Innovation and Business Strategy: Why Canada Falls Short

The Expert Panel on Business Innovation

Council of Canadian Academies
Conseil des académies canadiennes

Science Advice in the Public Interest

INNOVATION AND BUSINESS STRATEGY: WHY CANADA FALLS SHORT

Report of the Expert Panel on Business Innovation

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The reviewers assessed the objectivity and quality of the report. Their submissions – which will remain confidential – were considered fully by the panel, and most of their suggestions have been incorporated in the report. The reviewers were not asked to endorse the conclusions nor did they see the final draft of the report before its release. Responsibility for the final content of this report rests entirely with the authoring panel and the Council. We thank the following individuals for their reviews:

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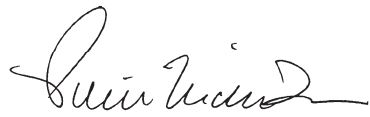

Peter J. Nicholson, President
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Table of Contents

PREFACE 1

EXECUTIVE SUMMARY 3

CHAPTER 1 Introduction and Charge to the Panel 13

CHAPTER 2 The Nature and Importance of Innovation 21

CHAPTER 3 The Innovation Performance of Canadian Business 45

CHAPTER 4 Innovation as a Business Strategy 81

CHAPTER 5 Structural Characteristics 87

CHAPTER 6 The Role of Competition 109

CHAPTER 7 The Climate for New Ventures 119

CHAPTER 8 The Influence of Public Policy 147

CHAPTER 9 Business Ambition 167

CHAPTER 10 Case Studies: Sectoral Perspectives on Innovation 177

CHAPTER 11 Conclusions 209

ANNEX I The New (Endogenous) Growth Theory 213

ANNEX II Growth Accounting 217

ANNEX III Analysis of R&D Intensity by Sector 221

ANNEX IV Individuals and Institutions Consulted 233

REFERENCES 237

Preface

The Expert Panel on Business Innovation first met in November 2007, a time when the Toronto Stock Exchange index was nudging 14,000, oil was close to $100 a barrel, the Canadian dollar was above par with the U.S. dollar, economic growth was solid and the unemployment rate was at a multi-decade low.

But beneath the bullish daily headline data were worrisome longer-term trends, particularly the poor performance of productivity growth in Canada. Growth of the hourly output of Canada's business sector had been falling behind that of the United States for more than two decades, and the trend had deteriorated significantly since 2000. Investment in leading-edge technology – particularly related to computers and communications – was lagging significantly behind not only that of the United States, but also many of the advanced countries with which Canada compares itself. Business spending on research and development as a share of the economy was down 20% from its 2001 peak at the end of the technology boom.

It was in this context of mixed signals – rosy on the surface but less so underneath – that the Government of Canada asked the Council of Canadian Academies to appoint a broad-based panel of experts to assess the innovation performance of Canadian business. This report records the panel's analysis and findings. It is a diagnosis rather than a policy prescription, though it provides a body of fact and informed opinion that is of policy relevance.

While the panel was completing its work in late 2008 and early 2009, the world changed dramatically. Because the extent of the global economic crisis is unknown, its full implications for the panel's analysis will only become clear with the passage of time. The panel has therefore not attempted to factor the crisis prominently into its diagnosis of business innovation in Canada – a longer-term perspective is needed in any event. The symptoms of lagging innovation by the business sector in Canada are of very long standing. The panel therefore focused primarily on long-run phenomena, stretching over decades and across several ups and downs of the economic cycle.

The panel's findings therefore remain relevant despite the severe contemporary shock to the global economy. As governments in Canada continue to take measures in the near term to mitigate the downturn, a sound diagnosis of the underlying causes of Canada's generally weak business innovation performance can help to target those measures so that they also strengthen the nation's economy for the long term.

Executive Summary

This report addresses the fundamental factors that influence the innovation behaviour of businesses in Canada. Innovation is of great economic importance because it is, directly and indirectly, the key driver of labour productivity growth (increased output per hour worked) and the main source of national prosperity. The panel has therefore approached innovation as an *economic* process rather than as a primarily science and engineering activity. The theme is the link between business strategy and innovation activity. The focus is on the long run, spanning several turns of the economic cycle. The findings therefore remain relevant despite the current shock to the global economy. As requested by the government, the report is primarily a diagnosis, not a policy prescription, though it provides a body of facts and informed opinion that is of policy relevance.

