CANADA'S INNOVATION GAP: POLICY OPTIONS TO INCREASE BUSINESS SECTOR R&D

by

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Abstract

A key culprit for Canada's lagging productivity growth is weak innovation in the business sector. Using the level of business R&D as a main indicator, I explore policy options for Canada to close its innovation gap with other countries. I first review previous research on the determinants of business R&D and highlight reasons for Canada's lacklustre performance. I then examine the innovation system in three business R&D intensive countries (Israel, Finland, and Sweden) to gain insights on critical success factors that drive business R&D. Based on these case studies and my literature review, I draw implications for Canada through comparative analysis and propose four main policy options to increase business sector R&D. Using a set of criteria, I evaluate these options along with the status quo. The strongest option is to remove foreign investment restrictions in R&D intensive sectors.

Keywords: research and development (R&D); business; innovation; policy; Canada; productivity

Subject Terms: R&D tax incentives; SR&ED; direct support; business taxes; foreign investment; competition; university-industry collaboration; clusters; R&D spillovers; skills; human capital; venture capital; culture; industrial structure; innovation system; endogenous growth

Executive Summary

Canada's productivity growth, an important contributor to prosperity and living standards, is lagging other countries and a key culprit is weak innovation in the business sector. This study explores the factors that have inhibited Canada's innovation performance in the business sector and proposes policy options to narrow the gap with other highly developed countries. While business innovation can be measured in many ways, the central indicator used in the study is business research and development (R&D)—an indicator that previous research shows is correlated with other measures of innovation, and that is a driver of both economic and productivity growth. To establish the policy problem more concretely, I examine Canadian and some international R&D data and conclude that Canada undertakes very little business R&D relative to comparator countries.

I use a combination of two analytical approaches to formulate policy options that will help achieve the study's objective of increasing business R&D. First, I undertake a comprehensive literature review on key determinants to business R&D and highlight reasons for Canada's lacklustre performance. The list of explanatory factors includes: an industrial structure specialized in natural resources; a relatively large proportion of small firms and a small domestic market; the extent of foreign ownership; international R&D spillovers and close integration with the US; policies that restrict competition; regionally concentrated R&D (clusters); high business taxes; an unsuitable mix of skilled individuals (human capital); an inadequate business culture for innovation; and finally, too little and poor quality venture capital. In the second approach, I undertake detailed case study analyses of the innovation system in three highly business R&D intensive countries: Israel, Finland, and Sweden. The case studies reveal both common and unique factors that drive business R&D. Through comparative analysis, I use the case studies and my literature review to draw implications for Canada and formulate policy options that will increase business R&D.

I propose four main policy options, in addition to several other peripheral options that I do not evaluate. The main options are:

- Replace tax credits available through the Science Research and Experimental Development (SR&ED) program with increased direct support (grants and contributions).

- Replace support through the SR&ED program with broad-based business tax relief.
- Remove foreign investment restrictions in R&D intensive sectors (telecommunications and air transport).
- Create a single pan-Canadian agency to co-ordinate federal and provincial innovation policy.

All four options assume the current policy framework for business innovation remains in tact, except for the proposed marginal change. The policy options are presented as being mutually exclusive to facilitate policy evaluation, although they do not have to be in practice. I evaluate the policy options and status quo using five equally weighted criteria: effectiveness, political feasibility, administrative ease, stakeholder support, and budgetary costs. The SR&ED program is assumed to be representative of the status quo, as it is Canada's most significant support program for business R&D. The evaluation of specific policies that target business R&D is complex given the interdependencies within the overall innovation policy environment, so my goal is to provide policymakers with loosely projected outcomes and to highlight salient tradeoffs. My evaluation suggests that removing foreign investment restrictions in R&D intensive sectors is the strongest option based on summation of individual criterion scores. Replacing support through the SR&ED with broad-based business tax relief and the status quo follow closely behind. Absent exact measures to rank the options, caution must be taken with interpreting the results of my policy evaluation.

The issue of Canada's lacklustre business R&D output has puzzled researchers for decades and my findings are no exception. This study shows that since innovation is a complex, multi-faceted process, no magic bullet exists for increasing business R&D. Effective innovation policy requires broad policy initiatives aimed at many areas spanning the availability of skilled labour, the business environment, the interaction between universities and industry, and the like. In the end, the study raises more questions than answers. But it does offer some options that policymakers can consider to increase business R&D. The best course of action emanating from my policy evaluation is removal of foreign investment restrictions in R&D intensive sectors. This option would increase the competitive pressure for domestic firms to innovate and/or adopt best practices and new technologies; it would also increase the availability of capital for innovative activities. The policy option of broad-based business tax relief is another strong alternative. Currently, the federal government support for R&D gives with one hand through generous tax credits (through the SR&ED) and takes with the other through business taxes that reduce the rewards to innovation. To extend the economic benefits, this option could be pursued simultaneously with the first best option. The status quo is also a possible alternative. Empirical studies show the SR&ED is effective, the political risks of the program are low, and stakeholder support for it is high. But problems with program administration must be addressed. Other, peripheral policies are available to stimulate business R&D, but these options were not evaluated.

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Term	Definition
BERD	Business Expenditures on R&D
GERD	Gross Expenditures on R&D
HERD	Higher Education Expenditures on R&D
GOVERD	Government Expenditures on R&D
ICT	Information and Communication Technology
OECD	Organisation for Co-operation and Development
SME	Small and Medium Enterprise
CCPC	Canadian-Controlled Private Corporation
LSVCC	Labour-Sponsored Venture Capital Corporation
SR&ED	Science Research and Experimental Development
SADI	Strategic Aerospace and Defence Initiative
ITO	Industrial Technologies Office
NRC	National Research Council
IPF	Industrial Partnership Facility
NCE	Networks of Centres of Excellence
IRAP	Industrial Research Assistance Program
CFI	Canadian Foundation for Innovation
NSERC	Natural Sciences and Engineering Research Council
CIHR	Canadian Institutes of Health Research
SSHRC	Social Sciences and Humanities Research Council
STIC	Science, Technology, and Innovation Council
OCS	Office of the Chief Scientist
Tekes	Finnish Funding Agency for Technology and Innovation
FDI	Foreign Direct Investment

1: Introduction and Policy Problem

No matter how you slice it, Canada has a productivity problem.[1] Whether compared to the United States or to other industrialized countries, report after report has shown that Canadian productivity growth, and especially labour productivity (or increased output per hour worked), is seriously lagging. Loosely defined, productivity growth can be thought of as working smarter, not necessarily harder. In a recent manifesto on Canada's productivity woes, Drummond & Bentley (2010, p. 5) noted that business sector labour productivity growth has been declining since the 1970s. Productivity grew at a robust annual rate of 4 percent between 1947 and 1973. But the pace eased in the 1970s, growing annually at 1.6 percent from 1973 to 2000. The trend slowed further in the most recent decade (2000 to 2009), with productivity registering growth of only 0.7 percent per year. The economic implications are grave since labour productivity growth is an important determinant of a country's prosperity and the living standards of its citizens.

Fundamentally, a country's productivity growth can increase by way of three sources: human capital, physical capital, or innovation. Canada is especially deficient in the latter. More specifically, the Council of Canadian Academies,[2] like many other organizations, has identified weak business innovation as a key culprit for Canada's relatively poor labour productivity growth. Business innovation drives such things as "better organization of work, improved business models, the efficient incorporation of new technology, the payoff from [R&D] and from the insights of entrepreneurs" (Council of Canadian Academies, 2009, p. 43). That then translates into increased labour productivity as workers produce more output with less input. While business innovation is a complex notion, one way to think about it is a new or better way of doing commercially valued things.

This study explores the factors that have inhibited Canada's innovation performance in the business sector and proposes policy options to narrow the gap with other highly developed countries. Business innovation can be measured in many different ways, but the central indicator used in the study is business research and development (R&D).

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[1] From the outset, I acknowledge that measuring productivity is a daunting and imprecise science, particularly in the service sector.

[2] The Council of Canadian Academies is a non-profit organization that assesses science-related public policy issues in Canada and provides advice to government. For more information on the Council, see http://www.scienceadvice.ca/en.aspx (available December 15, 2010).

The road map for my study is as follows. In the next section, I explain what business R&D is and why it is important for the economy and the well-being of Canadians. In section 3, I explore the innovativeness of Canada's business sector by examining R&D data. The conclusion and policy problem is that the business sector undertakes too little R&D in Canada relative to other countries. In section 4, I review previous research on the determinants and barriers to business R&D in Canada, highlighting specific reasons for Canada's lacklustre performance. To give the reader a flavour of the status quo, I review Canadian R&D and innovation related policies in section 5. In section 6, I conduct case study analyses on three top business R&D performing countries to uncover success factors for innovation. Based on these case studies and my literature review in section 4, I formulate policy options for Canada in section 7, with the goal of increasing R&D in the business sector. I then evaluate the proposed policy options and offer policy recommendations. I make conclusions in the final section.

2: What is Business R&D and Why is it Important?

This section defines R&D and key terms used in the analysis; it follows that with a discussion of why business R&D is important to our economic well-being.

2.1 Defining R&D

The OECD's Frascati Manual outlines an internationally recognized methodology for collecting and using R&D statistics.[3] According to the Manual, R&D is "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD, 2002, p. 30). The Manual's definition covers three R&D-related activities: basic research, applied research, and experimental development. The aim of basic research is to increase knowledge in science or to better understand a particular subject area without any application in mind. Most university research falls in this category. Applied research also aims to produce new knowledge, but it differs in one important way in that it attempts to meet a specific practical aim or objective. Experimental development uses existing knowledge or the knowledge gained from research for the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes (OECD, 2002). Business R&D falls under applied research and experimental development.

Strictly speaking, R&D is not innovation. R&D spending has the advantage of being quantifiable but is an imperfect indicator of innovation since it measures inputs into, rather than outputs from, the innovation process.[4] R&D also does not capture other aspects of innovation such as organizational change. Nonetheless, R&D is a meaningful indicator, correlating closely with other indicators of innovative activity including survey data (Council of Canadian

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[3] The purpose of the Manual was to develop a set of codified international standards allowing for the harmonization of R&D statistics across countries. Some, however, have criticized the definition of R&D used. Baldwin et al. (2005) argue that the Manual's criteria for distinguishing and measuring R&D and related activities may be too narrow, thereby understating the true value of such expenditures in Canada. For instance, activities such as a licence purchase of technologies from foreign firms might often constitute the equivalent of R&D expenditure that is not captured in statistics.

[4] Whether one looks at input, output, or outcome measures of innovation, Canada's performance does not change and is mediocre at best (Council of Canadian Academies, 2009; STIC, 2009).

Academies, 2009). Moreover, the various stages of the creative process (R&D, patenting, and commercial applications) are positively linked empirically (Jaumotte & Pain, 2005a).

I will use some key terms in my analysis. A number of entities perform R&D, including business enterprises, universities, governments, and non-profit institutions.[5] Combining all sources of performance yields a country's gross expenditures on R&D (GERD). Business expenditures on R&D (BERD) include R&D activities carried out by the business sector, regardless of funding source. I use the terms "BERD," "business R&D," and "industrial R&D" interchangeably throughout the study.

2.2 Why business R&D is important

I address the deficiency of business R&D in Canada for three key reasons. First, businesses account for the majority of R&D performed in Canada. Second, the business sector is where the R&D problem is most pronounced—higher education expenditures on R&D (HERD), for example, compares well internationally. Third, previous research shows that business R&D has a stronger impact on economic performance than R&D performed and funded by public institutions such as government and universities (OECD, 2003). The rest of this section provides background information to motivate an understanding of why business R&D is important for the economy and the well-being of Canadians.

Ever since Nobel Laureate Robert Solow's seminal work in the 1950s, economists have recognized that technological change is a crucial source of productivity and economic growth. Without technological change, simply adding more capital brings progressively fewer gains to labour productivity and economic growth. Building on Solow's earlier efforts, new approaches to understanding the sources of technological change have spawned "endogenous growth theory."[6] A major insight is that R&D and innovation bring about technological change that can sustain growth of labour productivity and the economy more generally.

Several empirical studies confirm the theoretical link between R&D and economic growth. A major cross-national study by the Organisation for Economic Co-operation and Development (OECD) examined the growth determinants for a group of developed countries and found that one of the strongest in magnitude and significance is the level of business R&D as a share of GDP (OECD, 2003). The results suggest that a sustained 0.1 percentage point increase in

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[5] I should note that the entities that perform R&D are not necessary the ones that fund it. For instance, governments can and do fund R&D that is performed by businesses.

[6] Appendix A contains an overview of endogenous growth theory.

a nation's business R&D as a share of GDP eventually leads to a 1.2 percent higher GDP per capita.[7] Roughly speaking, it would take about 10 years for that impact to take effect.[8]

The main channel through which business R&D affects the economy is productivity growth and specifically total factor productivity (TFP).[9] This link has been confirmed in many empirical studies (for example, see Guellec & van Pottelsberghe de la Potterie, 2001). Even a small percentage point rise in TFP growth could substantially increase the economy's productive efficiency—a desirable feat in light of Canada's low productivity growth.

The effects of R&D on productivity and economic growth are quite large, pointing to significant spillovers from R&D activities. Bernstein (1994, p. 1) explains the notion of R&D spillovers:

> It is a distinctive feature of R&D investment that firms undertaking such activity are unable to exclude others from obtaining the benefits of their R&D efforts. Hence, the benefits from R&D cannot be completely appropriated and, inevitably, spillovers occur. R&D spillovers are ideas borrowed by one R&D performer from the knowledge of another performer.

The spillover notion suggests that the benefits to society from R&D activities are often greater than the benefits to the performing firm. As other firms and individuals copy or adopt a new idea, the idea spreads throughout the economy. Ample empirical evidence supports the existence of spillovers (see Hall et al., 2009, for a comprehensive review). In general, empirical research shows the social benefit from R&D is greater than the private benefit. Moreover, many researchers point out that the social benefit is likely underestimated since spillovers are difficult to measure.

Practically speaking, the Government of Canada (2007) highlights several ways that R&D performed by profit-seeking firms can benefit Canadian society:

- Creating products and processes that improve productivity performance and strengthen the ability of Canadian firms to compete internationally.

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[7] The OECD study also speculated that a sustained increase in R&D intensity may in fact, by virtue of spillover effects in the economy, produce a permanent increase in the rate of output growth, rather than merely a one-time increase in the level of output.

[8] This time frame is based on my interpretation of the OECD's results.

[9] Total factor productivity (TFP) is a proxy for technological change and is a more inclusive measure of productivity growth than labour productivity. TFP captures the efficiency of all productive inputs. When TFP increases, it signals that firms in the economy are producing more output from a given quantity of inputs. While economic theory tells us that many factors affect TFP, one important factor is innovation. Positive changes in R&D, the introduction of new production processes, and the adoption of innovative technologies contribute to increased TFP growth.

- Producing socially desirable goods and services such as clean production technologies, energy-efficient innovations, and new medical discoveries.
- Increasing the collective knowledge base and skill sets of employees.
- Creating high-quality and well-paying jobs across industries.

Boosting business R&D also enhances what Cohen & Levinthal (1989) call “absorptive capacity,” the ability to recognize the value of external knowledge, assimilate it, and apply it to commercial ends.[10] Canada like many other countries does not rely solely on domestic R&D for new ideas and innovation; a chief source comes from abroad in the form of knowledge embodied in new machinery and equipment, the minds of scientists and engineers, scientific and technical journals, and manufacturing specifications. To exploit foreign knowledge effectively, Canada must invest in its absorptive capacity. So, strong domestic R&D is necessary not only to be technology leader, but also an effective imitator and adapter.

In sum, increased business R&D would significantly improve Canada’s productivity and economic growth. The commercial exploitation of R&D provides Canadians with new and improved products that can be produced more efficiently. The benefits from R&D are large and spill over throughout the economy. A strong domestic R&D base also enhances Canada’s ability to absorb technologies and innovations developed abroad.

2.3 Market failure theory and rationale for policy intervention

Economists and policymakers presume that, if left unfettered, firms will perform a level of R&D that is below the socially optimal level. This provides a rationale for government support of industrial R&D. Two main factors explain the potential under-investment in R&D by individual firms: spillovers and financial constraints. The first relates to the inability of a firm to prevent others from making use of the knowledge generated by R&D. While social benefits arise from the widespread sharing of new knowledge, firms have less incentive to invest in R&D if the benefits cannot be fully appropriated. Knowledge spillovers from R&D suggest that some research with potentially significant social benefits will not be undertaken by profit-seeking firms, leading to an under-investment of R&D in the economy.

The second factor relates to difficulties in financing R&D. Investors may be unwilling to finance some R&D projects because the success of an innovation is often uncertain. Asymmetric

[10] Absorptive capacity also depends on a country’s general knowledge infrastructure. For instance, the availability of highly skilled individuals such as scientists and engineers determine whether a country can successfully absorb foreign technologies.

information between the firm and the investor also makes financing R&D difficult. Empirical evidence suggests that financial constraints do in fact affect R&D investment decisions, particularly for small and newly created firms (Hall, 2002).

To overcome the problem of under-investment, governments adopt a wide range of measures aimed at stimulating business R&D. The two broadest are tax incentives and direct subsidies. R&D tax incentives are indirect subsidies that compensate firms for the spillover benefit that their research provides to others. They reduce the cost of R&D through the tax system, allowing firms to decide independently the nature and amount of R&D to undertake. By contrast, direct R&D subsidies are essentially grants given to firms for R&D and are distributed independent of the tax system. Ideally, they should provide financial support to research activities that are thought to offer high social but low private rates of return. They should also provide support to young and small firms that have relatively little taxable income and face borrowing difficulties. Both tax incentives and direct subsidies can impact business R&D. I will review Canada's support system for business R&D in a later section.

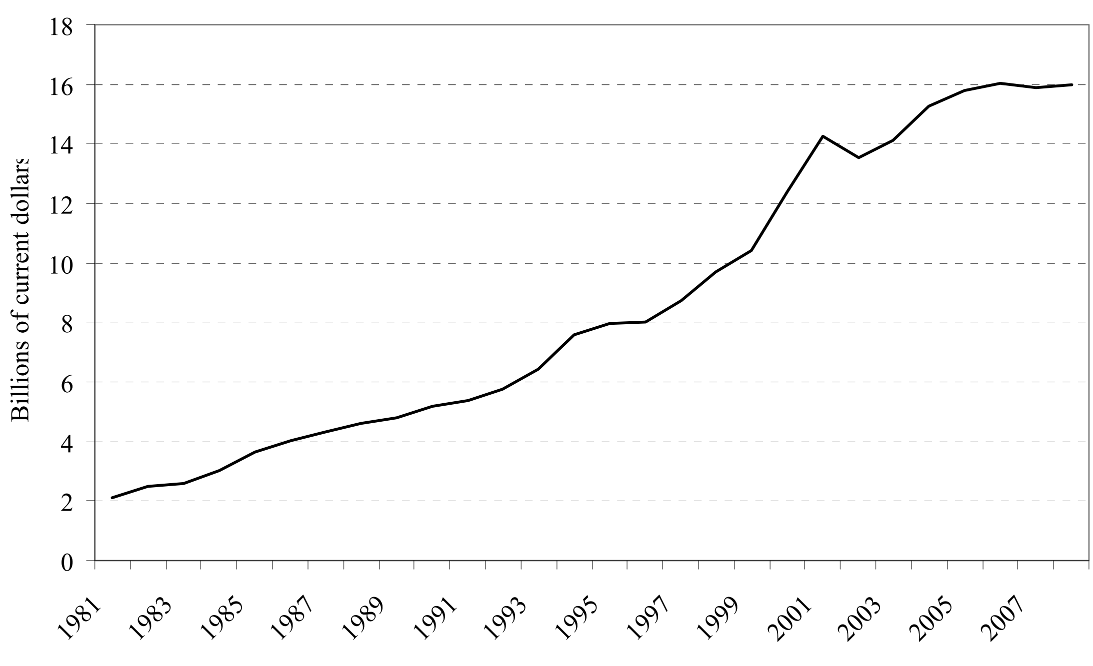
3: Innovation in Canada's Business Sector

This section examines Canadian and some international R&D data and establishes that the business sector in Canada undertakes very little R&D relative to comparator countries.

3.1 Overview of R&D data

Business expenditures on R&D (BERD) in Canada totalled approximately $16 billion in 2008 (see Figure 1). Historically, BERD rose steadily but the pace picked up in the late 1990s until the peak of the tech boom in 2001. After declining slightly, BERD resumed growth but has flattened since 2006. On an inflation-adjusted basis, however, BERD has been falling (Council of Canadian Academies, 2009).

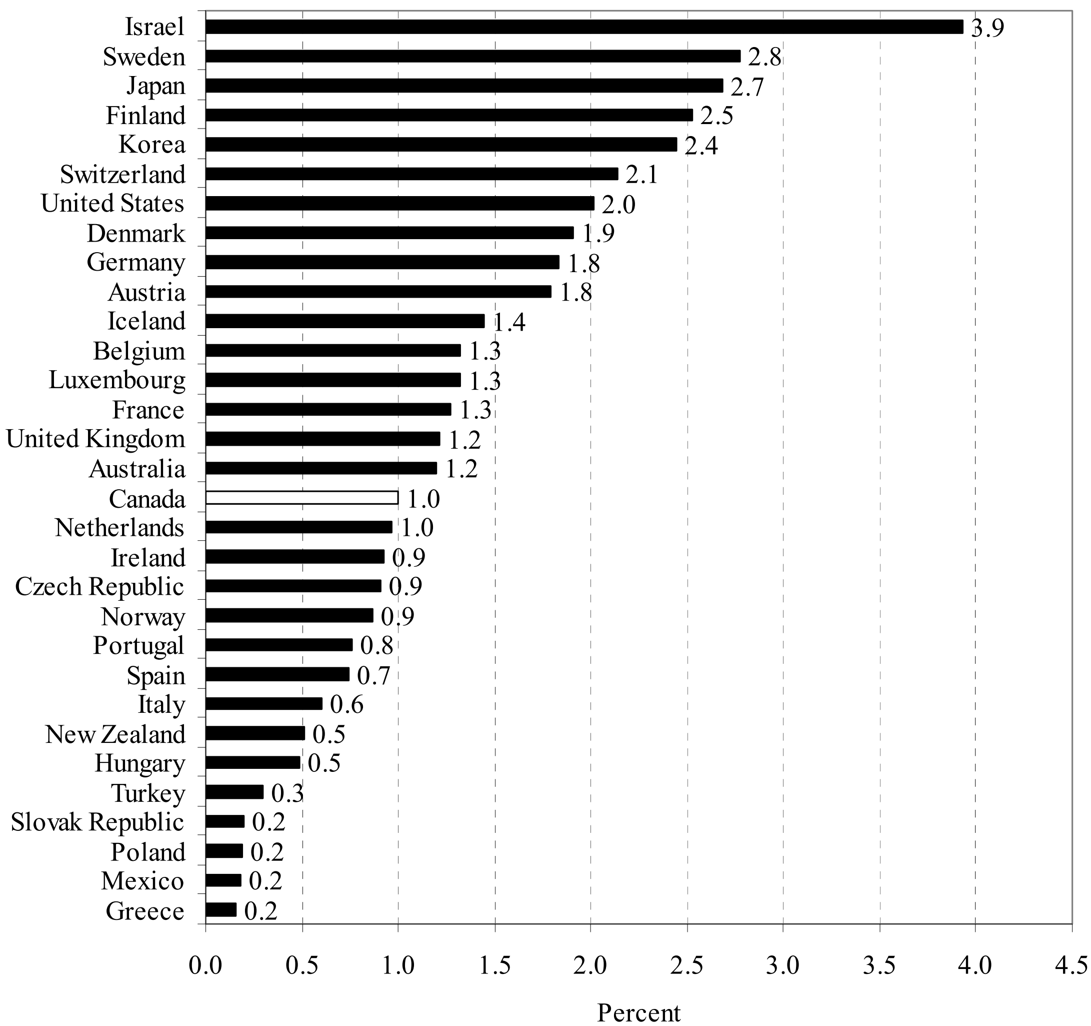
Figure 1: Business expenditures on R&D (BERD) in Canada, 1981-2008



Source: OECD (2009a)

The ratio of R&D spending to GDP, R&D intensity, is a widely used indicator for comparing the R&D performance of nations. On this indicator, Canada's business R&D output is lagging other countries. Figure 2 presents the BERD intensity of Canada, 30 countries belonging to the OECD, and Israel (the country with the highest BERD intensity in the world). Canada ranks 17th out of 31. At 1.0 percent, Canada's BERD intensity is below both the OECD average (1.6 percent) and a great deal behind Israel (3.9 percent) and the other top performers.

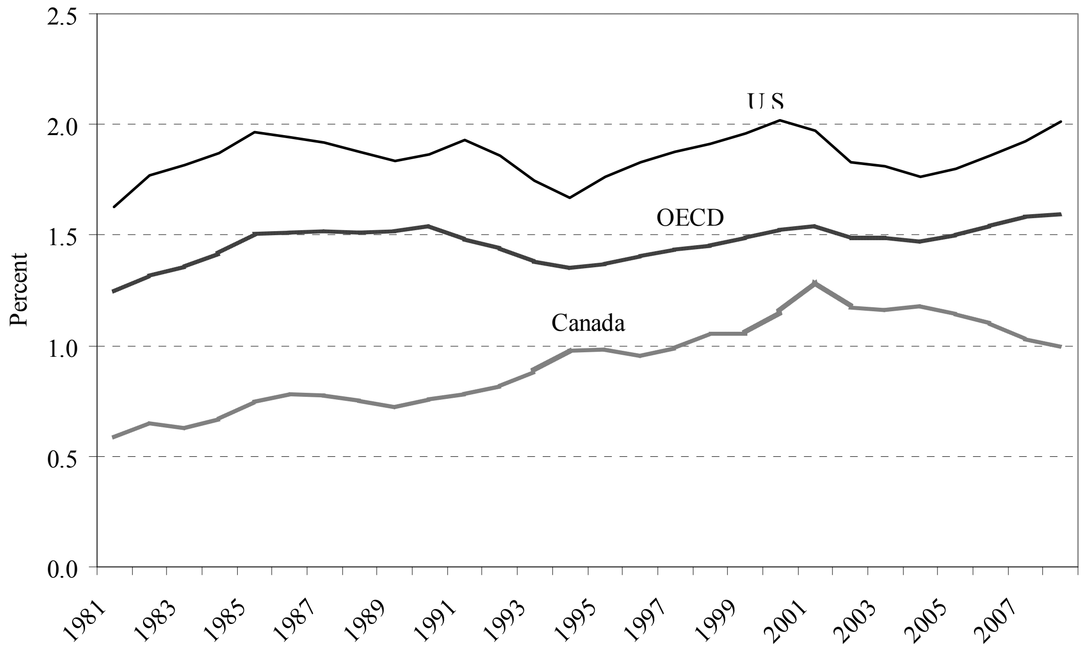
Figure 2: BERD intensity in OECD and Israel, 2008 or latest available year



Source: OECD (2009a)

Canada's BERD intensity has lagged for an extended period. As Figure 3 shows, Canada's BERD intensity trailed both the OECD average and the US from 1981 to 2008. Like elsewhere, there was a run-up in Canadian BERD intensity in the years leading to the bursting of the dot-com bubble in 2001. But R&D intensity declined thereafter—decreasing 22 percent since 2001—and the gap between the OECD average and US has widened as a result.

Figure 3: Trends in BERD intensity: Canada, OECD, and US, 1981-2008



Source: OECD (2009a)

BERD intensity is not evenly distributed within Canada. This is demonstrated by the provincial variation in intensities (see Table 1). Quebec leads the provinces at 1.6 percent; Ontario is the only other province with BERD intensity above 1 percent. While Quebec has the highest BERD intensity, Ontario tops the provinces in business R&D dollars with nearly 50 percent of all Canadian business R&D being performed there.

