased attention has been targeted to fostering high-value growth in both agri-food products and services. R&D for primary and food-sector innovation

[64] Statistics New Zealand, *Research and Development Survey: 2008*. Wellington, April 2008.

is well-developed and the mechanisms to fund, identify, and disseminate research targets appear to be effective.

Small economies can achieve success in emerging high-technology sectors through well-focused targeting of resources. Given its limited R&D resources, New Zealand has sensibly refined its targeted key sectors. For example, in biotechnology, there is a focus on growth efforts in sectors and niches where New Zealand has some comparative advantage such as agri-bio and plant-bio. In other high-technology areas, niche software development (for example, in health IT or graphics) and advanced medical devices are among other select areas where New Zealand seems able to build and deploy private and public-sector capabilities which are competitive globally.

The encouragement of global-local strategies in public as well as private sectors is an important aspect of innovation strategy in a small open economy. The most successful private companies typically adopt global-local strategies, for example strategically allocating R&D and product development at home and abroad, as well as developing international linkages based on organizational proximity. Similarly, New Zealand's most successful universities have pursued internationalization strategies and seek to attract international students (e.g. international doctoral students pay home fees) and research activities.

Redesign in the role and function of research institutes is a critical ingredient in innovation-led development. Privatization of public research functions does not necessarily guarantee success. Indeed, the separation of policy, contracting, and research implementation functions in New Zealand imposes high transaction costs. Where research institutes, including those of universities, are most effective in fostering innovation, including in the primary sector and in key high-technology sectors, common factors appear to be organizational reform, leadership, the development of tighter linkages between researchers and industry, and specific initiatives to disseminate results.

Well-designed innovation initiatives can reach traditional manufacturing sectors and induce significant spillovers. The offer of substantial "free" R&D services through Industrial Research Ltd's "What's Your Problem New Zealand" programme attracted significant interest from companies throughout the country, improved the visibility of this Crown Research Institute, and leveraged new projects and interactions with companies.

Open and transparent governance and broad government orientation to learning and evaluation, support effective development and upgrading of competiveness and innovation policies.

Active public-private exchange is important in developing strategies for targeted sectors. New Zealand appears to make effective use of non-profit organizations and associations to facilitate exchange and networking between private sector representatives and policymakers. Examples include Plastics New Zealand and NZBio, an association active in national and regional networking in the bio and life sciences sector.

4.2 Singapore

Singapore has enjoyed a sustained period of investment in infrastructure and education, supplemented by the attraction of talented people and foreign direct investment (FDI). This provides a strong foundation for high-value economic growth. The government's commitment to creating superior infrastructure has been successful and this is being continuously developed. A current focus is on the investment and creation of a new R&D framework to generate high-value growth. Supplementing this is the attempt to develop indigenous knowledge capabilities and intangible assets such as quality of life and national identity. R&D expenditures remain significantly higher in Singapore than in the other economies considered here.

4.2.1 Underlying Trends

Singapore is an island-state of 710 square km on the southernmost tip of the Malay Peninsula. The population is nearly 5.1 million (2010) of which 1.3 million are non-nationals,[65] following the Government's drive over the last two decades to attract skilled foreign workers. Although geographically small, Singapore is an advanced economy, with excellent infrastructure, an educated labour force, political stability and an efficient English-speaking business environment. Singapore has few resources to support agriculture, farming or mining, and hence has focussed on industry, services, and trade to develop its economy. As a share of all goods and services in GDP in 2009, manufacturing contributed about 20%, while services (including business services, financial services, and trade) contributed 72%.[66] In many pillars of competitiveness, Singapore ranked well globally compared to other advanced economies, particularly in the quality of Institutions, Infrastructure, Goods Market Efficiency (including tax) and Labour Market Efficiency (including productivity); see Table 9. Singapore's Financial Market Sophistication has grown in tandem with industrialisation, trade, and the accelerated economic changes in South East Asia since 1980. Singapore currently hosts the world's 4th largest financial centre.

Table 9. Competitiveness Index Measures: Singapore

	Competitiveness Pillars	2007-2008		2008-2009		2009-2010	
		Score	Rank	Score	Rank	Score	Rank
A	**Basic Requirements**	6.08	3	6.14	3	5.99	2
	Institutions	6.03	3	6.19	1	6.15	1
	Infrastructure	6.36	3	6.39	4	6.35	4
	Macro-Stability	5.68	24	5.74	21	5.24	35
	Health & Primary Education	6.24	19	6.24	16	6.22	13
B	**Efficiency Enhancers**	5.38	6	5.52	2	5.61	2
	Higher Education &Training	5.42	16	5.56	8	5.62	5
	Goods Market Efficiency	5.76	2	5.83	1	5.77	1
	Labour Market Efficiency	5.67	2	5.71	2	5.91	1
	Financial Market Sophistication	6.02	3	5.94	2	5.91	2
	Technological Readiness	5.36	12	5.64	7	5.90	6
	Market Size	4.06	50	4.41	41	4.53	39
C	**Innovation & Sophistication**	5.14	13	5.16	11	5.15	10
	Business Sophistication	5.19	16	5.25	14	5.20	14
	Innovation	5.08	11	5.08	11	5.09	8

Source: *Global Competitiveness Report*, annual editions 2007-2009, World Economic Forum, Palgrave Macmillan

Annual labour productivity growth averaged 3.5% in Singapore over the period 1998-2007 – a strong performance, although labour productivity has seen declines in 2008 and 2009 with the onset of the global economic crisis and falling demand particularly for Singapore's manufacturing sector.[67] To boost Singapore's position as an attractive investment destination, corporation tax rates in Singapore have been reduced consistently from 26% in 1997 to a flat 17% in 2010.

[65] Singapore Department of Statistics, *Key Annual Indicators*, http://www.singstat.gov.sg/stats/keyind.htm, accessed January 21, 2011.
[66] Calculated from data provided by Singapore Department of Statistics, *Gross Domestic Product by Industry* [Table A1.1], http://www.singstat.gov.sg/stats/themes/economy/natac.html, accessed January 21, 2011.
[67] Calculated from data at the International Labour Office, Key Indicators of the Labour Market (KILM), Table 18, labour productivity, http://kilm.ilo.org (accessed February 12, 2011); and Singapore Department of Statistics, *Yearbook of Statistics Singapore*, 2010, Table 4.13 Changes in Labour Productivity by Industry.

Corporation tax operates on a sliding scale of 0% on the first S$100,000 (£42,500) of taxable income for each of the first three tax filing years for a newly incorporated company, and 8.5% on taxable income up to S$300,000 (£127,700) per annum. There are also tax incentives for certain sectors including IT and financial companies, with a reduced rate of 10%.

Singapore has performed well in attracting and fostering large-scale manufacturing and continues to have a strong base in chemicals and refinery operations.[68] This sector employs 12.5% of manufacturing employees and contributes 40% of the total manufacturing output (with only 14.3% of the establishments in the manufacturing sector).[69,70] Singapore has leveraged its capabilities in processing industries to attract foreign pharmaceutical and chemicals companies. The chemicals and pharmaceutical sectors cluster around Tuas and Jurong Island (on the western end of Singapore); Jurong Island is among the top ten petrochemical hubs in the world, with ExxonMobil planning to complete the construction of the corporation's largest integrated chemical and refining site in Singapore by 2011.[71] Shell has also announced the successful completion of the Shell Eastern Petrochemicals Complex (SEPC) investment project in Singapore. SEPC is Shell's largest petrochemicals investment to date and the second world-scale petrochemicals project the company has completed in Asia in four years.[72]

Food and beverage production and exporting remain strong despite a limited primary sector. In fact, Singapore is the 11th largest global exporter of processed food. Over the past decade, output has increased by 40% despite a decrease in total investment, indicative of productivity improvement in the sector. This sector accounts for 2.7% of Singapore's manufacturing output and 5.4% of employment in manufacturing.[73] Food and beverage sector turnover (2006) was S$15.2 billion (approximately £6.47 billion), of which two-fifths was exported.[74] The main markets are Japan, USA, Malaysia and China, with 63% of exports going to Asian markets and a further 10% to the USA.[75] This sector is technologically advanced and benefits from Singapore's reputation for strong hygiene requirements and the emphasis on high quality and safety in its production. There is no specialized food research institute in the public sector or the university sector. However, firms in the sector can work with five local polytechnics that have a food technology specialisation, on process and product improvement.

Singaporean financial institutions still trail behind international competitors in terms of efficiency due to the relative scale of inputs. However, Singapore embarked on a journey in the early 1970s to establish itself as a competitive international financial centre with the Asian Currency Unit (ACU) and offshore banking. Today, the financial sector employs about 60,000 people and now accounts for some 15% of GDP, with some 700 financial institutions including more than 150

[68] EDB Singapore Chemicals Facts & Figures, Chemicals Factsheet, http://www.sedb.com/edb/sg/en_uk/index/industry_sectors/Chemicals/industry_background.html.
[69] Ministry of Manpower, The Profile of chemical industry in Singapore, [Available at http://www.mom.gov.sg/ publish/etc/medialib/mom_library/Workplace_Safety/bc_chemicals.Par.26931.File.tmp/ Profile%20of%20 Chemical %20Industry%20in%20Singapore.pdf]
[70] Annual Economic Survey (Principal Statistics of Manufacturing by Industry Cluster), 2008, from the Ministry of Trade and Industry
[71] EDB Singapore Chemicals Facts & Figures, Chemicals Factsheet, http://www.sedb.com/edb/sg/en_uk/index/industry_sectors/Chemicals/industry_background.html.
[72] EDB Singapore. http://www.sedb.com/edb/sg/en_uk/index/news/articles/shell_cracker_plant.html
[73] Singapore Department of Statistics, Principal Statistics of Manufacturing by Industry Cluster, 2008 (Table 9.2), http://www.singstat.gov.sg/stats/themes/economy/mfg.html, accessed January 21, 2011.
[74] Singapore Information Services, *General Overview: Food & Beverage*, http://www.insis.com/Web/main.aspx?ID=,59ae96c4-27ab-4dfd-98c6-9d7a21c63cb9, accessed January 21, 2011.
[75] Singapore Information Services, *Ibid.*

global banks.[76] It recently underwent liberalization, with new licenses granted to a handful of foreign banks to compete in domestic retail banking. In 2004, seven local banks consolidated to become three large local banking groups – the Development Bank of Singapore, the United Overseas Bank and the Overseas Chinese Banking Corporation. The Monetary Authority of Singapore (MAS) supports ICT development, such as automating electronic transactions in the sector through 50:50 co-subsidies.

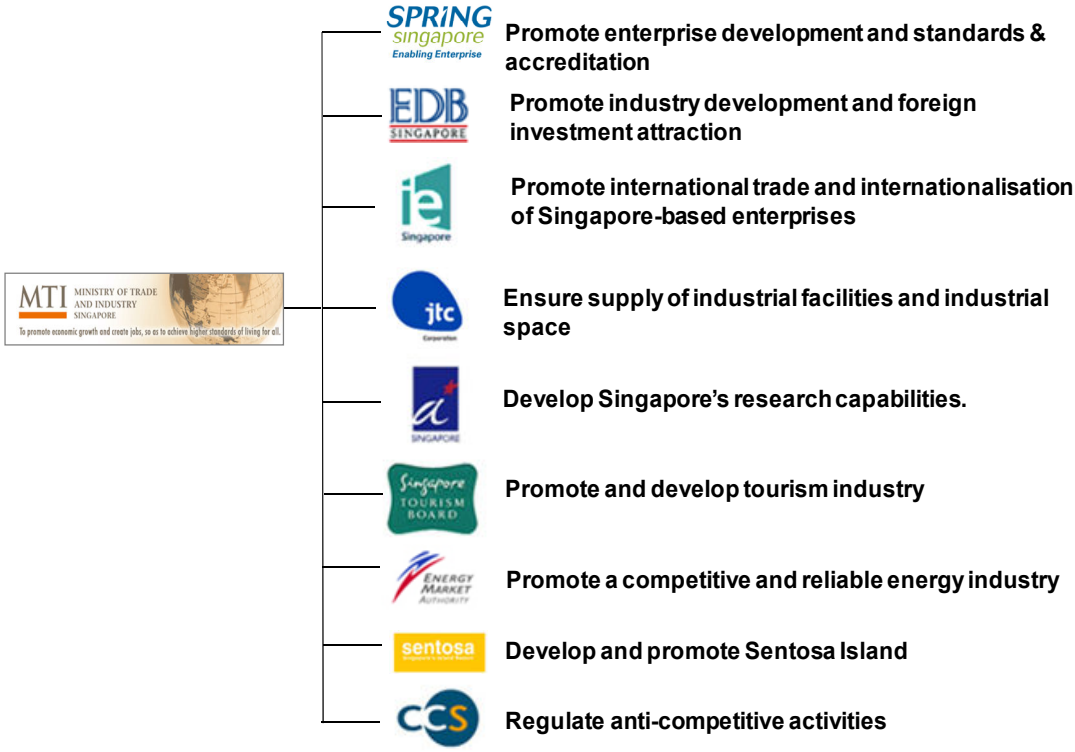
4.2.2 Policymaking & Implementation

The Ministry of Trade and Industry (MTI) is Singapore's main governmental department of industrial and economic development policy. MTI's mission is to promote economic growth and create jobs, leading to higher standards of living.[77] The agencies under the Ministry of Trade and Industry (MTI) coordinate with one another, meeting regularly (at least monthly) and guided by 5-year strategic plans. Singapore seeks to promote a business orientation in agency operations and relationships. Agencies are given mandates and autonomy, and they are expected to perform and to coordinate with related government units. Other government ministries, such as the Ministry of Education (MoE) or the Ministry of the Environment and Water Resources (MEWR), operate in a similar way with their own (but fewer) autonomous agencies. While there is flexibility, a long-term view is maintained in the core structure and policy: there are few sudden shifts in policies, although there is on-going fine tuning and adjustment, for example, to improve regulation or enterprise support schemes.

Singapore has devoted significant attention to attracting foreign direct investment (FDI), supporting high technology enterprises, and fostering value-chain growth development, through the Economic Development Board (EDB) under the umbrella of the MTI (see Figure 10). EDB supports FDI by maintaining close contact with business needs, and receives business support for the Government's willingness to invest in industry development.[78] The EDB acts as a central port of call for large businesses and purportedly enjoys direct access to all government ministries. For example, the EDB spearheads meetings with the Ministry of Education, SPRING, MAS and the Ministry of Health on planning the future workforce requirements, in particular to attract the bio-medical industry. This includes forecasting workforce requirements so that universities can deliver the appropriate skills and graduates in time to support the targeted growth of this industry. The EDB claims to provide a "whole-government approach" to supporting FDI.