INNOVATION DEFINED

Innovation is new or better ways of doing *valued* things. Innovation is not limited to products but includes improved processes like the assembly line, and new business models like web-based commerce. An "invention" is not an innovation until it has been implemented to a meaningful extent. Radical innovations like the steam engine and the transistor create entirely *new markets*. Much more prevalent is incremental innovation in *established markets* in which goods and services are continuously improved – a process that is responsible for the majority of labour productivity growth. Although the strategies and policies appropriate for innovation in new markets are generally quite different from those in established markets, they are complementary because successful new markets, like the "smartphone" market today, eventually become established markets.

INNOVATION AND PRODUCTIVITY

Canada has a serious productivity growth problem. Since 1984, relative labour productivity in Canada's business sector has fallen from more than 90% of the U.S. level to about 76% in 2007. Over the 1985-2006 period, Canada's average labour productivity growth ranked 15th out of 18 comparator countries in the OECD.

Long-term analyses by Statistics Canada and the OECD show that Canada's relatively poor productivity growth is due mainly to weak growth of *multifactor productivity* or MFP. (MFP broadly reflects the effectiveness with which labour and capital are combined in the economy.) Canada's productivity weakness is not due to shortcomings in its workforce. Neither, for the most part, does it reflect inadequate capital investment, though business investment in information and communications

technologies (ICT) has been especially weak and subpar investment in advanced equipment and software can also hold back MFP growth. The rate of MFP growth over suitably long periods primarily reflects the contribution of business innovation to labour productivity growth – including better organization of work, improved business models, the efficient incorporation of new technology and the payoff from research and development (R&D) and from the insights of entrepreneurs. *Canada's weak growth of MFP indicates that the country's lagging productivity growth is largely due to weak business innovation.*

OTHER INNOVATION INDICATORS

Canada's weakness in business innovation is also signalled, more conventionally, by persistently lagging investment in R&D and, more recently, in ICT, though these indicators are far less comprehensive as measures of innovation than is the long-run rate of MFP growth.

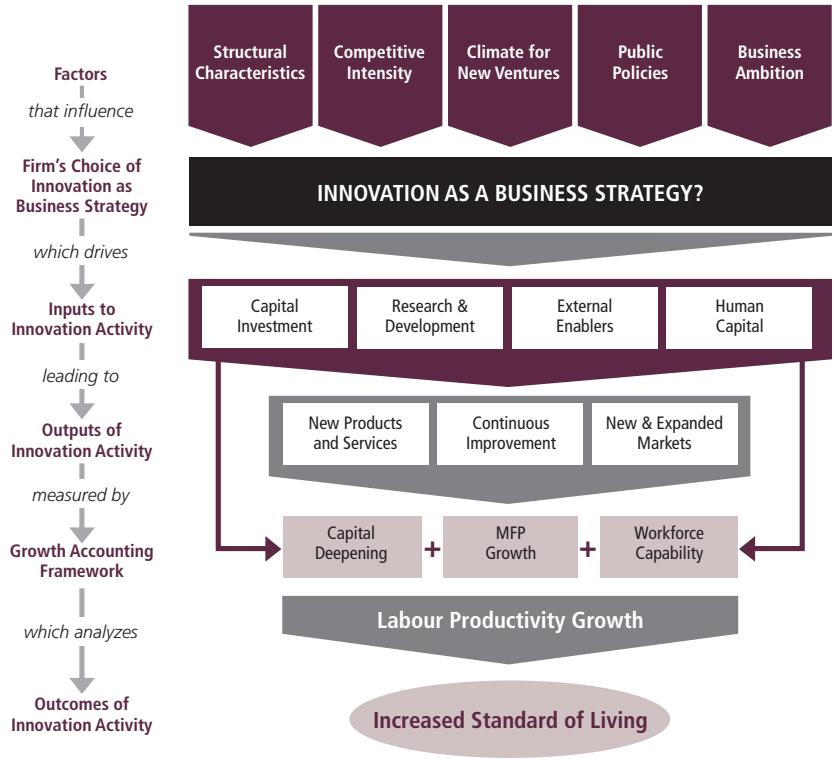
Research and development: Since the collapse of the technology boom in 2001, Canada's business expenditure on R&D has remained roughly flat after taking account of inflation. Expressed as a percentage of GDP, business R&D declined by 20% between 2001 and 2007 and has consistently fallen below the OECD average. The gap in business R&D spending between Canada and the United States diminished significantly between the mid-1980s and the peak of the technology boom in 2001, but has since begun to open up again. The most significant drivers of the long-run trend have been (i) a sharp reduction in the contribution of the manufacturing sector to the Canada-U.S. gap, implying that Canada has been making some progress in manufacturing innovation; and (ii) an offsetting increasing gap in business services R&D (particularly in wholesale and retail trade). The broad shift of output and employment toward services and the application of ICT in service sectors have been occurring more rapidly in the United States than in Canada.