Table 1: BERD intensity by province, 2006

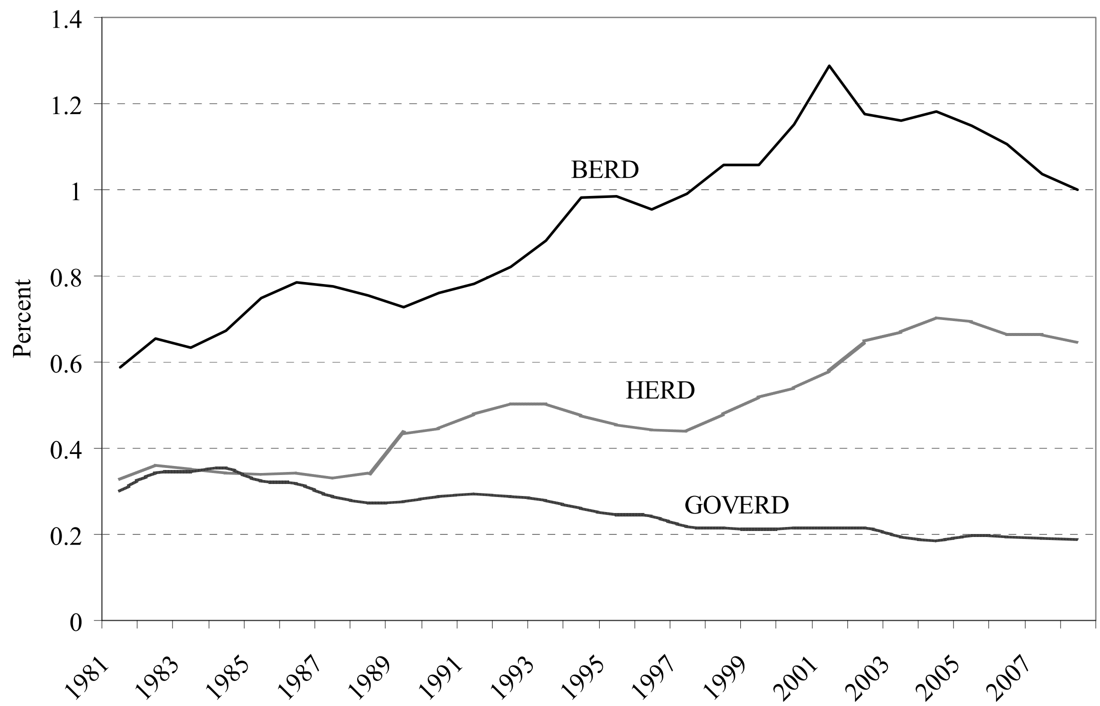
	BERD intensity %	BERD billions $	Share of BERD in Canada %
Quebec	1.6	4.6	28.5
Ontario	1.4	8.0	49.8
British Columbia	0.9	1.6	9.9
Alberta	0.5	1.2	7.7
New Brunswick	0.4	0.1	0.6
Manitoba	0.4	0.2	1.1
Newfoundland	0.4	0.1	0.6
Saskatchewan	0.4	0.2	1.1
Nova Scotia	0.3	0.1	0.7
Prince Edward Island	0.3	0.0	0.1

Source: Council of Canadian Academies (2009)

Business R&D in Canada is not only low by international standards, but the share of total R&D performed by businesses is too. In 2008, Canadian businesses performed just 56 percent of the country's $29.5 billion in gross expenditures on R&D; universities performed 34 percent and governments 10 percent. The comparable figures for the OECD average are 70 percent (businesses), 17 percent (universities), and 11 percent (governments) (all figures sourced from OECD, 2009a).

Finally, a look at Canada's total R&D performance reveals that the intensity of gross expenditures on R&D (GERD) in 2008 was 1.8 percent. This percentage ranks midway in the OECD and is below the average of 2.3 percent. Breaking down GERD into its components shows that the drop in BERD intensity since 2001 was partially offset by significant gains in the intensity of higher education expenditures on R&D (HERD) that started back in 1997 (see Figure 4). The ramp up in HERD reflects the federal government's efforts to boost university funding for research through initiatives such as the Canada Foundation for Innovation, Genome Canada, Canada Research Chairs, and the granting councils (Council of Canadian Academies, 2009). Government expenditures on R&D (GOVERD), on the other hand, have trended downward since the 1981—a trend in most OECD countries.

Figure 4: Trends in components of GERD intensity in Canada, 1981-2008



Source: OECD (2009a)

Whether one looks at R&D data or other indicators of innovative activity, the same picture emerges: Canada is a laggard internationally. Several reports highlight a Canadian innovation gap, including reports by the federal government, the Council of Canadian Academies, the Science, Technology, and Innovation Council, the OECD, the Conference Board of Canada, and the World Economic Forum.[11] Using indicators ranging from the number of patents filed per person to the level of investment in information and communication technology (ICT) per worker, these reports have found that Canada is mediocre at best and often significantly behind leading countries in creating and adopting innovative technologies.

Canada's sub-par performance on R&D and other innovation indicators has led to numerous calls to improve the nation's innovation capacity. However, despite repeated calls from countless commissions, official reports, and expert panels to stimulate more business R&D over the past 25 years, little progress has been made. In fact, as this section has showed, Canada's business R&D output is worsening, not improving. Though clearly ambitious, my goal in this

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[11] See Government of Canada (2002), Council of Canadian Academies (2009), STIC (2009), OECD (2006a; 2008), Conference Board of Canada (2007), and Schwab (2010).

study is to offer a fresh new look at the problem from a policy analysis perspective and to formulate policy options that may help reverse this trend and increase Canada's business R&D.

4: Literature Review: Determinants and Barriers to Business R&D in Canada

This section reviews previous research on the determinants and barriers to business R&D in Canada. The list of barriers is long and ranges from an industrial structure heavily oriented in natural resources to a dearth of venture capital to finance innovative ventures. Unfortunately, no comprehensive analysis has been undertaken (to my knowledge) that singles out which factors are most important for business R&D. Part of the challenge is that the determinants of business R&D are a combination of both micro- and macro-economic factors. Nonetheless, the review is intended to give a more complete understanding of Canada's low business R&D output and to help later on with forming policy options.

4.1 Industrial structure specialized in natural resources

A country's R&D intensity is partly a reflection of its industrial structure (Mathieu & van Pottelsberghe de la Potterie, 2008). R&D intensive countries generally have a larger share of business R&D and total economic output concentrated in high-technology industries. For example, high-technology industries account for 75 percent or more of business performed R&D in countries like Finland, Germany, Japan, Switzerland, and the US (Sheehan & Wyckoff, 2003). In low R&D intensity countries like Canada, Norway, and Australia, high-technology industries account for less than 40 percent (Sheehan & Wyckoff, 2003). Given the Canadian economy's specialization in natural resource industries (forestry, fishing, energy, agriculture, and mining), a widely regarded barrier to business R&D is the economy's industrial structure.

Business R&D is lower in natural resource industries because the goods produced are homogeneous commodities requiring little if any product innovation (Sharpe & Guilbaud, 2005). Product innovation is generally where an innovating company holds a patent on the product and gains monopoly rents until close imitators are developed by other companies. In natural resource industries, innovation is typically process oriented. That is, innovation is embodied in the capital (i.e., machinery and technology) that is usually supplied by a source outside of the company utilizing it and can be purchased by any firm in that industry internationally. The acquired capital is then used to improve production processes and/or reduce costs.[12]

That said, empirical research has found that Canada's specialization in natural resource industries explains only a small part of the country's low BERD intensity. A Department of Finance study found that Canada's industrial structure explains around one third of the business R&D intensity differential between Canada and the US (ab Iorwerth, 2005). The other two thirds results from some Canadian industries having a lower R&D intensity than their US counterparts independent of industry mix. Of the Canadian industries that are less research-intensive, service sector industries (i.e., wholesale and retail trade) and the motor vehicle industry especially pull down the country's total BERD intensity (more on the motor vehicle industry later).[13]

A separate study that compared the innovation performance of Canadian natural resource industries to those in other countries found Canadian R&D intensities are consistently lower than in comparator countries, even in resource industries where Canada has a comparative advantage and where we would expect the country to excel (Sharpe & Guilbaud, 2005).

Finally, an OECD study re-calculated the BERD intensities of member countries assuming each had the same industrial structure (OECD, 2006b). Canada's BERD intensity increased after the calculation but its relative ranking did not change, suggesting that industrial structure plays only a minor role in depressing Canada's relative BERD intensity standing.

4.2 Small size of Canadian firms and domestic market

The literature on firm size and R&D implies that differences in BERD intensity between Canada and other countries are partially attributable to differences in average firm size. For instance, the US has a higher BERD intensity than Canada and a relatively bigger proportion of large firms. In 2002, 49.9 percent of American employees were working in firms with 500 or more employees, compared to only 40.9 percent in Canada (Sharpe, 2005).

According to the R&D literature, the likelihood of performing R&D generally rises with firm size.[14] However, the relationship between firm size and R&D intensity tends to disappear

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[12] Process innovation does not strictly require capital acquisition; it could, for example, emerge from organizational changes.

[13] Not all Canadian industries have low relative R&D intensities; some Canadian industries (i.e., high-technology) are research intensive by world standards (ab Iorwerth, 2005). The problem is that these industries are smaller (as a proportion of GDP) in Canada relative to other countries.

[14] See Cohen and Klepper (1996) for a synthesis of the literature on the relationship between firm size and R&D. See Baldwin & Gu (2004) for Canadian evidence.

among R&D performers, as some small firms (i.e., start-ups) devote a greater percentage of company revenues to R&D and thus have higher R&D intensities (Industry Canada, 2008). Statistics Canada's Survey of Innovation, which uses a broader definition of innovation than R&D, confirms that large Canadian firms are more innovative than small firms.

Large firms are more likely to perform R&D and be involved in innovative activities for several reasons. Large firms are better positioned to apply the fruits of R&D and its returns over a greater output stream (Cohen & Klepper, 1996). In addition, large firms have resources for innovation-related activities; they usually have dedicated R&D teams within the firm, allowing them to more efficiently generate ideas internally and absorb ideas from outside the firm. Large firms have other advantages for R&D performance: economies of scale in R&D technology, more efficient implementation of innovations, higher returns from R&D, and a greater ability to secure financing for risky projects (Becker & Pain, 2008).

A related barrier to BERD is the size of a country's domestic market. Larger homogeneous markets for new technologies may benefit innovative firms due to economies of scale and higher returns to innovation (Mathieu & van Pottelsberghe de la Potterie, 2008). For instance, the US and Japan have the largest homogeneous markets in the OECD and both have relatively high BERD intensities. However, some small countries like Sweden, Finland, and Denmark are research-intensive, despite their relatively small size, implying that size isn't the only driver. Measured by population, Canada's economy is medium in size but through trade agreements like the North American Free Trade Agreement (NAFTA) Canadian firms have access to larger markets, and thus strong incentives to capitalize on innovations. The size of Canada's domestic market could, however, serve to limit the rewards to innovation in non-tradable product and service sectors. In short, it is not clear by how much, if at all, Canada's size is a barrier to higher BERD.

4.3 Extent of foreign ownership

A larger than average share of R&D is financed and performed by foreign multinational corporations in Canada, sparking debate about whether foreign ownership is a structural barrier to increasing overall business R&D intensity.[15] Some blame foreign-owned firms for Canada's R&D woes because early evidence found that foreign-owned firms perform less R&D as a percentage of sales than Canadian firms (Tang & Rao, 2001). As subsidiaries of multinationals, foreign-owned firms perform less R&D in host countries because they often introduce

[15] See McFetridge (2006) for a critical review of this debate.

innovations or transfer technologies from R&D that was performed abroad, typically at the company's headquarters. The motor vehicle industry is a well-known example of such an arrangement in Canada. In most industrialized countries, the motor vehicle industry's R&D intensity averages above 10 percent but in Canada it is a mere 1 to 2 percent, owing largely to the centralization of R&D in the foreign multinational's home country. Most Canadian auto-manufacturing plants are subsidiaries and assemble pre-designed vehicles, while R&D activities are performed by parent companies located in places like the US, Germany, and Japan.

However, more recent analyses of individual firms based on R&D spending data and innovation surveys suggest that earlier research was incomplete. New findings show that Canadian subsidiaries of foreign multinationals are more R&D intensive than purely domestic Canadian firms (i.e., firms with only domestic operations) but less so than Canadian-owned multinationals, which are most likely to engage in R&D spending and product innovation (Baldwin & Gu, 2005). In addition, new empirical evidence from China shows that the R&D activities of multinational enterprises in an industry actually stimulate the entry of domestic firms into the same industry and enhance the R&D activities of newly entering domestic firms (Cai et al., 2007). The authors conclude that: "Since [multinationals] are substantially more efficient and technologically more advanced than domestic firms, our findings provide strong evidence supporting the knowledge-diffusion hypothesis that diffusion of [multinationals'] advanced knowledge to potential indigenous entrepreneurs through [multinationals'] R&D activities stimulates entry of domestic firms (Cai et al., 2007, p. 25).

Beyond these results, I should note that many of the benefits derived from foreign-owned firms do not show up in R&D statistics of the host country since multinationals can easily introduce into each subsidiary the R&D findings developed in other countries in which they operate. The resulting benefits include higher productivity levels and wages relative to Canadian-owned firms (Globerman et al., 1994) as well as productivity spillovers to domestic plants through increased competition and technology adoption (Baldwin & Gu, 2005). In addition, foreign-owned firms are active participants and key partners in Canada's innovation efforts, as evidenced by their collaboration with domestic universities and other firms, which also benefits the host country (Baldwin & Hanel, 2003).

4.4 International R&D spillovers and economic integration with the US

Canada is a relatively open economy with trade patterns heavily oriented to the US. This has strong implications for R&D performance since a country's productivity is increased by the R&D activity of its trading partners, and the impact is greater for countries more open to international trade and for countries smaller in size (Coe & Helpman, 1995; Guellec & van Pottelsberghe de la Poterie, 2001).

Productivity gains from foreign R&D originating in the US are especially large, given Canada's geographical proximity to and economic integration with the US.[16] Through statistical analyses, Keller (2001) found that 69 percent of total world technology diffusion to Canada originates from the US. Since the US performs a significantly larger absolute value of R&D than Canada (around 40 times more), Keller's findings imply that US R&D spending is significantly more important for Canadian productivity growth than is Canada's own (see also Hejazi, 2001). The findings also imply Canada's economic integration and unique trading relationship with the US could hinder domestic business R&D efforts. That is, Canadian firms may free ride on innovations created by their southern counterparts (i.e., through adoption), diminishing the incentive to perform R&D domestically.

4.5 Policies that restrict competition

The link between competition and R&D is complex. Theory tells us competition can have two distinct effects on a company's decision to engage in R&D. First, greater competition may reduce the incentive for incumbent firms to perform R&D because it is more difficult to extract monopoly rents from innovation. Second, greater competition may encourage firms to use R&D as a strategic tool to either gain an edge over rivals or defend their market share. Contemporary theoretical models place more emphasis on the latter hypothesis: more competition stimulates R&D (Fantino, 2008).

Empirical research by Aghion et al. (2005) points to an inverted-U relationship between innovation and competition. That is, firms have little incentive to innovate if they are not stimulated by competition, but too much competition discourages innovation as firms are unable to capture the benefits. However, one of Aghion's co-authors recently surveyed the Canadian economy and urged policymakers to take a more aggressive stance in favour of competition to

[16] See Harris (2005) for more discussion on this point.

promote innovation (Howitt, 2007). Research by Tang (2003) supports that advice. In a study for Industry Canada, Tang (2003) found that the possibility of competing products arriving on the market spurs innovation in Canadian firms and encourages the invention of new technology. Similarly, Becker & Pain's (2008) review of the literature on business R&D and market structure concluded that the empirical evidence suggests that increased competition, controlling for other factors, has a positive effect on R&D.[17] But they differentiate between the effect in high and low-tech industries—competition likely raises R&D expenditures in high-tech, but not low-tech industries. In sum, my review shows that increased competition generally has positive effects on innovation and R&D.

Competitive pressures in Canada are present across most industries (Council of Canadian Academies, 2009). This is especially true for sectors of the economy open to trade and thus exposed to global competition where firms struggle to gain export market share or defend against imports that threaten domestic market share. In certain markets, however, international competition is lacking. For example, regulations on foreign ownership and investment in key sectors such as telecommunications and air transport erect artificial barriers to entry into the Canadian market and shield domestic firms from competition. These regulations not only reduce the impetus to innovate but also slow down the diffusion of new technology and management practices as well as block access to foreign capital for investments in R&D. As a result, consumers have fewer choices and pay higher prices. Several organizations, including the OECD and the Competition Policy Review Panel,[18] have recommended reforms to boost competition in Canadian markets, including the removal of sector-specific restrictions on foreign investment (see OECD, 2006a; CPRP, 2008).

In cases where no such regulations on foreigners exist, Canada's relatively small domestic market may make the country a low priority for foreign businesses and in the process reduce the competitive pressure on domestic firms. Retail trade is one example (see Council of Canadian Academies, 2009).[19] Internal regulations may also hinder competition. For example,

[17] Ahn's (2002) extensive survey of both the theoretical and empirical literature on the relationship between competition and innovation likewise concluded that increased competition has a positive effect on innovative activities.

[18] The Competition Policy Review Panel was established by the ministers of industry and finance in July 2007 to review the state of Canada's competition and foreign investment policies and make recommendations for improvement. Its final report was released in June 2008.

[19] In addition, Canada's dual-language labelling requirements may act as an impediment to competition in retailing of consumer goods, particularly in import and export markets. This is an important yet understudied impediment. What we know, though, is that the Official Language Act (OLA) imposes significant public and private costs that are borne by Canadian taxpayers (Vaillancourt & Coche, 2009).

inter-provincial barriers to trade in goods and services can suppress competition and have a dulling effect on innovation (Conference Board of Canada, 2006). Regulations in product markets can do the same. According to Conway & Nicoletti (2007), product market regulations in the electricity, air transport, retail distribution, and professional services sectors are more prevalent in Canada than in the US, and this type of regulation holds back productivity growth mainly by slowing the adoption of information and communication technology (ICT).

Finally, the predominance of state-owned enterprises in Canada and sectors with regulations that secure unnatural monopolies (i.e., electricity) also hinder competition and innovation. Evidence shows that state-owned enterprises, more commonly known as Crown corporations in Canada, are less likely than their private counterparts to invest and innovate.[20]

4.6 Regionally concentrated R&D (clusters)

R&D activity is often concentrated in economic clusters, which are "geographic concentrations of interconnected companies and institutions in a particular field" (Porter, 1998, p. 78). Clusters drive innovation through two channels: support and pressure (Trefler, 2008). Support is provided to firms by concentrations of specialized input supply industries and pools of highly skilled workers who interact and facilitate the flow of tacit knowledge. Pressure is provided by both intense local competition and sophisticated consumers who constantly place new demands on firms to innovate. Clusters create an increasing degree of both specialization and interdependence among firms, and this interdependence pushes the innovation process towards greater co-operation among firms in the supply chain.

Canada has a healthy number of clusters (Trefler, 2008), but these clusters are disproportionately concentrated in Quebec and Ontario. Two popular clusters in these provinces are the aerospace cluster in Montreal and high-tech cluster in Waterloo. Of all business R&D, about 80 percent is performed in those two provinces (see Table 1). While clusters are an important driver of business R&D and innovation, public policies designed to create clusters from scratch have not been successful in Canada or elsewhere (Council of Canadian Academies, 2009). Pre-existing advantages and a strong local catalyst are critical factors. Led by Research in Motion Ltd., the Waterloo cluster is a good example and shows that cluster development requires both time to mature and convergence of several factors that are typically location specific (Council of Canadian Academies, 2009).

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[20] See Lammam & Veldhuis (2009) for a review of this evidence.

4.7 High business taxes

Economic research generally shows that high business taxes discourage capital investment and entrepreneurship (Djankov et al., 2008).[21] Since decisions to invest in capital go hand-in-hand with decisions to invest in R&D (Chiao, 2001), high business taxes also discourage R&D. Empirical evidence of the direct relationship between business taxes and R&D is provided by McKenzie & Sershun (2010). These authors looked at the effect of production taxes on R&D in nine industrialized countries (including Canada) and found that, holding constant other factors like R&D tax incentives, increasing the marginal effective tax rate on production decreases business R&D intensity.[22] This means that both the impact of tax incentives and other business tax provisions must be considered when designing tax policy for R&D. Otherwise, "failing to take account of both effects may result in governments giving with one hand and taking away with the other—encouraging R&D by offering generous tax subsidies that lower the cost of undertaking research, but discouraging R&D by imposing high production taxes on the fruits of the R&D, the discovery of new products and processes" (Mckenzie & Sershun, 2010, p. 316).

Canada has among the world's most generous system of tax incentives for R&D (see section 5.1), but it has long had among the highest tax burdens on business investment. As recently as 2005, Canada had the fourth highest effective tax rate on business investment among 80 countries and the highest in the OECD (Chen & Mintz, 2010).[23] This history of high taxes has likely depressed business R&D. However, recent corporate income and corporate capital tax reductions have improved the business tax regime, pushing Canada's 2009 effective tax rate ranking down to 10th highest out of 80 countries (Chen & Mintz, 2010). Additional business tax cuts at the federal and provincial levels, along with sales tax harmonization in Ontario and BC in 2010, will further reduce Canada's effective tax rate on investment, making it more competitive globally. But since other countries are also improving their business tax regimes, there is no guarantee that recent moves in Canada will improve the country's international ranking.

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[21] See Parsons (2008) for Canadian evidence on lower business taxes sparking investment.

[22] The marginal effective tax rate on production is slightly different than the marginal effective tax rate (METR) on capital investment. Please see McKenzie et al. (1997) for methodology calculating the former, which includes other production taxes like excise taxes, export taxes, import duties, and payroll taxes.

[23] Argentina had the highest, China had second highest, and Chad had third highest.

4.8 Unsuitable mix of skilled individuals (human capital)

A skilled workforce—including employment in occupations such as scientists, engineers, and business managers—is a critical input into the innovation and R&D process. Canada's international standing with respect to general skills and education is quite strong, but some deficiencies are evident.[24]

- Post-secondary education: The share of the workforce with post-secondary education is considered an indicator of a nation's supply of advanced skills, and Canada ranks first internationally in this regard. In 2006, 47 percent of Canada's working age population attained post-secondary level education (STIC, 2009, p. 42). However, half of Canada's high percentage comes from college, not university education. In other OECD countries, the college component is much smaller, and looking at just the university component of post-secondary attainment, Canada's rank drops to sixth (STIC, 2009, p. 42).
- Science and engineering degrees: Over time, the strength of Canadian innovation requires constant growth in the number of workers possessing science and engineering (S&E) skills. In 2005, 20 percent of new degrees were awarded in S&E, which places Canada 21st among 26 OECD countries (STIC, 2009, p. 43). Despite this low ranking, Canada performs better than the US, whose proportion is about 16 percent. According to surveys of business executives in the latest Global Competitiveness Report from the World Economic Forum, the availability of scientists and engineers doesn't appear to be a problem in Canada (Schwab, 2010)—a result that might reflect a comparatively low demand from industry for these skills.
- Business degrees: Good management is a significant driver of innovation as it creates the demand for better ways of doing things. Recent studies by the Institute for Competitiveness and Prosperity (2007, 2009) note that, while science and engineering graduates are dominant founders of successful high technology firms, these skills become less important as firms mature. As companies mature, different sets of skills such as management and leadership need to keep them growing. In Canada, survey data reveals that a key challenge for growing innovative firms is access to management talent (Barber & Crelinsten, 2005). Education data shows that Canadians have far fewer degrees in business (at both the undergraduate and graduate levels) than Americans (Institute for Competitiveness and Prosperity, 2009). Overall, Canadian managers have lower

[24] This sub-section draws heavily from STIC (2009).

educational attainment than their US counterparts, and CEOs of Canada's largest companies have less formal business education at the graduate level.

- Doctoral degrees: Phd training is also important, but perhaps less so, for sparking business innovation. While the number of Phds in Canada has grown in the last decade, much of the growth came through immigration, underscoring the potential role immigrants can play in increasing Canada's innovation capacity (STIC, 2009). Growth in Phds aside, Canada ranks 20th in the number of new PhD graduates per million people among 20 OECD countries (STIC, 2009, p. 46).

I believe that a general "skills deficiency" does not explain Canada's weak business R&D. The relatively low share of high-skilled workers (scientists and engineers) is more likely driven by a lack of demand (see also OECD, 2006a, for more discussion on this point). Consider the following telling evidence. The monetary returns to higher education are lower in Canada than in many developed nations.[25] For example, the increase in earnings from a university degree relative to a high school diploma in Canada is in the bottom half among OECD countries and last among G-7 countries (OECD, 2007b). Compared to Americans, Canadians with a university degree earn a much smaller wage premium relative to those with only a high school diploma—about 20 percent lower for men and 25 percent lower for women (Expert Panel on Commercialization, 2006). The unemployment rate for university graduates in Canada is among the highest in the G-7, with Canadian rates doubling those in the US (Expert Panel on Commercialization, 2006). This all points to sluggish demand being the root cause for Canada's low share of high-skilled workers.

If the opposite were true—that supply constraints were the cause—then we would expect persistent upward wage pressure in occupations related to R&D, and relatively high rates of return on advanced degrees in related professions (Dion & Fay, 2008, p. 41). But the returns to higher education reveal that the net rate of return for a master's degree in science and engineering is barely positive (Stark, 2007). The net rate of return for a PhD in these fields is also relatively low. This suggests no excess demand for these qualifications, and increasing the supply of S&E

[25] That is not to say that the returns to higher education in Canada are insignificant; only that they are lower than in other countries. In a recent study, Boothby and Drewes (2010) calculated education returns in Canada from 2006 census data. They estimate an internal rate of return on a bachelor's degree relative to high school of 13 percent for men and 17 percent for women. They also estimate the premium over high school in 2005 is 45 percent for men and 60 percent for women. The authors do acknowledge, however, that their results are sensitive to parameter changes.

graduates may simply lead to increased migration to other countries like the US, where the returns are significantly higher.[26]

By contrast, a master's degree in commerce and business generates the highest rate of return in Canada (16.3 percent for men and 19.5 percent for women), indicating that the labour market values these qualifications more and is willing to pay a premium for them. So increasing the stock of management skills may have a stronger impact on innovation (and R&D) than training more scientists, at least until the Canadian demand for scientists and engineers increases and the rate of return to those human capital investments rises. Encouragingly, research shows that the supply of engineers responds quickly to changing demand (Ryoo & Rosen, 2004).

4.9 Inadequate business culture for innovation

Culture is a weakly understood factor for innovation. Some observers speculate that Canada's business culture is not conducive to innovation and that attitudes toward competitiveness, entrepreneurship, and risk-taking are weak (Drummond & Bentley, 2010; McFetridge, 2008; Council of Canadian Academies, 2009; McKinsey & Company, 2008; Barber & Crelinsten, 2005). Other theories suggest that Canadian company managers do not adopt globally oriented business strategies and that Canadian business people lack sufficient growth ambition and aggressive spirit compared with their US counterparts (Council of Canadian Academies, 2009).

The survey-based empirical evidence is conflicting, with business leaders reporting more negative views about Canada's business culture than the general public (Council of Canadian Academies, 2009). Surveys of the broad population reveal that Canadians do not differ much from Americans in their attitudes regarding risk and entrepreneurship (Council of Canadian Academies, 2009).

The perceived problems with Canada's business culture might not be due to innate shortcomings of Canadian business people. As the Council of Canadian Academies (2009, p. 174) explains, "the traditional attitudes of business people have been shaped over a very long time by the particular circumstances of Canada's economy. For many exporters, easy access to the world's largest market next door has blunted the incentive to venture farther afield. With

[26] Analysis by Statistics Canada (2005) found that Canadians are more likely to leave their home country after completing a doctoral degree: 18 percent of Canadians intend to leave the country after completion while the corresponding rate is only 5 percent in the US. The highest proportions of "leavers" are in scientific fields.

relatively subdued domestic competition, there are fewer market incentives to push toward the kind of competitiveness that can survive in larger world markets." Maybe other factors, such as lack of access to risk capital, dull the desires of Canadian business people to be more innovative, entrepreneurial, and growth oriented. The lack of a definitive answer warrants additional research and is beyond the scope of this study.

4.10 Too little and poor quality venture capital

Financing from banks or through equity (i.e., new share issues on stock exchanges) may be irrelevant to fledgling innovative firms, which often have negative cash flows, untried business models, and uncertain prospects of success (OECD, 2008). Venture capital is often needed to take an idea or invention with commercial potential from the laboratory to market success. This is especially true for new technology-based firms with breakthrough innovations. Venture capital funds are an important source of finance as innovative firms go through stages of the product life cycle, from product development and initial marketing, to production expansion, to increased sales and profitability. But effective venture investing offers more than financial capital; it also offers exceptional business acumen to monitor and manage high risk investment and valuable mentorship to new entrepreneurs, supplying business contacts and specialized market knowledge.

Venture capital in Canada seems to be in a poor state. Fundraising for Canadian venture capital firms has been falling—2007 marked the fifth decline in the previous six years (Council of Canadian Academies, 2009). Meanwhile, the United States experienced five consecutive years of growth (Council of Canadian Academies, 2009). As of 2006, Canadian venture capital as a percentage of GDP ranked 17th in a comparison of 28 OECD countries (OECD, 2008).[27] The performance of Canadian venture capital, in terms of net returns, has also lagged that of US venture capital (Council of Canadian Academies, 2009; Cumming & MacIntosh, 2006).

The Council of Canadian Academies (2009, p. 119-130) highlights several reasons for Canada's seemingly weak venture capital industry:

- Lack of good quality opportunities is reducing the level of investment available.
- The low level of institutional venture capital and high level of individually contributed venture capital weakens performance.

[27] As of December 2010, 34 countries belong to the OECD. In 2006, there were 30 members but data for this comparison was only provided for 28.

- The industry is still relatively young and has not fully developed the necessary skills for success.
- The historical predominance of tax-advantaged Labour Sponsored Venture Capital Corporations poses “structural issues.”[28]

[28] Labour Sponsored Venture Capital Corporations are government supported investment vehicles that use personal tax credits as an incentive to draw capital into the industry.

5: Canadian Business R&D Policy

Yet another determinant of business R&D is the level of government support. This section presents government support policies in Canada for business R&D and innovation.[29] It outlines the three broad instruments used by Canadian governments (mainly federal) to address market failures and stimulate the performance of business R&D. These include tax incentives, direct subsidies, and support for university-industry collaboration.[30]

5.1 R&D tax incentives: The Scientific Research and Experimental Development (SR&ED) Program

Both the federal and provincial governments provide indirect support to business R&D performers through the tax system, and the largest tax incentives are offered through the federal Scientific Research and Experimental Development (SR&ED) program.[31] The SR&ED program is by far the most significant government support for business R&D in Canada. About 20,000 businesses claim SR&ED tax credits each year. The value of foregone tax revenues due to the SR&ED program amounts to well over $3 billion per year.