[76] Kuah, A.T.H. (2008). Managing Competitive Advantage: Clustering in the Singapore Financial Centre. Manchester Business School Working Paper No 549: 3-35.
[77] For MTI's mission statement, see http://app.mti.gov.sg/default.asp?id=98#2
[78] Based on interview with Chevron Phillips, see PICSOE Report 3, p 43.

Figure 10. Agencies of Singapore's Ministry of Trade and Industry



Source: Presentation from SPRING Singapore

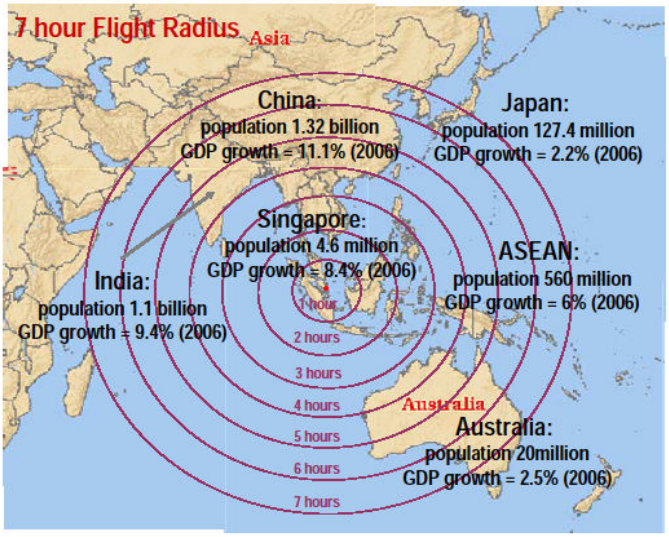
Priorities and sectors for targeting by the EDB and its associated agencies emerge through a series of processes that are as much relational as they are based on formal evidence-based planning. Singapore has indeed embraced a broad and long-term strategic vision of moving its economy up the value chain, from primary products and routine manufacturing through high technology production to life sciences, creative industries, information technologies, and advanced knowledge-based services. Senior political leaders and civil servants work together to build consensus around sectoral development strategies, and knowledge is acquired about sectors that are targeted for growth by other leading economies. The EDB is organised along the lines of the key sectors or clusters it supports. The Industry Development Division of the EDB is divided into two key clusters divisions, with each Cluster Group headed by an Assistant Managing Director. Cluster Group 1 comprises cluster teams in Clean Technology; Electronics; Infocomms & Media; Precision Engineering and Transport Engineering. Cluster Group 2 comprises Biomedical Sciences; Consumer Businesses, Energy & Chemicals, Logistics and Professional Services. Each cluster team is headed by a Director and a Deputy Director, and supported by several economists and senior officers. Most importantly, EDB draws on close relationships with senior private sector managers and international panels of advisors to provide often tacit guidance as to key priorities for investment and training.[79] For example, the senior officials and business practitioners we interviewed stated that the EDB sector officials maintain very close contact with the businesses they have attracted and supported over the years, and seek and respond to their inputs. Drawing on the strengths and stock of knowledge in engineering, chemistry and material science, EDB is

[79] S. Kumar and S. Siddique, *The Singapore success story; Public-private alliance for investment attraction, innovation, and export development*, Division of International Trade and Integration, Economic Commission for Latin America and the Caribbean, Santiago de Chile, March 2010.

now targeting the life sciences, biotechnology and nanotechnology sectors, while understanding the need to boost research capabilities to supplement current industrial value-chains.

After more than 30 years focusing on productivity - the National Productivity Board was established in 1972 – the remit of its successor SPRING was refocused to small and medium enterprise development, the adoption of standards and raising domestic SME's productivity. In terms of enterprise development, SPRING seeks to (a) develop a supporting environment; (b) seed innovative start-ups; (c) develop supporting clusters; and (d) grow innovative growth-orientated firms of up to S$100 million (£42.5 million) in turnover. SPRING provides support to upgrade firm capabilities (trade mission, training grants, and management skills), accelerate technology commercialisation and link businesses with venture capitalists and other financing mechanisms. Increasingly, FDI and export-oriented growth is supplemented by strategies to internationalise high-potential domestic firms and to encourage business linkages within the hemispheric region. International Enterprise Singapore (IE) encourages and provides support to high-potential domestic firms for outward investment. The explicit targeting of regions and markets within 7-hours flight distance from Singapore by the government is noteworthy for attracting foreign talent and inward investment, and supporting outward investment (see Figure 11).

Figure 11. Regions within 7 hours flight distance from Singapore



Source: Presentation from A*STAR Singapore

Singapore places increasing emphasis on R&D and is currently completing its 4th five-year Science and Technology Plan (the first was in 1990), with R&D funds directed at areas with potential for scientific breakthroughs. Spearheading this is the creation of its lead agency for R&D, the Agency for Science Technology and Research (ASTAR). A*STAR's remit is to strengthen Singapore's status as a research hub. A*STAR currently oversees 14 research institutes and nine consortia and centres located in its Biopolis and Fusionopolis, and supports extramural research with universities, hospital research centres, and other local and international partners. For example, ***Biopolis*** (Figure 12) is strategically located next to the Singapore Science Park, which hosts major pharmaceutical and biotech R&D laboratories, the National University Hospital (NUH), and the

National University of Singapore's medical school and cancer research centre. The intention, according to A*STAR, is to co-locate public sector research institutes with corporate labs and foster a collaborative culture under one roof. It will allow companies to cut R&D costs by co-sharing expensive facilities and accelerating the development timeline. Since the start of the National Science & Technology Plan, Singapore's Gross Expenditure on R&D (GERD) as a percentage of GDP has increased from 0.85% in 1990, to 2.39% in 2006 and 2.77% in 2008. Singapore is on track to meet its aim of achieving 3% GERD by 2010.[80]

Figure 12. Biopolis Complex (Concept)

Urban planning (by the Urban Renewal Authority, URA) has been prominent over the last four decades, resulting in clear economic zones within the country. URA is a statutory agency at the Ministry of National Development. However, the Jurong Town Corporation (JTC), which coordinates the infrastructure and environment for competitive small enterprise and large firms, comes under MTI's remit. It was founded in 1968 and supports development of land suitable for industrial purposes and ready-built facilities. It too has an innovation role having recently launched an innovation fund (for projects up to 1 year and S$1 million or £0.425 million) to explore innovative ideas to intensify industrial land use.

4.2.3 PIC Policy and Programmes

Networking with Business. EDB supports high technology enterprises and fosters value-chain growth, while maintaining close contact with businesses. The EDB acts as a central port of call for large businesses and has direct access to all government ministries. By working closely with businesses, the EDB ensures that business needs are communicated to the Government and hence planning and policies can reflect them. Networking and public-private partnership with multi-national business, indigenous firms, institutions, and sectoral organisations permeates the agencies of government in Singapore. We found this approach at MTI agencies (EDB, SPRING, A*STAR, IE) and even at the Financial Services Development Department (MAS). Government uses the intelligence gleaned from these (often informal) interactions to improve and guide policymaking to assist business performance, innovation, and economic development.

Fostering Productivity and Innovation in Indigenous Enterprises. Attention to productivity, standards and supporting other non-high tech sectors is a principal mission of SPRING Singapore. SPRING highlights the entire value chain approach to support firms' productivity. Domestic SMEs who are competitive and productive in supporting MNCs in Singapore are encouraged to develop and grow alongside these large firms. They both benefit as a total entity in exporting competitively. SPRING anticipates that some of these SMEs may eventually become large exporters and the country will benefit with the HQ or high value operations remaining in Singapore.

[80] As reported by the Agency for Science, Technology and Research in its latest *National Survey of R&D, 2008*.

SPRING offers an innovation voucher scheme which offers up to S$5,000 (about £2,125) in consultancy and technical support services to SMEs to incentivize them to work with universities and public knowledge institutions.[81] This scheme is similar to innovation vouchers offered in the UK, including in Northern Ireland, although the value of Singapore's voucher (in market terms, not accounting for differences in purchasing power) is a bit less than Northern Ireland's voucher. However, a creative modification is that SPRING encourages SMEs to pool their vouchers, to as to foster networking and the development of collaborative group projects.

Domestically-focussed sectors are supported in terms of automation and other innovation investments, up to 50% for highly commendable schemes. These schemes were used, and were regarded as beneficial, by many of the firms (including banks and food manufacturers) that we interviewed. Specific examples that we encountered included SH Donut and Food Empire. SH Donut was invited by SPRING to participate in the Intellectual Property of Singapore Programme, and received further training on branding in support of innovation and the protection of its intellectual property. Food Empire, which manufactures coffee and snack products and predominantly exports most of its produce, was encouraged to apply for schemes in automation and environment protection.

Access to finance. Singapore is well-ranked (6th overall in a recent international study of business conditions) for providing credit compared to good practice and selected economies.[82] Financial institutions in Singapore have been placing greater emphasis in recent years on meeting the financing needs of SMEs. Government also offers a series of funding options, including:

- Internationalisation Finance (IF) Scheme - loans of up to S$15 million (£6.4 million) to buy fixed assets and finance overseas projects or orders.
- Loan Insurance Scheme (LIS) - secures loans through insurance against default. The Government subsidises 80% of the insurance premium.
- Micro-loan Programme – provides loans of up to S$100,000 (£43,000) to very small businesses.
- Trade Credit Insurance (TCI) Programme – accounts receivable are insured against non-payment risk at rates normally available only to companies with substantial trade volume.
- Local Enterprise Finance Scheme (LEFS) which provides fixed interest rate loans.
- Business Angels Funds (BAF). SPRING matches each dollar invested by business angel funds. The maximum investment by SPRING is S$1 million (£0.43 million).
- Start-up Enterprise Development Scheme (SEEDS). SPRING will match each dollar an investor puts into a start-up. The maximum investment by SPRING is S$300,000 (£128,000)

There are a number of other Singapore funding programmes targeted at start-ups, growing, and internationalising businesses, including the Growth Financing Programme (which supports early-stage SMEs that have the potential to grow rapidly). Additionally, to address the recent financial crisis, Singapore moved rapidly to introduce enhanced financial support for its companies, including a Special Risk-Sharing Initiative (SRI). In the period since December 2008, 14,000

[81] http://www.spring.gov.sg/EnterpriseIndustry/TI/Pages/innovation-voucher-scheme.aspx (accessed February 22, 2011).
[82] International Finance Corporation and the World Bank, *Doing Business 2011: Making a Difference for Entrepreneurs*. http://www.doingbusiness.org/reports/doing-business/doing-business-2011 (access February 22, 2011).

companies were assisted under a total loan portfolio of about S$9.2 billion (£3.9 billion). The SRI ended in January 2011, with the return to stability in financial markets, although some other schemes are still available.

Creating a National R&D Framework. R&D framework articulation is the latest focus of MTI and A*STAR – to foster a comprehensive eco-system to support innovation. A*STAR is attempting to strengthen Singapore's position as an R&D hub for multinational pharmaceutical companies with seven research institutes and five research consortia in key fields that includes clinical sciences, genomics, bioengineering, molecular/cell biology, medical biology, bioimaging and immunology. Singapore's R&D plan will continue to emphasise the commercialisation and exploitation of science and engineering – an orientation which underpins the high number of patents now emanating from Singapore. The Science and Technology Plan covers a 5-year cycle, the most recent being 2006-2010. The country is committed to doubling R&D spending to S$13.55 billion (£5.77 billion) over this cycle. Singapore is now closing the gap with leading developed economies in targeting (and being close to achieving) a GERD/GDP ratio of 3%.

Internationalising High Potential Small Firms. IE Singapore encourages and provides support to high-potential domestic firms to undertake outward investments, targeting markets as far as 7 hours flight distance from Singapore. SH Donuts, a 3 year old firm, received subsidised trade support from IE Singapore for trade missions, which led to setting up branches and factories abroad in Malaysia (2 outlets), Dubai, Indonesia, India, Brunei and China. Internationalization initiatives are generously supported by IE Singapore for high potential candidates in terms of internationalization skills. Export-oriented candidates, such as SH Donuts and Food Empire are able to produce new and innovative products, and expand with extensive support, into regional markets.

Cross Agencies GETUP Programme. The Growing Enterprises with Technology Upgrade (GET-Up) scheme is an example of a cross-cutting inter-agency programme, under the aegis of MTI. GET-Up offers an integrated approach to boosting the global competitiveness of local technology-intensive enterprises by harnessing the existing schemes (and combined resources) of EDB, SPRING Singapore, and IE Singapore, and the technical capabilities of A*STAR Research Institutes, to address financial, human resource and technology constraints.[83] Assistance can include loaned research personnel, strategic planning/road-mapping assistance, loaned consultants and access to A*STAR laboratories and facilities for specific R&D efforts. A*STAR researchers can be seconded to SMEs for up to two years to provide them with R&D and technology expertise to help them improve their production process or develop products. Under the Operation & Technology Roadmapping (OTR) scheme, A*STAR researchers work with SMEs in developing long-term plans to enhance products or services. Under the Technical Advisors (TA) Support scheme A*STAR researchers provide in-depth technical consultancy to SMEs, while the Facility Sharing Programme permits A*STAR to provide SMEs with access to its world-class laboratories and facilities to intensify businesses' R&D activities.

More than 250 local SMEs enrolled in the GET-Up programme which projected twice as much revenue and employment growth over three years as counterparts not on the scheme. The companies involved in GET-Up projected revenue and employment growth of 15% and 18% respectively, compared to the 6% and 7% estimated by companies not participating in GET-Up. GET-Up participants also reported a higher proportion of new and improved products in their annual sales, and report that 16%-20% of their sales came from new and improved products,

[83] Agency for Science, Technology and Research, Singapore, *Programmes for SMEs*, http://www.a-star.edu.sg/tabid/98/default.aspx#getup, accessed January 22, 2011.

relatively higher than the 11%-15% of sales for new and improved products reported by companies that are not supported by GET-Up.[84]

Partnering to boost service delivery. The excellent service award (EXSA) is a programme championed by ten industry associations (of different sectors) and promoted by SPRING to develop service models for staff to emulate, create service champions and professionalise the services sector. The award is given to individuals across different firms for excellent service delivery since 1994.

4.2.4 Singapore Lessons

Investments in infrastructure and education over a prolonged period, supplemented by the influx of foreign talent, are critical to economic growth. The human capital base and education system in Singapore have been greatly strengthened over the last four decades. Singapore has also promoted significant inward migration and foreign direct investment. There has been consistent focus on infrastructure development, by the JTC and the URA. Such investments now incorporate a knowledge orientation, with a current thrust on the development of an expanded R&D framework (building on 15 years of prior R&D investment) to further build the innovation eco-system in Singapore.

In exploring a new economic model, learning and un-learning may be required. As Singapore has moved from a follower nation in innovation to a position at the frontier, the country is searching for new models for continued economic success. Older models focussed on attracting routine manufacturing plants have been replaced. There is now increased attention to the development of indigenous knowledge capabilities, as well as the need to learn how to manage the nation's intangible assets, to incorporate international talent into its labour pool, and to foster an outward orientation to exporting services as well as manufactures.