SR&ED expenditures may qualify for investment tax credits (i.e., a reduction in income tax payable), cash refunds, or both. Qualifying expenditures include wages, materials, machinery, equipment, travel and training expenses, property taxes, utility expenses, some overhead, and SR&ED contract work. In order to claim such expenditures, an assessment on scientific or technological eligibility of the claimed activities is performed. The Department of Finance is responsible for the legislation that governs the SR&ED program, while the Canada Revenue Agency is responsible for its administration.

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[29] Additional details are contained in Appendix B on the structure of Canada's research system and key government support programs for innovation.

[30] The federal government also uses patent policy as a tool to boost innovation. However, since a convergence across developed countries has taken place with regard to patent policy over the last few decades, I left patent policy out of the discussion. Also, research shows that intellectual property rights have little impact on R&D spending (Jaumotte & Pain, 2005d).

[31] Canada has offered R&D tax incentives for several decades; the current system has been in place since the mid-1980s.

The main component of the SR&ED program is the investment tax credit for eligible R&D expenditures in Canada. For small Canadian-Controlled Private Corporations (CCPCs),[32] the credit rate is 35 percent on the first $3 million of qualified expenditures and is refundable, which means SR&ED benefits are paid as a cash refund, even if the R&D performer has no tax payable.[33] For large and foreign-owned businesses, the credit rate is 20 percent and is non-refundable, which means benefits are provided in the form of a tax credit against taxes payable. Unlike in other countries, Canada imposes no minimum amount of R&D spending for claiming the credit.[34]

All provinces except Prince Edward Island offer R&D tax incentives in addition to the federal government's SR&ED program.[35] The nominal provincial tax credits for CCPCs are 10 percent (in British Columbia, Ontario, and Alberta), 15 percent (in Saskatchewan, New Brunswick, Nova Scotia, and Newfoundland and Labrador), 20 percent (in Manitoba), and 37.5 percent (in Quebec).[36] The respective rates for large and foreign firms are 4.5 percent (in Ontario), 10 percent (in BC and Alberta), 15 percent (in Saskatchewan, New Brunswick, Nova Scotia, and Newfoundland and Labrador), 17.5 percent (in Quebec), and 20 percent (in Manitoba).[37] The combined federal-provincial rates for CCPCs range from a low of 35 percent (in Prince Edward Island) to a high of just over 60 percent (in Quebec). Meanwhile, the combined rate for large and foreign firms ranges from a low of 20 percent (in PEI) to 36 percent (in Manitoba). Qualifying expenditures in the provinces may differ from those in the SR&ED program. For example, Quebec's 37.5 percent rate applies only to labour and not to materials, equipment, and overhead. Quebec also offers a tax credit for research contracted out to certified institutions such as universities and other post-secondary institutions.

By any measure Canada's tax subsidy system for business R&D is very generous internationally. Figure 5 shows just how generous the Canadian system is. Importantly, the subsidy rate in the figure excludes the various provincial tax credits for business R&D. So by only including the federal portion, Canada's rate is understated. Also important is that countries ahead of Canada in terms of their R&D tax subsidy (like France) have just recently increased the

[32] A CCPC is a private corporation without shares listed on a public stock exchange and cannot be controlled either directly or indirectly by a public corporation or by non-Canadian residents.

[33] However, some restrictions apply based on taxable capital and income. If eligible, CCPCs can apply unused credits to taxes dating back up to three years or carried forward up to 20 subsequent years.

[34] In the US, for example, R&D tax credits are paid only on year-to-year increases in R&D spending.

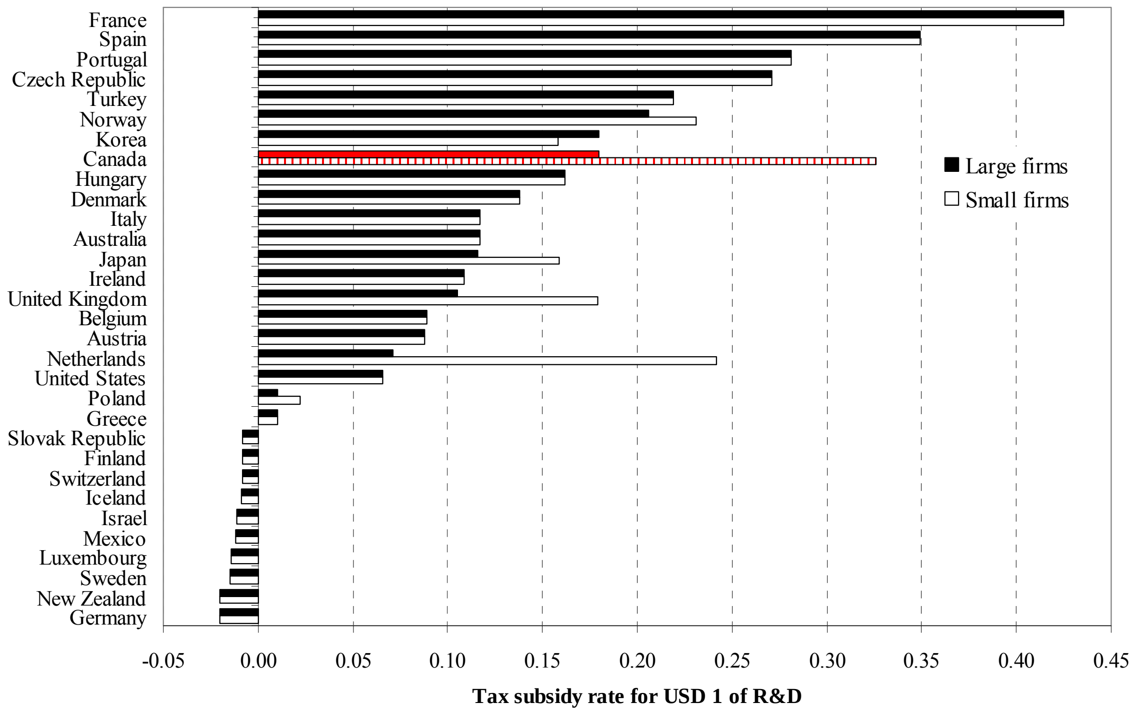
[35] For details on R&D tax incentives in Canada and the provinces (including rates), see http://investincanada.gc.ca/download/142.pdf (available December 15, 2010).

[36] Only Manitoba's tax credit for CCPCs is not refundable.

[37] The provincial tax credits for large and foreign firms are not refundable in BC, Manitoba, and Ontario.

generosity of their R&D tax credits, thus diminishing Canada's historically leading position. Accounting for the total value of tax incentives and direct (provincial and federal) support, Canada ranks second among OECD countries on support for business R&D as a percentage of GDP (Industry Canada, 2010).

Figure 5: R&D tax credit for small and large firms in the OECD and Israel, 2008



Source: OECD (2009a)

Several empirical studies have examined the effects of R&D tax incentives on business R&D.[38] For the most part they find positive effects, but the magnitude is sensitive to the methodology used. In general, researchers find that R&D tax incentives produce incremental business R&D that is about equal to the cost of the tax incentive. This finding, however, does not include the costs associated with administering and complying with the tax incentive program or the spillovers emanating from commercially successful innovations. So, it is incomplete. A recent, comprehensive cost-benefit analysis of the SR&ED program by Parsons & Phillips (2007) accounted for these and other considerations (i.e., the marginal cost of public funds to pay for the tax expenditure). Their analysis for the federal Department of Finance estimated that the SR&ED

[38] See Hall & Van Reenen (2000) for a survey of this literature.

program produces a net economic benefit for the Canadian economy of 11 cents per dollar of tax expenditure, or a net benefit of about $400 million annually (Parsons & Phillips, 2007).

Nevertheless, the SR&ED program has undergone much scrutiny over the years. An often-heard complaint is that the program does not provide refundable credits for large firms. If credits are non-refundable, they are of little use to firms not making income in the current tax year.[39] More generally, we hear complaints of the program discriminating against larger firms since they receive a 20 percent credit versus 35 percent for small firms. Foreign firms face similar discrimination. Problems with the program's administration and compliance costs are well documented (Conference Board of Canada, 2002; McDowell, 2010; Cayo, 2010). Complaints allege inconsistent application of what R&D expenditures are eligible for the tax credit, an adversarial attitude from program administrators, and unreasonably high paperwork/compliance costs. In addition, the tax credit may not target R&D activities with the greatest spillover return. Finally, the program may not encourage additional R&D since those claiming the credit would have performed the research anyhow.

Criticisms like these, along with Canada's underwhelming business R&D activity, sparked the federal government's formal review of the SR&ED program and other support programs for business R&D. In October 2010, the government appointed an expert panel to "conduct a comprehensive review of all existing federal support for business R&D to see how this support could be enhanced to make sure federal investments are effective and delivering maximum results for Canadians" (Industry Canada, 2010). The panel's recommendations are due next year.

5.2 Direct R&D subsidies

The federal government spends roughly $4 billion annually in direct subsidies for private-sector innovation (Mayeda, 2010) which is spread across a number of industries. Allocated through several programs, direct R&D subsidies are key elements of the federal government's support for business innovation. For example, the Strategic Aerospace and Defence Initiative (SADI), administered by the Industrial Technologies Office (ITO),[40] "provides Canadian aerospace and defence (A&D) industries with repayable contributions for strategic R&D

[39] There is, however, a carry-forward provision for unused non-refundable credits, so that they can be used to offset future tax liabilities.

[40] The ITO acts as the administrator for Industry Canada's programs for "strategic industrial projects."

projects."[41] Contributions for each project are supposed to equal the minimum amount necessary to ensure the project becomes successful. This typically equals 30 percent of eligible costs. SADI replaced Technology Partnerships Canada, an R&D program that provided funding for large-scale, private sector pre-commercialization projects supporting government policy objectives. Meanwhile, the National Research Council (NRC) operates the Industrial Partnership Facility (IPF), where early-stage R&D companies benefit from NRC's support, including access to specialized facilities/equipment and research collaboration opportunities.

The OECD has included a number of Canadian support initiatives in its list of best practice policies and programs to promote a knowledge-based economy (Hirshhorn et al., 2002). The Networks of Centres of Excellence (NCE) program was singled out for establishing strong links between universities and industry (more details in section 5.3). The Industrial Research Assistance Program (IRAP) was noted for promoting personnel and knowledge transfers between universities and industry. Administered by the NRC, IRAP provides technology advice and financial support on a matching basis with innovative companies for R&D projects and for larger pre-commercialization projects. The program supports over 3,500 companies per year and is the principal program for direct support of small and medium-sized enterprises (SMEs). Industry Canada's Strategis initiative was also recognized, for promoting the diffusion of technologies.

Empirical research on the effect of direct R&D subsidies on business R&D is inconclusive.[42] Some studies find a positive relationship—that is, higher direct subsidies are associated with increased business R&D, particularly when the level of subsidization is modest and when businesses face financial constraints.[43] Other studies find a negative relationship whereby direct R&D subsidies substitute for, or even crowd out, business funding.[44] Political economy considerations and the government's inability to "pick winners" make direct subsidies a highly risky form of support. These drawbacks are especially relevant in the Canadian context. On the other hand, the ability to target high return projects is one area where direct support has an advantage over indirect support.

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41 See http://ito.ic.gc.ca/eic/site/ito-oti.nsf/eng/h_00023.html (available December 15, 2010).

42 David et al. (2000) surveyed the econometric evidence over the past 35 years on R&D subsidies and concluded that "the findings overall are ambivalent."

43 Czarninitzki & Fier (2002) found that R&D subsidies in Germany's service sector produced additional R&D, while Lach (2003) found that Israeli R&D subsidies produced a strong stimulating impact for small firms, but not for large enterprises.

44 Wallsten (2000) found that grants given through the Small Business Innovation Research (SBIR) program in the US crowded-out business R&D one-to-one, while in Spain Busom (2000) found mixed results on the effect of R&D subsidies: 30 percent of firms reduced R&D spending whereas the rest increased it.

5.3 University research and university-industry collaboration

A key component of Canada's innovation strategy since 1997 has been to increase research undertaken at universities and the commercialization of this research (Mueller, 2006). Currently, higher education expenditures on R&D (HERD) are just below 0.7 percent of GDP, and Canada is among the top OECD countries on this indicator. The surge in Canadian HERD over the last decade is largely due to the creation and extension of initiatives such as the Canadian Foundation for Innovation (CFI) and the Canada Research Chairs program, as well as increased direct funding to Canada's three main granting councils. Founded in 1997 with an endowment of $3.8 billion, CFI's mandate is to strengthen the innovation capacity of universities; the Foundation provides grants for research infrastructure and partners with public, private, and non-profit organizations. The Canada Research Chairs program began in 2000 with the federal government setting aside $900 million to establish 2,000 research professorships in universities across the country by 2008 to keep highly qualified academic researchers in Canada. Through Canada's three main granting councils, the federal government funds, administers, and supports many foundations, organizations, partnerships, and scholarships designed to fuel innovation and broaden Canada's R&D base in universities. The Natural Sciences and Engineering Research Council (NSERC) supports basic research and advanced training, the Canadian Institutes of Health Research (CIHR) funds researchers in specialized life science institutes across Canada, and the Social Sciences and Humanities Research Council (SSHRC) supports research outside technical and scientific fields. Research through the granting councils totals well over $1 billion annually. Additional scholarships, fellowships, chairs, and awards for researchers through the granting councils equals about half that sum.

The assumption driving greater public funding to the higher education sector is that universities are potentially large and untapped sources of commercial knowledge. This assumption has influenced policy in Canada in three ways (OECD, 2006a). First, government funding for academic research has been linked more closely to economic objectives. Second is an attempt to foster relationships between firms and academic researchers. Third, universities have been, and continue to be, encouraged to actively seek the commercialization of their research. As a result, governments have made a concerted effort to develop and bring to market innovations based on publicly funded research in universities. For example, the Networks of Centres of Excellence (NCE) program brings university and industry researchers together, under the leadership of the university, to advance science and technology developments with practical applications.[45] The NCE program manages around 20 R&D networks involving the private sector, academic, and federal and provincial departments and agencies. It is widely perceived to be effective for commercialization of science and technology among key industry, government, and university stakeholders (Council of Canadian Academies, 2006). The program has substantial industry investment and involvement; participating companies have contributed more than $386 million in cash and in-kind support for the R&D undertaken by the networks. To date, the NCE program has spun off more than 100 companies and contributed to the development of more than 36,000 highly qualified professionals including researchers, post-doctoral fellows, graduate students, and technicians.[46]

In 2007, the federal government launched three new programs that expand the collaborative model developed in the original NCE program. These evidently successful initiatives are the Centres of Excellence for Commercialization and Research (CECR), Business-Led Networks of Centres of Excellence (BL-NCE), and Industrial Research and Development Internships (IRDI). The CECR primarily focuses on facilitating commercialization of technologies, the BC-NCE mimics the NCE but is headed by industrial consortia, and the IRDI links graduate students and postdoctoral fellows with industry.

The Industry-University Research Chairs is yet another initiative to encourage university-industry linkages. In this initiative, NSERC provides five-year grants, matched by a company, to a professor working on a collaborative project with industry. This collaboration aims to develop and transfer technology and skilled researchers from the university lab to industry.

Overall, the weight of the literature suggests that basic research performed in universities stimulates applied R&D in the business sector (Jaumotte & Pain, 2005c; Cohen et al., 2002). However, the benefits emerge after a considerable time lag and are disproportionately realized by firms that are either large, in the start-up phase, or in high-tech industries.[47] Very high levels of university research have been found in some cases to crowd out business R&D, particularly if high-skilled labour is scarce. In this case, rising demand for high-skilled workers by universities reduces the number available to the business sector and drives wages to high levels (Goolsbee, 1998).

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[45] See http://www.nce-rce.gc.ca/NCESecretariatPrograms-ProgrammesSecretariatRCE/NCE-RCE/Index_eng.asp (available December 15, 2010).

[46] All told, the commercialization of university research in Canada has more than doubled to a total of 876 spin-off companies (OECD, 2006a). Two thirds of the spin-offs were in health, information, or engineering and applied sciences.

[47] Cohen et al. (2002) find that university research is especially influential in a small number of industries in the manufacturing sector and the influence is greater for larger firms, as well as start-ups.

The main benefits of university research to the business sector come from the improved flow of information between the two sectors. Collaboration between universities and industry particularly strengthens the impact of the former's research on the latter. However, survey results of R&D managers in the US reveal that the key channels through which university research impacts industrial R&D are published papers and reports, public conferences and meetings, informal information exchange, and consulting (Cohen et al., 2002). These results stand in contrast to the notion that university research largely generates new ideas for industrial projects. Rather, they suggest that university research influences industrial R&D by generating new areas of research and by contributing to the completion of existing projects. That said, empirical evidence shows that university-industry collaboration boosts business R&D (Falk, 2006; Jaumotte & Pain, 2005a).

6: Case Studies

To explore ways to increase R&D in Canada's business sector, I examine the innovation system in other countries. Using primarily academic literature and reports from government bodies and non-profit organizations, I explore both quantitative and qualitative information on three countries selected as case studies. The information I seek is derived from my earlier review of the determinants of business R&D. That includes factors such as venture and human capital, the business environment, government support policy, and so on. The goal of my analysis is to highlight particular characteristics and factors that lead to higher levels of R&D and innovation.[48] After examining each country's case, I summarize commonalities among all three as well as features that are unique to particular countries and then draw implications for Canada through comparative analysis. The analysis will assist in my formulation of policy options.

My case studies include three countries: Israel, Finland, and Sweden. I chose these countries for their diversity and because they are among the most R&D intensive countries in the world. These countries have also experienced striking growth in R&D since 1981 (Sheenan & Wyckoff, 2003). In some cases, they completely reshaped the industrial structure of their economy from a heavy natural resource orientation to a more knowledge-intensive system of production (i.e., Finland). These countries are also relatively small, meaning their strong innovation performance is not driven, or inhibited, by size factors.

Summary data for the case countries and Canada is provided in Table 2. The data highlight two points. First, business R&D as a percentage of GDP is high in all countries (compared to other OECD countries and especially Canada). Second, the share of GERD both funded and performed by the business sector is also comparatively high. So clearly the business sector plays a major role in R&D and innovation.

[48] In addition, Appendix C contains some key challenges facing each studied country.

Table 2: Summary data for the case countries and Canada, 2008 or latest available year

	BERD intensity %	**GERD intensity %**	**Share of GERD funded by business %**	**Share of GERD performed by business %**
Israel	3.9	4.9	77.2	80.8
Sweden	2.8	3.8	64.0	74.1
Finland	2.5	3.5	68.2	72.3
Canada	1.0	1.8	47.6	54.2
OECD	1.6	2.3	64.2	69.6

Source: OECD (2009a)

6.1 Israel

6.1.1 Background and general characteristics

Located in western Asia on the eastern shore of the Mediterranean Sea, Israel has a population of about 7 million. For the region of south-western Asia, Israel has a relatively advanced economy. In 2008, Israel had the 26th highest GDP per capita in the world at US$27,548 (Canada had the 12th highest at US$36,444).[49] Israel has limited natural resources but an advanced agricultural system. Major exports from the country include fruits and vegetables, pharmaceuticals, software, chemicals, military technology, and diamonds. Sometimes referred to as the "second Silicon Valley," Israel has developed several advanced high-tech companies, including Amdocs, Check Point, and Comverse in areas such as software, communications, and the life sciences (The Economist, 2005). Intel and Microsoft built their first overseas R&D centres in Israel,[50] and other high-tech multinational companies like IBM, Cisco Systems, and Motorola have opened facilities in the country. Israel currently has the world's highest density of high-tech start-ups, the highest concentration of high-tech companies in the world after Silicon Valley, and the largest number of companies listed on NASDAQ outside North America (Dutta et al., 2008). Israel also attracts twice the number of venture capital investments as all of Europe (The Economist, 2005).

[49] All GDP per capita figures are based on World Bank data, which are at purchasing power parity. See http://siteresources.worldbank.org/DATASTATISTICS/Resources/GDP_PPP.pdf and http://siteresources.worldbank.org/DATASTATISTICS/Resources/POP.pdf (available December 15, 2009).

[50] See http://en.wikipedia.org/wiki/Science_and_technology_in_Israel (available December 15, 2010).

6.1.2 Israeli innovation indicators

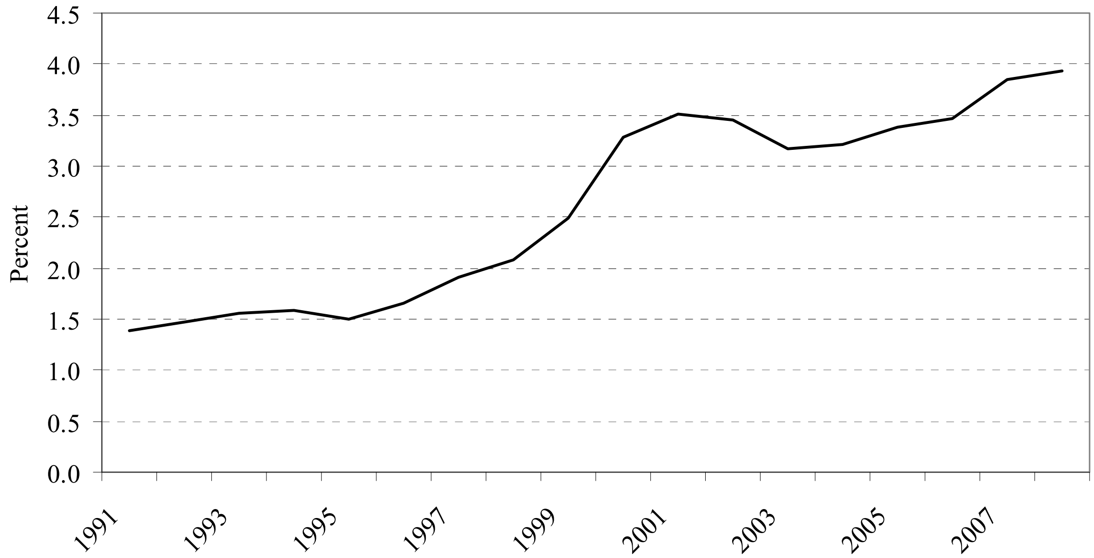
Israel excels on a number of innovation indicators (all sourced from OECD, 2008, p. 170-171). At 4.9 percent of GDP it has the world's highest GERD intensity, over twice the OECD average of 2.3 percent. The intensity of business R&D, at 3.9 percent of GDP, is also a global leader. Israel produces the fifth highest number of scientific articles per capita, after Switzerland, Sweden, Denmark, and Finland. It is also among the leaders in the number of triadic patent families per capita. In addition, Israel has a strong information and communication technology (ICT) sector that accounts for a large share of business sector output and employment. Indicators on human resources for science and technology show no shortages: the tertiary educational attainment ratio is the third highest worldwide, behind Russia and Canada, and the share of graduates in science and engineering, at 24.3 percent, equals the average of advanced OECD countries.

6.1.3 How did Israel do it?

In the following case study, I highlight the factors that helped Israel develop into a knowledge-intensive economy and propel its BERD intensity from 1.3 percent in 1991 to the highest in the world at nearly 4 percent (see Figure 6). The case study is based mainly on the following sources: Dutta et al., 2008; Breznitz, 2007; De Haan, 2008; Trajtenberg, 2002; the Economist, 2005.[51]

[51] I draw heavily from Dutta et al. (2008).

Figure 6: BERD intensity in Israel, 1991-2008



Source: OECD (2009a)

The main conclusion is that public policy played an important role in the emergence of Israel as a high-tech power. Notable components of government action have taken the form of: heavy investment in education, reinforced by large scale immigration and a strong military sector, to provide the necessary human capital for development; effective investment incentives for foreign investors to spark industrial activity; several R&D policies including direct public investment in industrial R&D, technological incubators, and initiatives to foster collaboration between industry and universities; and finally a program that sparked the Israeli venture capital market, which helped convert technical research into market opportunities. Against this backdrop are Israel's improvements to the business environment and a culture with characteristics conducive to innovative activity.

Education, human capital, and university-industry collaboration

Israel's competitive advantage in R&D has origins in the academic research system (Dutta et al., 2008). As a small country with limited natural resources, the government recognized the importance of investing in human capital for economic development and began building upon a "strong cultural heritage stressing excellence in education" as early as the 1920s (Dutta et al., 2008, p. 4).[52] Following independence in 1948, the government continued to focus on developing

[52] From 1917 to 1948, the Middle East, including the area of modern day Israel, was under British rule. Although no formal Israeli government existed at the time, the British did allow for various government-like entities to raise taxes and provide services (such as education and health care).

a top notch educational and research system (Dutta et al., 2008). By the early 1970s, Israel was an international leader in academic publications (Breznitz, 2007).

Over time, the Israeli higher education system has been used to meet industry demands for specific skills (Dutta et al., 2008, p. 3-5). For instance, with growing demand for higher education since the 1970s, the university system was liberalized to allow for private institutions and foreign competition (Dutta et al., 2008). In the 1990s, when business leaders established the need to retrain graduates from top universities in electronics and computer science, task forces were created and universities ultimately gave a boost to these areas (Dutta et al., 2008). By 2000, degrees from non-traditional post-secondary institutions responding to market demand for business and technical training represented about one third of the total (Dutta et al., 2008). With this additional training, the Israeli workforce was better positioned to provide key skills for a growing high-tech industry. Currently, about 25 percent of all Israeli graduates receive degrees in sciences and engineering (OECD, 2008).

In Israel, the interaction between top universities and certain industries is significant (Dutta et al., 2008). More generally, however, Israel ranked 14th internationally (out of 139 countries) on the extent of university-industry collaboration in R&D according to recent survey data from the World Economic Forum (see Figure 10).[53] All universities have a Technology Transfer Office and are actively engaged in transferring research results to the private sector (De Haan, 2008). University-industry interaction in Israel has been facilitated in part by programs administered by the Office of the Chief Scientist such as the Magnet program (more on the OCS and Magnet later).

Military sector

A unique feature of Israel's R&D system is the facilitating role played by the military sector (Dutta et al., 2008; De Haan, 2008; Breznitz, 2007). Following the French arms embargo imposed after the Six Day War in 1967, the development of Israel's defence industry accelerated because of the need for an independent military sector (France had been Israel's major arms supplier prior to the embargo). Subsequently, the military sector grew both in size and technological prowess with the government channelling large investments and R&D into military high-tech efforts (Breznitz, 2007). The size of Israel's military sector peaked in the early 1980s, with defence spending hovering around 25 percent of total economic output (De Haan, 2008).

[53] Finland ranked 3rd, Sweden 5th, and Canada 7th.

In 1985, Israeli defence spending was sharply cut partially due to the growing military alliance with the US, which diminished the need to develop weapons domestically (Breznitz, 2007). The downsizing benefited private industry, especially high-tech, as thousands of highly trained and experienced engineers were let go by the defence sector with many receiving packages enabling them to dedicate time and money to entrepreneurial activities (Breznitz, 2007). While the scope of the military sector has declined considerably, it continues to influence industrial R&D through spillovers to the private sector in several ways.[54]

- Through the infusion into the private sector of about 1,000 highly trained engineers annually. Most Israelis (men and women) are drafted into the military at the age of 18 for mandatory service lasting between two and three years. After finishing their compulsory military service, engineers enter the job market often bringing with them advanced skills and social networks that create strong links between researchers in the military and industry.
- Through defence contracts to universities. Faculty and graduate students working on defence contracts later apply their defence-related know-how to civilian projects.
- Through customer relations of the military with its suppliers. Leading private sector companies (particularly arms suppliers) benefit from close co-operation with demanding customers such as the Israeli Defence Forces.
- Through spin-offs of private sector companies. While the military has not explicitly sought to commercialize its technologies, many Israeli companies have roots in the military sector. Examples are Scitex (computerized print systems), Elscint (medical imaging), and Orbotech (a world leader in electric-optical inspection equipment).

In summary, spillovers from the military sector are key sources of knowledge input to the high-tech business sector.

Immigration

Traditionally open to and supportive of immigration, Israel is among the largest immigrant absorbing countries in the world.[55] Openness, coupled with the good fortune of benefiting from a large immigration wave of highly skilled individuals, has reinforced Israel's strong human capital base. It has also provided a supply of skilled labour to meet the demands of a rapidly growing high-tech sector.

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[54] The following spillover points are described in De Haan (2008, p. 87-88) and Dutta et al. (2008).
[55] See http://www.zionism-israel.com/Israel.htm (available December 15, 2010).

A notable source of immigration to Israel comes from the large number of Jews who have returned to their homeland over the years after the Diaspora (Dutta et al., 2008). 1989, in particular, marked a critical year for Israel as the Soviet Union democratized and broke apart. Jews who were previously unable to emigrate started a large immigration wave to Israel with around one million refugees from Eastern Europe arriving in Israel between 1989 and 1999 (Dutta et al., 2008). This immigration wave increased Israel's population by 20 percent. Those who emigrated were among the "best and brightest;" many had technical training and came with ambition, innovative problem solving skills, and a strong academic background (Dutta et al., 2008).

The immigration wave created a challenge to absorb so many people, so the government set up retraining and business development programs to facilitate the process (Dutta et al., 2008). For example, technological incubators were set up largely to harness the creative and scientific capabilities of new immigrants (more on this later). With rapid expansion of the high-tech industry, skilled immigrants were quickly integrated. According to Dutta et al. (2008, p. 6), "the expansion also attracted highly trained and experienced Israeli engineers, many of whom had previously emigrated to the US and Europe, but who now saw opportunities to set up research centres for their foreign employers or start-ups of their own in Israel."

Culture

Israelis are described as an entrepreneurial people, making the country a fertile region for innovation (De Haan, 2008; Dutta et al., 2008). Typical Israelis are open to risk-taking, "improvisers," "energetic," and confident with strong social networks. The country has a relatively large number of serial entrepreneurs—"people who start up new high-tech ventures, develop them, take them to the market, and then sell them, before starting the same cycle again with a fresh idea" (Dutta et al., 2008, p. 6-7). Repeat entrepreneurs are at the helm of roughly 30 percent of start-ups in Israel versus just 5 percent in the US (The Economist, 2005). This reflects the general philosophy in Israel toward entrepreneurship: try again despite previous failures (Dutta et al., 2008).

Foreign investment incentives and capital market reforms

Measures to encourage domestic and foreign capital investment have helped Israel's high-tech development (Dutta et al., 2008). Investment incentives originated in the Law for the Encouragement of Capital Investment (LECI), which was adopted in 1959 to attract private investment and foster business development, employment, and exports (Dutta et al., 2008). LECI does not explicitly favour specific sectors, but targets ventures with high value-added and marketing opportunities in local and international markets (Dutta et al., 2008). The incentives vary according to the location of investment and contribution to exports and local employment. Eligible domestic and foreign firms benefit from government grants (up to 24 percent of tangible fixed assets) and/or tax benefits depending on the geographical location and the percentage of foreign ownership (Dutta et al., 2008).

Under LECI, foreign investors receive preferential tax treatment (Dutta et al., 2008). Policymakers figured that a favourable tax regime and abundance of well-trained engineers and scientists would strengthen the attractiveness of Israel as a location for multinational corporations. Multinationals, it was hoped, would not only create employment in Israel, but also bring with them the technology, know-how, and exporting channels to help a young Israeli industry (Dutta et al., 2008). Put differently, multinationals would create spillovers and help develop local industry. The strategy apparently worked well with international investors setting up operations in Israel during the 1960s and 1970s including high-tech powerhouses IBM, Motorola, and Intel, followed by many others (Dutta et al., 2008). While Israel has long been open to foreign investment, the influx of multinationals was limited until the 1990s because of the political situation and because of the dominance of local, defence-related companies that generated a strong demand for scientific labour (De Haan, 2008). However, since the 1990s, foreign direct investment (FDI) in Israel has increased significantly, and the contribution made by multinationals to the development of Israel's high-tech industry is generally seen as positive (Dutta et al., 2008).

Investment incentives through the LECI were buttressed by several capital market reforms—such as deregulation and elimination of restrictions and interventions—that improved the workings of Israel's financial system (Dutta et al., 2008). Modernizing the financial sector supported development of the high-tech industry by making it easier for emerging companies to obtain funding, while controlling rampant inflation also created a more stable macroeconomic environment conducive to business activity (Dutta et al., 2008). Moreover, the Israeli government has over the years initiated several policies with the aim of improving the investment climate including investment in R&D. Key policies were contained in budget 2005: an increase in higher education funding; a reduction in the corporate tax rate from 36 percent to 30 percent in 2008; a reduction in personal income taxes; a simplification of the incentive program for "approved investments;" and development of transportation and communication infrastructure (Erawatch, 2009b).

Government support for industrial R&D

A final factor in Israel's success story is government policy in the area of business R&D and innovation. Support for R&D began in the late 1960s as the need to define a new development strategy became a priority (Dutta et al., 2008). With a lack of natural resources, Israel focused on its strengths: a strong human capital base and technological culture. Specifically, the government began promoting the development of a high-tech sector by subsidizing private sector R&D projects and implementing a series of programs to strengthen and stimulate industrial R&D (Breznitz, 2007; De Haan, 2008; Dutta et al., 2008).

Providing direct support through R&D grants

The first course of action was establishment of the Office of the Chief Scientist (OCS) in 1969 as part of the Ministry of Industry, Trade, and Labour. The OCS's objective was to increase industrial R&D by addressing market failures without targeting specific sectors or technologies (Breznitz, 2007). The OCS implemented a series of horizontal industrial and technological policies (HTPs). "HTPs are a defined set of industrial innovation policies that are neutral in terms of sectors, industries, or technologies, and aim to encourage the maximization and institutionalization of R&D activities by private companies" (Breznitz, 2007, p. 1466).

The first program, which continues to this day, provided conditionally repayable grants for industrial R&D. Qualifying firms submit grant applications for specific R&D projects that are reviewed by a Research Committee chaired by the Chief Scientist (Trajtenberg, 2002). If approved, applicants receive a grant covering 20 to 50 percent of the approved R&D expenditure budget (Trajtenberg, 2002). Priority is generally given to projects that result in know-how and technology, and that lead to either new products and processes or improvements in existing ones (Trajtenberg, 2002). Conditions for grant approval are enshrined in the 1984 Law for the Encouragement of Industrial Research and Development[56] and require recipients of R&D grants to abide by the following: (1) the R&D project must be executed by the applicant firm; (2) the product(s) that emerge from the R&D project must be manufactured in Israel; (3) know-how acquired from the R&D efforts may not be transferred to third parties (Trajtenberg, 2002). The latter two conditions have been relaxed recently (Dutta et al., 2008). The annual budget for the R&D grant program, the largest support program for industrial R&D in Israel, is US$300 million and covers an average of 1,000 projects from 500 companies (Dutta et al., 2008).

[56] Enactment of the 1984 R&D Law was a notable milestone in Israel. A key provision was that the OCS would have an unlimited annual budget for R&D grants so all approved projects to develop high-tech products would receive grants (a budget limit, however, was introduced in the 1990s).

If the products and processes from government-sponsored projects are commercially successful, the company must pay the government royalties amounting between 3 and 5 percent of total annual product sales up to the value of the grant (Trajtenberg, 2002). The OCS's grant outlays and paybacks are presented in Table 3 for the period 1988 to 1999. The table shows that the payback to grant ratio has risen over time, increasing from 7 percent in 1988 to 32 percent in 1999. After implementation of the OCS grant scheme, industrial R&D rose rapidly in Israel.[57] From 1969 to 1987, R&D spending grew by 14 percent annually, and high-tech exports grew from US$422 million to US$3,316 million (all in 1987 dollars) (De Haan, 2008).[58]

Table 3: The OCS's R&D grants and paybacks (in $US millions), 1988-1999

Year	R&D grants	Paybacks	Paybacks / grants %
1988	120	8	7
1989	125	10	8
1990	136	14	10
1991	179	20	11
1992	199	25	13
1993	231	33	14
1994	316	42	13
1995	346	56	16
1996	348	79	23
1997	397	102	26
1998	400	117	29
1999	428	139	32

Source: Trajtenberg (2002); Breznitz (2007)

Fostering international R&D co-operation through BIRD

Since the 1970s, the strength of Israel's high-tech sector was in the R&D phase, but weaknesses stemmed from deficiencies in downstream activities (i.e., skills in international marketing and distributional networks) (Dutta et al., 2008). So the focus of government R&D policy shifted to fostering contacts between domestic and foreign companies leading to joint R&D, manufacturing, and marketing (Dutta et al., 2008). To that end, the OCS established Bi-

[57] That is not to suggest that the grant scheme alone caused the growth in R&D.

[58] According to Breznitz (2007), the availability of R&D grants encouraged founders of key companies to return to Israel to establish their companies.

national Industrial Research and Development (BIRD) funds,[59] along with other partnering funding agreements (i.e., Eureka). The annual budgets for the BIRD funds and Eureka are US$23 million and US$16 million, respectively (Dutta et al., 2008). To assist the OCS in the implementation and administration of these agreements, MATIMOP was created—a government agency that generates and implements international co-operative industrial R&D programs between Israeli and foreign enterprises.[60]

Assisting entrepreneurs through technological incubators

Technological incubator programs were also instrumental in developing Israel's high-tech economy. Geared mainly to assisting the new wave of immigrants from the former Soviet Union, the OCS established technological incubators in 1991 to capitalize on the new supply of skilled workers (Dutta et al., 2008). The incubators were initially targeted at Soviet immigrants because many had the technical skills but lacked the know-how required for commercial success (i.e., knowledge of language, financing, and social norms) (Dutta et al., 2008). Today, the incubators promote business start-ups and enable first-time entrepreneurs with innovative ideas to develop them into a business. With a budget of US$30 million, a total of 24 technology incubators have been set up throughout Israel, each with an average of about 10 projects; projects last on average two to three years (Dutta et al., 2008). While 20 percent of the incubators are government funded, 80 percent comes from the private sector (Erawatch, 2009b). Of the 24 incubators, 16 have been privatized (OECD, 2008).

The incubators program is Israel's main producer of start-ups, which in terms of numbers increased five fold over the ten year period 1990 to 2000 (Dutta et al., 2008). Israel now has the world's highest density of high-tech start-ups (Dutta et al., 2008). The success rate of incubator

[59] The first BIRD fund was established jointly by Israel and the United States. BIRD was approved in 1975 and began fostering co-operation between Israeli and US companies (Breznitz, 2007). It funded projects where the R&D was done in Israel and the marketing in the US. BIRD became crucial not only in sponsoring and helping new technology based Israeli firms, but also as an organization that ensured firms had a window into their main market, the US (Breznitz, 2007). BIRD helped entice US multinational corporations such as Intel and Motorola to open R&D subsidiaries in Israel (Breznitz, 2007; De Haan, 2008). Since the US-Israel BIRD foundation, Israel has established other international partnership foundations, including the Canada-Israel Industrial Research and Development Foundation (CIIRD), which was founded in 1994. CIIRD promotes collaborative R&D between firms in Canada and Israel. The governments of Israel and of Canada each contributed CDN$1 million per year, for an initial three-year period. Their commitment was renewed in February 1997 for another three years and in 2000 for an additional 5-year period. An Agreement to set up the Singapore-Israel Industrial R&D Fund was signed in 1996.

[60] For more on MATIMOP, see http://www.matimop.org.il/ (available December 15, 2010).

start-ups is 50 percent,[61] compared with only 10 percent for start-ups in the US (Dutta et al., 2008).

Encouraging university-industry collaboration through Magnet

Designed in 1991, Magnet began operations in 1992 to strengthen university-industry collaboration and exploit untapped, high quality academic research in Israel (Breznitz, 2007). The Magnet program gives a consortium of industrial firms and at least one academic institution multi-year grants (usually three to five years) for up to 66 percent of the total approved R&D budget to develop generic technologies (Trajtenberg, 2002). No royalty payments are required. The consortium shares the intellectual property and agrees to licence the resulting technologies to any local interested party at a reduced cost (Trajtenberg, 2002). In 2005, Israel had 31 consortia and the Magnet program had a budget of US$40 million (Dutta et al., 2008).

Jumpstarting the venture capital industry through Yozma

Israel long lacked the ingredients (i.e., skills, knowledge, and financing) for a well functioning venture capital industry (Dutta et al., 2008). By filling this gap, the Israeli government played a role in creating one of the world's most vibrant venture capital industries. In 1992, the OCS established the Yozma program to jumpstart the venture capital industry.[62] The government provided US$100 million to encourage international venture capital to enter Israel, invest in high-tech firms, and mentor local venture capitalists (Dutta et al., 2008). International venture capital firms created ten funds, through matched government money, that were led by Israeli managers (Dutta et al., 2008). Private investors were offered the option to buy back Yozma's shares at a set price within a five year window. Yozma had a fixed duration (operational until 1997) and was eventually privatized with the government selling its interest to the private sector.

By many accounts, Yozma successfully jumpstarted the private Israeli venture capital industry and became a model of venture capital policy worldwide (Dutta et al., 2008; Breznitz, 2007).[63] In 1990, Israel had two venture capital funds, managing US$59 million.[64] By 2000, over 50 venture capital firms raised US$9.4 billion. In that year, Israel raised US$600 per capita in

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[61] Success is measured as the ability to raise private funding to allow the company to operate for at least two years.

[62] Prior to Yozma, the Inbal program was intended to fill the venture capital void but the program failed (Breznitz, 2007).

[63] It is possible and indeed likely that the venture capital surge was driven by other factors independent of Yozma.

[64] The data in this paragraph are taken from Dutta et al. (2008).

venture capital, compared with US$30 per capita in Europe, making it the most attractive high-tech market outside the US. The level of Israeli domestic venture capital as a percentage of GDP is now the highest in the world, with multinationals playing a significant role.

6.1.4 Summary

Summarized below are what I consider to be the main factors accounting for Israel's success.

- Nature of public policies for innovation support. While the OCS's R&D policies were instrumental for Israel's success, certain characteristics deserve attention.
  - Neutrality. Israeli innovation policy involves much government intervention but it remains market friendly. The guiding principle of the intervention has been "neutrality" toward private sector innovation activity, with focus on remedying market failures in innovation rather than on seeking to pick winners.
  - Industry driven. Israeli innovation policy is driven by industry. In submissions for public support of R&D, the principle for choosing research topics is bottom-up, with firms actively involved in the process (i.e., submitting proposals).
  - Holistic and responsive to changing needs. The OCS's policy interventions adapted well to changing industry needs over time, and programs and interventions accounted for the whole spectrum of the innovation process. For example, the OCS focused on international orientation (selling innovative products on global markets) since the domestic market was too limited. The OCS also helped jumpstart the venture capital industry after recognizing the lack of domestic capabilities. All told, programs covered everything from basic to applied R&D.
  - Direct support versus tax incentives for R&D. The main form of support to industrial R&D in Israel is direct (through grants, repayable and conditionally repayable loans); Israel does not have a system of tax credits for R&D.
- Centralized policy making. Israel started its independence as a highly socialist economy with government exerting significant control over the allocation of resources. This allowed the state to pursue a highly centralized form of industrial policy that other, more advanced countries may find difficult to emulate. In addition, unlike countries such as Canada, Israel has no provincial or regional government to complicate the administration and implementation of innovation policy, enabling greater centralization.

- Strong technical research base and university-industry collaboration. Although Israel's industrial innovation system contained virtually no business R&D until the late 1960s, the country's public and scientific research institutions were global leaders. This strong academic base facilitated the subsequent transition to a knowledge-based economy. To further harness the academic base, the OCS forged links between universities and industry through the Magnet program.
- International orientation and openness to foreign investment. The Israeli innovation system is characterized by strong international links reinforced by OCS programs (i.e., BIRD). R&D is generally performed locally but collaboration with foreign firms allows for technologies developed in Israel to be distributed in international markets. Joint projects and the influx of foreign venture capital allows for Israeli firms to benefit from foreign expertise and financial/management resources. Israel is also relatively open to foreign direct investment (FDI). In fact, investment policies have given preferential treatment to foreign firms.
- Strong military sector. Israel's innovation capability is strengthened by its strong military sector. Mandatory military service ensures a constant supply of highly trained labour into the private sector each year. More generally, the military sector produces spillovers through various channels to the private sector and catalyzes innovation activity.
- Availability of skilled labour. Part of Israel's ability to increase R&D so rapidly is due to a historical accident which provided private industry with a large pool of qualified labour from the immigration of Jews from the Soviet Union throughout the 1990s. The OCS, however, did not rest on its laurels. Through the incubators program, action was taken to capitalize on this fortuitous event.
- Culture. Israeli people are described as having entrepreneurial characteristics, making the country fertile for innovation and enabling a seamless transition to a knowledge-based economy.
- Business environment improvements. The Israeli government has taken steps to improve the investment climate. Among other things, it has reduced the corporate income tax rate.

6.2 Finland

6.2.1 Background and general characteristics

With a population of 5.3 million, Finland is one of the most sparsely populated countries in Europe. Yet it is also one of the world's most competitive and technologically advanced countries. Finland was ranked first three times in the World Economic Forum's Global Competitiveness Report between 2000 and 2007 (Ylä-Anttila & Palmberg, 2007).[65] In 2010, Finland ranked 7th. Its education system is also world class (The Economist, 2008). According to the OECD's Program for International Student Assessment (PISA) surveys, Finnish students consistently register high scores.[66] Tertiary education is of high quality. The World Economic Forum ranks Finland's higher education system as the best in the world. Finland's strong performance in innovation has been matched by strong economic performance. Since the early 1990s, Finland has consistently out-performed peer countries on labour productivity growth rates (OECD, 2008). Highly integrated globally and very open to international trade and investment, Finland had the 16th highest GDP per capita in 2008 at US$35,426. For many years, Finland's economic development rested on natural resources, particularly forestry products. Finland successfully transformed its economy in the latter part of the 20th century, becoming more technologically oriented—a change reflected in the shift of export structures (see Table 4). Pulp and paper accounted for 42 percent of exports in 1960 but only 20 percent in 2003. Over the same period, the share of electronic and electrical industries grew from zero to a third.

Table 4: Percentage of Finnish exports by industry, select years, 1960-2003

Industry	1960	1970	1980	1990	2000	2003
Other	15	15	15	9	9	7
Mechanical wood	27	16	15	8	5	6
Pulp, paper, and graphic	42	40	30	31	21	20
Machine and transport equipment	0	17	18	24	19	18
Electronic and electrical	0	2	4	11	28	33
Basic metal	15	6	7	8	9	10
Chemicals	1	4	11	9	6	6

Source: OECD (2005)

6.2.2 Finnish innovation indicators

Finland is a frontrunner on many innovation indicators (all sourced from OECD, 2008, p. 116-117). The country ranks second in the OECD in terms of GERD intensity at 3.5 percent. BERD intensity is 2.5 percent and among the top performers. Meanwhile, HERD intensity has

[65] The report ranks countries on 12 pillars covering key competitiveness factors such as the quality of public institutions, macroeconomic stability, general business conditions, and innovation performance. See Schwab (2010).

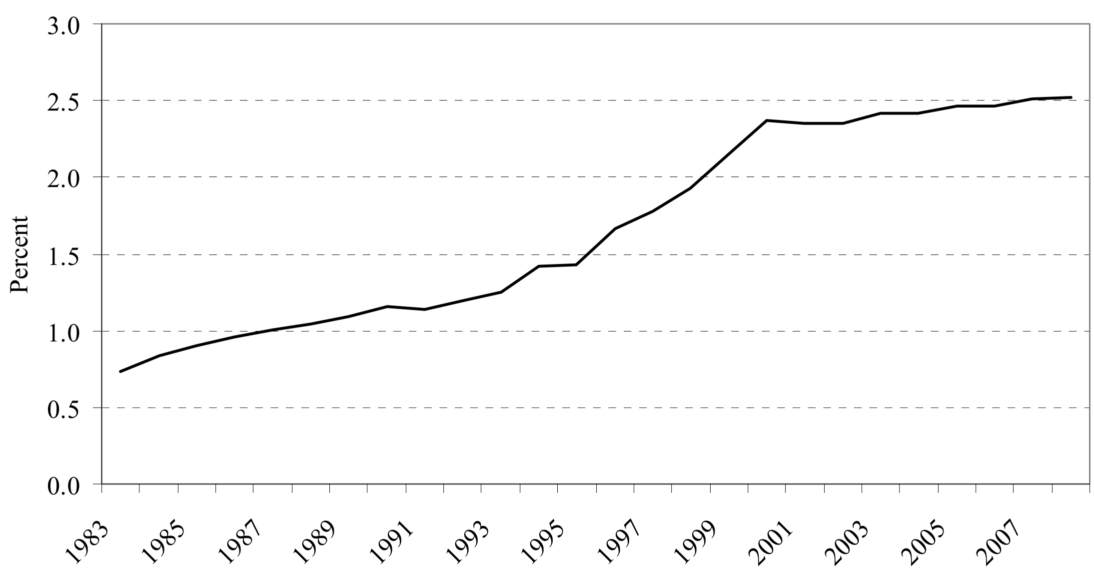
[66] Finland's impressive PISA results for 2009 are: 3rd in reading overall; 6th in math (counting China-Shanghai and China-Hong Kong as two countries ahead of Finland); and 2nd in science. I thank Professor John Richards for this data.

doubled over the past 15 years. Finland leads the OECD in the number of researchers per employed person; it ranks fourth among OECD countries in terms of scientific articles per population and is above average in number of triadic patents per capita. Finnish companies, especially large firms, also rank high in new-to-market product innovations and obtain a substantial share of their turnover from them.

6.2.3 How did Finland do it?

In the following analysis, I highlight the key ingredients that helped transform Finland's economy from its heavy reliance on natural resources to being one of the most technologically sophisticated in the world. Fundamentally, the transformation was driven by the country's strength in innovation and R&D, particularly business R&D which as a percentage of GDP increased more than three–and-a-half-fold from 0.7 percent in 1983 to 2.5 percent in 2008 (see Figure 7). However, the transformation process did not happen overnight; it took several decades to develop. The case study is based mainly on the following sources: Blomström et al., 2002; Georghiou et al., 2003; Häyrinen-Alestalo et al., 2005; Lemola, 2002; OECD, 2005; Schienstock, 2007; Ylä-Anttila & Palmberg, 2007; Toivanen, 2009.[67]

Figure 7: BERD intensity in Finland, 1983-2008



Source: OECD (2009)

[67] I draw heavily from Blomström et al. (2002).

The Finnish model: A systems approach

Finland pioneered the concept of a "systems approach" to innovation.[68] The roots of the Finnish approach to innovation policy strengthened in the early 1980s, when Finland's economy struggled with structural transformation (Blomström et al., 2002). Being a latecomer among European industrialized nations, Finnish policymakers recognized that catching up required increased productivity, specialization, and international competitiveness (Blomström et al., 2002). The goal was to diversify the economy away from forestry and metals towards high-tech areas like electronics and information and communications technology (ICT). A consensus emerged that policy areas traditionally considered separately (education, science/technology, and economic development) were closely linked and needed to be integrated (Blomström et al., 2002). That sparked a systems approach.

Several institutional changes were made during the 1980s to promote R&D (all described in Blomström et al., 2002). Universities were previously not allowed to collaborate with industry but were now encouraged to establish joint projects with the business sector. The Finnish Funding Agency for Technology and Innovation (Tekes) was established in 1983 to finance applied and industrial R&D. In 1987, the Science Council was reformed and renamed the Science and Technology Policy Council (STPC):[69] membership was expanded to representatives from industry and the research community, and the Council's status as an advisory organization was augmented. Targets for R&D investments were set. At the time, GERD intensity was around 1.5 percent and the aim was to reach 2.0 percent by 1990. With limited public resources for R&D, a cluster approach to R&D policy was pursued. By targeting R&D subsidies in industries and companies that belonged to major clusters, resources were concentrated in sectors with stronger prospects for spillovers and technology diffusion. Finnish policy supported clusters rather than individual companies to improve integration, collaboration, and specialization.

These policy choices helped transform the economy's structure (Blomström et al., 2002). By 1990, Finland almost reached its 2 percent R&D intensity target, but a major financial crisis and collapse of the Soviet Union threatened on-going progress (Blomström et al., 2002).[70] GDP

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[68] As Ylä-Anttila & Palmberg (2007, p. 173) explain: "the systems view [is] reflected in an emphasis on … longer-term policies aimed at improving the general framework conditions for companies and industries, particularly in terms of knowledge development and diffusion, innovation, and industrial clusters—formulated through public-private partnerships involving economic research organizations, industry federations, and companies, and anchored in a broader economic policy."

[69] The STPC has since been renamed the Research and Innovation Council.

[70] Prior to the crisis, Finland was heavily dependent on bilateral trade with the Soviet Union—one of the few countries where trade restrictions were low.

contracted three consecutive years between 1991 and 1993; unemployment skyrocketed from 3 to nearly 20 percent; the government budget turned from balance to a large deficit; and public debt grew from 11 to 64 percent of GDP by 1995.[71] R&D targets, however, were strengthened by the crisis as policymakers recognized that structural transformation was necessary to maintain living standards and prepare for membership to the European Union (Blomström et al., 2002). The focus on innovation continued and R&D was one area of public spending that did not receive budget cuts during the crisis (Blomström et al., 2002).

The 1990s saw increased emphasis on a systems approach to innovation policy. Early on in the decade, the first Finnish "cluster study" was commissioned (Blomström et al., 2002). The results were published in the 1993 white paper *National Industrial Strategy for Finland* and called for more interaction between key actors including government, public research bodies, and industry (Blomström et al., 2002). Eventually, the concept of a National Innovation System (NIS) was introduced, emphasizing policy co-ordination across areas. Both cluster policy and the NIS concept underscored the role of government as a "facilitator" rather than "driver" of industrial policy (Blomström et al., 2002); the latter, however, suggested that policy should not favour any particular cluster but should provide an environment for any cluster to emerge. The systems approach led to efforts to improve the business environment through regulatory and institutional reform. Institutionally, Tekes and the STPC played important roles (Blomström et al., 2002). Since establishment in 1983, Tekes has provided between 75 and 80 percent of the public R&D funding for the manufacturing sector (Blomström et al., 2002). Tekes typically funds a significant portion of total business R&D costs in product development projects, and, importantly, its programs often mandate collaboration between industry and universities.

R&D efforts increased rapidly in the late 1990s after commitments were made by the public and private sectors to raise GERD intensity to 2.9 percent by 2000 (Blomström et al., 2002). The target was reached by 1998. While government expenditures on R&D (GOVERD) increased in the 1990s, business R&D grew even faster. Currently, almost 75 percent of total Finnish R&D is performed by the business sector compared to about half in the early 1980s. At just under 70 percent, the privately funded share of total R&D is high by international standards.

The present Finnish system

The Science and Technology Policy Council (STPC) is an advisory body to the government on science and technology issues and is responsible for establishing the broad

[71] All sourced from Blomström et al. (2002).

direction of national innovation policy. The Council is made up of the Prime Minister, various ministers (Education, Trade and Industry, and Finance ministers plus a maximum of four others), and up to ten members representing key stakeholders in the innovation system (such as Tekes, the Academy of Finland, universities, industry, and employer/employee organizations). The Council has a profound impact on Finnish innovation policy (Häyrinen-Alestalo et al., 2005). It plays a major role in balancing interests between different sectors and policies, co-ordinating policy related to science and technology with other policy areas, and diffusing information to major actors in the system. Internationally, the Council is held as an excellent example of a high level body capable of coherent and efficient governance of the innovation system (Häyrinen-Alestalo et al., 2005). In general, an important element of Finnish co-ordination relates to inter-ministerial collaboration (Blomström et al., 2002). That is, the Finnish model attributes importance to establishing a strong foundation for policy co-ordination within the public sector. In addition, collaboration between universities and industry is strong internationally (see Figure 10).[72]

Tekes is the main organization for Finnish innovation policy making (the following is described in Toivanen, 2009).[73] It is the sole source of funding for R&D subsidies. It also provides expert advice and promotion of national and international networking. In terms of R&D subsidies, Tekes provides a maximum subsidy of 50 percent of incurred costs for large firms, 60 percent for medium sized enterprises, and 70 percent for small businesses. Funding limits are exceeded in certain cases. Tekes also funds feasibility studies and some university research. It receives around 3,000 applications annually (half for business R&D projects), and about two thirds are accepted. Tekes grants a total of 300 million Euros in subsidies and loans spread across small, medium, large sized enterprises. Some special funding arrangements are designed in close co-operation with industry. Tekes uses three funding instruments to disburse R&D subsidies: grants, low interest loans,[74] and capital loans. Firms often interact with Tekes officials before submitting an R&D subsidy application. Tekes screens the application on a various dimension upon receipt. Tekes attempts to evaluate all of its programs, undertaking research to assess the impact of its policies.

[72] See also OECD (2007).

[73] See Toivanen (2009) for further details on the current Finnish innovation policy environment, including a description of the roles and responsibilities of the main public sector organizations.

[74] The low interest loans are subject to soft budget constraints—that is, if recipient firms demonstrate the R&D project failed, then Tekes waives repayment in part or completely (Toivanen, 2009).

Underlying factors

In addition to adopting a systems approach to innovation, several underlying factors have contributed to Finland's success—some of which reflect the systems approach. I next discuss those factors.

Pro-market reforms and increased competition

After the financial crisis, industrial policy shifted to a more market oriented approach, and this had a positive impact on Finland's structural transformation (OECD, 2005; Häyrinen-Alestalo et al., 2005). As late as the 1980s, Finland was a relatively closed economy with many monopolies and cartels, state-owned enterprises, price regulations, and international trade restrictions. Change in the market environment started in the late 1980s with abolition of price controls; capital market liberalization and European Union membership soon followed. In particular, liberalization of the telecommunications sector in Finland began well before most other industrialized countries and set the stage for development of the ICT sector. Of note, the Finnish government used money from privatization initiatives to finance large increases in public R&D and to upgrade the country's education infrastructure (Blomström et al., 2002).