EDB supports FDI, while SPRING improves productivity, standards and innovation in domestic sectors. The two agencies are aligned in a total value creation approach and organised according to key clusters. Support is given to potential winners from domestic and foreign businesses including training (e.g. employee skills), technology enhancement (e.g. product development, IT grants) and management skills (e.g. intellectual property protection, internationalisation) to improve productivity, innovation and competitiveness.

Comprehensive Approach to Value Creation. The concept of an innovation eco-system permeates all agencies and government bodies. FDI and export-oriented growth is strengthened by internationalization of domestic firms. IE Singapore encourages and provides support to high potential domestic firms for outward investment. A*STAR and the JTC Corporation (industrial infrastructure development), under the Ministry of Trade and Industry (MTI) seek to coordinate an environment where competitive small enterprise supports the domestic economy as well as value creation in larger firms.

Well-designed innovation and spill-over initiatives are core to policy implementation. There is a willingness and capability to experiment with new approaches. In addition to conventional university-industry partnerships, new efforts are underway to promote cross-fertilisation with industry, for example through the GET-Up scheme which places researchers into SMEs. This has resulted in strengthening start-ups in emerging sectors like nanotechnology and biotechnology. Research laboratories staff are encouraged and supported to leave and create spin-off firms. One

[84] Agency for Science, Technology and Research, Singapore, information communicated during meeting with staff, November 10, 2009.

example is Curiox Biosystems, a bioinstrumentation company that spun-out of A*STAR's Institute of Bioengineering and Nanotechnology and which has received support from a German venture capital company and Exploit Technologies (A*STAR's commercialisation unit). [85]

Government and its agencies operate like a business in their thinking and approach. The agencies under MTI coordinate with one another, meeting monthly, under the umbrella of 5-year strategic plans. Singapore seeks to promote a business orientation in agency operations and relationships. Agencies are given autonomy, mandates and expected to perform. While there is flexibility, a long-run view is maintained.

Strategies driven from the top can work, with participation from key business partners (for instance, through the ERC Committee). Feedback is sought from investors and businesses to identify new sources of industrial growth, and fed back to central government. Singapore exhibits a "top-down" structure which integrates various aspects of policy and governance. The Prime Minister and key ministers have substantial de facto powers, and these have been employed to ensure that economic development and innovation is maintained as a top priority.

Effective administration, with a meritocratic system of talent selection and career development is central to government in Singapore. Top civil servants rotate around key ministries and agencies. Yet, while the civil service maintains a meritocratic system of selection, significant attention is given to selecting leading scholars or business executives to head and serve on the management boards of important agencies.

Future-oriented strategies and a willingness to make large-scale investments. Many projects are attempted in Singapore, as part of an on-going process of building a base for the next wave of development and innovation. Large amounts of public resources are often committed to these projects, usually with leveraging of private funds. This has resulted in some successes but also some failures. The administrative and meritocratic culture encourages winning strategies and projects to be identified -- and losing initiatives to be culled without significant public attention or conflict. While long-run plans are developed and governmental auditing occurs, there is not a strong convention of public programme evaluation. Learning about policy and programme effectiveness typically proceeds through agency internal mechanisms, industry and academic consultations, and advisory boards.

4.3 Republic of Ireland

The Republic of Ireland demonstrates that an external-oriented economic development strategy can provide a stimulus for industrialisation, attract high-tech FDI and accelerate growth into internationally-traded services. The Republic of Ireland has achieved comparative advantages in new industries and sectors that at an earlier time were mostly absent in the economy. As multinational corporations (MNC's) were attracted to the Republic of Ireland, supported by activist development agencies and investments in education and training, a virtuous circle was established. The upgrading of MNC firm capabilities spilt over into indigenous firms and impelled improvements in tangible infrastructures of physical assets and intangible assets of lifestyle and identity.

Economic activity in the Republic of Ireland, however, dropped sharply following the banking and housing crisis of 2008. The Republic of Ireland entered into a recession with a severe collapse of domestic property and construction markets. There have been sharp overall reductions in public

[85] See: http://www.curiox.com/

expenditures accompanying the financial rescue package agreed with the European Central Bank and International Monetary Fund. Although there were budget cuts to research funding in 2009-2010, the Republic of Ireland's recovery programme continues to emphasise the role of science, technology and seeks to strengthen support for innovation over the period through to 2016.

4.3.1 Underlying Trends

In 2010, the Republic of Ireland's population stood at 4.5 million.[86] Over the past two decades, strong economic growth permitted a doubling of the workforce to 2 million. Employment is concentrated in the services sector (76%) with a further one fifth in industry and the remainder (5%) in agriculture. In five decades to 2003, labour productivity growth averaged over 3% (per annum).[87] Exporting activities of host operations of MNCs are largely responsible for employment and economic growth in recent decades, with exports (including goods *and* services) approximately 90% of GDP in 2009.[88]

In 2008 the Republic of Ireland generated GDP of $273.3bn and enjoyed living standards (GDP/capita) of $61,810, ranking it in the top ten countries internationally.[89] More recently, the Republic's economy has been hard hit by banking problems, and per capita income has fallen. The Republic of Ireland's Global Competitiveness Index rankings declined between 2005 and 2010 from 21st to 25th of over 130 countries (see Table 10). Poor macroeconomic stability, including banking-related challenges, offers a recent explanation alongside a longer-run substantial infrastructural deficit increasingly evident even during the "Celtic Tiger" boom period. Rankings in Innovation and Business Sophistication were maintained, indicative of the quality of local business networks and the quality of businesses operations, processes and strategies associated with increasingly sophisticated outputs in manufacturing and services.

The Republic of Ireland is the most FDI-intensive economy in Europe.[90] There are, for example, 530 US-owned companies employing 100,000 workers directly and 225,000 indirectly. Employment in such plants (initially in manufacturing) grew 50% between 1987 and 2000, matched in the last decade by growth in offshore services sectors,[91] including international financial services, other business-process activities and computer software. Sectoral export intensity is highest in chemicals and related products,[92] generating 60% of total Irish exports (36% of chemicals exports are organic chemicals with a further 46% comprised of medical and pharmaceutical products). Machinery and transport equipment generate 12% of exports, 40% from office machines and a further 30% from electrical machinery.

[86] Population and Migration Estimates, April 2010, Irish Central Statistics Office.
[87] Authors' calculations based on CSO data using GDP per worker. Between 2003 and 2008 this declined to 0.6% per annum.
[88] Data from Quarterly National Household Survey, Q3 2010, (employment) and National Accounts: Expenditure on Gross National Income, 2009, Irish Central Statistics Office.
[89] Data are sourced from the IMF Economic Outlook of the World Database. Performance is notable given the relative size of the Irish economy at 0.27% of world GDP (in PPPs, 2008).
[90] See Barry, F. (2007) FDI and Institutional Co-Evolution, *Scandinavian Economic History Review*, 55, 3, pp. 262-88.
[91] McKinsey (2003) identify The Republic of Ireland and India as the most popular destinations for offshore business services (BPO and IT). The Republic of Ireland (with 1% of EU15 population) was the destination for 50% of new shared services projects and 8% of regional headquarters projects in 2002/3 according to UNCTAD. Of the FDI attracted in 2008, 40% consisted of R&D investments.
[92] Export data are reported in Standard International Trade Classification (Rev 4) categories and are from the latest CSO External Trade release for 2010 covering the January-September period, representative of the annual trend.

Table 10. Competitiveness Index Measures: Republic of Ireland

	Competitiveness Pillars	2007-2008		2008-2009		2009-2010	
		Score	Rank	Score	Rank	Score	Rank
A	**Basic Requirements**	5.31	27	5.24	32	5.06	37
	Institutions	5.25	18	5.39	17	5.21	19
	Infrastructure	4.03	49	3.95	53	4.19	52
	Macro-Stability	5.69	21	5.33	47	4.63	65
	Health & Primary Education	6.28	16	6.28	14	6.23	10
B	**Efficiency Enhancers**	5.05	19	5.05	19	4.87	22
	Higher Education &Training	5.26	21	5.18	20	5.12	20
	Goods Market Efficiency	5.41	4	5.30	9	5.09	15
	Labour Market Efficiency	4.87	19	4.95	15	4.86	22
	Financial Market Sophistication	5.91	5	5.68	7	4.60	45
	Technological Readiness	4.65	25	4.98	24	5.27	21
	Market Size	4.17	46	4.22	48	4.26	52
C	**Innovation & Sophistication**	4.80	22	4.72	20	4.63	20
	Business Sophistication	5.07	22	5.05	19	4.97	18
	Innovation	4.54	19	4.39	21	4.29	22

Source: *Global Competitiveness Report*, annual editions 2007-2009, World Economic Forum, Palgrave Macmillan

The large base of MNCs enjoys rates of corporate taxes currently at 12.5%, substantially below prevailing rates across Europe.[93] No tax is paid on earnings from intellectual property where the underlying R&D activity is carried out in Ireland. The introduction in 2004 of a new R&D tax credit (covering wages, related overheads, plant/machinery, and buildings[94]) was designed to encourage new or additional R&D activity.

By 2008, over half of the world's top 50 financial institutions (with assets of €350bn) operated in the Republic of Ireland.[95] Financial services employing close to 90,000 accounted for 10% of national GDP and one third of all services exports. Growth here is indicative of increasing globalisation of innovation and knowledge-based competition particularly over the last two decades, evident in rising shares of overseas R&D staff recently engaged in services - previously evident in pharmaceutical and electronics plants. Substantial growth has been observed in the proportion of technology-sourcing R&D (also known as home-base augmenting R&D) engaged in by MNCs. From a low base in terms of expenditure on R&D over this period, the Republic of Ireland has substantially increased its share of gross R&D in output and scored successes in offshore R&D projects with, for example, Intel, Bell Labs, Microsoft, IBM and Hewlett-Packard. These in turn encouraged the first dedicated R&D investment by a financial services company in the Republic of Ireland, undertaken by Citigroup in its first such venture world-wide.

The chemicals/pharmaceuticals sector of the Republic of Ireland includes 500 companies from subsidiaries of global chemicals/pharma companies (including BASF, Pfizer, GSK, and Wyeth) to smaller speciality chemicals and plastics producers. Sixteen of the top 20 global pharma

[93] In a survey of executives of 10 major US MNCs that the corporate tax regime was the most important factor in attracting the firms to Ireland. Education and skill levels ranked second in importance. See Gunnigle, P. and McGuire, D. (2001) Why Ireland? A Qualitative Review of the Factors Influencing the Location of US Multinationals in Ireland with Particular Reference to the Impact of Labour Issues, *Economic and Social Review*, 32, 1, pp. 43-67.

[94] Stamp duty on intellectual property rights has been abolished.

[95] Kuah, A.T.H., Ward, D.R., Doyle, E. and Shapira, P. (2009). *A Comparison of Northern Ireland's Productivity and Efficiency across Services and Manufacturing*. Report submitted to the DETI, Northern Ireland.

companies have facilities in the Republic of Ireland, employing approximately 25,000 workers[96] and responsible for 60% of all exports. A further 10,000 people are employed in plastics and rubber with up to 24,000 more engaged in delivering services to the sector.[97] Pressures generated by patents coming to an end and consequent competition from generics has led to tendencies to consolidate across the industry (e.g. merger of Pfizer and Wyeth), with the move to biologics illustrating the uncertainty of the sector. Biotechnology R&D is a strategic focus of Science Foundation Ireland (SFI) – the governmental organization which serves as the national sponsor for research. Support for biotechnology has been accompanied by SFI R&D sponsorship in information and communications technology and in sustainable energy and energy-efficient technologies – sectors that are viewed as central to generating strategic value for long term competitiveness and development in the Republic of Ireland.[98]

The food and beverage sector generates approximately 8% of GDP, 18% of manufacturing GVA[99] and 10%[100] of exports. As the single largest indigenous sector, its supply chain extends nationally. Total sales in 2008 were €25bn, with half of its exports (of over €8bn) destined for the UK. Over 600 food and beverage companies employ over 43,000 people. The sector absorbs most of the output of 120,000 domestic farmers – where, including distribution and retail, over 230,000 people are directly and indirectly dependent on the sector. Its strengths lie in traditional areas of meat and dairy generating over 50% of sectoral exports.[101] Prepared foods have expanded, accounting for around half of total sales with 15% of global infant formula milk originating in the Republic of Ireland.[102] The sector comprises Irish subsidiaries of MNCs such as Unilever, Cadbury, Heinz, specialised manufacturers such as Nutricia, and large locally based companies including Kerry Group, Greencore Group and Donegal Creameries. Recent sectoral business expenditure on R&D (BERD) was 0.35% of output comparing well with the EU15 average of 0.24%.[103] Of more than €5.9bn investment on R&D domestically, 11% is allocated to the Agri-Food Research Programme and the sector has invested to expand its research capability.[104,105]

Despite recent success in attracting more R&D-intensive investment, gross expenditure on research and development (GERD) in the Republic of Ireland is 1.4% of GNP, lagging EU (and OECD) averages. A GERD target of 2.5% has been set for 2013. Government-funded R&D (GOVERD – including expenditure by Higher Education and State Research bodies) remains below EU 25 and OECD levels by more than 50%, despite significant recent investment. A doubling of GOVERD to 0.8% of GNP is the 2013 target. Business Expenditure on R&D (BERD) stands at 0.9% of GNP with a 2013 target of 1.7%. Reaching such targets is questionable given current fiscal pressures. Growing BERD is proving difficult: MNCs undertake over 70% of such research, but

[96] See PharmaChemical Ireland is an association of approximately 50 companies and a major sector within IBEC.
[97] Estimate provided by PharmaChemical Ireland.
[98] See Powering the Smart Economy, Science Foundation Ireland Strategy 2009-2013, Science Foundation Ireland.
[99] See Food and Drink Industry in Ireland: Competitiveness Indicators 2009, Irish Business and Employers Confederation, the main source of data in this paragraph.
[100] Based on the 2008 total value of exports of €86bn, provided by the Irish CSO.
[101] External Trade Release for 2010, Irish CSO, covering the January-September period, representative of the annual trend.
[102] See: An end-to-end strategy for the Irish Food and Drink sector: Economic impact and policy challenges, Irish Business and Employers Confederation, 2006.
[103] See Section C in: *Food and Drink Industry in Ireland: Competitiveness Indicators 2009*, Irish Business and Employers Confederation, 2009.
[104] 1,085 research personnel (researchers, technicians and support staff) were employed in the food & drink sector in 2005, an increase of 58% over 2003 as reported in *Research & Development Performance in the Business Sector Ireland 2005/6*, Forfás 2007. Also the fourth Forfás *Community Innovation Survey* indicated that 80% of firms in the food, drink and tobacco sector were engaged in innovation activity. The regional distribution of BERD reflects a strong regional spread.
[105] See http://www.socialinclusion.ie/documents/NationalDevelopmentPlan2007-2013.pdf

most Irish-owned large companies are in non/low-R&D-performing sectors and other indigenous companies grow slowly, increasing R&D proportionately.[106] Many indigenous firms are dependent on the UK market and have been under severe price pressure due to Sterling depreciation. The Republic of Ireland has a dearth of innovative, large indigenous high-tech companies and is under-exposed to the export base of the US and mainland Europe. Despite its international rankings and successes of the Celtic Tiger period, substantial catching up is required by the Republic of Ireland to build research and innovation capabilities.

4.3.2 Policymaking and Implementation

For the Republic of Ireland, the attainment of European levels of living standards allowed the central policy focus to switch from competitiveness and productivity to innovation, most evident following the Technology Foresight (TF) exercise of 1998/9.[107] The TF exercise informed state prioritisation of investment in science and technology concluding that biotechnology and ICT should be central in developing a world class research capability in selected niches. Subsequent substantial commitment to fundamental research and postgraduate training lead to the Programme for Research in Third-Level Institutions and establishment of Science Foundation Ireland (2000). The ability to absorb knowledge generated abroad expanded with attraction of MNCs, particularly relevant as absorptive capacity is as important as innovation in contributing to the social rate of return from R&D.[108] To assimilate R&D that 'spills over' from other countries, an economy needs to undertake R&D itself.[109]

Since 2004, the national science, technology and innovation (STI) governance system consists of an STI Subcommittee of Cabinet chaired by the Taoiseach (Prime Minister), an interdepartmental committee of senior civil servants from the eight main Departments responsible for STI to assist in policy development and ensure co-ordination, a Chief Scientific Adviser to the Government and the Office of Science, Technology and Innovation (OSTI) of the Department of Enterprise Trade and Innovation (DETI – renamed in 2010, replacing "Employment" with "Innovation"). OSTI is advised by Forfás, a state agency operating under DETI (reporting to its Minister), and is also responsible for basic research funding which it allocates to Science Foundation Ireland (SFI) and two Research Councils - Science Engineering and Technology and the Humanities and Social Sciences. The Chief Science Adviser advises on scientific issues, typically in areas of public concern. Further advice is provided by the National Competitiveness Council (NCC) established in 1997. An advisory Science Council advises on medium and long-term STI issues contributing towards the development and implementation of a coherent and effective national STI strategy.

Responsibility for implementation is shared. Enterprise Ireland focuses on development and promotion of the indigenous business sector. The Industrial Development Agency (IDA) deals with the attraction and development of foreign investment in Ireland. Science Foundation Ireland provides grants for international researchers wishing to relocate to the Republic of Ireland and

[106] In Annual Reports (2008) Enterprise Ireland reported 49 companies involved in R&D expenditures over €2m per year, a further 707 clients over €100,000 per year while the IDA reported 204 of its client companies invested over €250,000.
[107] The first White Paper on Science, Technology and Innovation was released in 1996. The innovation turn in policy is evident in a five-fold increase in investment in STI under the 2000-2006 National Development Plan.
[108] As argued by Swan, J. (2002), Innovative Business and the Science and Technology Base: An Analysis Using CIS 3 Data, Report for UK Department of Trade and Industry and Schmidt, T. (2005) Absorptive Capacity – One size fits all? A Firm Level Analysis of Absorptive Capacity for Different Kinds of Knowledge, Centre for European Economic Research, ZEW Discussion Paper, 05-72.
[109] As outlined by Griffith R., Redding, S. and Van Reenen, J. (1999) Mapping the Two Faces of R&D; Productivity Growth in a Panel of OECD Industries, Centre for Economic Policy Research, Discussion Paper.

those already based there, for outstanding investigators, conferences and symposia, and industry collaboration. The Higher Education Authority (HEA) has statutory responsibility for planning and policy development for higher education and research. The HEA funds teaching and research in universities, institutes of technology and a number of designated higher education institutions (HEIs) are assisted by two research councils. InterTradeIreland has responsibility to boost north/south economic cooperation between the Republic of Ireland and Northern Ireland, with a particular focus on supporting SMEs throughout the island to develop trade and business across both economies.

4.3.3 PIC Policy and Programmes

Building Skills Capabilities through Tertiary Education. Prior to the 1980s, industry in Ireland was traditional and small-scale and there were few public or private research institutions. The largest was TEAGASC, the agricultural and food research body, with the industrial sector under-served. Two technological universities and a network of regional Institutes of Technology were established during the 1960s-1970s, providing a pool of technicians to support industrial expansion. This enabled the Republic of Ireland to achieve higher than average OECD levels of post-secondary and sub-degree tertiary educational qualifications which provided an educated labour pool to support MNC activity.[110]

Evolving Role of IDA in Economic Development. The IDA was central to creating conditions that expanded the absorptive capacity of the economy. It leveraged its autonomous status as a state-sponsored agency with its own Board of Directors, an embedded external review process to support its own transformation, and holds full responsibility for all aspects of industrial development including identification and promotion of FDI and targeting of specific industries, with direct reporting to government.[111] Employees' perspectives differed from other civil servants - closer to a private sector orientation - with more extensive industry experience and openness to working overseas. IDA's networks of overseas offices and investors offers market feedback on trends in targeted sectors including potential legislative changes, additions to infrastructure (such as upgrading telecoms in the 1970s and 1980s) or training/education gaps (engineers and scientists).[112,113]

Exploiting International Networks of Policy Implementing Agencies. The IDA and EI play key roles in supporting research, development and innovation. The IDA focus broadened into developing initial MNC investments through supporting R&D in high-end manufacturing initially and later global services as well as supporting export growth, and investment in research and innovation. The mission of EI is to deliver development of Irish companies to achieve positions in global markets. Both agencies leverage extensive networks of international offices[114] which EI uses to provide overseas incubation space, assistance in identification and securing overseas key reference customers, financial assistance towards costs of international trade fairs, fact-finding

[110] As outlined in Science and Technology Report of the European Commission, (2002) the Republic of Ireland enjoyed the highest share of science and engineering graduates per 1,000 population aged 20-34.
[111] Initially its remit was to provide support to indigenous firms, transferred in 1994 to Forbairt and later to Forfás.
[112] Executives from Irish-based MNCs participating in the TF initiative identified Republic of Ireland weaknesses for further evolution of their plants emphasising the need to devote greater resources to innovation, research, design and development.
[113] Both the IDA and the Singaporean Economic Development Board have been identified as examples of best practice for investment promotion e.g. the IDA contributed to Costa Rica's successful programme CINDE.
[114] IDA opened its first overseas offices in the 1960s targeting London, Paris, Cologne, New York, San Francisco and Chicago and a further 7 followed with 5 in the Asia-Pacific region.

missions, access to overseas market intelligence and research and introductions to overseas industry experts.

Collaboration. The Republic of Ireland's developmental agencies are keen to support and collaborate with major investors. For example, GlaxoSmithKline (GSK) established a manufacturing plant in Ireland in 1975 and subsequently built a further two manufacturing plants.[115] The company had complemented its initial manufacturing operations[116] with R&D and trading operations for Europe. Sales and Marketing functions were further located in Dublin, employing 1,500 staff in total. GSK is investing a further €280m supported by IDA creating up to 200 new positions. Most output is destined for international markets and it has established a research project into gastrointestinal diseases, in collaboration with Alimentary Pharmabiotic Centre (APC) - one of SFIs Centres for Science, Engineering & Technology. This project is jointly supported by the IDA and SFI and involves an investment of up to €13.7m.[117]

Access to finance. The Republic of Ireland was ranked 15th overall in a recent international study of business conditions) for providing credit compared to good practice and selected economies.[118] Market conditions for obtaining business credit in the Republic have worsened dramatically since 2008, with the onset of a deep financial crisis. During the crisis, demand for working capital has been expressed by business. However, business finance has been difficult to acquire in this recent period, especially for small firms.

Enterprise Ireland is the agency with lead responsibility for supporting manufacturers, exporters, and internationally-traded services, and there are several funding programmes available for firms.[119] These include support for established SMEs, high potential start-ups, and larger companies, including through state and European Union grant aid. Local country enterprise boards also offer support for start-ups and SMEs. There are varied other programmes to stimulate business angels and venture capital. Enterprise Ireland and Invest NI have a joint scheme of Innovation Vouchers. This programme provides up to €5,000 or £4,000 for qualified SMEs to access consultancy and technical assistance services from knowledge providers (including universities and technical institutes) throughout Ireland. There are major cutbacks underway in public expenditure in the Republic of Ireland, and it remains to be seen how business support and funding programmes will fare.

Over the last two years, the Irish government has been particularly focused on stabilising and recapitalising the Republic's two major banks (Allied Irish Banks and the Bank of Ireland). The repercussions of the banking crisis on small businesses have been recognized, and the Government has taken some actions. A review process was established in 2009 by the Ministry of Finance to address the concerns of SMEs, sole traders, and farm enterprises denied credit by banks. In April 2010, a Credit Review Office was set up to assess SME lending policies of several key financial institutions in the Republic of Ireland. Guidelines on funding options open to business have also been issued by a Credit Supply Steering Group. Although there is still a widespread perception that banks are not lending sufficiently to SMEs, official reports indicate that the credit situation has eased somewhat for SMEs in the Republic of Ireland in recent months.

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[115] Products include Panadol, Coldrex, Solpadeine and Panadol Extra.

[116] The sole production site for Seroxat, an anti-depressant, Avandia: Type 2 diabetes and Coreg: serious heart conditions.

[117] GlaxoSmithKline (GSK), supported by IDA Ireland, is investing €14.6m in collaboration with the Trinity College Institute of Neuroscience (TCIN) and NUI Galway, on an R&D programme to discover new therapies to treat Alzheimer's disease.

[118] International Finance Corporation and the World Bank, *Doing Business 2011: Making a Difference for Entrepreneurs*. http://www.doingbusiness.org/reports/doing-business/doing-business-2011 (access February 22, 2011).

[119] http://www.enterprise-ireland.com/en/funding-supports/

Creating a National Science Fund Leveraging Academic Research. Science Foundation Ireland (SFI), modelled on the US National Science Foundation, was established in 2000, initially to administer the Technology Foresight Fund. It has expanded its focus and now provides awards to scientists and engineers in the Republic of Ireland, or willing to relocate there, in focus sectors of biotechnology, information and communications technology and sustainable energy and energy-efficient technologies development. SFI provides grants for outstanding investigators, for conferences and symposia, and industry collaboration. By 2009, more than €1.2bn in over 2000 awards had been allocated. The main funds allocated were for individual investigators who collaborate with over 300 companies, 9 Centres for Science, Engineering & Technology, Research Frontiers Programmes and 17 Strategic Research Clusters involving collaborations with 173 MNCs and 106 SMEs.

Developing a World Class Niche in Internationally Traded Financial Services. The proposal for an Irish Financial Services Centre (IFSC) was a radical new approach by the Industrial Development Agency (IDA) and part of a broader project of urban renewal and redevelopment. Acknowledging the global slowdown in manufacturing, the IDA was focussed on attracting alternative types of FDI. Using tax incentives and enactment of appropriate legislative changes, it marketed the Republic of Ireland as a centre to operate a niche market where it could provide financial services not operational already or more competitive services than European counterparts. As one of the least sheltered industries in the global economy, development of the international fund industry as one element of the IFSC activities required its location and its operations to be extremely competitive internationally.

Developing Management Capability. Beginning with an initial tranche of 31 CEOs from Irish high-growth software, services and technology companies in 2006, the Leadership 4 Growth programme, developed by EI in association with the Irish Software Association and the Stanford Graduate School of Business in the US (and subsequently Duke Corporate Education), brings experienced managers and academics together. The programme aims to develop the leadership ambition and capability of participants to achieve tangible growth and business improvements for EI's clients. By enhancing CEO-level leadership and strategic capabilities it is expected that impacts will be felt sector-wide. Individual coaching and monthly group sessions support execution of newly-defined leadership and business strategy plans. While there are still weaknesses in management development in many SMEs, these programs have bolstered the infrastructure and provided innovative models for building management capabilities in companies in Ireland.

4.3.4 Republic of Ireland Lessons

Success in attracting FDI creates new growth and innovation opportunities for outward oriented companies. The general restructuring of the economy that followed adoption of an outward focus contributed to creating export platform potential. Major international companies were attracted to, and traded successfully out of, the Republic of Ireland. Changing the focus of value-added activities of businesses from routine manufacturing towards high-technology and innovation is supported through active agency and business collaborations.

Evolution and integration in policy focus to support a changing economy is required. Such evolution is evident in for example, a competitiveness fund offered by EI for 2003/4 while a greater focus on productivity was evident in 2006/2007 with the organisation by Forfás of focus groups and a conference on Irish productivity followed by the publication of *Perspectives on Productivity*. The current policy focus is directed clearly towards R&D and innovation with targets for BERD, GERD and GOVERD clearly set. A GERD target of 2.5% has been set for 2013.

Government-funded R&D (GOVERD – including expenditure by Higher Education and State Research bodies) remains below EU 25 and OECD levels by *more than 50%* despite significant recent investment. A doubling of GOVERD to 0.8% of GNP is the 2013 target. Business Expenditure on R&D (BERD) stands at 0.9% of GNP with a 2013 target of 1.7%.[120]

Internationally competitive MNCs generate both direct and indirect economic benefits. The attraction of key firms in sectors including pharmaceuticals, electronics, ICT and financial services has indirectly generated incentives for further business development. Development in logistics, supply chain services and in retail banking have generated sectoral and broader economy benefits encouraging business innovation in competitive environments.

The challenges for indigenous businesses in an Export-Platform economy can be addressed through policy supports. Application of metrics of export success – such as the maintenance of export shares and further penetration of export markets – has given focus and discipline to domestic firms lacking the local competitive context due to limited market size or focus only on the UK economy. In terms of its expenditure, EI ranked R&D programmes (both in-company and collaborative) second to supports provided through its High Potential Start Ups (HPSU) Programme that offers a range of supports leveraging EI's skills and market knowledge.[121]

Effective roll-out of technology transfer functions from universities takes time to implement and to become an embedded feature of the economy. The importance of developing this function of higher educational institutions is particularly necessary when they are such central players in the generation of scientific publications and research. To support delivery of the technology transfer mission may require greater financial and strategic flexibility to be granted to educational institutions to effectively shift to a more business-driven agenda.

Impact of cluster policies extends beyond agglomeration. The Republic of Ireland's developmental agencies have supported the development of industry clusters. The contribution of clusters to innovation arises from the support they provide for greater collaboration (e.g. suppliers, customers, education and research institutes) and focused attention on shared competitiveness problems.

Consistent and on-going evaluation of programmes underpins the selection of interventions for support, in the context of effectiveness in achieving set goals and value-for-money criteria. Openness in disseminating results generated through evaluation processes indicates the confidence of agencies in the Republic of Ireland in sharing learning.