Finnish industrial policy was transformed by the mid 1990s. Emphasis went from supporting ailing industries and picking winners to improving the overall operating conditions for industry (Yla-Antilla & Palmberg, 2007). With increasing international mobility of capital, policy aimed to make the country a more attractive place for business activity. Opening the economy to competition strengthened and diversified international trade; it also increased demand for new products and created new opportunities for Finnish companies. The impact of deregulation was strongest in telecommunications which helped the ICT sector flourish (OECD, 2005; Blomström et al., 2002). A thriving ICT cluster and deregulated telecommunications sector also attracted foreign firms (and capital) to Finland.[75]

Strong ICT cluster and the "Nokia effect"

Finland's quick recovery from the recession and strong economic performance during the late 1990s was driven in large part by the ICT cluster. While policies played a role, some observers conclude that the success of private companies (Nokia and others) was mainly responsible (Yla-Antilla & Palmberg, 2007). They argue that, despite outward appearance, there was no "master plan" aimed at promoting the deep structural change and expansion of the ICT

[75] Ericssson, Siemens, ICL, and Hewlett-Packard are just a few examples of foreign firms that located R&D facilities in the country to benefit from possible spillovers of technology and skills.

sector. In fact, Nokia alone is mainly responsible for the growth in Finnish business R&D over the last two decades, accounting for between 40 and 50 percent of total BERD.

Supply of (venture) capital

Until the mid 1980s, Finland lacked a well developed risk capital market, presenting weak conditions for entrepreneurship and financing start-up companies. But a vibrant venture capital market emerged following liberalization of the financial sector, providing new financing opportunities for innovative high-tech firms to enter the market at a relatively early stage of product development (Blomström et al., 2002). The amount of venture capital investment increased more than tenfold between 1995 and 2000 with roughly one-third of private equity investment in Finland going to ICT during the period (Blomström et al., 2002).

Growth and internationalization of the Helsinki Stock Exchange (HEX) also provided capital for development (Blomström et al., 2002). With the ratio of stock market capitalization[76] to GDP at below 20 percent and with limited foreign portfolio investment until the early 1990s, the stock market was not a very important source of capital (Blomström et al., 2002). After Nokia's breakthrough, the stock market capitalization rate rose to well over 200 percent of GDP by 2000, with around 70 percent of shares held by foreigners (Blomström et al., 2002). Many companies besides Nokia had significant foreign ownership as well (Blomström et al., 2002).

Increased human capital support

The availability of skilled labour helped the growth of Finland's ICT sector. In particular, the case of Nokia shows that the initial breakthrough in the telecommunications sector was made possible by the availability of specialized skills (Blomström et al., 2002). By the early 1990s, a shortage of skilled labour prompted an expansion of higher education. The total intake in universities nearly doubled between 1993 and 1998, and a system of polytechnic higher education was established along with a graduate school system (Blomström et al., 2002). Polytechnics are a relatively new form of non-university higher education in Finland; they were instituted during the 1990s in response to rapid economic development to raise the level and quality of Finnish education and training. They offer more practically and vocationally oriented options in higher education.

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[76] Stock market capitalization refers to the total market value of publicly traded shares.

Culture

Cultural factors—such as homogeneity, egalitarian values, and small socio-economic differences between groups—helped Finland's modernization (OECD, 2005). Finnish people are also described as having strong trust in technological solutions to overcome economic challenges (OECD, 2005). In addition, Finland has a consensual political climate on issues related to science and technology policy (Häyrinen-Alestalo et al., 2005). Sharp political divisions rare and policy decisions are centralized in closed processes of deliberation and negotiation. That facilitates effective policy making.

Demand factors

Finally, demand factors such as rapid technology adoption and competition in domestic clusters helped Finland transition to a knowledge economy. Because Finnish consumers are open-minded, they accept new products and services with relative ease (OECD, 2005). As a result, diffusion of new technologies is rapid. Finnish trade unions also openly accept and apply new technologies. And a high willingness to apply new technology exists in the public sector as well. Business demand in the production chain offers further opportunities to develop technology (Blomström et al., 2002). Overall, Finnish end users spark innovation through demand channels.

6.2.4 Summary

Summarized below are what I consider to be the main factors accounting for Finland's success.

- Systems approach to innovation. Finland focused early on science and technology policy and was the first to adopt a systems approach to innovation policy. The Finnish approach views innovation and R&D policy in the context of a national innovation system, which acknowledges the multitude of factors that influence innovation outcomes (the business environment, demand conditions, openness to trade and investment, university-industry collaboration, government support, etc.). A systems approach attempts to use resources efficiently and to identify bottlenecks and obstacles to innovation. Such an approach requires policy consistency and a long term view on the part of government.
- Cluster policy and emphasis on specialization. As a small country with limited public resources, Finland R&D support was channelled to certain industries. Clusters were identified on the basis of existing comparative advantages. To facilitate specialization,

Finnish innovation policy promoted linkages, knowledge flows, and technology diffusion within clusters.

- University-industry collaboration. Collaboration between universities and industry is strong in Finland. This was facilitated by Tekes, which often mandated collaboration as a condition for receiving public R&D funds. The condition applied to both industry and universities.
- Industry driven innovation policy. Finland made major advances in developing a co-ordinated national innovation system with frequent consultation from industry and highly developed linkages between industry and government (for example, industry is represented on the Science and Technology Policy Council). The Council recognizes that all the main actors in the innovation system including industry, universities, labour organizations, and other central players must be represented in the policy discussion. It is a major force in decisions about industrial and innovation policy.
- Government support for R&D. The Finnish government supports R&D exclusively through direct means (i.e., grants) and historically has targeted that support to specific clusters to achieve the greatest potential for knowledge spillovers.
- Policy co-ordination. Finnish innovation policy is well co-ordinated. The Science and Technology Policy Council and Tekes play important roles in this regard. As a central agency for industrial R&D support, Tekes clarifies and simplifies the support process for firms.
- Culture. Finnish culture helped the country transition to a knowledge-based economy. Finnish people are described as having strong trust in technological solutions. A consensual political climate among actors in the system also facilitates decision making on issues of science and technology.
- Business environment improvements and deregulation in key sectors. Innovation policies played an instrumental role in Finland's transformation, but they were not the only factors. The transformation took off only after significant reforms to the business environment were implemented, particularly reforms that opened the country to international trade, investment, and competition. Early deregulation of the telecommunications sector was especially critical. Openness helped Finland benefit from international spillovers, gain access to foreign capital, and spark competitive pressure.
- Strong human capital base and expansion of skilled labour. A strong initial human capital base plus later expansion of skilled labour through upgrades to the educational system

(i.e., creation of polytechnic schools) provided the inputs for R&D and innovation to flourish.

6.3 Sweden

6.3.1 Background and general characteristics

Sweden is a Nordic country located on the Scandinavian Peninsula in Northern Europe, bordering Norway and Finland. Its land mass is large by international standards but its population is only around 9 million. In 2008, Sweden had the 9th highest GDP per capita in the world at US$37,383. The World Economic Forum's 2010 Global Competitiveness Report ranked Sweden 2nd in the world. The Swedish economy is characterized by a large knowledge-intensive and export-oriented manufacturing sector that is dominated by large enterprises.[77] Key sectors include engineering industries (i.e., transport equipment), forestry (i.e., wood and pulp and paper), information and communication technology (i.e., telecommunications), and biotech and life science industries (especially pharmaceuticals) among others.

6.3.2 Swedish innovation indicators

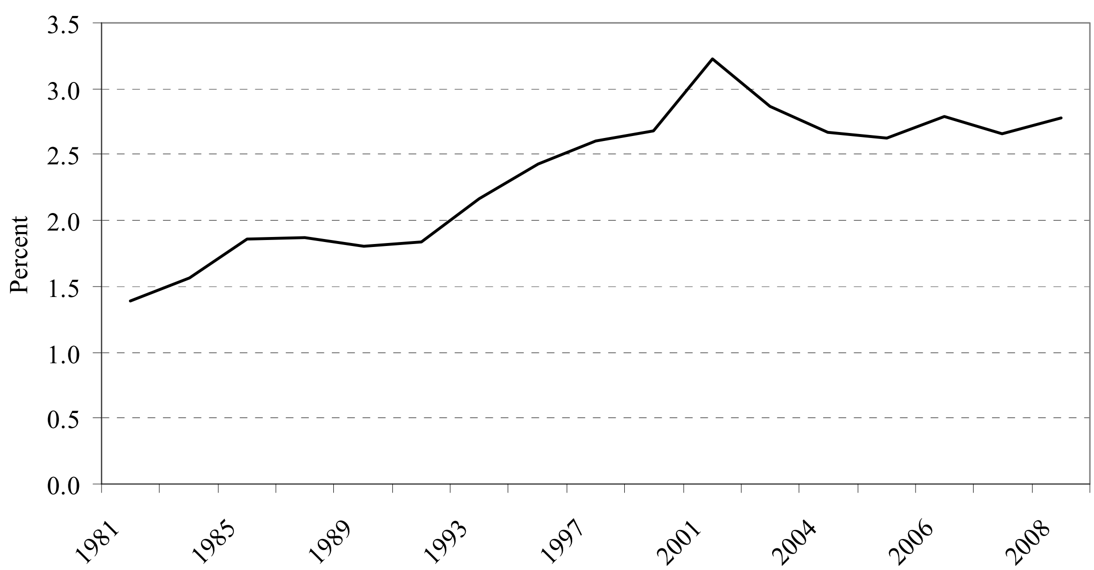
Sweden performs well on several indicators of innovation (all sourced from OECD, 2008, p. 154-155). At 3.8 percent, its GERD intensity leads all OECD countries and is second in the world only to Israel. BERD intensity is also high at 2.8 percent compared to the OECD average of 1.6 percent. Higher education R&D (HERD) spending as a share of GDP is highest in the OECD (0.8 percent). Sweden has 12.6 researchers per 1,000 total employed persons, second only to Finland. Sweden also has one of the highest graduation rates in advanced research programs (PhD or equivalent) among OECD countries; however, the number of science graduates per 100,000 employees is just below the OECD average and behind Finland. Scientific publications have increased since the 1990s to reach 1,109 articles per million population in 2005, placing the country second only to Switzerland. The output is of high quality; in 2003 Sweden ranked fourth worldwide in terms of citations of scientific literature. University-industry collaboration is strong but dominated by larger firms, consistent with the country's industrial make-up.

[77] Among the largest companies registered in Sweden (by turnover) are Volvo, Ericsson, Vattenfall, Skanska, Sony Ericsson Mobile Communications AB, Svenska Cellulosa Aktiebolaget, and Electrolux. IKEA began in Sweden and but is now controlled by Almhult in the Netherlands.

6.3.3 How did Sweden do it?

Figure 8 presents Sweden's BERD intensity from 1981 to 2008; it shows strong historical performance along with steady increases. The Swedish case is an interesting one. Unlike the other countries studied here, it provides a unique perspective on the role of history in achieving current innovation success. It also offers insights on policy decisions that could put R&D activities at risk. In the end, Sweden has come full circle: while a formal innovation policy was virtually non-existent in the past, attempts have been made recently to change course and integrate industrial policy with technical based research policy, two historically separate tracks. The case study is based mainly on the following sources: Blomström et al., 2002; OECD, 2005; Andersson & Ejermo, 2005; Hedin et al., 2008; Granat Thorslund et al., 2005; EURAC Research, 2006.[78]

Figure 8: BERD intensity in Sweden, every two years, 1981-2008



Source: OECD (2009)

History matters: Sweden's industrial policy

Sweden's strong business R&D performance is largely a by-product of historical policy choices. For nearly a century, Swedish industrial policy has supported the development of a highly concentrated industry structure with a few large firms devoting considerable resources to R&D. Table 5 displays some large firms that have dominated Swedish industry, all of which were founded long ago on major inventions. Since the emphasis of Swedish industrial policy has been

[78] I draw heavily from Blomström et al. (2002).

on large firms, I focus on the historical context. The predominance of large firms, after all, largely explains the country's high R&D output.

Table 5: Old and large Swedish multinational companies built on major inventions

Company (founding year)	**Invention (year)**	**# of employees globally (in 2002)**
Asea (1883, 1890)	Triple phase electrical system (1879)	139,051
Electrolux (1901)	Vacuum cleaner (1915)	81,971
Ericsson (1876, 1918)	Automatic telephone switchboard (1886)	73,420
SKF (1907)	Self-aligning ball bearing (1907)	39,739
Sandvik (1862)	Ingot steel production (1862)	37,388
Atlas Copco (1873)	Pneumatic hammers (1901)	25,787
Tetra Pak (1951)	Packaging system for liquid food products (1945)	20,900
AGA (1909)	Gas storage system (1906)	9,821
Alfa Laval (1883)	Continuous cream separator (1878)	9,125
Nitroglycerin Compagniet (1865)	Dynamite (1867)	4,300

Source: Andersson & Ejermo (2005)

Ever since the Social Democrats (a left wing political party) were voted into power in 1936, Swedish industrial policy has emphasized "efficient production" in large firms and "competitive exports" as necessary foundations for increasing living standards and building a welfare state (Granat Thorslund et al., 2005). Following World War II, a corporatist approach was adopted, characterized by a shared interest and compromise between labour unions and big businesses.[79] That strange arrangement aided the internationalization and growth of Swedish industry in two ways (Blomström et al., 2002, p. 26).

> First, industrial policy supported growth with a strong bias in favour of large firms: given the limited size of the domestic market, the response of large firms was often to grow even larger by expanding foreign operations. Secondly, unlike labour unions in many other parts of the world, the Swedish labour movement did not oppose investment abroad by Swedish [multinationals]. The

[79] As Granat Thorslund et al. (2005) recount: after World War II, Sweden experienced a boom. Exports and world market shares grew rapidly during the 1950s and 1960s. Sweden was well positioned for the boom; the country's industrial capacity was intact because Sweden stayed out of the war and it was specialized in producing the goods that were needed to rebuild war-torn Europe. Of note, during this period a compromise was made between Swedish unions and industry. In return for rapidly increasing wages and employment, Swedish unions accepted continuous restructuring and rationalization of industry. On the other hand, industry accepted high rates of taxation and focused on internal production efficiency.

> establishment of foreign affiliates was instead seen as a necessity to keep foreign competitors at stake.

Historically, the main policy instruments in Sweden to support large, internationally oriented firms have been tax policy, credit market regulations, R&D policy, and public-private partnerships (Blomström et al., 2002; Granat Thorslund et al., 2005). I next discuss each of these instruments.

Tax policy

Swedish tax policy has favoured large, established firms at the expense of smaller, younger, and less capital-intensive firms (Blomström et al., 2002). While statutory corporate income tax rates historically have been high (around 60 percent),[80] a large gap existed between the statutory and effective rate due to generous deductions and allowances available for certain investments. In addition, untaxed profits could be put aside in special investment funds for future use.[81] These tax arrangements mainly benefited large, capital-intensive firms. Moreover, with dividends being taxed at very high marginal rates, this provided another motive for companies to retain capital and grow larger. According to Blomström et al. (2002), shareholders didn't mind because the increased value of their shares was typically larger than the after-tax dividend.

Credit market regulations

Swedish credit market regulations also favoured big business (see Blomström et al., 2002). Until the 1980s, credit markets were heavily regulated and lending to industry was subject to quantitative restrictions. In response, commercial banks directed most of their lending to larger, older, and more successful companies as well as to capital-intensive companies with sufficient collateral.

R&D policy

Since 1967, the Swedish government has undertaken measures to encourage businesses to increase spending on R&D which was already world leading at the time (Blomström et al., 2002). Businesses were allowed to make extra deductions for R&D costs, while the government channelled funds to support R&D infrastructure in industry (i.e., through technical research

[80] The current statutory rate is 28 percent.

[81] Untaxed profits include retained earnings, the portion of a corporation's profit that it does not pay in taxes and does not distribute to shareholders. This is an important source of financing for investment. In addition, untaxed profits can result from large diversified companies cross-subsidizing loss-making activities.

projects and co-operative ventures). Because larger firms are major R&D performers, big businesses benefited from these policies.

Public-private partnerships

Close relations between government and leading industrial corporations is an aspect of Sweden's industrial policy that deserves attention. In certain sectors, the Swedish government has been a major customer of big manufacturing firms, sometimes undertaking joint long-term R&D projects (Granat Thorslund et al., 2005). Multinationals like Ericsson and ASEA have benefited greatly from such public procurement (or "public-private partnerships") as they subsequently marketed their technological innovations abroad. According to some observers, the interaction between the public and private sectors accounts for a sizable share of the growth of large firms and private R&D spending in Sweden (Granat Thorslund et al., 2005).

Crisis and subsequent reforms

Five crises hit the Swedish economy between 1991 and 1993 (Blomström et al., 2002): the Swedish real estate market collapsed (75 percent fall in prices); the stock market bubble burst; the financial market went into deep crisis; a currency crisis developed, forcing Sweden to abandon its fixed exchange rate system; and finally a crisis in the real economy occurred (business investment fell, labour demand declined, and unemployment rose).[82] As the crisis hit, Swedish industrial policy was no longer sustainable. The Swedish banking system was restructured and the financial system recovered. Banking sector reforms were joined by reforms in other parts of the economy that improved the business environment and set the stage for rapid R&D growth throughout the 1990s (Blomström et al., 2002). Reforms included:[83]

- Better macroeconomic conditions (i.e., low inflation, price stability, and reduced unemployment).
- Dramatic business and personal income tax cuts. The statutory corporate income tax rate was reduced from 60 percent in 1989 to 30 percent in 1991 and further to its current rate of 28 percent in 1994. While Sweden's statutory rate has fallen considerably, its current marginal effective tax rate (METR) is even lower at 19.5 percent.[84] The 1991 tax reforms also reduced the highest marginal rate on personal income to around 50 percent from 70 percent.

[82] All sourced from Blomström et al. (2002).

[83] These reforms are described in Blomström et al. (2002) and Andersson & Ejermo (2005).

[84] In 2004, Sweden's METR was lower still at 11.2 percent (McKenzie & Sershun, 2010, p. 311). I do not know the rate immediately following the tax reforms.

- Increased higher education funding. The Swedish government invested massively in higher education to turn the economic tide. Currently, Swedish attainment in tertiary education is around the OECD average whereas it was significantly below before the large expansion of the 1990s. Education reform expanded universities and colleges, and various adult education programs.
- Deregulation and market liberalization in key sectors including telecommunications, electricity, and housing. Integration with world markets followed after the crisis.

The new Swedish model

While Sweden's business R&D intensity increased during the 1990s, the globalization of R&D and production caused policymakers to rethink the old Swedish model (Granat Thorslund et al., 2005). During the 1990s, many flagship companies were taken over by foreigners while at the same time Swedish companies expanded R&D operations abroad. Policymakers viewed this as weakening previously strong links with the Swedish home base. With increased globalization, Swedish innovation policy was set to change. Instead of supporting certain industries or projects through subsidies and public procurement, the government recognized the need to compete globally for investment by providing an attractive environment for innovation, R&D, and production.

While talk about adopting a systems approach to innovation policy (like Finland) floated around in the early 1990s, nothing concrete materialized (Granat Thorslund et al., 2005). So the old Swedish model, which viewed research policy and industrial policy as two separate tracks, persisted. The first steps to a broader approach to innovation policy were taken in 2001 with the establishment of Vinnova (the Swedish Governmental Agency for Innovation Systems) (Hedin et al., 2008). Vinnova administers government funding for R&D (including business R&D); its overall goal is to promote the development of efficient policies across a number or priority areas. In 2004, Swedish research and industrial policies were officially combined into a united innovation policy (Hedin et al., 2008). The white paper *Innovative Sweden—A Strategy for Growth through Renewal* was then adopted as a framework for developing innovation policy. Most notably, the strategy takes a broader approach to innovation policy. It is centered on four priority areas: knowledge base for innovation; innovative trade and industry; innovative public investment; and innovative people.[85] It recognizes that investments are becoming increasingly mobile internationally and that Sweden must remain competitiveness along many dimensions to be an attractive place for multinationals to invest. These dimensions include: a strong human

[85] See http://www.sweden.gov.se/content/1/c6/03/25/51/29e722a9.pdf (available December 15, 2010).

capital and research base, R&D collaboration between industry and universities, competitive business taxes, regional specialization (clusters), innovation capacity among small firms, networking among businesses, commercialization of university research, entrepreneurship, financing for risky ventures, increased competition in industries, etc. A combined focus on these areas is a marked shift in economic policy making for Sweden and is indicative of the country adopting a systems approach to innovation.

6.3.4 Summary

Summarized below are what I consider to be the main factors accounting for Sweden's success.

- Historical policies that promote big businesses. Swedish industrial policy has long provided more generous support for large firms and a handful of those helped bolster Sweden's R&D output.
- An improved business environment. The old Swedish model survived as long as multinationals were tied to their home country. But globalization caused the Swedish government to rethink its strategy and compete for investments by providing an attractive environment for innovation, R&D, and production.
- Systems approach to innovation policy. Sweden realized—although later than Finland—that a systems approach to innovation policy is necessary. This required integration of technical based research and industrial policy.
- Co-ordination. Co-ordination of innovation policy has received greater attention in Sweden, particularly with the creation of Vinnova, but challenges stemming from old institutional structures may impede progress.
- Government support for R&D. Sweden, like both Israel and Finland, relies exclusively on direct R&D support to spur innovation. In the past, the Swedish approach was to disburse funds through public procurement of technologies (so-called public-private partnerships).
- Openness to trade and investment. Deregulation of key sectors (such as telecommunications) facilitated innovation and growth.

6.4 Comparative analysis

This sub-section has two parts. In the first, I group commonalities observed in the case study countries and through comparative analysis draw implications for Canada. In the second, I highlight unique observations in the case countries and again draw implications for Canada. The ultimate purpose of the comparative analysis is to assist in formulating policy options for Canada to increase R&D in the business sector.

6.4.1 Commonalities among case countries and implications for Canada

Despite their diversity, the three case countries have a series of common factors that contribute to their success in innovation. I highlight general similarities based on my own assessment.

Direct support for business R&D

None of the case countries uses a system of tax credits for R&D; instead they all rely exclusively on direct R&D support. In fact, all three countries slightly tax rather than subsidize R&D expenditures through the tax system (see Figure 5). But differences exist in how public funds for direct support for business R&D are disbursed. Israel uses a neutral approach, not favouring particular firms, industries, or sectors. Finland employs a cluster policy approach to facilitate specialization in sectors where Finland has a comparative advantage (i.e., ICT). The principle of cluster policy is that small countries can't be jacks of all trades and instead must direct scarce public resources for innovation in areas where they hold comparative advantages. Sweden, at least historically, channelled direct R&D support mainly to large firms through public procurement of technologies.

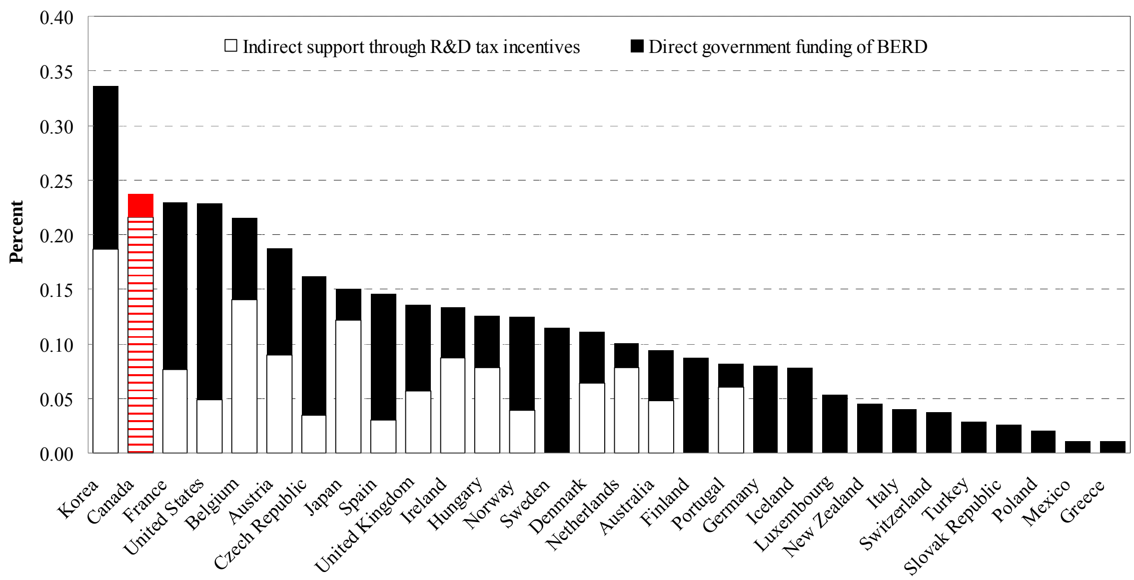
Implications for Canada

Government support for business R&D in Canada uses a mix of direct and indirect measures but support is heavily skewed toward indirect forms such as R&D tax breaks (see Figure 9).[86] In addition, the share of business R&D in Canada that is financed directly by government (2.3 percent) is low compared to the case countries (4.6 percent in Israel, 4.3 percent in Sweden, and 3.5 percent in Finland). While direct R&D support is relatively low in Canada, on the whole Canada maintains one of the most generous support systems for business R&D in the world. But since none of the case countries employ R&D tax incentives, and since some countries with higher business R&D output than Canada don't either (i.e., Switzerland, Germany, Iceland, and Luxembourg), an alternative course for Canada is to shift the focus of support from tax credits to direct subsidies including grants for business R&D. Such a shift would, of course, encounter the thorny issue of picking winners (more on this later). While a system of refundable tax credits might achieve a similar goal without political interference, direct support might permit

[86] Data for Israel were not available.

greater (and perhaps better) discretion as to which projects or firms get support. For instance, it would allow for targeted support of innovations with large social returns but low success probabilities. R&D tax incentives, on the other hand, are more neutral and broad-based in nature. Or, unlike indirect support provided through the SR&ED program, direct support can be channelled to companies regardless of profitability. For the non-refundable aspect of the SR&ED program, firms can apply the tax credit only to earned income. Moreover, direct support may better ease short-term liquidity constraints than tax credits, particularly for small firms, facilitating R&D that would not otherwise occur.

Figure 9: Direct and indirect government funding of business R&D as a percentage of GDP, 2007 or latest available year



Source: OECD (2010)

A systems approach to innovation policy

The systems approach has been adopted implicitly or explicitly by all case countries (at different times in their development). The systems approach to innovation policy accounts for all the important factors that drive and facilitate innovation and their interactions. R&D policy cannot be viewed in isolation; it must recognize the supporting roles of human and venture capital, the business environment, the interaction between key actors such as universities and industry, and demand conditions. In Israel, the OCS's approach to innovation policy did not use the terminology of national innovation system explicitly, but its actions demonstrated such an approach, providing support to firms in various stages of the innovation process and ensuring strong conditions for innovation to flourish. Finland was the first country to explicitly adopt the concept of a national innovation system in practice and in policy discussions. Sweden was slow to adopt the systems approach and instead relied on large firms and flagship industries for innovation. When it became apparent that the model was unsustainable, the government took action and officially adopted the systems approach.

Implications for Canada

The federal government's last two official innovation strategy documents—*Canada's Innovation Strategy 2002* and the more recent *Mobilizing Science and Technology to Canada's Advantage 2007*—have emphasized a systems approach to innovation policy (see Government of Canada, 2002; 2007). However, the explicit language of national innovation systems is absent from both documents. The current strategy, Mobilizing S&T, is structured around the concept of creating an advantage in three areas: entrepreneurship, knowledge, and people.[87] Policy commitments have been made within each area to address related areas of strengths and weaknesses in the Canadian R&D environment, with the overarching goal of improving commercialization of university research and private sector R&D. A total of 36 policy commitments and 40 actionable initiatives are listed, affecting a range of policy areas. Specific commitments include changes to: competition and investment policy; the Scientific Research and Experimental Development (SR&ED) tax credit program; policies affecting labour mobility; and the regulatory environment as it affects key technology areas such as nanotechnology, biotechnology, and ICT. On top of this, Canadian R&D policy is making concerted efforts through its various programs to encourage interaction between science-based research performed at universities and applied industrial research. Recognition by the federal government of the multi-faceted aspect of innovation is encouraging and shows Canada is on the right path in this regard.

Industry-driven innovation policy

While the case countries generally adopt a systems approach, the needs and representation of industry are at the heart of innovation policy. In Israel, innovation support has responded to industry needs at various times indicating a focus on commercially-driven research. Proposals for public R&D support are judged on basis of demonstrated benefits and marketing potential. Support in Finland is industry-driven in two ways. First, industry members participate

[87] See Creutzberg & Low (2007) for a summary of this document.

actively in setting the innovation policy agenda through representation on the Science and Technology Policy Council (STPC). Second, support for R&D is based on existing comparative advantages and is responsive to industry needs. Sweden recently abandoned its traditional approach to innovation policy in favour of a more integrated approach (at least on paper). The traditional approach viewed technical research (i.e., university research) and related policies as separate from industrial needs. Thus, research and industrial policy were devised separately.

Implications for Canada

Starting in the 1990s, Canadian innovation policy began focusing more on support for research performed at universities rather than research driven by market demands. Universities, the theory goes, are well equipped for the "R" in R&D, while the private sector's advantage lies in the "D." The intent to use the private sector to commercialize new university discoveries follows from a linear view of the innovation process. However, commercially valued research projects are best determined by the private sector where the demands and pressure to innovate come from.

Canada's current innovation strategy includes reforms that increase industry representation on research granting council boards including a new tri-council private sector advisory board for granting councils (Creutzberg & Low, 2007). The strategy also outlines a number of new initiatives with the needs of industry in mind, ranging from consultations with industry on how to improve the R&D tax credit system (SR&ED program) to business led Network Centres of Excellence. In terms of broad policy advice, a relatively new outfit has been created—the Science, Technology, and Innovation Council (STIC)—that replaces three other advisory bodies. The STIC consists of 17 members from industry, academia, and public research institutions. It is tasked with providing policy advice on science and technology issues, reviewing research priority areas, and producing regular "State of the Nation" reports that benchmark Canada's science and technology performance against international standards (Creutzberg & Low, 2007).[88] My interpretation of recent policy changes is that Canadian policymakers are realizing that innovation policy must be industry driven. This is demonstrated by increased private sector involvement on matters pertaining to policy formulation and implementation. However, it is too early to know whether the changes have had the intended effect on innovation and economic outcomes.

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[88] See STIC (2009) for the latest report.

Coherent innovation policy

All case countries have special public agencies and institutions that co-ordinate national innovation policy and ensure a coherent and efficient functioning innovation system. In Israel, the OCS has long played this role (since 1969). In Finland, Tekes (since 1983) and the Science and Technology Policy Council are the responsible authorities (since 1987). Sweden recently created Vinnova (in 2001) to promote development of efficient innovation systems.

Implications for Canada

Canada has long pursued the objective of horizontal policy co-ordination in past science and technology strategies and reports (Creutzberg & Low, 2007). But with multiple sites of policy leadership and development across government departments and agencies, Canada has no comprehensive oversight of its innovation policy mix (Creutzberg & Low, 2007). Nor have efforts been made to examine effectiveness of the mix or relative importance of the various policies (Creutzberg & Low, 2007).

Canada is also plagued with the complexity of governing a national innovation system within a federal governance system marked by shared jurisdiction in key R&D and innovation related policy areas. This is something the case countries do not face. The provincial governments, though much smaller funders of R&D than their federal counterpart, are significant contributors to the innovation system through their own set of R&D policies and programs. Many of these policies and programs, while relatively low cost, can have important interaction effects with policies and programs at the federal level (Creutzberg & Low, 2007). This introduces a need for multi-level co-operation and co-ordination of the system. Perhaps Canada needs a national agency to co-ordinate and oversee the innovation system, bringing coherence to the wide array of federal and provincial policies and programs.[89] A central go-to body could be developed that parallels the OCS in Israel, the Science and Technology Policy Council and Tekes in Finland, and Vinnova in Sweden.

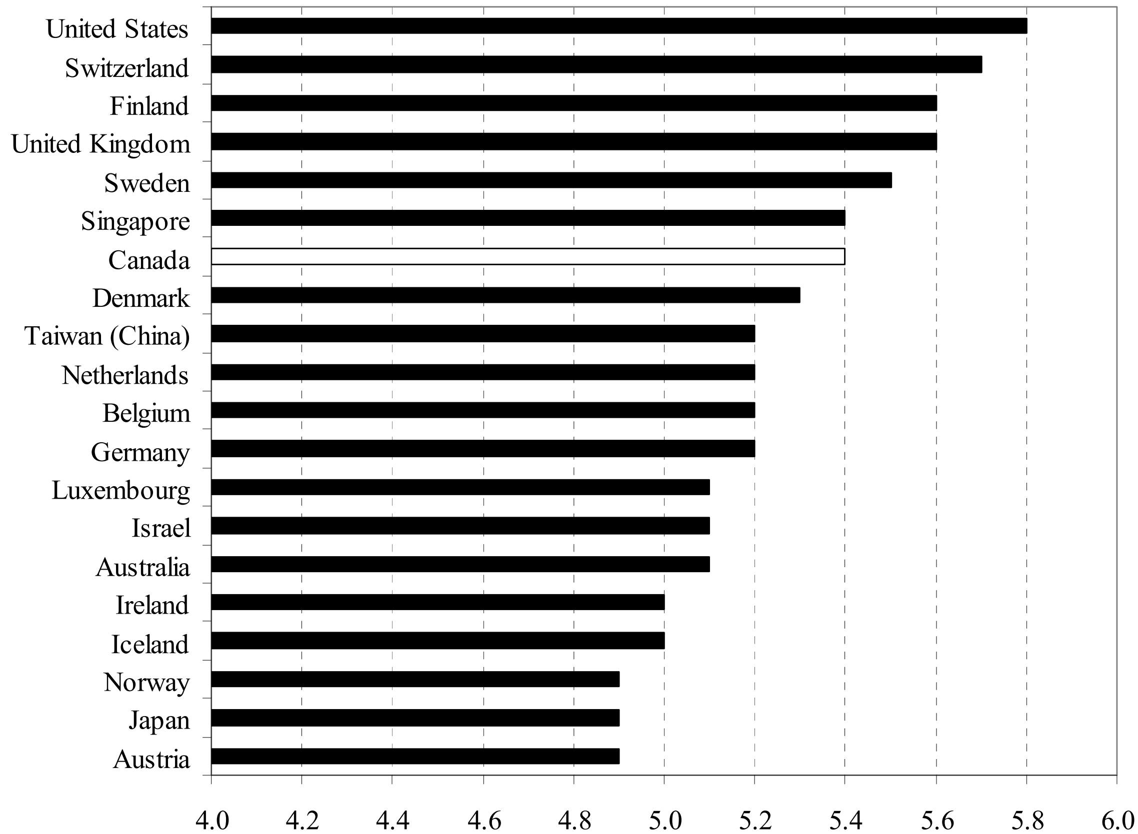
Strong university research and collaboration with industry

All case countries have strong technical research bases, demonstrated by well above average scientific articles per capita. Perhaps more important for business innovation, in all cases concerted attempts have been made—through various programs—to foster collaboration between

[89] Stanley (2007) has made this recommendation.

universities and industry. Survey data from the World Economic Forum show that collaboration is especially strong in Finland and Sweden.[90]

Figure 10: University-industry collaboration in R&D (top 20 globally out of 139 countries)



Note: These data are survey based and come from the most recent World Economic Forum Competitiveness report. Respondents were asked: "To what extent do business and universities collaborate on research and development (R&D) in your country?" where 1 = do not collaborate at all; 7 = collaborate extensively
Source: Schwab (2010)

Implications for Canada

Canada's universities are a key component of the national innovation system (STIC, 2009, p. 7).[91] Canadian university researchers publish widely and their research tends to be of a high quality in terms of citation numbers (OECD, 2008, p. 110). Whether measured as a share of GERD or by HERD intensity, Canadian universities contribute more to R&D (in terms of

[90] See also OECD (2007a), but the OECD data is for the period 2002 to 2004 so it is somewhat dated.
[91] This paragraph draws heavily from STIC (2009).

performance) than in most OECD countries (STIC, 2009, p. 31). Funding for university R&D in Canada was fairly stable from 1990 to 1997, but grew significantly after 1998. Federal R&D funding and provincial government transfers to universities are the main sources for university R&D funding. Licensing revenues to Canadian university R&D are lower than in the US, but Canadian universities produce spinoff companies at a higher rate than other countries including the US (STIC, 2009, p. 7).

While Canada clearly has a strong university research base, measuring the extent of collaboration between universities and industry is imprecise. One often-used measure is the level of business sector funding for R&D performed at universities. This type of R&D cross funding is high in Canada by international standards both as a share of total Canadian research and as a share of GDP (STIC, 2009, p. 7). In addition, the latest survey data from the World Economic Forum suggest that the proportion of Canadian businesses collaborating with universities on R&D is relatively high by international standards—7th highest out of 139 countries (see Figure 10).

To encourage university-industry collaboration in the innovation process, Canada has support programs in place that bring these key players together (i.e., Networks of Centres of Excellence, Industry-University Research Chairs, business incubators, etc). As part of the Mobilizing S&T strategy, the government recently set aside $41 million annually to create and support new business led Networks of Centres of Excellence and new Centres of Excellence for Commercialization and Research. It also established a new Industrial R&D Internship Program. These and other initiatives have encouraged collaborative research between universities and industry as well as the commercialization of discoveries and technological advances. Given Canada's low R&D ranking, perhaps the available support programs for collaboration are not large enough in scope or the structure is ineffective. As noted above, Canadian R&D policy has in part pursued a linear approach: from lab to market. An alternative approach is to target support to meet industry needs and structure the collaboration thereafter. But this should be pursued cautiously since the current approach seems to be producing positive results.

A final observation is warranted about the balance between pure science (HERD) and applied science (BERD). While Canada does well internationally on HERD intensity, ranking among the top countries and well above the OECD average (OECD, 2009a), the share of GERD performed by universities is unusually high, particularly when compared to the case countries. In 2007, Canadian universities performed 33.7 percent of GERD. The comparable shares were 21.3 percent in Sweden, 18.7 percent in Finland, 12.6 percent in Israel, and 16.8 percent for the OECD average (OECD, 2009a). This suggests that Canada has a considerably higher share of total R&D

geared toward the pure sciences (including social sciences). The direct implications are not entirely clear but the results do reflect a greater emphasis placed on HERD by Canadian governments since 1997. Further study is needed to determine the impact on business R&D.

Available skilled labour (scientists and engineers) for technological innovation

All case countries have a strong human capital base with advanced skills for technological innovation. Israel uniquely benefits from a continuous influx of highly qualified labour from the military. Science and engineering degrees as a proportion of all degrees are above average in both Finland and Sweden. Notably, a strong human capital base was entrenched in all countries before business R&D took off, particularly in Israel and Finland. Yet, through either luck or conscious policy, the availability of skilled labour increased during a period of rapid R&D growth to accommodate industry demand. Israel was fortunate to have the large immigration wave during the 1990s coincide with a period of rapid expansion of the high-tech sector. In Finland, the government responded to the shortage of skilled labour during the ICT boom in the 1990s by expanding higher education funding, creating a system of polytechnic institutions and establishing a graduate school system. Likewise, the Swedish government increased education funding during the 1990s to strengthen the human capital base during a period of economic transformation.

Implications for Canada

I concluded in section 4.8 that Canada does not suffer from a supply deficiency of scientific and engineer capabilities. The relatively low level of science and engineer graduates is likely due to lack of demand. Nonetheless, the government's Mobilizing S&T strategy commits to: enhancing opportunities for science and technology graduates; increasing the supply of highly qualified and globally connected science and technology graduates; and "getting Canadians excited about science and technology." Rather than attempt to boost the supply of scientists and engineers, my preferred policy choice is to closely monitor progress of business R&D to ensure an adequate supply of human resources. If the demand for business R&D and scientists and engineers picks up, policymakers could shore up efforts to more aggressively expand supply. Fortunately, economic research shows the supply of engineers is responsive to changes in demand through ordinary market incentives such as increased remuneration (Ryoo & Rosen, 2004).

Section 4.8, however, provided evidence of a dearth in business management skills. While science and engineering skills are important for innovative firms, they become less so as firms grow and expand. Emphasis switches to effective management and strategic ability, and research shows that managers with business and economics degrees, versus engineering or science degrees, have greater strategic ability (Institute for Competitiveness and Prosperity, 2009). So targeting efforts to raise the formal business education of Canadian managers may provide greater bang for the innovation buck. In practical terms, that could mean increasing university appropriations for business departments at both the undergraduate and graduate levels to increase university intake for that speciality.

Improvements in the business environment

The globalization of production and R&D, coupled with major economic crises, increased pressures on case countries to reform their business environment to attract investment from domestic and international investors. Reforms included better macroeconomic management, privatization of state-owned enterprises, and reductions to corporate and personal income taxes. The Finnish government made the politically smart move of earmarking privatization revenues for increased public investments in R&D and education.

Implications for Canada

Over the years, Canada has made improvements to the business environment. The business tax regime has steadily improved with the federal government taking the lead in tax reduction since 2000. Measures have included federal tax reductions in the statutory corporate tax rate from 29.1 percent in 2000 to 15.0 percent by 2012. The federal capital tax has been fully eliminated for non-financial institutions. Incentives have been provided for the provinces to harmonize their sales tax with the federal GST to avoid the taxation of intermediate capital goods. With Ontario and BC adopting a harmonized sales tax (HST) in 2010, Saskatchewan, Manitoba, and PEI are the only provinces that maintain investment-damaging retail sales taxes. In general, most provinces have reduced taxes on business investment, including cuts to the corporate income tax rate and elimination of the capital tax. Accounting for planned business tax changes announced by the end of 2009, Canada’s effective tax rate on additional business investment will drop to 18.9 percent by 2013 from 28.0 percent in 2009 (Chen & Mintz, 2010). This is a more competitive rate internationally and roughly in line with the rate in the case countries for 2009: 15.1 percent in Israel, 19.5 percent in Sweden, and 19.6 percent in Finland (the simple 80 country average is 18.2 percent).

Despite the progress on business taxes, Canada’s overall tax mix relies more heavily on the most damaging types of taxes (profit and income taxes) than the case countries. For the 2007 tax year, profit and income taxes accounted for roughly 50 percent of all tax revenue in Canada versus 39 percent for both Finland and Sweden (OECD, 2009b).[92] Admittedly, this aggregate tax revenue data may not give a complete picture of the split between production and consumption tax revenue sources. Canada, for example, relies heavily on personal income taxes (similar to the US). But the personal income tax system has many provisions that tilt it toward a consumption base rather than an income base, so for many earners, it might do little to discourage saving and investment. It does, however, have negative incentive effects on additional work effort.[93] Nonetheless, evidence shows that Canada can improve economic and R&D performance by changing the tax mix to rely less on production taxes such as capital and personal income taxes (Baylor and Beauséjour, 2004; McKenzie & Sershun, 2010). A more detailed analysis is beyond the scope of this study.

Openness to international trade and investment

All case countries have low barriers to international trade and investment. Israel provided specific investment incentives favouring foreign firms. As a condition for European Union membership, Finland and Sweden opened their economies to trade and investment. Early deregulation of the telecommunications sector in these countries set the stage for subsequent growth in the ICT sector. Openness to investment in all countries helped spark domestic venture capital markets (Israel's Yozma program played a unique catalyzing role). Openness also allowed capital to flow to growing high-tech sectors, bringing needed financial resources and management expertise, facilitating knowledge spillovers, sparking competitive pressures on domestic firms to innovate, and opening new demand channels for domestically produced technologies.

Implications for Canada

The case studies (and literature review) demonstrate that openness to international trade provides a larger market for the sale of new products or processes, increases competitive intensity, and fosters knowledge spillovers. While Canada is an open economy with relatively limited barriers to international trade, internal barriers to trade in goods and services exist between provinces (Conference Board of Canada, 2006; Knox & Karabegović, 2009; OECD, 2006a). This hurts consumers and businesses alike. Interprovincial trade barriers pose problems for innovation by minimizing competitive pressures on firms to create or adopt new technologies

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[92] OECD data is not available for Israel.

[93] OECD research has found that personal income tax rates affect not only work incentives, but also incentives to set up and develop businesses. The latter incentive effects are important for innovative and entrepreneurial enterprises. For a summary of OECD tax research, see http://www.oecd.org/dataoecd/28/12/46600079.pdf (available December 15, 2010).

and by impeding labour mobility. Trade restrictions also shrink an already small consumer market for the sale of new products and processes.

The barriers are worse in the realm of international investment. As in most countries, Canada has legislation that restricts ownership or investment in certain industries. In some cases, legislation places direct restrictions on foreign ownership to ensure that such businesses do not fall under the control of non-Canadians. In other cases, the restrictions limit the degree to which any investor may hold more than a prescribed percentage of the business in question. Whereas the case countries have relatively minimal restrictions, Canada maintains some of the greatest restrictions on foreign business activity in the industrialized world (see Figure 11).[94]

Several pieces of legislation affect foreign business activity in Canada. The broadest is the Investment Canada Act, which is administered by Industry Canada and applied to all foreign investments in Canada. Under the Act, foreign investments are reviewed (screened) before they are approved in order to ensure that the investment will be of "net benefit" to Canada. Just recently the Act was invoked to block foreign investment deals involving the purchase of MacDonald Dettwiler and Associates Ltd. in British Columbia by US-based Alliant Technology and takeover of Potash Corp in Saskatchewan by the Australian mining company BHP Billiton Ltd. In addition to the Investment Canada Act, a number of federal laws that affect foreign direct investment apply to specific sectors. Most notably, the Telecommunication Act, the Canada Transportation Act, the Bank Act, and the Broadcasting Act have provisions that limit foreign ownership in the sectors where these acts apply.

Two sectors where foreign investment restrictions are high by OECD standards and especially damaging to Canada's innovation performance are: telecommunications and transportation (particularly air transport). Restrictions on the former affect related "network" industries like ICT that are driving forces of innovation and increased R&D (see case studies). Restrictions on air transport also hurt innovation because the design and production of commercial aviation products are often R&D intensive.[95] Recall from section 4.5 that foreign investment restrictions erect artificial barriers to entry and reduce domestic competition; they not

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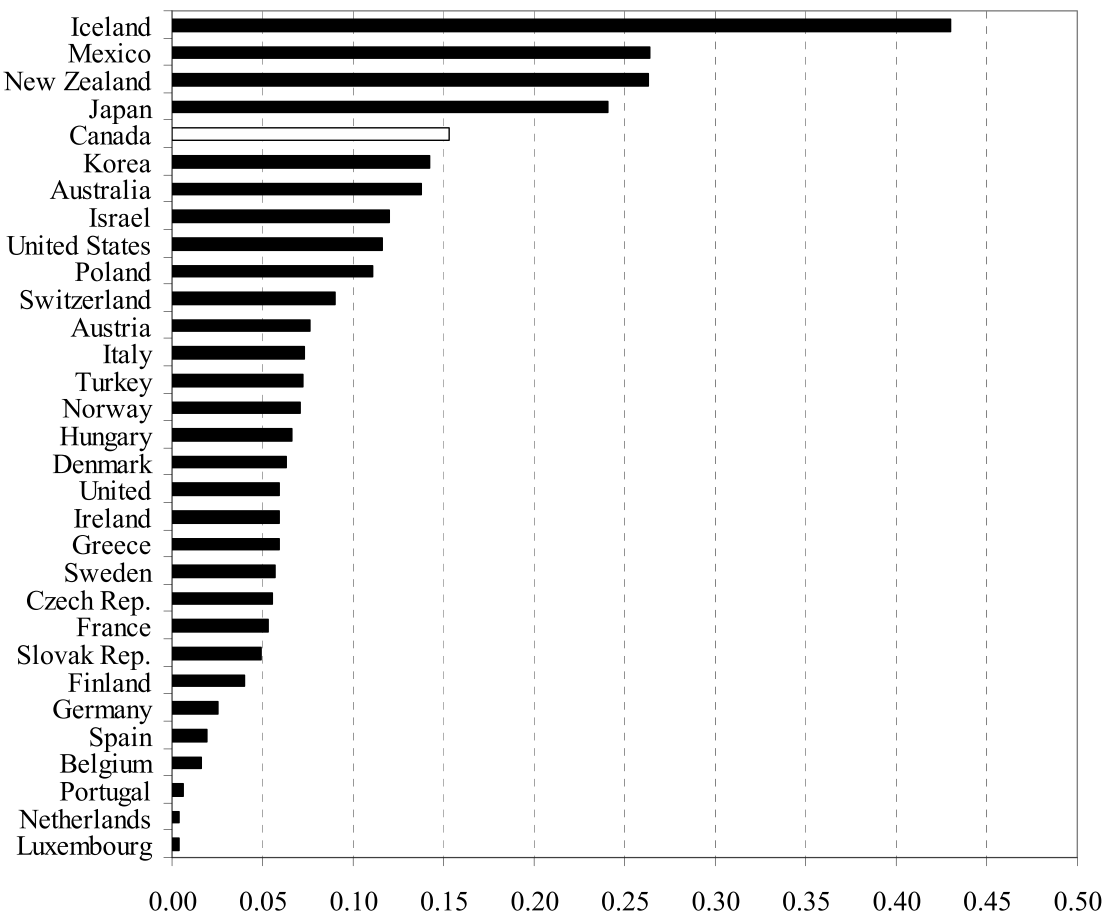
[94] The data in the figure are taken from the OECD's FDI Restrictiveness Index (see Kalinova et al., 2010). The Index assesses the degree of restrictions by accounting for discriminatory barriers to entry in the form of limitations on foreign ownership, special screening procedures which apply only to foreign investors, as well as post-entry management and other operational restrictions. The overall Index is an average of scores on sub-indices in areas such as mining, electricity, transportation, media, telecoms, financial services, etc.

[95] Indeed, restrictions are on airline companies not companies that produce aircraft and related products. But foreign investment restrictions on the former inhibit competition and demand for the latter.

only reduce the impetus to innovate but also slow down the diffusion of international technologies and management practices as well as block access to foreign capital for investments in R&D. Given these innovation-hindering implications, an alternative course for Canada is to remove or at least significantly reduce such restrictions.

Figure 11: Foreign direct investment (FDI) restrictions in OECD and Israel, 2010



Note: Closed = 1; Open = 0

Source: Kalinova et al. (2010)

Cultural attributes conducive to innovation

Each of the case countries has innovation friendly cultural attributes. Israeli people are described as entrepreneurial and open to risk-taking. Finnish culture is homogeneous and egalitarian, and the people welcome technological solutions making them sophisticated users, sparking demand for innovation. A consensual culture among major actors in the Finnish innovation system facilitates decision making on issues related to science and technology policy. Similarly, Sweden's corporatist governance structure facilitated an unusual compromise between labour unions and industry. Swedish culture and people also have a high degree of homogeneity culturally and ethnically, as is the case in Israel to some extent (particularly among Israeli Jews).

Implications for Canada

While each case country has its own set of cultural attributes conducive to innovation, culture is a weakly understood factor for innovation (see section 4.9). In Canada, crude evidence points to a lacking business culture, but the cause is likely not that Canadians are somehow innately different than their counterparts in innovative countries. Rather, the cause is likely an artefact of historical factors or result of incentives produced by the current policy mix. For example, on the surface Canadian business people may appear to lack ambition and entrepreneurial drive but that perception is probably driven by artificial restrictions that shield their industries from competition. With restricted competition, the incentives for innovation and entrepreneurship are weakened. Regarding openness to technological solutions, I am unaware of evidence suggesting any apprehension on the part of Canadian consumers. The delayed introduction of Apple's highly innovative iPhone to the Canadian market did not stem from a shortage in demand. Prior to introduction, media reports and consumer web forums were critical of the delay with many complaining that the device was already offered in the US. When the device was finally available for sale in Canada, it was adopted quickly by consumers with anecdotal evidence of waitlists indicating strong demand. A more recent example is Amazon's Kindle, which, despite high Canadian demand entered the Canadian market only after being available elsewhere. Delays such as these are driven by regulations in network industries, not a weak appetite for technological uptake. Moreover, unlike the case countries, Canadian culture is ethnically heterogeneous, which introduces social issues that could influence receptivity to and demands for innovation. Even acknowledging that certain cultural characteristics help innovation, it is not clear how public policy could mould Canadian culture in that regard, although suggestions have been put forth (The Impact Group, 2006).

6.4.2 Unique features of case countries and implications for Canada

Here I point out unique features of the case countries and then briefly discuss the implications for Canada.

Israel: Immigration wave, military sector, and venture capital growth

Factors unique to Israel include the large immigration wave of many highly trained engineers and scientists, a military sector that provides a constant stream of skilled labour to industry (through mandatory service) and spillovers to industry, and a world-leading venture capital industry sparked by a government program (Yozma).

Implications for Canada

Many of Israel's unique factors, especially the military sector's role, cannot be replicated in Canada. However, Canada, like Israel, is relatively open to immigration. In fact, roughly 20 percent of the Canadian population comprises immigrants. This raises the question: is Canada making use of this valuable resource? A recent Conference Board of Canada report shows that the country benefits economically from its immigrant population through increased innovation, but it also highlights actions that Canada can take to "develop the innovative capacities of immigrants and harness the benefits of immigrant-driven innovation."[96] The report notes that "immigrants face many obstacles, including inadequate recognition of their international experience and qualifications, failure of employers to utilize immigrants' foreign language skills, and lack of opportunities for newcomers to use their skills."[97] So one way policymakers can facilitate rapid supply increases in skilled labour (should demand pick up) is through better recognition of foreign credentials of Canadian immigrants.[98] Moreover, Drummond & Bentley (2010, p. 18-20) outline several proposals to increase the contribution of immigrants to Canada's productivity growth. They recommend improving the immigrant selection process by better targeting individuals that are most likely to succeed when they arrive in Canada. This means weighing heavily four characteristics in the selection process: language, education, occupation, and Canadian contacts.

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[96] See http://www.conferenceboard.ca/documents.aspx?did=3825 (available December 15, 2010).

[97] See http://www.vancouversun.com/entertainment/Improved+innovation+Canada+linked+immigration/3716751/story.html (available December 15, 2010).

[98] This proposal is not intended to oversimplify the implication of immigration for innovation. On the contrary, the issue is complicated by many factors. For instance, if immigrants are primarily low-skilled or family immigrants, they likely will not contribute much to innovation. And if the quality of country-of-origin diplomas is suspect, that too will pose a problem. Also, if immigrants do not have English or French as their mother tongue, literacy and social integration issues might arise. However, recent evidence from the US on the H-1B visa program, which governs the admissions of temporary immigrants to the US for employment mainly in science and engineering and computer-related occupations, shows that increased admissions can stimulate both the domestic rate of patenting and employment (Kerr & Lincoln, 2010).

Public policy in Canada has failed miserably to support development of a venture capital industry (see evidence below),[99] so Israel's success through the Yozma program is unlikely transferable to the Canadian context. Lack of policy co-ordination (particularly across federal and provincial governments) might explain the failure of policy to spark Canadian venture capital. Or it might be that Canadian governments have supported poor quality deals that have been rejected by private venture capitalists, making government sponsored venture capital inherently more prone to failure.[100]

A comprehensive study examined the performance of virtually all Canadian enterprises financed by both government and private venture capital between 1996 and 2004 (3,720 enterprises in total) (Brander et al., 2008). It found that companies financed by government-sponsored venture capital were less likely to grow operations and tended to generate significantly lower commercial value than their privately financed counterparts. Companies financed by the government were also more likely to go out of business over relevant time horizons, less likely to attract investment from the US, and less likely to engage in innovative activity. The poor performance stemmed from weaker mentoring services and managerial performance by government venture capitalists. The study also found evidence of government-sponsored venture capital crowding out more effective private venture capital.

A separate study that examined the performance of Canadian Labour Sponsored Venture Capital Corporations (LSVCCs) between 1978 and 2002 revealed similarly disappointing results (Cumming & MacIntosh, 2006). LSVCCs are government-supported venture capital initiatives intended to encourage investment. The study found that LSVCCs displaced private venture capital funds and lowered the level of capital available to Canadian entrepreneurs. In fact, federal LSVCCs alone have resulted in more than 400 fewer venture capital investments per year in Canada, representing nearly $1 billion. The study also found that LSVCCs performed poorly when compared to private venture capital funds and yielded rates of return that were consistently below those of investments considered to be risk-free (i.e., Treasury Bills).

Yet another explanation for failed attempts in Canada to spark the venture capital industry posits that venture capital may not be a pre-existing input to innovation and R&D. Rather than venture capital stimulating R&D, the line of causation may run the other direction: R&D stimulates venture capital. That hypothesis is consistent with the Israel case; the Israeli venture capital industry took off only after the high-tech sector matured. In fact, Yozma was the

[99] See also Cumming (2007) for a non-technical summary of the problems with and solutions to Canadian venture capital policy.

[100] In economic terminology, government support of venture capital may suffer from an adverse selection problem.

Office of the Chief Scientist's second attempt to jumpstart the venture capital industry after a previous initiative failed. Recent evidence supports the notion that invention (i.e., patented R&D) stimulates venture capital investment, not the other way around (Hirukawa & Ueda, 2009).

Finland: Nokia effect and ICT cluster

Finland's business R&D benefited greatly from the growth of Nokia and related cluster of ICT industries. Nokia was able to singlehandedly drive business R&D because it is a big company operating in a relatively small country and because its operation has impacted a large number of partners, subcontractors, and interdependent industries.[101] Nokia's direct share of Finland's total business R&D is roughly half, but the indirect share is substantially larger when its suppliers and partner companies are counted. While Finnish innovation policy targeted development of the ICT cluster, some claim success was a result of sheer luck, not a "master plan."

Implications for Canada

Historically, Nortel Networks played a similar role as Nokia in Canada's business R&D landscape. In its hey-day in 1999, Nortel accounted for around 45 percent of all Canadian BERD. But since filing bankruptcy protection in 2009, that share dwindled to 5 percent and will decline further as the company liquidates. Currently, Research in Motion Ltd. (RIM) is the single largest business R&D performer in Canada, accounting for just 7 percent of the total.[102] So clearly Canada lacks the R&D presence of a major firm like Nokia, and its business R&D output has no doubt been hurt by the decline of Nortel.[103]

Section 4.6 noted that government attempts to nurture cluster development from scratch have generally failed. However, Canada can take a page from the Finnish playbook and nurture cluster development in sectors where the country has an existing comparative advantage. That, in turn, might spark new R&D giants like Nokia and Nortel. In 2006, the Council of Canadian Academies undertook an extensive survey of experts (from universities, business, and government) on matters relating to innovation policy (Council of Canadian Academies, 2006). Respondents identified four clusters as particular strengths for Canada in descending order: natural resources (particularly oil sands and related production technologies), ICT (particularly wireless and broadband networks), health and related life sciences, and environmental science

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[101] See http://www.etla.fi/files/940_FES_01_1_nokia.pdf (available December 15, 2010).