[120] These targets, expressed as percentages of GNP, are set at 1.7% for BERD, 2.5% for GERD and GOVERD of 0.8%. See: *Strategy for Science, Technology and Innovation 2006-2013*, Department of Enterprise, Trade, and Innovation, Dublin, 2006. http://www.deti.ie/publications/science/2006/sciencestrategy.pdf

[121] EI would like to increase its support from 70 start-ups annually, depending on project quality. HPSUs must have a likelihood of exports of €1m in 3 years with long-term potential and are beyond the scale and profile of micro-companies supported through County Enterprise Boards. EI considered the potential deadweight loss was less likely in the case of R&D policies rather than direct grants or similar supports to such companies.

5. Policy Insights

5.1 Introduction

This chapter highlight and discuss policy pathways to enhancing productivity, innovation and competitiveness in Northern Ireland. We consider the applicability, comparability and significance of findings from our benchmark country analyses and cases studies of New Zealand, Singapore, and the Republic of Ireland, and identify policy areas for Northern Ireland where opportunities for improvements are evident. We seek to guide and stimulate further discussion about these policy pathways and subsequent action steps.

The insights and observations contained in this section draw on the analyses reported in the earlier chapters of this report, on secondary sources, and on a series of field research interviews conducted in the four countries as part of the study (for further details of our field interviews, see Footnote 3 in the introduction to this report).

We begin by organising our observations and findings around four interrelated pillars of productivity, innovation and competitiveness. These pillars are macro-frameworks, targets and strategies, organisational design, and policy and governance. *Macro-frameworks* comprise and enable the developmental environment within which efforts to enhance productivity, innovation and competitiveness are situated. This includes the economic and political context, and the level of priority and extent of shared vision associated with productivity, innovation and competitiveness. *Targets and strategies* encompass the objectives, strategies, and targets (including sectoral and technological targets) of policies for productivity, innovation and competitiveness. *Organisational design* includes the instruments and mechanisms, institutional arrangements, and partnerships put in place to attain productivity, innovation and competitiveness goals. *Policy and governance* includes stakeholder engagement, the processes of decision-making, performance assessment, learning, and policy and system improvement. From an innovation systems perspective, all four of these dimensions need to be aligned and mutually-reinforcing for progress in productivity, innovation and competitiveness to be optimised.

5.2 Macro-frameworks

There are significant contrasts among the four small open economies of New Zealand, Singapore, the Republic of Ireland, and Northern Ireland in terms of economic and political contexts. This includes the level of priority and extent of shared vision attached to issues of productivity, innovation and competitiveness.

Singapore has experienced several decades of consistent and sustained investment in infrastructure and education, supplemented by the attraction of talented people and foreign direct investment (FDI). As one of the world's most competitive and innovative nations, Singapore cannot be a follower country any longer. Policy has shifted to create and invest in the nation's R&D framework. R&D expenditures remain significantly higher in Singapore than in the other economies considered here. The country is also searching for a new model for economic success by increasing its attention to the development of indigenous knowledge, the capabilities of its people and intangible assets, in addition to infrastructural investments.

The Republic of Ireland also exhibits a developmental context that is in the process of transition. Over several decades, the Republic has established a record of attracting foreign direct investment from multi-national enterprises and has leveraged their knowledge, capabilities, international

supply chains, and distribution linkages as sources of export-led growth. The availability of a well-educated and young population and recent inward migration (particularly from other EU countries) has bolstered the workforce base. The Republic's labour productivity growth grew, trending above 3% annually. Economic development linkages were expanded through expatriates and the Irish Diaspora in other countries (especially the United States). In recent years, more attention has been focused on indigenous economic growth, as some multi-national enterprises have relocated functions to lower cost locations. The current economic crisis has also exposed vulnerabilities in financial services, public sector finances, and lagging infrastructural investment.

New Zealand initiated major reforms in economic orientation beginning in the 1980s, reducing protection and public ownership, cutting regulation, and opening up markets. Agriculture and food processing continue to be highly important to the economy, although the services sector has expanded strongly in recent years. Net in-migration has continued as a major source of growth. While labour utilisation has increased, productivity growth remains well below the OECD average. Analysts suggest that one of the factors contributing to this is New Zealand's low gross expenditure on R&D. Concern was expressed in a recent OECD review that New Zealand at times has an overreliance on maintaining "policy principles" at the expense of "efficacious implementation", resulting in high transaction costs, for example, through the strict separation of customer and contractor functions in public R&D funding.[122] The New Zealand case reminds us that market liberalisation and openness is a necessary but not sufficient condition for country success in globalised competition. Investments in human capital, R&D, and infrastructure, along with effective policies, are also critical in building the foundations for high-value economic growth.

As in several other UK regions, Northern Ireland has experienced a fundamental shift in economic structure as heavy and traditional industries declined. New growth areas have emerged in services sectors including financial services, and in selected high technology niches. Similar to the Republic of Ireland, foreign direct investment by multinational enterprise has been an important element in Northern Ireland's development strategy, although there has also been increased attention in recent years to encouraging indigenous business development. The 2009 Independent Review of Economic Policy (IREP), midway during the research phase of the PICSOE study, highlighted lagging productivity as a major issue in Northern Ireland.[123] While the labour force is relatively skilled and wages are competitive, Northern Ireland continues to faces challenges related to improving capabilities in science, technology, engineering and mathematics. Northern Ireland's R&D investment remains relatively low, with the need to encourage more companies to embrace innovation, increased engagement with sophisticated value-chains, and export-led expansion.

As a region, Northern Ireland does not have control over national economic or fiscal policy. Significantly, with devolved powers, and akin to Scotland and Wales, Northern Ireland possesses greater authority over regional economic development than regions in England.[124] However, economic development functions in Northern Ireland have suffered from fragmentation, bureaucracy, and a lack of flexibility to foster approaches that are increasingly entrepreneurial and business-oriented. In our field work, several interviewees reported that there was a lack of high-level political consensus and shared vision on issues related to economic development policy in Northern Ireland.

[122] OCED, New Zealand: OECD Reviews of Innovation Policy, Paris, 2007.
[123] Independent Review of Economic Policy (DETI and Invest NI), R. Barnett (Chair), September 2009. Available at http://www.detini.gov.uk/independent_review_of_economic_policy-2.pdf, accessed January 21, 2011.
[124] The UK government (in 2010) announced plans to close the English Regional Development Agencies, to be replaced by new Local Enterprise Partnerships (in 2011).

There are on-going discussions about organisational change and the strategic realignment of departmental and agency functions for economic development and innovation in Northern Ireland. In addition to adapting to on-going competitive and technological developments and to recover from the economic crisis, Northern Ireland also has to transition to a regime where major public grants for business expansion will be phased out over the near term and where overall public spending levels will be reduced. In this context it is particularly important to develop and implement policies and organisational approaches that can secure accord and pursue long-term strategies to the enhancement of productivity, innovation and competitiveness.

5.3 Targets and Strategies

In all four small open economies, there have been, and continue to be, identifiable targets for economic development and associated productivity, innovation and competitiveness strategies. Organisational divisions of labour in targeting are apparent.

For Singapore attracting foreign direct investment (FDI), supporting high technology enterprises, and fostering an entire value-chain proposition to enhance competitiveness is delivered through the Economic Development Board (EDB). A companion agency, SPRING, addresses related issues of enterprise upgrading, productivity improvement, and supporting enterprise innovation in domestic sectors. Agencies such as A*STAR and the JTC focus on broader system issues that create barriers for small enterprise development. Singapore's outward orientation – for both non-domestic multinational companies and indigenous companies – is emphasised by its target of doubling international trade with India over the next five years as it maintains an export-focus centre stage in its development strategy across all support agencies.

In the Republic of Ireland, there has been a concerted focus on attracting leading multinational companies in sectors such as pharmaceuticals, electronics, and specified areas of information and communications technologies (ICT). The Industrial Development Authority (IDA) has primary responsibility for attracting FDI. In recent years, strategies have supported evolution in the focus of multinational businesses in the Republic of Ireland to more innovation-intensive activities and away from manufacturing, with successful initiatives to attract financial services, support services, and other service sectors. Challenges remain to upgrade existing indigenous Irish enterprises to be more innovative, although this is now a principal policy goal with Enterprise Ireland as the lead implementing agency. The Republic of Ireland has also developed a strategy to enhance science and technology, with particular emphasis on the development of ICT, biotechnology and sustainable energy. Science Foundation Ireland (SFI) administers strategic public investments in science and technology, and other initiatives have been established to encourage closer linkages between industry and higher education and to foster industry clusters. Although policy to date has viewed indigenous competitiveness and economic growth significantly as a function of investment in leading-edge science and technology, there is emerging recognition that innovation also depends on organisational change, identification and exploitation of niche markets, and the engagement of a broad set of businesses – not only high-technology companies.

New Zealand maintains an open posture to FDI and in certain sectors, such as banking, there is a high level of foreign ownership. However, reflecting its location and small domestic market, New Zealand places little formal emphasis on attracting foreign direct investment. Conversely, policies supporting internationalisation and accessing foreign markets (particularly beyond its closest neighbour, Australia) take policy precedence. Key agencies and companies are international in their orientation, aided by explicit cultivation of the New Zealand diaspora. Significantly, the primary and food-processing sectors are seen as significant targets for innovation and export-led

growth. Through public funds, industry levies, and contract research, an effective R&D and technology transfer infrastructure has been developed in agriculture. Productivity and quality is high in the primary and food processing sectors, and innovative large and small companies have developed with a strong export orientation. New Zealand has also developed targeted strategies in biotechnology and creative industries. In biotechnology, efforts have been targeted to sectors and niches where New Zealand has some comparative advantage such as agri-bio and plant-bio. Private sector activities are supported by a capable research and university research infrastructure, with an increasingly strong user and client orientation and a willingness to collaborate. Some efforts are also targeted at upgrading existing manufacturing industries, although these are at a relatively small scale.

In Northern Ireland it is through Invest NI that the policy objectives of aiding existing and new businesses and attracting inward investments are primarily implemented. Invest NI devotes a relatively large share of resources to business expansion and training with a defined set of corporate clients. Invest NI is now challenged to modify this strategy – to expand efforts to raise attention to innovation across a broader share of companies in Northern Ireland and to focus available businesses support to encourage more companies to focus on R&D, innovation, exporting, and productivity improvement. The evidence obtained through our case studies reinforces the desirability of this strategy. It is important to go beyond working only with those companies who are presently engaged in R&D, innovation or exporting. This is likely to be a limited pool of companies in a small regional economy. In addition, it is vital to identify, mentor and develop the next generation of companies, mostly but not exclusively SMEs, who have the capabilities and motivation to upgrade their PIC performance. New Zealand's Beachhead program represents an example of how a small economy supports SMEs with the promise of high export growth.

5.4 Organisational Design

Organisational design encompasses the instruments, mechanisms, institutional arrangements, and partnerships put in place to achieve productivity, innovation and competitiveness goals.

Singapore exhibits a combination of multiple initiatives and coordinated organisations to achieve its strategic goals in fostering innovation, R&D, and value-chain linkages. Co-ordination is enhanced by strong business contacts built up over time from companies both attracted to Singapore and/or supported by Singapore's business support agencies in such a way that the civil service functions as a number of flexible, pro-active departments in their dealings with companies. For example, all heads of agencies under MTI coordinate explicitly through monthly meetings. This appears to work particularly well in economic planning and implementation, identifying gaps in labour market requirements, meeting needs speedily by co-ordinating activities for education, training and skills enhancement in support of specific sectors. Such cross-organisational delivery is evident also in relation to the implementation of Science and Technology plans through agencies focusing on R&D (A*STAR) and universities, hospitals and other collaborators.

The Republic of Ireland has an established mechanism for coordination and foresight capabilities through Forfás – an advisory agency for enterprise and science. Forfás, an agency of the Department of Enterprise, Trade and Innovation, has staff capabilities, and a board which brings together the main agencies engaged in productivity, innovation and competitiveness, including the IDA, Enterprise Ireland, SFI, the National Competitiveness Council, and the Training & Employment Authority (FAS). Third-sector organisations, including universities, have traditionally not been well-funded in the Republic of Ireland, but increasingly they are being resourced to

undertake business engagement and technology transfer functions.[125] These university-industry partnerships are still in the process of becoming embedded. Initiatives have been undertaken to insert new applied research institutions into the Republic's innovation system. The MIT Media Lab Europe was established in Dublin in 2000 to advance innovation in digital technologies, but closed in 2005, to be replaced by the National Digital Research Centre (NDRC) run in conjunction with five Irish universities with industrial collaboration. The US-based Georgia Tech Research Institute (GTRI) established an applied electronics technologies research facility in Athlone in 2006 and is developing linkages with Irish universities. Initiatives have also been sponsored to foster cluster policies to encourage greater collaboration (e.g. suppliers and customers), closer linkages between business and higher education and focused attention on shared problems.

New Zealand has undertaken fundamental reforms in its organisational landscape for R&D. In particular, former public research institutes have been amalgamated and privatised into eight Crown Research Institutes with mandates to undertake commercially-oriented research and to collaborate with industry. Universities have also enhanced their functions and units for technology transfer and industry partnerships. For example, the University of Auckland has engaged a New Zealander with some twenty years of technology transfer experience in the US to head the technology transfer office, with a team of patent lawyers and faculty promoters. Industry consortia involving research institutes and universities have emerged; these typically match public with industry funds. While the generally low-level of private R&D investment in New Zealand constrains the total set of resources available for public-private initiatives, innovative schemes are established with private sector support. For example the Structural Timber Innovation Company – an industry-university partnership that undertakes applied research on innovative and sustainable approaches to using timber for large-span non-residential applications that typically use concrete or steel.

Several government agencies and departments are involved directly in productivity, innovation and competitiveness in New Zealand, including the Ministry of Economic Development, the Ministry of Research, Science and Technology, and the Foundation for Research, Science and Technology. The current management style distinguishes policy development and oversight (in Ministries) from implementation (in agencies, foundations, research institutes, and non-profits). While raising transaction costs, the informal nature of interaction in New Zealand helps to overcome such barriers. There is active public-private exchange in developing policies and targets, with consultation and engagement of industry, universities, and other stakeholders. Resource levels allocated to new initiatives are often not large, and there are often expectations of self-sufficiency or at least raising significant non-governmental income.