[102] The top five consisted of RIM, Nortel Networks Corp., BCE Inc, Telus Corp, and IBM Canada Inc.

[103] For data on Canada's top corporate R&D performers, see http://www.researchinfosource.com/2010-DIR-Industrial_Research.pdf (available December 15, 2010).

and technology. As a medium sized country with limited public resources, Canadian R&D policy could focus on these areas.

Sweden: Dominance of and policies that favour large firms

Swedish industrial policy—through different channels including tax policy—has provided incentives that encourage the development of large firms. The result has been an innovation system dominated by large firms but at the expense of entrepreneurship and small, start-up firms.

Implications for Canada

In stark contrast, Canadian industrial policy provides incentives that favour small firms and discourage their growth (see Tomlin, 2008). Tax policy, in particular, gives preferential treatment for small firms in two key ways: through the corporate income tax system and through the SR&ED program.[104] For example, the federal government taxes small business income up to a limit of $500,000 at a reduced rate of 11 percent versus 18 percent for large business income. The tax wedge between small and large firms is even more pronounced at the provincial level (i.e., 0.0 and 12.0 percent, respectively, in Manitoba). In addition, federal R&D tax credits offered through the SR&ED program are more generous for small firms (35 percent) compared to large and foreign-owned firms (20 percent). Besides Canada, only the Netherlands, United Kingdom, and Japan offer significant R&D tax credit rate differentials for small and large firms (see Figure 5). Very little empirical research has examined the notion that preferential tax treatment for small firms discourages small firms growing into larger businesses.[105] In theory, however, favourable rates for small firms may encourage underreporting of income or lead entrepreneurs to divide businesses into separate corporations for tax purposes (Chen et al., 2002).[106] According to Mintz (2008), "a typical arrangement in the [Canadian] high-tech community is for employees to quit large companies to form their own startups…the game is to increase research and development tax credits that are much greater for small businesses compared with large public companies."

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[104] Chen et al. (2002, p. 12) explain that lower tax rates for small firms are motivated by efficiency and equity concerns. "The efficiency objectives are based on the notion that small businesses are prone to market failure, for example, due to higher compliance costs with regulations associated with diseconomies of scale and reduced access to financing, necessitating government policy. The equity objectives are in part motivated by the lower the profits earned by [small firms]."

[105] Tomlin (2008) reviews this sparse literature.

[106] Canada, however, has rules to address these issues. Consolidated tax returns for groups of related companies are not permitted. This prevents losses incurred by an individual corporation within a corporate group to be offset against the profits of other corporations of the same group. In addition, associated corporation rules prevent large firms from artificial tax-induced divisions to benefit from the preferential rates offered for small businesses.

That said, my hypothesis is that preferential treatment for small firms is a non-trivial barrier with potentially important repercussions for innovation since large firms are more R&D intensive than small firms. Further research is needed to bear out this assumption.

7: Policy Options

I use the findings from my comparative analysis in the previous section, combined with the findings from my literature review in section 4, to formulate policy options aimed at increasing business R&D in Canada. The likelihood of a magic bullet solution, however, is low. Innovation is a multi-faceted process and requires many policy initiatives to address different gaps. And increasing R&D is only one component of improving a country's overall innovative capacity. Despite unchangeable realities in the Canadian economic landscape such as an industrial structure specialized in natural resource extraction, heavy economic integration with the US, and a culture that may not be optimal for innovation, my research shows that Canada could pursue the following peripheral policy options, in addition to more central ones discussed later, to improve the innovation environment.

- Eliminate the tax advantage of Labour Sponsored Venture Capital Corporations, Canada's largest support program for venture capital. These and other government sponsored venture capital initiatives have a historical record of poor performance and seem to crowd out more effective private venture capital.
- Reduce interprovincial trade barriers to increase competitive pressures on domestic firms to innovate and expand the size of domestic markets.
- Remove unnecessary product market regulations that give rise to unnatural monopolies that inhibit competition.
- Turn over control of state-owned enterprises to private interests, where feasible, and liberalize domestic monopolies or near monopolies to spark investment and innovation.
- End, or least reduce, the discriminatory taxation of small firms to remove the disincentive for growth into large firms.
- Structure programs that foster university-industry collaboration for applied research around the needs and demands of industry where the pressures to innovate stem.
- Increase the level of formal business education to improve managerial capabilities in industry. One approach is to increase university appropriations for commerce departments. Despite the growing waitlists for undergraduate and graduate business programs, governments have not recently increased their funding (Martin, 2002).

- Strengthen the human capital base by recognizing the foreign credentials of immigrants,[107] which are key contributors to labour force growth and innovation. Improving the immigrant selection process to focus on key characteristics would increase the likelihood of immigrants contributing positively to Canadian productivity and innovation growth.

This list of peripheral policy options is long, and many options cross the jurisdictional powers of the federal and provincial governments. But the more central policy options presented below are those I deem will provide the greatest impact on business R&D and innovation. They are also policy options derived from the comparative analysis of common factors that drive business R&D in the case countries. Given the associated complexities of the Canadian innovation policy environment, I focus on broad policy options that fall largely under the federal government's control and that are national in scope. All options assume the status quo policy framework remains intact, except for the proposed marginal change. Unless stated explicitly, the policy options do not call on Canada to abandon any component of its current innovation policy approach, which encompasses a range of economic policies across different areas (i.e., competition, education, taxation, venture capital, international trade and investment, etc).

7.1 Option 1: Status quo

The status quo is essentially the innovation policy framework outlined in sections 4 and 5. It includes all the drawbacks and gaps in Canada's innovation system discussed throughout the study. For the purpose of my evaluation of policy options in a later section, I associate Canada's single largest support program for R&D, the SR&ED program, with being representative of the status quo.

7.2 Option 2: Replace SR&ED tax credits with direct support

This option proposes to replace all or a portion of the SR&ED tax expenditure with direct R&D support (grants). That is, any cost increases for direct support must be offset by an equal reduction in the value of foregone revenue from the SR&ED tax program. A spending-neutral change in the mix of R&D support would minimize budgetary pressures.[108] Given limited public

[107] The federal government has begun this process by providing support to implement a Pan-Canadian Framework for the Assessment and Recognition of Foreign Qualifications. See http://www.hrsdc.gc.ca/eng/workplaceskills/publications/fcr/pcf.shtml (available December 15, 2010).

[108] A change in the mix of R&D support is more appropriate than an expansion because Canada's support is already one of the most generous internationally.

resources for R&D support, the subsidies could be targeted to clusters where Canada shows strength (natural resources, ICT, health and related life sciences, and environment technology). Subsidy eligibility could be conditional on recipient firms collaborating with a Canadian university. The condition of university collaboration for public support of industrial R&D is often used in Finland. An additional condition of support for long-term consideration to ease budgetary pressures is instituting a royalty component that would make repayment conditional on R&D projects becoming successful (similar to the Israeli system).[109] The increased direct support proposed in this option could be administered and disbursed through the existing Industrial Research Assistance Program (IRAP). According to the Council of Canadian Academies' survey of informed innovation policy opinion (including key industry, university, and government stakeholders), respondents ranked IRAP as Canada's most highly valued support program for commercialization of science and technology (Council of Canadian Academies, 2006). Since IRAP currently provides direct support and has the infrastructure, policies, and procedures already in place, it could be expanded to provide the increased direct R&D support.

7.3 Option 3: Replace indirect support through the SR&ED program with broad-based business tax relief

Currently, federal government support for R&D gives with one hand through generous tax credits offered by the SR&ED program and takes with the other through business taxes that reduce the rewards to innovation. This option proposes to replace all or some portion of indirect support provided by SR&ED tax credits with broad-based business tax relief. The shift is to be neutral to the federal coffer (with no net increase in cost). Business tax relief could include further reductions to the corporate income tax rate (which stands currently at 18 percent), elimination of the corporate capital tax on financial institutions, and incentives (transition payments) for provinces with a retail sales tax to implement a harmonized sales tax (HST). Each of these alternatives would contribute to reducing Canada's marginal effective tax rate on capital

[109] Canada's own Strategic Aerospace and Defence Initiative (SADI) employs conditional repayment schemes for government contributions.

investment (28.0 percent), and bring it more in line with the average of the case countries (17.0 percent). As section 4.7 noted, lower capital taxes are associated with higher business R&D.[110]

7.4 Option 4: Remove foreign investment restrictions in R&D intensive sectors

I have emphasized the role of competition in putting the necessary pressure on firms to innovate or adopt best practices and new technologies. Canada, unfortunately, maintains restrictions on foreign investment that inhibit competition. The restrictions have other negative consequences: they reduce the availability of capital and spillovers from foreign firms (through diffusion of management practices, know-how, and technologies). None of the case countries maintain the same level of restriction on foreign investment. In some cases, they have actually introduced policies that deliberately favour foreign firms over domestic ones.

This option proposes to remove outstanding foreign investment restrictions, particularly in R&D intensive sectors primed for innovation: telecommunications and air transport. In terms of telecommunications, this option proposes a complete removal of foreign investment restrictions.[111] This is in line with the recommendations put forth by the Competition Bureau of Canada in its submission to the Competition Policy Review Panel which also supported such action (see CPRP, 2008). The Bureau notes that it is important to remove restrictions in the telecommunication sector because "telecom is a key enabler in many other sectors of the economy and as such, its impact on innovation and competitiveness is seen nationwide."[112]

Similarly in air transport, the Bureau notes "there does not appear to be any compelling economic reason why the air transportation sector should continue to have such restrictions."[113] A first-best option is to eliminate foreign ownership restrictions on Canadian air carriers. But the elimination of all ownership restrictions may not be feasible under current bilateral air

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[110] Another tax related option for Canada that would increase the rewards to innovation is reducing or eliminating capital gains taxes. Cumming (2007, p. 8) notes that "theory and empirical evidence suggest a direct causality between lower capital gains taxation and venture capital… As entrepreneurial companies typically do not have the positive cash flows to pay interest on debt and dividends on equity, venture capitalists invariably invest with a view toward exiting the market and taking the ensuing capital gains."

[111] Other, more incremental options for reform are contained in Industry Canada's public consultation paper *Opening Canada's Doors to Foreign in Telecommunications*, which is available online at http://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/TelecomInvestment-eng.pdf/$file/TelecomInvestment-eng.pdf (available December 15, 2010).

[112] See http://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/eng/02555.html (available December 15, 2010).

[113] See http://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/eng/01445.html (available December 15, 2010).

agreements that require domestic air carriers to be substantially owned and controlled by their government or home country nationals. So a second-best alternative is, as the Bureau recommends, to increase the limit on foreign ownership in Canadian air carriers from the current 25 percent to 49.9 percent. After all, "the airline industry is capital-intensive. New entrants, as well as established players, would benefit from the greater access to foreign capital through liberalized ownership rules."[114]

7.5 Option 5: Create a single pan-Canadian agency to co-ordinate federal and provincial innovation policy

Canadian innovation policy is somewhat fragmented and incoherent due in large part to the lack of co-ordination between federal and provincial innovation policy. Through countless programs, funding initiatives, ministries, departments, and agencies, Canadian governments offer a wide range of support for business innovation and entrepreneurship.[115] However, these initiatives lack policy coherence. This option proposes to create a single pan-Canadian agency tasked with co-ordinating the country's innovation policy. While certain policy areas have clear jurisdictional mandates (for instance, provinces are responsible for health and education while the federal government is responsible for national defence), innovation policy does not fit neatly into a particular government's mandate since the policies required for a well functioning innovation system are cross-jurisdictional in nature (education, industrial, competition, tax, trade, etc.). In addition to co-ordinating policy, the proposed agency would be responsible for regularly evaluating the impacts of the various government support initiatives targeted at innovation. Besides the Auditor General of Canada's infrequent audit of particular programs, no national organization undertakes substantive evaluation.

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[114] See http://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/eng/01445.html (available December 15, 2010).

[115] See the Canada Business website for details on the various services available to Canadian entrepreneurs and specifically those targeted at innovation: http://www.canadabusiness.ca/eng/145/147/ (available December 15, 2010). Canada Business is "a cross-jurisdictional government organization that helps Canadian entrepreneurs get the information, advice, and support they need to build their businesses." While Canada Business helps entrepreneurs navigate through the litany of available initiatives, it is only informational in nature and does maintain policy coherence across jurisdictions. See also the Small Business BC website for a collection of some of the more popular federal and provincial programs intended to support small businesses: http://www.smallbusinessbc.ca/pdf/overview.pdf (available December 15, 2010).

8: Policy Analysis

The diversity and broadness of the proposed policy options make it rather difficult to evaluate them in a meaningful way. I nonetheless undertake policy analysis in this section. To do so, I evaluate each option against the same set of objective criteria. Ideally, I would construct specific, quantifiable measures for the evaluation. But given the issues associated with even ball-parking reasonable measures—so many factors influence the performance of R&D—I instead rely on my own subjective assessment based on theory and evidence. Admittedly, that makes my evaluation rather crude.

The section begins by outlining the criteria used to measure the impacts of each policy alternative relative to one another. The criteria and measures are useful for examining trade-offs and revealing which policy alternatives are best suited to fulfill the policy objective of increasing business R&D. The overarching goal of the criteria and measures is to capture the salient features of each alternative with respect to achieving the policy objective. I use a total of five criteria covering effectiveness, political feasibility, administrative ease, stakeholder support, and budgetary costs. After defining the criteria and measures, I then evaluate the proposed policy options and conclude with recommendations.

8.1 Criteria and measures

8.1.1 Effectiveness

The effectiveness criterion asks the fundamental question: will the policy option help achieve the overall objective of increasing business sector R&D? I determine effectiveness based on existing literature and my own subjective assessment. The expected impacts of the policies should be interpreted as probabilities, not guarantees. Where applicable, this criterion also addresses secondary questions such as whether the policy benefits the Canadian economy in other ways than simply increasing business R&D. For instance, does the policy fill a void in or enhance Canada's national innovation system? Moreover, does the policy provide additional economic benefits such as increased investment, competition, and so on? Indeed, a policy could provide benefits that are unrelated to R&D and innovation. Conversely, it is important that alternatives do not negatively affect other areas of the economy.

8.1.2 Political feasibility

Political considerations can often derail sound policy making by, for example, imposing barriers to policy adoption or distorting the policy from its ideal form. The political feasibility criterion asks: what are the political risks associated with the policy option? It considers issues such as whether the government of the day would find the alternative acceptable. It also considers the probability that a particular option would be politically hijacked with politicians flexing their muscles to influence bureaucrats.

8.1.3 Administrative ease

The administrative ease criterion evaluates the issues and challenges associated with government administering the policy. The analysis accounts for the fact that each option requires different levels of competencies and bureaucratic capabilities. Given Canada's jurisdictional realities, it is important to assess the required level and likelihood of intergovernmental co-operation.

8.1.4 Stakeholder support

This criterion evaluates the level of approval primarily by industry stakeholders for a policy alternative prior to implementation.[116] A policy that seeks to increase business R&D should be evaluated on whether it will garner support from those who actually perform the research. An option that would face fierce and widespread opposition from industry is politically unpopular and unlikely to be implemented. This does not mean that mildly unpopular options should be ruled out. The important consideration for this criterion is to gauge the level of support for or opposition to the proposed policy.

8.1.5 Budgetary costs

This criterion evaluates the option's budgetary costs to government and taxpayers. With the budget balance of Canadian governments turning negative as a result of the recent economic recession and with growing fiscal pressures arising from an aging population, no policy would be

[116] I acknowledge that stakeholder support is not so clearly differentiated from political feasibility in this context, but I deem it differentiated enough to warrant a separate criterion.

fiscally prudent if the budgetary costs are prohibitive. Budgetary costs cover both implementation and operating costs.

8.2 Evaluation of policy options

The evaluation of specific public policies that target business R&D is complex given the interdependencies within the overall innovation policy environment. My goal is to present policy makers with loosely projected outcomes of the different options and highlight major trade-offs. Table 6 displays my overall policy evaluation. For each option, I indicate whether it ranks low, medium, or high on the five criteria outlined above. I transform the rankings using the following scoring method: low = 1; medium = 2; and high = 3. I then sum up the scores on the five criteria, assuming equal weighting, to give each policy option an overall score. In the absence of exact measures to rank the options, caution must be taken in interpreting the results.

Table 6: Policy evaluation matrix

	Option 1: Status quo (SR&ED)	**Option 2: Replace SR&ED with direct support**	**Option 3: Replace SR&ED with business tax relief**	**Option 4: Remove foreign investment restrictions**	**Option 5: Create pan-Canadian agency**
Effectiveness	Medium (2)	Medium (2)	Medium (2)	Medium to High (2.5)	Medium (2)
Political feasibility	High (3)	Low (1)	Medium (2)	Medium to High (2.5)	Low (1)
Administrative ease	Low (1)	Medium (2)	High (3)	Medium to high (2.5)	Low (1)
Stakeholder support	High (3)	Medium to High (2.5)	Medium (2)	High (3)	Medium (2)
Budgetary costs	Medium (2)	Medium to High (2.5)	Medium to High (2.5)	High (3)	Medium (2)
Totals	**11**	**10**	**11.5**	**13.5**	**8**

Scoring method based on: Low = 1; Medium = 2; High = 3

8.2.1 Option 1: Status quo

Effectiveness: I ranked the status quo as medium on effectiveness. Economic research shows that R&D tax credits stimulate additional R&D that is roughly equal in value to the cost of the foregone revenue. A comprehensive analysis for the federal Department Finance of the

SR&ED (see Parsons & Phillips, 2007) found the program produces a net benefit for each dollar of foregone tax revenue after accounting for R&D spillovers to the broader economy and related program costs (administration, compliance, and tax revenue raising costs). So based on empirical research, the SR&ED seems effective. But I did not give the program a high ranking because of the following structural shortcomings. The program provides more generous tax credits for small firms (35 percent) than large firms (20 percent). While this may better help address market failures in financing R&D and innovation, it may also discourage firm growth. Discouraging firm growth has implications for business R&D output since large firms are more likely to perform R&D and be more R&D intensive (see section 4.2). In addition, SR&ED tax credits are not targeted, which means the subsidy may not support R&D projects with the greatest social benefit. While a tax credit has the advantage of being neutral and avoiding the problem of picking winners, the subsidy may go to firms that would have performed R&D anyhow. The volume-based eligibility structure of the SR&ED is another issue that may hinder effectiveness. The program does not require firms to perform incremental R&D on a year-to-year basis as in R&D tax credit systems in other countries (like the US). Instead, the tax credit is applied to the volume of R&D performed in a given year. This eligibility structure could reduce firms' incentive to do more R&D than in the previous year. Finally, issues with the program's administration and compliance costs have posed long-standing problems. Higher compliance costs in particular reduce the value and thus effectiveness of the tax credit. On complying with the SR&ED, one business leader has said: "We'll probably lose 20 to 25 percent of our claim to the consultants. So we'll take that money and instead of putting it back into research and development, we'll give it to some accounting firm" (McDowell, 2010). The bottom line is the SR&ED program has been around since the early 1980s with little improvement to Canada's international standing on business R&D performance. The federal government's on-going review of the program further suggests the SR&ED may be producing suboptimal results.

Political feasibility: Political risks are low with the status quo, so I gave it a high ranking on political feasibility. The SR&ED program, in its current form, has been operating for nearly three decades with strong support from key stakeholders (see below), so continuing with it imposes low political risks. Also, the political risks of this option are mitigated by the fact that support through the tax system minimizes the potential for politicians to use the program as a political tool or to influence bureaucrats administering the program. A political risk of the status quo concerns support by the incumbent government, which has initiated a formal review of the SR&ED.

Administrative ease: The Canada Revenue Agency (CRA) is tasked with administration of the SR&ED program. Frustration by business practitioners and frequent criticisms of the program's administration over the years suggests CRA is doing a poor job. This view is supported by the Auditor General of Canada's 2000 audit of the SR&ED program.[117] The scathing audit found, among other things, that the program is an administrative disaster. Poor administration has resulted in high compliance costs, especially for small firms, which reduce the benefit (value) of the tax credits. In April 2010, however, the federal government made significant changes to improve the administration of SR&ED program,[118] so time will tell if those changes are effective. But from a current standpoint, I gave the status quo a low ranking on administrative ease.

Stakeholder support: SR&ED program receives high praise from innovation policy experts in industry, government, and academia. According to the Council of Canadian Academies' survey of informed innovation policy opinion (including key industry, university, and government stakeholders), respondents ranked the SR&ED as Canada's second most highly valued support program for commercialization of science and technology (Council of Canadian Academies, 2006). This, I believe, warrants a high ranking on the stakeholder support criterion.

Budgetary costs: The status quo is the baseline from which all other policy options are evaluated. While the status quo does not entail additional budgetary costs, the SR&ED program has a heavy price tag, costing the federal government well over $3 billion per year in lost tax revenue. Despite being the benchmark, I did not give it a high ranking since it would not allow room for any of the alternative options to have lower costs (and thus a higher ranking on the cost criterion). Instead, I gave the status quo a medium ranking on budgetary costs mainly because a tax expenditure provision has costs that cannot easily be controlled by a government (since it is demand driven).

8.2.2 Option 2: Replace SR&ED tax credits with direct support

Effectiveness: Option 2 received a medium ranking on effectiveness because the jury is still out on whether direct forms of R&D support stimulate additional business R&D, with some evidence showing a positive relationship (especially for small firms) and other evidence showing

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[117] See http://www.oag-bvg.gc.ca/internet/English/parl_oag_200004_06_e_11193.html (available December 15, 2010).

[118] See http://www.pwc.com/en_CA/ca/sred/developments/publications/cra-enhancements-2010-01-en.pdf (available December 15, 2010).

a crowding-out effect (see section 5.2). That said, all case countries (Israel, Finland, and Sweden) solely use direct subsidies to support R&D, with no support provided in the form of tax credits. Other high R&D performing countries also rely exclusively on direct support (Switzerland, Iceland, and Germany). And countries ahead of Canada in international rankings of BERD intensity have a greater proportion of R&D support coming from direct support (US, France, United Kingdom, and Austria). Importantly, however, R&D subsidies are one of a multitude of factors that influence business R&D so we cannot attribute positive performance entirely to the type of R&D support (see section 4). Perhaps direct support works in some countries because, unlike tax credits, direct subsidies permit better targeting of risky R&D projects with large social returns that might not otherwise be undertaken. Direct support also allows for support to be targeted to small firms, where financial constraints are most pronounced. Small firms may experience problems getting R&D funding since investors and other lenders have little information to base decisions. Start-ups in particular do not have a track record of financial performance and their key business assets are often intangible. Whether the advantages of direct support are transferable to Canada is unclear. As Toivenen (2009, p. 12) explains, "While the Finnish innovation support system seems to function relatively well and the R&D subsidy part especially so, it is still an open question what their role is in Finland's transformation into an (more) innovation-driven economy. In particular, it is not clear to what extent Finnish institutional arrangements can be copied into other environments, and whether it makes sense to copy them piece meal or not."[119]

The reality is that Canada's track record on direct subsidies to industry isn't encouraging. Experience shows that such attempts have largely been unsuccessful (Milke, 2007). Even if structured with good intentions, Canadian-specific hurdles (regional tensions such as the "East vs. West" focus at the national level, complex federal-provincial relations and division of powers, unequal fiscal capacity of provinces due to resource rents) as well as more general hurdles (public choice considerations, government knowledge constraints, rent-seeking), coupled with the next to impossible challenge of picking winning projects, firms, or industries, reduce the likely effectiveness of option 2—particularly for a direct support program that would be national in scope. An example of regional tensions and politicization reducing subsidy effectiveness in Canada is the federal government's award of a construction contract for CF-18 military aircraft. In 1986, Brian Mulroney's Progressive Conservative government was presented with two

[119] Toivanen (2009) argues that Finland might be better off adopting a system of R&D tax credits, mainly because tax credits would provide support in a more transparent way than R&D subsidies. He also warns about the problem of governments having the capacity and knowledge to deliver effective subsidies.

options: a cost-effective and prepared contractor located in Manitoba or a significantly higher cost and ill prepared contractor located in Quebec. It chose the latter purely on political grounds. This event and the National Energy Program of the 1980s (which was especially detrimental to Alberta's interests) catalyzed the Reform Party to form, citing as impetus federal indifference to Western Canada and favouritism to Eastern Canada.

Other risks lower the probability of success. For instance, empirical research indicates that direct public financing of business R&D sometimes crowds out privately financed R&D (see section 5.2). This does not apply to the tax incentive approach since evidence generally shows a one-for-one to slight incremental effect on R&D. Another risk is the possibility of creating a substitution effect—an R&D subsidy may encourage recipient firms to pursue unsuccessful subsidized projects (due to reduced costs) at the expense of successful, non-subsidized projects. The substitution would result in a loss of social welfare. This substitution potential also applies to R&D tax incentives, but perhaps less so, since grants encourage more risk-taking due to moral hazard—incentives for prudent R&D projects are diminished when firms have little if any of their own money at stake.

Political feasibility: I ranked this option low on political feasibility. Direct support is susceptible to political hijacking, with politicians channelling support to their pet projects or industries not to provide the greatest benefit but to garner the largest political benefit (votes).[120] With direct support, the risks of rent-seeking and regulatory capture are high, which would ultimately reduce effectiveness. Compounding the problem is the government's inability to pick winners. Despite general knowledge on sectors where Canada currently has an advantage, bureaucrats in Ottawa are unlikely aware of what specific projects, firms, or industries deserve support. These decisions are better made by private industry. Business people have highly specific knowledge and expertise, giving them an enormous advantage in this regard—after all, pressures from competitors and customers and the production process are what drive decisions to innovate.

Administrative ease: This option received a medium ranking on administrative ease. I based my assessment largely on the Auditor General's 1999 review of the main grant and

[120] Indeed, some drawbacks of direct support such as the potential for politicization apply to more than one criterion, giving rise to overlap across criteria.

contribution programs for innovation in Canada.[121] The audit indicated that program administration was generally satisfactory with program managers developing goals and measures for assessing performance. But expected results were not expressed in innovation performance terms. In addition, the Auditor General noted that "significant opportunities for management to improve the exercise of due diligence in approving contributions […] and grants." Regarding a now defunct program (Technology Partnerships Canada), the Auditor General said "project and results monitoring and reporting to Parliament on expected performance need to be improved." An internal audit by Industry Canada in 2003 revealed similar problems and highlighted the lack of bureaucratic expertise to appropriately administer grants and contributions.[122] Absent strong administrative controls and procedures, direct R&D support has the potential to become an administrative disaster. Canada's large geographical area raises important issues as well as conflict over jurisdictional power between the federal and provincial governments.

Stakeholder support: I ranked this option as medium to high on stakeholder support because current direct R&D support programs, namely IRAP, have strong stakeholder support. The Council of Canadian Academies (2006) surveyed innovation policy experts in industry, government, and academia regarding Canada's innovation support programs, and experts indicated that IRAP was the most highly valued program. However, I ranked this option as medium to high because an increase in direct support, while likely welcomed by industry, comes with a reduction in support through the SR&ED program under the proposed option. Firms that currently benefit from the SR&ED and that do not receive direct support would likely oppose the shift.

Budgetary costs: This option received a medium to high ranking on budgetary costs. Since a spending neutral shift in the mix of R&D support is proposed, additional budgetary costs would be minimal. And unlike a tax expenditure program, a direct support spending program can be controlled in its outlays via a budgetary allocation. That is, when the funds run out for a given year, no more projects are approved. This gives option 2 a slight cost advantage over the status quo.

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[121] See http://www.oag-bvg.gc.ca/internet/English/parl_oag_199909_19_e_10148.html (available December 15, 2010).

[122] See http://oti.ic.gc.ca/eic/site/ito-oti.nsf/eng/h_00189.html (available December 15, 2010).

8.2.3 Option 3: Replace indirect support through the SR&ED program with broad-based business tax relief

Effectiveness: I gave option 3 a medium ranking on effectiveness. Research shows that lower taxes on production are associated with increased business R&D (see section 4.7) and other business investment including inward FDI. In fact, reducing taxes on production has roughly the same positive effect as R&D tax credits, in terms of elasticity with respect to business R&D (McKenzie & Sershun, 2010). But the effect of the former may be greater due to lower administrative and compliance costs. By reducing the tax penalty on production, this option not only increases the rewards of creation new innovations, but it also reduces the cost of acquiring and adopting existing innovations embodied in machinery, equipment, and technology. So the benefits of production tax reductions are widespread and reach many more sectors than just R&D intensive ones. This gives option 3 an advantage over options 1 and 2. While business tax relief benefits both R&D and the broader economy, certain firms—particularly small and unprofitable ones without taxable income—would lose support through the SR&ED. But the impact on aggregate business R&D would be negligible since large firms are proportionally larger performers of R&D.

Political feasibility: I gave this option a medium ranking on political feasibility because of opposing factors that make the option both politically risky and politically attractive at the same time. Replacing some portion of or Canada's entire flagship support program for business R&D will be met with political pushback, particularly from organized special interests that benefit from the status quo. But the pushback will be mitigated by increased business tax relief—a move that avoids the thorny issue of picking winners, which is a plus for political feasibility. Enacting broad-based business tax relief also has mixed support at the federal level. On one hand, the incumbent Conservative government set forth a plan in 2007 to reduce the federal corporate income tax rate to 15 percent by 2012, and it seems committed to that plan. The leader of the official opposition Liberal party, however, has mused about rescinding the scheduled business tax cuts, arguing for a reallocation of public spending priorities to social policy initiatives (i.e., a new Family Care Plan).[123] This increases the politically risks of option 3.