In Northern Ireland, the overall institutional landscape now involves an executive, the legislative assembly, and multiple ministries and agencies charted with responsibilities that affect productivity, innovation and competitiveness. Significant resources are devoted to ensuring accountability and responsiveness to the legislative assembly. At the governmental level, there is an emerging recognition that current arrangements may not be well aligned and may be too cumbersome and inflexible. IREP has recommended further consolidation and coordination of governmental functions, including the creation of a single Department of the Economy, amalgamating the Departments of Enterprise, Trade and Investment (DETI) and Employment and

[125] OECD figures indicate that while the average spend on third-level education is 1.5% of GDP, the corresponding figure for Ireland is 1.2%. The OECD's *Education at a Glance 2010* reports Ireland's investment of 4.7% of its GDP on education compared to an OECD average of 5.7%. While spending on all levels of education combined doubled between 1995 and 2007 in Ireland GDP more than doubled over the same period leading to a decrease in expenditure as a proportion of income. The OECD portrays a chronically underfunded education system in Ireland with poor levels of investment at primary, secondary and third level compared to most other OECD states.

Learning (DEL). More priority to economic policymaking and coordination is also recommended, including through a permanent subcommittee on the economy chaired by a new Minister for the Economy and by more effective liaison with Invest NI. How and when such reforms will be implemented, and whether they achieve the desired results, are pending questions. Reorganizing government departments and focusing Ministerial attention can improve the environment for economic growth and innovation, and may result in the better targeting of resources. However, in and of itself, governmental reorganization is unlikely to lead to step-wise changes in business performance.

Outside of government, there is a small but active set of organisations engaged in promoting innovation in Northern Ireland. The two universities are increasingly engaged in business-facing activities, technology transfer, and university-industry partnerships. Models for science parks, incubators, and public-private partnerships are established. For example, we observed effective and innovative relationships, both formal and informal, between the emerging financial technology services sector in Belfast and Queen's University.

If there is a prominent gap in Northern Ireland, it may be in instruments and mechanisms to foster innovation and productivity improvement among existing small and mid-sized firms. This may be achieved through means such as industrial extension i.e. enhancing the reach of productivity-enhancing technologies, technical assistance and modernization services provided by government, universities, research labs, community colleges and other organizations. Invest NI's current business client model currently excludes many of these firms, and although Invest NI is being encouraged to diversify its client base, as yet we did not learn of specific proposals to substantially upgrade efforts to work with these firms.

IREP has recommended the development of a new applied research institute, based on the model of Finland's VTT Technical Research Centre. While agreeing on the desirability of enhancing applied research in Northern Ireland, we suggest that it would be useful to expand the scope of this debate and to consider insights from other models. There are several variations and contrasting models for fostering applied R&D, including those presented by US state universities and industrial extension systems, the New Zealand Crown Research Institutes, Germany's Fraunhofer and Steinbeis centres, NDRC and GTRI in the Republic of Ireland, and Scotland's intermediate technology centres.[126] One important dimension is how to more effectively engage Northern Ireland's Agri-Food and Biosciences Institute (its largest non-university research institute) in applications that can enhance innovation in the primary, food processing, environmental and biosciences sectors in Northern Ireland.

5.5 Policy and Governance

There are important structural differences and nuances in policy formulation, governance, and evaluation across the four economies.

Singapore exhibits a "top-down" structure which integrates various aspects of policy and governance. The Prime Minister and key ministers take a great interest in economic development and innovation. Building on earlier experience with tripartism (by government, employers and unions) in developing economic policy, the government has continued to build institutional and social capital to support economic development and innovation. The civil service has been used

[126] For a review of several of these models, see P. Shapira, J. Youtie, and L. Kay, Building capabilities for innovation in SMEs: a cross-country comparison of technology extension policies and programmes, *International Journal of Innovation and Regional Development*, forthcoming.

explicitly to guide Singapore's development strategy with a shared outlook and approach evident between higher civil servants and government-political leadership; the evident meritocracy also reveals a technocratic orientation with advanced educational qualifications and performance determining entry and career development in both spheres. While the public sector and its agencies remain dominant, its role has transitioned away from a regulatory stance more towards a facilitative stance in the case of business activities. However, evaluations of policies remain largely internal and unpublicised.

The Republic of Ireland has evolved a series of mechanisms to promote policy deliberation and evaluation. Policy has evolved as the economy has changed and new problems and opportunities appear. This evolution is evident, for example, in the development of a Competitiveness Fund by Enterprise Ireland in the early 2000s; by the mid-2000s the emphasis turned to productivity. The current policy focus is directed clearly towards R&D and innovation. There is consistent and on-going evaluation of programmes and the findings underpin the selection of interventions for support, in the context of effectiveness in achieving goals set and value for money criteria. There is openness in sharing results generated through evaluation processes and willingness to engage in the sharing and discussion of learning. Additionally, attention is given to prospective studies, with Forfás taking the lead in commissioning foresight studies and road-mapping by sectors and technologies, in developing planning documents, and encouraging public-private exchange on future development strategies.

New Zealand's open and transparent governance and the government's broad orientation to learning and evaluation are important dimensions in the development and improvement of competiveness and innovation policies. Consultation on new policies is typically undertaken at the policy formulation stage, with engagement from business, academia, local governments, and other stakeholders. This active public-private exchange is important in developing strategies for targeted sectors. New Zealand also appears to make effective use of non-profit organisations and associations to facilitate exchange and networking between private sector representatives and policymakers - examples include Plastics New Zealand and NZBio, an association active in national and regional networking in the bio and life sciences sector. Public programmes related to productivity, innovation and competitiveness are typically subject to formal evaluations, as well as to benchmarking and performance reviews. To reduce administrative burden and facilitate comparability, evaluations of related programmes (such as business assistance programmes) can be undertaken in batches. Evaluation reports and results are usually open, and are drawn upon in discussions of policy improvement and funding allocations. At the same time, there is a high level of informal sharing of information and insights.

Northern Ireland has multiple departments, agencies, and organisations with interests in economic development and innovation. However, mechanisms to ensure consistent planning, policy formulation, coordination, and implementation of economic development and innovation priorities remain a challenge. Such challenges may remain even if the proposed departmental merging of DETI and DEL takes place. Adherence to EU competition and state aid rules present additional considerations, with careful preparation needed to develop ways to address changes in EU rules and to allocate available EU resources to support innovation.

There is also the noticeable influence of "treasury-think" in Northern Ireland's administrative culture and policy formulation. Northern Ireland not only focuses on productivity gap measures (as in other regions of the UK) but uses similar rationales to justify policy development (i.e., the Northern Ireland Guide to Expenditure Appraisal and Evaluation). Such rationales, which tend to focus on economic costs and benefits in the context of current systems rather than seeking major strategic changes in standing, can lead to the avoidance of risk-taking. The high-level of legislative

accountability on a detailed project-by-project basis (rather than across a complete portfolio as seen in best practice examples in New Zealand) also discourages risk-taking. In terms of policy and programme evaluation, Northern Ireland is well-developed. There are periodic major reviews, as well as evaluations of projects which are public.

Northern Ireland's Science and Industry Panel provides strategic advisory input from business, academic, and non-profit perspectives on science, technology and innovation issues. Nonetheless, there is probably scope for more organised initiatives to develop foresight and vision around strategic innovation objectives, particularly to build-in policymakers and other stakeholders and to secure longer-term consensus.

5.6 Insights and Recommendations for Northern Ireland

Northern Ireland (seeks to improve its performance and standing in productivity, innovation and competitiveness (PIC). The restructuring of traditional industries, the limitations of conventional FDI attraction policies, and increased globalisation have intensified challenges to achieving these objectives. Organisations such as Invest NI, DETI, and MATRIX have been commissioned with tasks related to PIC objectives, while science parks, incubators, technology initiatives, networking efforts, and other programmes have been established by universities and non-governmental organisations.

Measured by output and employment, Northern Ireland has experienced growth. Yet by most key measures related to innovation and competitiveness, Northern Ireland continues to lag not only other UK regions, but also other economies in Europe and elsewhere. There is still much to be done to improve its position. The step-wise progression in performance that is desired in Northern Ireland represents a fundamental challenge - major improvements are required in the capabilities, strategies and performance of firms and associated organisations in the operation and governance of the innovation system. These will surely necessitate sustained investments of economic, institutional and political capital over many years. The challenge is made more difficult by the fact that many other competitive small open economies are also seeking to maintain and advance their positions, with countries like Singapore able to dedicate high levels of financial and political resources to advancing development.

The recent economic downturn and the UK government's determination to reduce public spending impacts both the environment and the availability of resources for innovation policy and programme development in Northern Ireland. There will likely be significant reductions in the budgets of departments and agencies, universities, and other organizations concerned with innovation in Northern Ireland. Additionally, there is a reorientation in overall UK government policy, with an emphasis on supporting private sector jobs, exports, investment and enterprise while reducing spending on welfare and quasi-governmental organizations. On the other hand, there will be an increased UK government emphasis on adult apprenticeship, while public research and development spending has been mostly held constant, and UK Consulates overseas are being encouraged to assume larger roles in fostering international business linkages. Additionally, following the Hauser Report,[127] the UK government plans to invest over £200 million in a network of applied technology and innovation centres.

[127] H. Hauser, The Current and Future Role of Technology and Innovation Centres in the UK, Department for Business, Innovation and Skills, London, 2010

An important step in assessing and addressing Northern Ireland's real strengths and weaknesses in productivity, innovation and competitiveness, and in developing improvement strategies, is for Northern Ireland to benchmark itself internationally against other leading small economies, and not only against selected UK regions. Such benchmarking needs to consider a composite of measures broader than the current UK standard of gross value-added to include such elements as R&D investment, human capital capabilities, knowledge generation and innovation performance, as well as, comparative performance in innovation system operations and governance. Singapore, for instance, has moved beyond improving domestic productivity to focusing on the development of a broad range of capabilities in (a) improving its business profile in niche research, marketing and management skills to compete with other developed nations; (b) upgrading human resource in industry relevant and mid-career training and creativity ; (c) soft infrastructure like a social climate and institutional structure that supports innovation; and finally (d) global city policies in immigration and internationalisation. [128]

While the PICSOE Project has laid down a foundation of evidence and analysis that facilitates such comparisons, international benchmarking and scanning should be viewed as an on-going activity which is essential to the formulation of policies appropriate to move Northern Ireland closer to the innovation frontier. In this last section of this chapter, we highlight key areas and opportunities for improvement in productivity, innovation and competitiveness for Northern Ireland. We identify several policy areas where further deliberation and sustained action could lead to significant results.

5.6.1 Developing Strategic Capabilities

Northern Ireland seeks to expand advanced technology sectors in biotechnology, nanotechnology, and medicine, through such means as university research collaborations and business incubation. Such efforts need to be sustained. Additionally, our research identified sectoral and clustering opportunities that appear, by comparison with benchmark economies, to be under-exploited in Northern Ireland at present. These include the following:

Develop innovative capabilities in the agri-food value-chain. Northern Ireland's Agri-food sector appears to be much overlooked in the context of innovation strategies. Strategic opportunities need to be identified, grasped and organised in Northern Ireland to strengthen innovation, move up the value-chain in agriculture food production, and further develop innovative agri-food capabilities. There are many lessons here from New Zealand, which has extensively fostered innovation in the agri-food sector in order to export. Part of the strategy for Northern Ireland may well be to radically rethink the role and integration of existing agricultural research capabilities in the region (as New Zealand did with the reform of its research-oriented public labs into more innovation and mission-focused institutions able to serve as hubs for agri-food innovation), and to identify new mechanisms to exploit branding and marketing opportunities in export markets, especially for high-value agri-food products.

Build up the financial services technology cluster. A burgeoning financial services technology cluster is developing in Northern Ireland, particularly in Belfast, as firms from the US, the UK mainland, and elsewhere are locating various functions in the region. There are a series of higher-level activities within these functions in maintaining and developing financial services software technologies, with a few dynamic local firms and links with universities already emerging. Policymakers in Northern Ireland need to look beyond the current financial crisis to ensure that

[128] Ministry of Trade and Industry (MTI).For details, see http://app.mti.gov.sg/data/pages/885/doc/NWS_plan.pdf

the needs of this cluster are identified, in terms of joint human capital development and training, high-speed and reliable communications technologies, air travel, university partnerships, and local networking and exchange opportunities.

Retain and upgrade capabilities in engineering innovation. Northern Ireland has been a traditional centre of excellence in engineering, and retains capabilities in engineering research and corporate engineering innovation. Yet, the level of effort and growth in engineering research in fast-growing economies such as Singapore raise issues of the strategies to be pursued in Northern Ireland. Key challenges include not only retaining these capabilities in the few larger engineering-oriented companies in Northern Ireland (such as in the aerospace sector), but also supporting and encouraging improvements in existing small and medium-sized enterprises linked into the supply chain of these larger companies. The upgrading of SME capabilities and supply-chains inevitably requires sustained, "hands-on" effort over a period of time: upgrading needs to be viewed as an on-going process rather than a one-time or short-term programme, and an embedded set of institutional support arrangements is essential. (See also Section 5.6.2). Complementary mechanisms to support upgrading including promoting appropriate engineering curricula at universities, enhancing vocational training and apprenticeship for technical staff, working with new companies to bring them into supply chains, exploiting new materials and manufacturing methods, and building up transferable capabilities to access related sectors and new markets.

In further developing the three strategic domains of agri-food, financial services, and advance engineering innovation, very close ties will be needed with applied research institutes, as discussed in section 5.6.5.

5.6.2 Fostering Indigenous SMEs

The small open economies we studied are focusing additional efforts on indigenous firms, particularly small medium sized enterprises (SMEs). In the Republic of Ireland, but most particularly in New Zealand, there is evidence of the growth of exports by indigenous companies, in agri-food, manufacturing and advanced services. In Singapore, there are dedicated agencies supporting the productivity and technological innovation in SMEs (SPRING) and the internationalisation of Singaporean firms (IE Singapore). As there are different varieties of indigenous firms, ranging from new high-tech start-ups to existing but mature companies, this leads to different needs and strategies. All economies (including Northern Ireland) have devoted attention in recent years to fostering high-tech start-ups.

Our results indicated that the level of patent stock accumulated over time was an important factor in explaining the level of innovative activity in a small economy, thus emphasising the need for critical mass in research. As a regional economy with a large base of small and medium sized businesses, many of which cannot afford in-house R&D, Northern Ireland requires creative thinking in supporting partnerships across related companies for innovation purposes. Small businesses need to be encouraged to engage with research, since evidence suggests that firm size is no barrier to research output. Separating out the issue of business scale and critical mass would be useful in this regard.[129]

We learned of valuable initiatives in Northern Ireland to cultivate and draw upon the Irish Diaspora in the US high technology community. IREP recommended that Invest NI should expand

[129] Small economies that appear to have reached such levels of critical mass in terms of inputs to, and outputs from, expenditure on innovation include Denmark, Finland and Israel.

its firm-oriented services beyond its current restricted client list without detailing what kinds of services might best be offered. When compared with the benchmark economies, more attention needs to be given to support SMEs in Northern Ireland, including by addressing capital needs and by supporting small "born global" firms to enter international markets.

We would therefore suggest that particular attention be paid towards the means of upgrading innovation and internationalisation in SMEs. This can be achieved in the following ways:

Identify and support new "born global" firms. "Born global" firms are new start-up enterprises that almost immediately enter into international markets, typically with innovative products, technologies or services that attract attention and premiums from international companies and leading markets. While initially they can be niche players, "born global" firms have the potential for rapid growth. At the same time, they face tremendous challenges and risks as small firms with limited resources entering international markets. We recognised that Invest NI provides multiple programmes to assist various components of business growth and to help firms to export, and is aware of the "born global" concept. But, compared to other countries that we studied, we do not see that Invest NI is as focused, integrated and intense in its approaches to identifying, mentoring and supporting small enterprises to grow through access to international markets. We recommend that more intense examples such as the NZ Beachhead programme or the dedicated Singapore IE model be considered. The Beachhead programme provides a model, with mechanism to identify firms with very high growth potential and means to support those firms to gain access to international markets. For Invest NI, new resources are not necessarily needed, although there are opportunities to make further use of the Irish Diaspora and UK Science and Technology and Invest NI international connections. Rather, there is a need to integrate and target available resources to more intensively focus on identifying, mentoring, stimulating and enabling small enterprises in advanced manufacturing, technology and services to grow through access to international markets.

Build initiatives to upgrade innovation capabilities in indigenous firms. Northern Ireland, like other UK initiatives, has had a succession of initiatives to support the broad development of innovation and other capabilities in indigenous SMEs. Such initiatives have often been fairly thin in coverage, not necessarily well-coordinated, and often subject to change, leading to a lack of business trust. The current round of public sector cutbacks will likely further reduce existing SME support mechanisms, at least in the short term. Yet, the need to encourage more SMEs to develop and implement innovation strategies remains. There is a need and opportunity to rethink how indigenous SMEs can best be supported in Northern Ireland, in an era of reduced public resources. This may include initiatives to leverage partnerships whereby SMEs are encouraged to pool resources together to conduct joint innovation projects in conjunction with larger supply chain partners or with applied university research units (as in the case of such partnerships in New Zealand). Joint development work may include pre-competitive technology development, product development, specialist training and exploiting international markets. Existing business and technical assistance services (for example, at Invest NI) should be oriented towards fostering innovation and internationalisation, focusing resources on SMEs that have the motivation, management, and potential to upgrade. Such strategies will also assist in supporting and attracting further inward foreign direct investment (FDIs), as a greater critical mass of capable SME suppliers and innovators is developed, as noted in the next section.

5.6.3 Fiscal Policy

As a region of the UK, Northern Ireland is subject to national fiscal policies. There has been a long-running debate in Northern Ireland about the favourable 12.5% level of corporate tax in the

Republic of Ireland whereas in the UK (including Northern Ireland) the corporate tax rate is 28% (in 2010). By comparison, for 2010 the corporate tax rate in Singapore was 17% while for New Zealand the rate was 30%.[130] The UK government has announced a lowering of corporate tax rates from 28% to 24% for large companies over the four years to 2014, with the rate for SMEs to be lowered from 21% to 20% by 2011.[131] Along with related corporate tax reforms including focusing UK corporate taxation of multinational corporations on profits from activities in the UK rather than worldwide income, the aim is for the UK to have the most competitive corporate tax systems among leading developed nations. Nonetheless, proposals for a separate rate of corporation tax in Northern Ireland remain on the agenda.[132]

We did not find from our analysis of other countries that corporation tax has a major impact on fostering innovation and productivity in particular.[133] Corporate taxation can be one of many influences on business growth and foreign direct investment, but it is rarely among the most important. The type of businesses attracted to a location by relatively lower corporation taxes often fall into the footloose category of firms attracted by low costs (and not innovation capabilities). The ability for Northern Ireland to lower its corporate tax further than the already declining UK rate would place it closer to the Republic of Ireland on this measure, although at potentially considerable cost in lost tax revenues. This may be viewed as desirable by some business advocates, and it may marginally help in specific business attraction projects. But, corporate tax rates are only one of many factors that come into play in business attraction and it is not necessarily a major factor in encouraging or discouraging innovation. While the debate about further lowering Northern Ireland's corporate tax rate to try to attract foreign multinationals is likely to continue, it should not detract from broader-based efforts to foster improvements in indigenous research and innovation capabilities, skills, and infrastructures, most of which require public as well as private investment to cultivate (as the leading innovative regions and countries that Northern Ireland competes with have demonstrated).

5.6.4 Strategies for Foreign Direct Investment (FDI)

In the Republic of Ireland, foreign-owned electronics and pharmaceuticals companies remain among the most productive and export-oriented parts of the economy. The Republic remains the most FDI-intensive economy in Europe. Similar FDI-intensive production is a feature in Singapore, with leadership from foreign-owned chemicals and electronics companies. Singapore is notable for its on-going partnering and close contact with foreign direct investors, seeking to stimulate them to upgrade their in situ capabilities and activities. Northern Ireland, through Invest NI has sought foreign direct investment as a major part of its economic development strategy. Compared

[130] OECD Tax Database, Corporate and capital income taxes, Part II. Taxation of Corporate and Capital Income (2010), http://www.oecd.org/dataoecd/26/56/33717459.xls, accessed January 23, 2011; Inland Revenue Authority of Singapore, Tax rates & tax exemption schemes (for companies), http://www.iras.gov.sg/irasHome/page04.aspx?id=410, accessed January 23, 2011.

[131] HM Revenue and Customs, Corporation Tax Rates (2008-2011), http://www.hmrc.gov.uk/rates/corp.htm, http://www.hmrc.gov.uk/rates/corp.htm, accessed January 23, 2011; HM Treasury, Corporate Tax Reform: Delivering a More Competitive System, November 2010, Part I: The Corporate Tax Road Map, http://www.hm-treasury.gov.uk/d/corporate_tax_reform_complete_document.pdf, accessed January 23. 2011.

[132] See, for example: http://www.belfasttelegraph.co.uk/business/business-news/corporation-tax-cut-still-on-agenda-14852275.html#ixzz0zKLzlsGp; http://www.cabinetoffice.gov.uk/media/409088/pfg_coalition.pdf; http://www.belfasttelegraph.co.uk/news/local-national/northern-ireland/stormont-should-set-own-tax-rate-15061934.html.

[133] See also PriceWaterhouseCoopers LLP, Corporation Tax: Game Changer or Game Over? PwC Northern Ireland, January 2011, http://www.pwc.co.uk/ni/publications/ni-government-futures-corporation-tax.html, accessed January 23, 2011.

with Singapore, Invest NI appears to be less targeted to focusing on next generation higher value-added foreign firms, is less able to finance major infrastructural improvements, and is more loosely coordinated with universities in targeting specific FDI sectors for growth.

We believe there is also an opportunity for Northern Ireland to increase its distinctiveness, capability and innovativeness in attracting foreign-owned companies. We offer the following insights:

Supply Chain Improvements There are several pathways through which Northern Ireland might develop its ongoing strategies for FDI. This is much more than external marketing. Attractors for "high-end" investments of large companies include a strong base of small companies and suppliers that are competitive and an available labour force with sophisticated skills in designing, managing and implementing innovation. There is a need for Northern Ireland to continue to maintain continued relationships with incumbent foreign direct investors, particularly to develop R&D and innovation partnerships and the upgrading of indigenous supply chains, as in the case of Singapore and Republic of Ireland (where many MNCs initially refused to deal with local supply chains due to quality and reliability concerns – concerns that have been targeted and addressed).Strategic initiatives to develop and upgrade supporting suppliers and complementary services are likely to be significant in sectors including aerospace, pharmaceuticals, and financial services.

Long Term Public-Private Investments. The emerging model in Singapore and New Zealand show us that these countries work with companies on a strategic basis, with long-term and mutual private and public investment in complementary capabilities, rather than on a project-by-project basis or stopping when FDIs are established in the region. Strategic investments are involved periodically for these investors (over a period of several decades) in terms of infrastructure building and providing employment and training credits. There is a need for Northern Ireland to continue to maintain continued relationships with incumbent foreign direct investors in understanding their evolving needs. Areas where strategies for public investment may be matched by or used to attract further private investment include applied R&D, supply-chain development, specialized training, and communications and transportation infrastructure.

5.6.5 Repositioning Northern Ireland as an Innovation Hub

All three benchmark economies have seen reorientation and enhancement in their institutions and organisations for applied research. New Zealand has transformed its public research institutes into privatised commercial corporations (albeit still with some core public support). In Singapore, a model has evolved of powerful government agencies collaborating with universities in research in Singapore, and the creation of A*STAR to supplement the value creating proposition. The Republic of Ireland lags in this regard having identified it as a weakness requiring greater focus. In the UK, the recent Hauser report has highlighted the need to develop the landscape of applied technology and innovation centres throughout the country to expand translational capabilities to bridge research and technology commercialisation.[134]

It is appropriate that Northern Ireland also considers its institutional landscape for applied commercial research and innovation. However, simply investing more R&D funds in Northern Ireland without other changes in structures or incentives may not leverage desired results, given the high orientation of Northern Ireland's publicly-sponsored R&D workforce towards the production of academic papers. One possible institutional intervention is the foundation of a new

[134] *The Current and Future Role of Technology and Innovation Centres in the UK*. A Report by Dr. Hermann Hauser. Department for Business Innovation and Skills, London, 2010.

institution for commercially-oriented research. The VTT Technical Research Centre of Finland has been suggested as a model.[135] VTT is one of Europe's largest applied research organisations, with a staff of more than 2900 people and an annual turnover of €269 million (£242 million) of which 31% is core government funding and 14% is income from abroad.[136] Our interviewees in Northern Ireland indicated mixed views on this proposal: some in favour, others opposed. Clearly, there is further analysis, design-work, discussion and consensus building that need to occur on this proposal.

An obstacle for any effort to develop an expanded applied research capability in Northern Ireland is the generally low level of R&D expenditure in Northern Ireland. Between 2005 and 2008, Northern Ireland's R&D expenditure averaged about 1.2% of GDP, although for 2009 the equivalent figure rose to 1.7% based on total R&D expenditures by business, higher education and government of nearly £483 million.[137] The growth seen in 2009 was driven by an increase in Northern Ireland's private business sector R&D spending to £324 million, up by nearly £140 million or 76% over Northern Ireland's 2008 private R&D spend. Much of this increase derived from larger companies, mostly owned outside of Northern Ireland. In 2009, just 47 companies spent more than £1 million on R&D in Northern Ireland, with ten companies accounting for 57% of business R&D outlays. There was a 36% year-on-year increase by Northern Ireland SMEs between 2008 and 2009 in R&D spending. Whether this welcome growth in Northern Ireland's private-sector R&D will be sustained in the near future remains to be seen, particularly in the context of the broader economic slowdown and anticipated declines in real R&D expenditures by the higher education sector and government. Additionally, Northern Ireland's R&D spending as a percentage of GDP remains well below the levels of Finland (3.5%) and leading European regions such Braunschweig (Brunswick) and Stuttgart in Germany (6.8% and 5.9% respectively), East Anglia in the UK (5.7%), Pohjois-Suomi in Northern Finland (5.4%), and Hovedstaden (including Copenhagen) in Denmark (5.1%).[138] In Northern Ireland, the challenge is not only to sustain but to further increase private sector R&D, including broadening out the base of companies that undertake any R&D. Currently, the Northern Ireland Annual Business Survey reports that only 6% of all responding firms undertake R&D (within which 20% of manufacturing firms and 3% of services firms reported being research active).[139] Among active R&D firms, 92% of R&D outlays in 2009 were spent within the company on in-house R&D. Just 8% (under £27 million) of Northern Ireland's 2009 business R&D was purchased from outside sources.[140] This is an order of magnitude below the level that might support an applied R&D organization of the scale of VTT, suggesting that at least initially any new applied R&D organizational structure would need to be smaller and well-targeted. Further

[135] *Independent Review of Economic Policy* (DETI and Invest NI), R. Barnett (Chair), September 2009. Available at http://www.detini.gov.uk/independent_review_of_economic_policy-2.pdf, accessed January 21, 2011.
[136] http://www.vtt.fi/vtt/vtt_figures.jsp?lang=en, accessed January 23, 2011.
[137] Northern Ireland R&D data reported in this paragraph sourced from: Northern Ireland Statistics and Research Agency, *Northern Ireland Research and Development Statistics 2009*. December 1, 2010. Gross Value Added for Northern Ireland is used as a proxy for the regional GDP, from: *Regional, sub-regional, and local gross value added 2009*, NUTS1 Regional GVA 2009, Office for National Statistics, Newport, Wales, December 8, 2010, http://www.statistics.gov.uk, accessed January 23, 2011.
[138] OECD Factbook 2009, Economic, Environmental and Social Statistics, Science and Technology (Gross domestic expenditure on R&D as a percentage of GDP), Finland data for 2007, http://stats.oecd.org, accessed January 23, 2011; Eurostat, Total intramural R&D expenditure (GERD), by NUTS 2 region, Percentage of GDP (tgs00042), http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/data/database, accessed January 23, 2011.
[139] Northern Ireland Annual Business Inquiry, 2008 survey, reported in: Northern Ireland Statistics and Research Agency, *Northern Ireland Research and Development Statistics 2009*. December 1, 2010.
[140] Northern Ireland Statistics and Research Agency, *Northern Ireland Research and Development Statistics 2009*. Table 5, Business Expenditure on R&D – 2009, December 1, 2010.

consultation with leading and prospective R&D companies in Northern Ireland about the value, configuration, and business viability of any new applied research institution is clearly essential.

Government itself is a key stakeholder in such discussions, since over £50 million (or about 17%) of 2009 Northern Ireland business R&D outlays derived from government (including from Invest NI and other UK government sources). There is a case that at least some government R&D funds to business might be better leveraged through investment in a business-focused applied R&D institution, in the way that VTT (and other applied research institutions such as the Fraunhofer centres) receive a core of government funding used for facilities and activities to attract and support further private applied R&D projects. It is a difficult time in Northern Ireland to make such a case, given the pressures to reduce discretionary government spending in the near term, concerns likely to be raised by existing companies receiving government R&D support, and apprehension by universities who are themselves facing major budgetary constraints. Yet, building on the consensus that R&D is not only critical to future innovation and competitiveness but also requires investments and capacities developed over the long term, Northern Ireland has to look beyond these near term financial issues and consider how best to configure and augment its institutional R&D landscape over the next decade and beyond.