Administrative ease: This option ranks high on administrative ease. Scaling back the SR&ED program would save both governments and industry significant administrative and compliance costs currently associated with the program. Increased business tax relief would

[123] See http://www.liberal.ca/files/2010/10/lpc-family-care-en.pdf (available December 15, 2010).

impose virtually no new costs since a framework to administer and comply with tax regulation is already in place in government and industry.

Stakeholder support: I gave this option a medium ranking due to mixed stakeholder support. Support would likely be found in the broader industrial sector of the economy. However, sectors that benefit from very generous R&D tax subsidies, while open to additional tax relief, may prefer the status quo because it provides greater dollar value support. In some provinces, firms can write off up to 60 percent of R&D costs through the combined SR&ED and provincial R&D tax credit programs (see section 5.1). Innovative start-ups, in particular, may prefer the status quo since without taxable income they benefit very little from support in the form of broad-based business tax relief. Nonetheless, this option may garner support because it increases horizontal equity by treating all firms in the economy more equally rather than giving special treatment to those engaged in R&D.

Budgetary costs: I ranked option 3 medium to high on budgetary costs. Since my proposal for business tax relief is spending neutral, it does not impose new budgetary costs. It could, however, bring additional government revenue over the long-term that would partially pay for the lost revenue.[124] This dynamic process would result from improved incentives for firms to save, invest, and innovate. The ultimate impact is increased economic output and tax revenues. Lower business taxes could also increase revenue by increasing the taxable base in Canada from international firms that shift their profits to lower tax jurisdictions using transfer pricing and revised financing structures. In addition, this option could bring taxable industrial activity to Canada from firms that locate or re-locate operations in response to a more competitive business tax regime.

8.2.4 Option 4: Remove foreign investment restrictions in R&D intensive sectors

Effectiveness: I ranked option 4 medium to high on effectiveness. While it's difficult to judge the likely impact of removing foreign investment restrictions on business R&D with precision, research shows the potential for widespread economic benefits are large in terms of increased competition, lower prices,[125] greater availability of capital, more and higher paying

[124] Mankiw & Weinzierl (2006), for example, calculate that half of a capital tax cut is self-financing.

[125] Canada's mobile penetration rate is currently among the lowest in the industrialized world and the average Canadian monthly cell phone bill is the highest. See http://wirelessnorth.ca/2010/08/27/its-2010-and-canadians-pay-the-highest-cell-phone-bills-in-the-world/ (available December 15, 2010). High cell phone bills are in part due to foreign investment restrictions in the telecommunications sector.

jobs, knowledge spillovers, and technology diffusion. In addition, research on Chinese firms shows that foreign multinationals stimulate domestic R&D (Cai et al., 2007). Research also shows that a country's productivity growth depends not only on domestic R&D but also foreign R&D capital stocks, and that foreign direct investment (FDI) is an important channel that links foreign R&D to domestic productivity growth (Hejazi & Safarian, 1999). So, Canadian productivity growth stands to gain a lot from removing restrictions on the flow of cross-border investment. In fact, an OECD study concluded that Canada could have increased its productivity growth rate between 1995 and 2003 by 0.75 percent annually had it amended its regulations that restrained competition to conform to the least restrictive regulations of other OECD countries.[126] With respect to FDI restrictions, the OECD concluded that "reducing them to the level that is the least restrictive of competition (of all jurisdictions studied) would increase employment and provide a strong impulse to labour productivity growth."

Political feasibility: Canada seems to have a healthy political appetite for removing foreign investment restrictions. This is demonstrated by the federal government's explicit support and commitment in key policy documents, and its recent efforts to introduce competition in the telecommunications industry through new rules for auctioning wireless spectrum rights. However, I gave this option a medium to high ranking—and not a high ranking—because some of the federal government's actions have been inconsistent with its stated goals. For instance, the government overturned the Canadian Radio-Television Commission's (CRTC) decision regarding the ownership structure of the telecom company Globalive/Wind Mobile, allowing it to maintain foreign ownership levels beyond those stipulated by legislation, but the same government blocked two big investment deals (MDA in British Columbia and Potash Corp. in Saskatchewan) citing as grounds violation of foreign ownership rules and failure to pass the "net benefit" test.

Administrative ease: This option ranks medium to high on administrative ease. Legislative change is a one-time exercise, whereas review of foreign investment applications is an on-going exercise. With removal of foreign investment restrictions, the government could expend fewer resources on monitoring foreign business activity. Because the restrictions permit greater discretion, they ultimately increase administrative complexity. So removing them should reduce bureaucratic and political interpretation and influence, thereby streamlining operations. This option's biggest administrative hurdle stems from changing key legislation (the Investment Canada Act and sector specific legislation) to cement the proposed policy change. Barring some

[126] See http://www.oecd.org/dataoecd/60/33/42174422.pdf (available December 15, 2010).

political opposition, I don't expect changing such legislation is prohibitively onerous. After all, former Prime Minister Brian Mulroney's government managed to change the rules governing foreign investment in 1985, making significant changes to those enacted by the Trudeau government in 1974.

Stakeholder support: I gave option 4 a high ranking on this criterion. Perhaps surprisingly, industry stakeholders (including incumbents) seem to support the removal of foreign investment restrictions. In a news release responding the government's approval of Globalive/Wind Mobile's ownership structure, TELUS, a major player in the telecommunications sector, noted that "TELUS has never been opposed to foreign ownership restrictions being lifted by Parliament…All we have asked is simply that all communications companies in Canada operate under the same rules without an artificial and unfair advantage being handed to one company."[127] TELUS echoed its position in favour of liberalizing foreign investment restrictions in a submission to the federal government's consultation on foreign investment in the telecommunications sector.[128] New entrants also favour liberalization,[129] reinforcing stakeholder support for this option.

Budgetary costs: This option is an example of reduced costs relative to the status quo so it received a high ranking. While relatively small upfront costs may be required to alter legislation, removing restrictions could lower administrative complexities and related costs in the long term.

8.2.5 Option 5: Create a single pan-Canadian agency to co-ordinate federal and provincial innovation policy

Effectiveness: It is hazardous to forecast the probable of impact of option 5 on business R&D. But a pan-Canadian agency is sorely needed to co-ordinate Canada's fragmented innovation policy. Having such an agency seems central to effective innovation policy, as all case countries have one. In the Canadian context, however, serious questions arise about how a pan-Canadian innovation agency will create the legitimacy required to be effective. Moreover, would the agency reduce the ability of provincial governments to experiment with innovation policies, for good and bad? Uncertainty in this regard is why I gave this option a medium on effectiveness.

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[127] See http://about.telus.com/cgi-bin/media_news_viewer.cgi?news_id=1172&mode=2 (available December 15, 2010).

[128] See http://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/TELUS.pdf/$FILE/TELUS.pdf (available December 15, 2010).

[129] See http://www.globalive.com/anthony-lacavera-how-do-we-create-a-globally-competitive-wireless-industry-in-canada/ (available December 15, 2010).

Political feasibility: Due to high political risks, I ranked this option low on political feasibility. The level of inter-governmental co-operation to create the proposed agency may be prohibitively high. Historically, such co-operation has been elusive in Canadian politics. Regional power imbalances are partly to blame. Would the Quebec or Ontario governments willingly concede power to the feds on matters pertaining to innovation? Not likely. More generally, provincial governments would be unwilling to take direction and policy advice from their counterparts or the federal government, particularly in areas that infringe upon their jurisdictional power. Each province has different priorities and faces different economic circumstances. The risk is that the interests of the larger and more powerful provinces will dominate those of national interest regarding innovation policy. These are realities of the Canadian political landscape.

Administrative ease: To pursue this option, governments would outline the parameters of the agency, design a framework, provide funds, and appoint a number of innovation experts and bureaucrats to manage things. The agency would work with the federal and provincial governments to set agendas and fill gaps in Canada's innovation system. The ultimate goal would be to ensure innovation policy is coherent, eliminating redundant policies and ensuring policies are not operating at cross purposes. This sounds relatively straightforward. However, if previous attempts to create a national agency are any indication of what to expect, a pan-Canadian agency for innovation policy may be administratively problematic. Consider, for example, the federal government's attempt to create a national securities regulator. One informed observer documents major barriers—particularly legal and constitutional ones.[130] While the proposed agency differs from a national securities regulator, the principles of getting a national agency off the ground are the same. And based on experience with latter, the administrative ease of creating a pan-Canadian agency with any real power and legitimacy is low.

Stakeholder support: I ranked this option medium on stakeholder support. I suspect support would depend on how well the agency functions and whether it contributes in any way to industry's bottom line. This is hard to judge. If ineffective, however, industry participants may perceive the agency as an extra layer of unnecessary bureaucracy. In the end, the true value and quality of the agency can only be judged after it is operational—that is, the results are what matter.

[130] See http://www.nationalpost.com/todays-paper/Houdini+gambit/3869790/story.html (available December 15, 2010).

Budgetary costs: Option 5 received a medium ranking on the budgetary costs criterion. The main costs would be for setting up the proposed agency. There will be both upfront implementation costs as well as on-going budgetary costs to pay staff, provide infrastructure (offices, equipment), and so on. But the costs should be minor relative to other innovation support programs. To minimize federal costs, funding responsibility for the agency can be shared with provincial governments.

8.3 Policy implications and recommendations

As a quick and dirty tool, the policy evaluation matrix suggests that removing foreign investment restrictions (option 4) "scores" the highest overall based on summation of individual criterion scores. Replacing SR&ED tax expenditures with broad-based business tax relief (option 3) and the status quo (option 1) follow closely behind. What are we to make of these overall scores? While the matrix allows for determination of where particular options excel and others fail, the overall scores assume the criteria should all carry the same weight. This is an oversimplified aggregation. The matrix is most useful for understanding the trade-offs among and within policy options.

That said, option 4 dominates the others on effectiveness. The status quo (option 1) does best on political feasibility, but option 4 is a close second. Option 3 has a slight edge on administrative ease over option 4. Stakeholder support is highest for the status quo and option 4, with strong support expected for option 2. All options do relatively well on budgetary costs, except option 5, but option 4 has an advantage.

In my estimation, option 4 is the recommended alternative. It ranks high on all criteria. But we shouldn't necessarily view the policy options as mutually exclusive. Option 3 also does relatively well on all criteria. Policymakers could take a two-pronged approach to boost business R&D: remove foreign investment restrictions in R&D intensive sectors while at the same time enacting additional broad-based business tax relief. Together, these options would work well since each reinforces the impact on business R&D and the broader economy. Lower restrictions, coupled with lower taxes, would work well for attracting international firms to Canada, bringing the benefits that each option provides (increased R&D, capital, spillovers, competition, etc.). Whether the tax relief comes at the expense of the SR&ED program—either through complete removal or scaled back support—is a question policymakers need to answer. The choice boils down to the availability of public resources. Fiscal pressures as a result of the recent economic recession might mean delaying additional business tax relief (on top of that already planned) until government balance sheets return to black.

While direct support for R&D is used exclusively in the case countries (and in many other high R&D performing countries), option 2 does not appear to be effectively transferable to Canada. I have concerns about whether the increased support would better stimulate R&D than R&D tax credits and about the administration of a program designed to disburse R&D grants and contributions, especially in a decentralized federation like Canada with all its idiosyncratic obstacles.[131] Most worrying of all, however, are the political risks associated with option 2. Canada's track record in picking industrial winners is not encouraging, and regional tensions and political economy considerations give rise to the real possibility of R&D grants being politicized.

Creation of the proposed pan-Canadian agency to co-ordinate federal and provincial innovation policy (option 5) is a good idea in theory. But my policy evaluation revealed that it doesn't stand strong after scrutiny on the various criteria.

In the end, the status quo, despite its deficiencies, doesn't seem so bad. A low cost improvement to the status quo could be achieved through marginal tweaking, particularly in the area of SR&ED program administration. More predictable eligibility criteria, for one, would reduce compliance costs for businesses and make the tax credits more valuable. Another marginal reform is to follow the Australian example and introduce a premium tax credit for firms that perform additional R&D above the firm's most recent three year history of average R&D spending. According to Cumming (2007, p. 13), "the Australian R&D tax policy design has induced significantly more R&D in a cost-effective manner, and suggests Canada's tax policy toward R&D might benefit from implementing similar kinds of premium concessions."[132] Fortunately, a review of the SR&ED program is in the works and results are due out next year.

[131] My concerns are based on my policy evaluation, which I use theory and evidence to make conclusions. I determine that the approach used in the case countries likely won't transfer well to Canada.

[132] See Cumming (2007) for further discussion on the Australian case.

9: Conclusion

The issue of Canada's lacklustre business R&D output has puzzled researchers for decades, and my findings are no exception. As this study has shown, innovation is a complex, multi-faceted process. No magic bullet exists for increasing business R&D. Effective innovation policy requires broad policy initiatives aimed at many areas spanning the availability of skilled labour, the business environment, the interaction between universities and industry, and the like.

In the end, this study raises more questions than answers. But it does offer some options that policymakers can undertake to increase business R&D. The best course of action emanating from my policy evaluation is removal of foreign investment restrictions in R&D intensive sectors (telecommunications and air transport). The policy option of broad-based business tax relief is another strong alternative. The status quo is also a realistic alternative but problems with program administration must be addressed. Other, peripheral policies can be undertaken to stimulate business R&D, but these options were not evaluated.

Some limitations of this study should be noted. First, the policy options I explore are broad, and my evaluation lacks exact empirical measures to assess performance on the various criteria. As a result, my recommendations are loosely supported. Second, many feasible and indeed essential policy options were not formally evaluated. Third, I presented the options that I did evaluate as being mutually exclusive. This was done to help facilitate the analysis. In reality, they need not be. It is possible and in fact advisable to pursue certain options in unison. Finally, no matter what options are ultimately pursued, change in Canada's business R&D and innovation performance will not occur overnight. It will almost certainly necessitate a fundamental shift in the country's industrial structure. And that will take time.

Appendices

Appendix A—Endogenous Growth Theory

The formal theory linking innovation to economic growth sprung up over half a century ago when Robert Solow, a Nobel Laureate economist, developed a seminal model (see Solow, 1956).[133] The model is grounded on three specific assumptions. First, Solow assumes that the productive capacity of the economy can be characterized by the interaction of two factors of production, labour and capital, with each factor exhibiting diminishing returns.[134] Diminishing returns to capital, for example, implies that adding more capital and holding the number of workers fixed produces more output, but each additional unit of capital adds less to output than the previous unit. Second, Solow assumes that the economy's production function yields constant returns to scale. Constant returns to scale imply that a doubling of inputs doubles output. Third, Solow assumes that firms operate in a perfectly competitive marketplace, meaning individual firms possess no market power. Using this framework, Solow found that technological change is one of the most important sources of economic growth.[135]

Although Solow's model produces the valuable insight that technological change is critical to economic growth, its major limitation is that such change is exogenous. Exogenous technological change means that changes in technology over time are independent of the behaviour of consumers and producers in the economy and of government policies. The assumptions underlying Solow's model have been criticized as being unrealistic; technological change is not always an exogenous factor determined by an unknown process. For example, many discoveries and technological improvements that significantly raise living standards are made by firms seeking profits or an advantage over their rivals. In addition, markets are rarely perfectly competitive; they are often characterized by imperfect competition, increasing returns to scale, and asymmetric information.

[133] This survey on the development of endogenous growth theory draws from Law (2000).

[134] Specifically, Solow assumes an economy-wide production function of the Cobb-Douglas variety. The theoretical representation is $Y_t = A_t\, F(K_t, L_t)$ where Y_t is output at time t, K_t is the stock of physical capital (i.e., machines and equipment) at time t, L_t is labour (i.e., total number of people working or total time worked) at time t, F is some function (i.e., technology), and A_t is total factor productivity (TFP). In other words, combining physical capital and labour in a given time period produces some level of output that depends on the technology used and TFP.

[135] In a later paper, Solow calculated that a large portion of the growth in the US economy could not be explained by the growth in capital and labour inputs alone. He then concluded that the "residual," or unexpected portion of growth, must be attributed to something else. Solow speculated that his residual reflected technological change over time.

Beginning in the 1980s, new and more sophisticated growth models emerged relaxing many of Solow's assumptions.[136] These models fall under the rubric "endogenous growth theory." They no longer assume that technological change is exogenous. Instead, they endeavour to explain where technologically driven productivity growth comes from. The major insight is that growth is driven by the purposeful efforts of individuals to create, acquire, and accumulate knowledge—in particular, knowledge embodied in human capital and innovation.

Two strands exist in the endogenous growth literature.[137] The first takes its cue from the seminal work of Romer (1986) and Lucas (1988). These models assume that the economy's production function yields increasing returns to scale—the idea that output per person can grow without bound. This is made possible by the accumulation of, and investment in, knowledge-based factors of production such as human capital, where human capital is the stock of skills, knowledge, and ideas of a country's workers.[138] In this strand, investments in knowledge arise from decisions to save; some saving finances physical capital and some finances human capital. The policy implication is that governments can speed up technological change and economic growth by encouraging human capital accumulation. For example, governments can channel public savings to education and training initiatives, thus improving the economy's ability to produce sustained economic growth.

The second strand of endogenous growth models takes its cue from an influential article by Romer (1990), which has been extended by Grossman & Helpman (1991) and Aghion & Howitt (1998) among others. As in the first strand, knowledge plays a central role in the growth process, but the focus is on the creation of new knowledge—that is, innovation. The models assume that firms invest in R&D when they see an opportunity to earn profits from their innovation. But because R&D is costly and risky, while the end product may be easy to replicate, some firms may not pursue certain innovations. The policy implication, then, is to provide incentives for firms to innovate. The patent system is one incentive-based scheme that grants firms a monopoly right over an invention, giving them the exclusive power to profit from it for a specified period and recoup initial R&D costs. With patents, firms are assumed to compete in a

[136] Much earlier, yet less formal, models were advanced by Schumpeter (1942) who stressed that economic growth is a by-product of innovation that occurred in imperfectly competitive markets.

[137] See Romer (1994) for a survey of the developments in endogenous growth theory.

[138] Accumulating human capital (and knowledge more broadly) has a key distinguishing feature from accumulating physical capital, which is the centrepiece in Solow's growth model. Knowledge is non-rivalrous. That is, a given person's acquisition of knowledge does not reduce the ability of someone else to acquire the same knowledge. Accumulating physical capital, however, is rivalrous, as the acquisition of plant and equipment by a firm uses up resources that could be used by other firms for the same activity.

monopolistically competitive environment. As in the first strand of endogenous growth models, output per person grows without bound since there is no tendency for the economy to run out of innovative ideas.

Much of the new research on endogenous growth theory includes models of the diffusion and adoption of technologies.[139] Whereas Solow's model assumes that new technologies can be adopted at no cost by all countries, recent models analyze how technology is transferred across countries. International trade, foreign direct investment (FDI), joint ventures, strategic alliances, technology licensing, and the mobility of highly skilled workers have been found to facilitate the diffusion of technology, while investments in human capital and domestic knowledge infrastructures have been shown to increase a country's ability to adopt and benefit from foreign technology.

By making technological change endogenous, endogenous growth theories have underscored the importance of public policy in determining economic performance (Gera et al., 2006). Policies in areas such as education and innovation, as well as international trade and investment now receive special attention.

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[139] See Grossman & Helpman (1994) for a survey of this literature.

Appendix B—Structure of Canada's Research System and Key Support Programs for Innovation

Three institutional sectors form the backbone of Canada's research system: industry, governments (federal and provincial), and higher education.[140] Industry performs roughly 56 percent of total R&D in the country. The federal government, through various departments, agencies, and institutions, plays the role of funder, facilitator, performer, and regulator. It receives advice from the following sources of expertise on matters pertaining to science and technology (S&T) policy:

- The Science, Technology, and Innovation Policy Council (STIC). Established in 2007, the STIC provides S&T advice on issues determined by the Minister of Industry. It also provides regular "State of the Nation" reports benchmarking Canada's S&T performance against international standards (see STIC, 2009). STIC members include representatives from business, government, and academia.
- The Council of Canadian Academies. Founded in 2005, the Council provides advice regarding Canada's S&T strengths and weaknesses.
- The Prime Minister's Advisory Council. It provides advice on national S&T issues and performance.
- The Council of Science and Technology Advisors. It provides advice on S&T issues internal to the federal government.

The federal government administers several key innovation support programs (see table below). In addition, some provinces have their own programs to support innovation. The provinces also perform and fund research in ways similar to the federal government, sometimes through partnerships. Many provincial governments work with the federal government to start venture funds, incubators, and research facilities to promote potential R&D clusters. Canadian universities and colleges collaborate with national and international industry partners on R&D for commercial purposes. Finally, the Federal Partners in Technology Transfer (FPTT)—a network of people who work in Canada's federal science-based departments and agencies—work together to transfer research and technologies from government laboratories to the private sector.

[140] See http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=35&countryCode=CA&parentID=34 (available December 15, 2010).

Key Innovation Support Programs in Canada	**Description**
Scientific Research and Experimental Development (SR&ED) Tax Credit	The SR&ED tax credit is Canada's largest support program for business R&D. It reduces the cost of R&D activities for businesses through the tax system.
Industrial Research Assistance Program (IRAP)	IRAP attempts to stimulate innovation in smaller Canadian enterprises by providing cost-shared financing of research and pre-competitive technology development projects.
Networks of Centres of Excellence (NCE)	NCE facilitates collaboration among leading researchers in universities, industry, and government, and helps accelerate the commercialization of research. Programs under the NCE umbrella include Centres of Excellence for Commercialization and Research (CECR), Business-Led Networks of Centres of Excellence (BL-NCE), and Industrial Research and Development Internships (IRDI).
Strategic Aerospace and Defence Initiative (SADI), formerly Technology Partnerships Canada (TPC)	SADI supports Canadian aerospace and defence industries with repayable contributions for "strategic" R&D projects. Contributions for each project are supposed to equal the minimum amount necessary to ensure the project becomes successful. SADI replaced TPC.
Canadian Space Agency (CSA) Programs	CSA implements a variety of R&D-related programs in co-operation with other government departments/agencies, industries, universities, and international partners. R&D projects often require that firms establish alliances with other firms or with universities.
Industrial Partnership Facility (IPF)	IPF is a National Research Council (NRC) initiative where start-ups and spin-offs are "co-located" with NRC's research institutes and have access to serviced space, technical expertise, facilities, and communications networks. The Facilities allow companies to develop in close proximity to research laboratories and personnel.
Industry-University Research Chairs	Industry-University Research Chairs provide five-year grants, matched by the company, to provide the salary and research support for a professor working on a joint collaborative project with industry. The Chairs are intended to develop and transfer technology and skilled researchers from the university lab to industry.
Industry Canada (IC)	Through its Strategis website, IC disseminates information on technology developments and opportunities.

CANARIE Inc.	CANARIE Inc. promotes the development of communications infrastructure such as advanced broadband networks. Financial contributions from CANARIE are repayable if the R&D project is successfully commercialized.
PRECARN	PRECARN is a government funded organization that fosters technology transfer with companies that are interested in commercialization.
Canada Foundation for Innovation (CFI)	CFI provides grants for research infrastructure such as the development of national on-line databases that facilitate access to academia.
Canada Research Chairs (CRCs)	In 2000, the federal government created the CRCs program to establish 2000 research professorships in universities across the country by 2008. The goal is to attract and retain some of the world's best and brightest.
Canada Institutes of Health Research (CIHR), Natural Sciences and Engineering Research Council of Canada (NSERC), and Social Sciences and Humanities Research Council of Canada (SSHRC)	Project support for university research is channelled through three granting councils: CIHR, NSERC, and SSHRC.
Genome Canada	Genome Canada is the primary funding and information resource relating to genomics and proteomics in Canada.
Graduate Scholarships (i.e., Vanier Canada)	Graduate scholarships support Canada's "best students" in pursuit of advanced studies.

Appendix C—Challenges in Case Countries

Israel

Despite a remarkable upsurge in R&D activity over the last two decades, Israel faces the following economic challenges.

- Foreign investors have typically placed emphasis on setting up R&D facilities in Israel, taking advantage of Israel's ample supply of highly skilled engineers and its solid track record for innovation. But some argue this has been a mixed blessing for the Israeli economy because research facilities do not generally make the same contribution to job creation and exports as do manufacturing plants (Dutta et al., 2008). Another concern is that foreign R&D facilities "take away" skilled labour that could otherwise be used by local firms, but this is of little material consequence.
- The prevailing business model in Israel, which involves heavy reliance on foreign economies (especially the US), poses some risk in a globalized world economy where capital moves relatively easy to more highly valued use.
- R&D policy evaluation is generally weak in Israel or kept secret (Erawatch, 2009b).
- While Israel does well on innovation indicators, the benefits have yet to spread widely throughout the economy. The country is still relatively poor compared to other OECD members.
- Security is on-going risk in Israel, which threatens economic progress.

Finland

Finland has the enviable position as a world leader in innovation, but the country suffers from the following shortcomings.

- The Finnish knowledge economy lacks diversification. R&D investment is concentrated in certain manufacturing sectors (especially ICT) and dominated by a handful of large domestic multinational companies (OECD, 2008). For instance, Nokia alone accounts for almost half of overall business R&D. The shares of two traditional pillars of Finnish industry—the wood processing and the metal industries—have decreased and account for no more than 16 percent of business R&D (OECD, 2008). The share of the paper and pulp industry has similarly declined. With R&D concentrated in a few large firms, the country risks losing major R&D sources if an individual company (or group) terminates operations or moves abroad. Moreover, since Finland's recent economic success is largely driven by a single company (Nokia) success may be more attributable to good fortune than public policy.

- Finland has few R&D oriented start-up companies, which weakens entrepreneurship (OECD, 2008).
- Finnish innovation lacks participation from foreigners, as evidenced by the small number of patents involving foreign co-inventors and the small percentage of business R&D funded from abroad (OECD, 2008).
- According to Häyrinen-Alestalo et al. (2005), Finland is losing momentum on leading education policy, attracting FDI, utilizing innovations, and exploiting R&D investments.
- National innovation policy in Finland has been criticized for relying on the achievements of a model from the late 1990s, making it difficult to meet the challenges of globalization (Häyrinen-Alestalo et al., 2005). In particular, internationalization of R&D (the movement of R&D centres abroad) is a threat to future development of the Finnish national innovation system.

Sweden

Sweden's innovation system is strong on several measures compared to most other OECD countries. However, the country faces many challenges that threaten its ability to stay competitive and keep its leading position on innovation.

- Swedish investment in R&D produces inadequate returns (OECD, 2005). That is, high investments are not paying off in terms of economic growth to the extent expected. This has been termed the "Swedish paradox."
- Swedish R&D exhibits weak export performance in advanced industries. Swedish R&D focuses very little on high-tech industry and a large share of Swedish R&D has been devoted to streamlining the production of low- and medium-tech products such as pulp and paper and other activities that do not generate high-tech production and exports (Blomström et al., 2002).
- R&D investments are not equally distributed across firms. Four leading multinational corporations account for two-thirds of total R&D in manufacturing (OECD, 2005). Moreover, a few large corporations that are responsible for a sizeable chunk of R&D have recently reduced their R&D investments. Dependence on a few large firms for business R&D makes Sweden vulnerable.

- Many Swedish multinational companies have recently been bought out by foreign firms. Increased foreign ownership could hurt future innovation if foreign-owned firms invest less in Sweden for R&D and production. More generally, globalization challenges Sweden's traditional approach to innovation policy.
- Swedish industrial policy has been biased against small firm development for almost a century, impacting negatively the evolution of entrepreneurship (OECD, 2005). For example, start-up firms lack financial support from both the Swedish government and venture capitalists. The latter are typically interested in financing firms in later stages, after the period of high risk. A concentrated industrial structure may create a false reading on the strength of the country's innovation system.
- University research in Sweden is high but often not commercialized (Goldfarb & Henrekson, 2003).
- Sweden's business tax regime is competitive internationally, but personal income taxes are among the highest in the developed world. High personal income taxes create a disincentive for skilled individuals to stay in or come to Sweden (Blomström et al., 2002). In addition, high income taxes encourage relocation of advanced functions to foreign affiliates (Blomström et al., 2002). The tax system more broadly has created perverse unintended consequences. Several large family-controlled multinational corporations (i.e., Tetra Pak and IKEA) have relocated their headquarters abroad in order to facilitate the transfer of ownership to younger generations, which is difficult in Sweden because of high inheritance taxes (Blomström et al., 2002). Moreover, the combination of low corporate taxes and high personal income taxes has made it more attractive to retain earnings and reinvest them in existing businesses, leading to a system that seeks to reduce risks rather than rewarding risk-taking (Granat Thorslund et al., 2005).
- High personal income taxes have also had the detrimental effect of reducing the economic return to higher education (Andersson & Ejermo, 2005). This has in part contributed to low enrolment rates in tertiary education, especially technical universities, leading ultimately to a shortage of skilled professionals in Sweden (Blomstrom et al., 2002).
- Sweden's labour markets are inflexible and the mobility of skilled labour is relatively low. This is problematic because experienced individuals with knowledge and skills can generate new ideas and innovations.

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