Underlying these "supply-side" options of how best to structure applied research capabilities is a set of "demand-side" issues related to increasing the number of companies in Northern Ireland engaged in R&D. Invest NI already operates an R&D grant scheme for industrial research and experimental research targeted at SMEs. For small businesses (with fewer than 50 employees) new to R&D, this can provide up to 75% (up to a maximum of £70,000) of the costs of an R&D project. However, it could be possible to leverage available resources by increasing the match requested from companies to increase the maximum (public and privately-funded) project size and by encouraging group projects (multiple companies working with R&D centres or with larger customers). Small value R&D vouchers (e.g. of perhaps up to of £10,000, including some company match) might also be useful in "priming" R&D relationships between Northern Ireland SMEs and R&D organizations. There are some insights here from our benchmark economies. Low business expenditure on research and development has been a concern in the Republic of Ireland. Breaking a historically low propensity in this area remains a challenge. To some extent, the availability of grants created a corporate dependency on public funds for research and development activities. A carefully designed matching scheme might overcome this. However, the spillovers from FDI and changes in R&D practices have begun to modify how the Republic's indigenous companies view and pay for research and development. In New Zealand, private R&D spending is also low. However, industry-led consortia of large and small companies, applied research institutes, and universities have been one of the brighter spots in spurring applied collaborative R&D.

The development of the applied research landscape would need to be scaled appropriately for the Northern Ireland economy (starting out significantly smaller than VTT). Considerations of focus, ensuring world-class quality, university relationships, and long-term sustainability are vital. Potentially, some of the SME business technology assistance functions currently allocated to Invest NI might be redeployed and expanded in a focused applied research institute. IREP recommends that Invest NI should concentrate its support more on small firms and to projects with a high innovative content. Substantively, this is an important recommendation, but organisationally a new applied institute complements and motivates this proposal by offering an organizational framework with the capabilities, culture, and reach to achieve this goal.

The details of how the new UK Technology and Innovation Centres programme will be administered have yet to be fully released. It is expected that each centre might be funded at a level of £5-10 million annually for several years, with both existing and new centres supported.

Only a handful of centres (perhaps 4 or 5) will be supported initially (leading to intense competition from around the UK for selection). More specific details and application procedures have yet to be announced. The Technology Strategy Board is expected to do this later in 2011. It would be timely and opportune to establish in Northern Ireland a mechanism to consider and prepare for the various options, leading us to the following recommendation. We recommend that a design team be tasked to explore and counsel on options to substantially develop commercially-oriented applied research in Northern Ireland. Such a design team would involve expertise from the private, academic, applied international research, and public sectors, and would consider options that could start to be put into place within 2 years as part of a longer term strategy (to 2025 and beyond). DETI/Invest NI/DEL could be the appropriate organisations to be tasked with organising the design team. It would immediately begin to prepare for and develop a unified approach in investigating and responding to the opportunities that will be available in 2011 under the Technology and Innovation Centres programme. The design team should also consider opportunities beyond what might be immediately available under this programme (since a limited number of new centres will be established across the whole UK) to also consider how existing capabilities in Northern Ireland might be adapted and upgraded over the longer term to strengthen their contribution to innovation.

Consideration should be given to how to leverage the existing AFBI Agri-Food and Biosciences Institute to become more commercially-focused towards stimulating innovation in the agri-food sector in Northern Ireland. Other strategic areas include financial technology services and advanced engineering, as discussed earlier. This might lead to a configuration of three targeted applied research institutes, configured outside of yet linked to both universities and companies. One advantage of being outside the university system is that the organisation is not subject to the limitations of the Research Excellence Framework. Here, the Fraunhofer model is interesting in that while independent of universities, each Fraunhofer Institute is headed by a university professor and provides opportunities for younger researchers in applied research and associated training in industrially-oriented projects with companies.

While such discussion may appear ambitious, it is important to point out such major organisational redesigns and establishments have been initiated in other small open economies. For example, New Zealand corporatized and reshaped its public research labs into corporatized Crown Research Institutes, increasing the focus on applied research. Singapore and the Republic of Ireland have each established new lead R&D agencies (A*STAR and SFI Ireland).

The timing is perhaps appropriate for Northern Ireland to scan forward to at least 2025 to envision what would be its desirable and internationally-competitive configuration for R&D and technology diffusion (including university, public, and applied research), and begin to put into place the supply and demand-side mechanisms necessary to move towards this. Upcoming changes in EU regional aid and UK public spending present both opportunities (EU SFA funds released between now and 2013 that could be redirected towards applied research and innovation support) and constraints (general restraints on most UK governmental spending for the next few years) for immediate action. However, long-term strategies need to plan beyond the current period and ensure that there is basis for significant growth in applied and corporate R&D, innovation, and technology diffusion in Northern Ireland built on greater linkages with corporate collaborators.

5.6.6 Policymaking and Orientation: Changing the Culture

A key issue in achieving competitiveness is the robustness of the economic policy environment. Our study revealed that businesses in Singapore valued the stability and consistency of economic

policies. There are many risks in business and consistent policies help to achieve some stability as noted by business interview in Singapore. In New Zealand, while much less interventionist than Singapore, there are also clear policy principles. Policies in New Zealand appear to be more open with consultations when policy changes are considered.

In our discussions with businesses in Northern Ireland we received consistent feedback about the fragmentation of policymaking for economic development and innovation in Northern Ireland, with multiple agencies subject to numerous layers of executive and legislative oversight, and marked differences in perspectives among policymakers. The transaction costs involved in this process are high, potentially turning the devolved powers over economic development and innovation that should be an advantage to Northern Ireland into a disadvantage compared with the more unified operations of regional development agencies elsewhere in the world.

In this study, we learnt of the successful structure of the Singapore's Ministry of Trade and Industry. In Singapore, economic policy making and its implementation are delegated to different statutory arms. Yet, these agencies are aligned together with common goals and regular meetings. It was also revealed that through a driving agency like the Economic Development Board (EDB), government ministries are frequently brought together to address industry needs. For example, EDB spearheads regular meetings with the Ministry of Education, SPRING, MAS and Ministry of Health on planning future workforce requirements for the growing bio-medical industry. In the Republic of Ireland, we find examples of agencies displaying evidence of close working relationships with frequent information sharing.[141] New Zealand also exhibits close formal and informal working relationships among key agencies, with co-locations and secondments to reinforce collaboration.

Proposals have already been made to bring together core economic functions in Northern Ireland (covering existing DETI and DEL areas of responsibility) under a single 'Department of the Economy'. A permanent Ministerial-led subcommittee to prioritise action on the economy and innovation has also been introduced in Northern Ireland. [142] We judge that the departmental reforms proposed for Northern Ireland are useful administrative steps, although not by themselves sufficient to lead to major changes in orientation and culture. More fundamental organisational reforms and adjustments are necessary to ensure a situation where there is a competent, but lean and flexible, departmental structure with capabilities for policy development, assessment analysis, and foresight arms, as evident in the case of Singapore. It is likely that such a unit would be smaller, reflecting a shift in government orientation to strategic thinking and guidance rather than day-to-day management and program operations.

In this scenario, enhanced responsibilities for R&D and innovation support and front-line responsibilities to work with existing and new businesses could be located in re-chartered organisations outside government departments through more autonomous agencies (in promoting inward FDI, in fostering small indigenous firms, and in supporting internationalisation). A step in this direction has been made through Invest NI which, following IREP, has been given increased autonomy and is an arms length body of DETI. Additional implementation of PIC functions outside of government departments could be undertaken by universities, applied research institutes (if developed), and – most importantly – by private-public partnerships involving businesses. Organizations and programmes oustide of the government should be given

[141] A recent example, in March 2010, was the restructuring of government departments in an attempt to develop a greater focus on innovation, education, science and enterprise.

[142] There is a parallel here with the Economic Review Committee in Singapore, although in this case it comprises several sub-committees headed by industry leaders, advising the Government on their 5 year economic plan.

autonomy, without day-to-day oversight, but with the requirement to be accountable on a portfolio basis for allocated public resources over a longer planned period.

We are apprehensive that achievements may be less than desired if the administratively-oriented civil-service culture remains. It is very important to change the organisational mindset from a narrow focus on closing the productivity gap (and other accountability frameworks) to a broader remit on developing capabilities for innovation. This must involve encouraging universities to undertake more research focused towards industry, in collaboration with both inward investors and indigenous firms. It would also involve greater informal and formal dialogue with businesses on supporting their supply networks and business growth. We would also recommend the promotion of greater informal working relationships between agencies via cross-fertilisation of senior civil servants on a termed job rotation basis. Therefore, we would propose the following:

Changing the remit in the relevant civil service and statutory agencies toward a focus on innovation, industry growth and new business formation. This may involve using a different set of key performance indicators to measure progress, moving away from the sole fixation on gross value added to a more balanced performance assessment process addressing innovation, business formation and growth, exporting, and the robustness of supply-chains and clusters, as well as productivity.

Improve inter-agency integration and vision sharing. DETI/DEL, Invest NI and other agencies should work together to more effectively implement their existing liaison arrangements. A feasible alternative might be to develop an agreed framework of goals and visions, then give greater devolved flexibility to lead agencies and organisations to pursue appropriate strategies and resource allocations, holding those agencies accountable for the portfolio and performance of their actions over time rather than on an almost immediate project-by-project basis. New Zealand partly has this structure, with Crown Research Institutes and its distinction between mission organisations and policy agencies. Singapore also offers some important insights here, particularly in the close coordination and cross-agency working observed within the Ministry of Trade and Industry and its associated agencies. There is significant interaction between civil service professionals and business executives and academic and policy experts in its Economic Review Committee.

Devolving the implementation of productivity, innovation and competitiveness functions to organizations outside of civil service government departments. This would involve charging these organisations (which could include Invest NI, university units, and other institutions for collaboration) with clear missions, control over budgets, and responsibilities to deliver. Strategic accountability to elected and appointed authorities is essential, but what should be avoided is day-to-day supervision by legislators and civil servants. This in and of itself may lead to some efficiency savings in administration, which could be reinvested in longer term performance review and evaluation (see last item).

Foster public demand-driven innovation. Even with constraints on public expenditures, government in Northern Ireland is a large-scale purchaser of goods and services, and can promote innovation by being an informed, sophisticated and demanding buyer. Public procurement is both a substantial and visible instrument open to Northern Ireland in this respect and sends signals to the private sector. To encourage increased demand for innovation and make government more conducive to seeing itself as a key player in the local innovation system, government could be required to ensure that at least some of its procurement orders encouraged innovative solutions or led to innovation spillovers. Potential areas might include procurement of advanced public transport vehicles and management systems, electric vehicle charging stations, or renewable energy systems. If desired, public agencies could create enhanced opportunities for the

procurement of goods and services from SMEs. Specific financing and support programmes might be targeted at the technological development of SMEs, where public institutions purchase products/services for a certain period.

Developing programme and system evaluation. Evaluation is important in promoting learning that can lead to improvements in subsequent policy and program design and implementation. Where possible, Northern Ireland should consider undertaking evaluation not so much on a project-by-project basis but across portfolios and systems, e.g. on multiple projects, activities or agencies across major investment and programme objectives. This should facilitate a greater tolerance of risk where there is potentially a greater return by sponsoring agencies (such as Invest NI). But it also requires a greater appreciation of risk-reward relationships by oversight committees and organisations. A further insight can be gleaned from New Zealand, where evaluations are conducted in batches (e.g. all business assistance programmes are evaluated together) to reduce the administrative burden on business and to allow comparability. Such an approach will allow for greater elapsed time between assistance and evaluation, so that a fuller range of benefits and costs can be appreciated, and rapid short-term assessments avoided. This is consistent with a longer-term innovation orientation (rather than a year-by-year effort to gauge employment and value-added implications), and should involve using more varied methodologies (i.e. not just cost-benefit or break-even analyses) but portfolio and system evaluations of broader effects and progress in innovation capabilities.

5.7 Conclusion

This chapter provided a series of insights on small open economies - New Zealand, Singapore and the Republic of Ireland - in comparison with Northern Ireland. The chapter makes clear that the task of improving competitiveness in Northern Ireland is made more challenging by the fact that other small open economies are also actively seeking to maintain and advance their positions. At the same time, it is possible to draw from the experiences of these other countries to identify lessons and best practices for Northern Ireland.

Small open economies - as a result of their limited scale and resources - typically need to specialize and develop capabilities in focal high-value sectors. This is an important insight for Northern Ireland. Efforts are already underway to foster high technology companies, including in the life and health sciences and in information and communication technologies. That said, we judge that there are under-exploited opportunities to build enhanced strategic and innovative capabilities in three established sectors: agri-food, financial services technology and advanced engineering. Enhancing the agri-food value chain appears to be much overlooked, particularly in fostering higher-value outputs and innovative agri-food enterprises and relationships. There is an emerging set of financial services technology companies (large and small) in Belfast, and there are also opportunities here to enhance the development of this sector as a cluster, also involving universities and other organizations, and linking with the Irish Diaspora. Finally, there are opportunities to more explicitly support advanced engineering, including deepening the linkages of small engineering firms to larger companies, stimulating innovation in these SMEs, and improving training and apprenticeships so that there is a secure labour pool and transferable skills to advance engineering innovation.

The importance of fostering indigenous SMEs is recognized in the three small open economies we have reviewed, and also in Northern Ireland. Yet, we have identified practices and strategies in the other countries that suggest useful insights for Northern Ireland. In particular, Northern Ireland should consider how it can more strongly build up initiatives to upgrade innovative capabilities of

existing SMEs and also how to strategically support emerging and potentially fast-growing "born global" enterprises. There are interrelationships here with other objectives, since strengthening the base of innovative SMEs will assist existing domestic larger suppliers and make Northern Ireland more attractive for inward investment.

In addition to fostering a more innovative base of SMEs and advanced human capital skills, Northern Ireland's attractiveness for inward investment will be aided by the strengthening of long-term and explicit partnerships between major companies, high-value clusters, groupings of innovative SMEs, and key development and innovation agencies. Singapore and the Republic of Ireland offer good practices in this respect. Significantly, such relationships should not focus primarily on tax breaks or subsidies from government to enterprises, but on mutual dialogue and anticipation of skills needs, research and development opportunities, technological trajectories, supply-chain issues, and market developments.

We recommend Northern Ireland to strengthen its institutional landscape for applied research and innovation. We reviewed organisational arrangements and best practices in the Republic of Ireland, New Zealand and Singapore, and also note the applied R&D models (documented by other studies) pursued in Finland and Germany. Considering the capabilities of sectors and institutions already established in Northern Ireland, we envisage opportunities for targeted applied research institutes in one or more of the sectors of advanced engineering, financial technology and agri-food. These would be configured separate from yet linked to the two existing universities and to companies. It would be timely to establish a mechanism to consider the various options, leading us to recommend the tasking of a design team to explore and recommend options to substantially develop commercially-oriented applied research in Northern Ireland.

Finally, there are needs and opportunities in Northern Ireland to re-orientate policymaking and implementation away from the conventional civil service administrative culture toward a focus on innovation, industry growth and new business formation. As seen especially in Singapore, this can be achieved through leadership and improved inter-agency integration and vision sharing, and by devolving the implementation of productivity, innovation and competitiveness functions to organizations outside of civil service government departments, fostering public demand-driven innovation, and developing strategically-focused and actionable programme and system evaluations.