Machinery and equipment: Investment in machinery and equipment (M&E) is a principal channel through which innovation drives productivity growth because such investment "embodies" the prior innovation of producers of capital goods, including software. M&E investment also stimulates innovative changes in processes and work organization to take best advantage of the new capital. (The productivity improvement resulting from such changes is captured statistically within MFP growth.) Annual investment by Canadian business in M&E (as a percentage of GDP) has not always lagged the United States as has been the case with R&D, though a gap has opened up since the early 1990s. The M&E investment gap has been mostly due to Canada's persistently weaker investment in ICT.

Average ICT investment per worker in Canada was only about 60% of the U.S. level in 2007. This is a serious shortcoming since the production and application of ICT have been the key drivers of innovation and resulting productivity growth in the United States and several other countries.

THE CENTRAL ROLE OF BUSINESS STRATEGY

Business strategy drives innovative behaviour. Explaining business innovation performance in Canada therefore comes down to explaining the business strategy choices of Canadian firms. *If innovation is good for business, why don't more businesses in Canada choose to compete on the basis of innovation?* To address this question requires a shift of perspective away from innovation activities themselves – e.g., inputs like R&D and investment in M&E – to a focus instead on the factors that influence the choice of business strategy. This reframing of the innovation puzzle is the most important contribution of the panel's analysis – see diagram below.



Logic Map of the Business Innovation Process

FACTORS THAT INFLUENCE CHOICE OF AN INNOVATION STRATEGY

The principal factors that influence the business innovation decision can be categorized broadly as (i) particular characteristics of the firm's sector; (ii) the state of competition; (iii) the climate for new ventures; (iv) public policies that encourage or inhibit innovation; and (v) business ambition (i.e., entrepreneurial aggressiveness and growth orientation). The relative importance of these factors will vary from sector to sector and over the life cycle of individual firms.

The foregoing factors are themselves influenced by certain long-standing features of Canada's economy, of which the two most significant are the following:

- *Canada is "upstream" in many North American industries.* This positioning is the result of Canada's resource endowment and development history as a commodity supplier and technology adopter. Canada's upstream position in many continentally integrated value chains limits contact with ultimate end-customers – who are a strong source of motivation and direction for innovation – and shapes the nature of business ambition in many sectors.
- *Canada's domestic market is relatively small and geographically fragmented.* Small markets offer lower potential reward for undertaking the risk of innovation and tend to attract fewer competitors, thus providing less incentive for a business to innovate in order to survive. On the other hand, the innovation success of countries like Finland and Sweden shows that the disadvantage of a small domestic market can be offset by a strong orientation toward innovation-intensive exports.

Industry Structure Characteristics

The effect of structural factors – particularly sector mix and foreign control – on business strategy choice is most readily seen through analysis of the gaps between Canada and the United States in respect of R&D spending and ICT investment (interpreted as indicators of emphasis on innovation as a business strategy).

Sector mix: A sector by sector analysis of the overall U.S.-Canada R&D gap shows that generally lower Canadian R&D spending within the *same* sectors in both the United States and Canada accounts for a greater portion of the gap (the precise share of which varies from year to year) than does Canada's adverse sector mix – i.e., the greater weight in Canada's economy of resource-related and other activities that have inherently low R&D spending. Resource-based industries invest heavily, though indirectly, in innovation that is embodied in advanced equipment. The

puzzling failure of Canada to develop global export leaders in advanced M&E for the resource sector is one particularly telling indicator of the country's innovation shortcomings.

Foreign control: The foreign control of several major Canadian businesses is part of the explanation for low R&D intensity – e.g., accounting for very low Canadian R&D in the automotive and chemicals industries. This reflects the traditional tendency of global corporations to conduct most innovation activity near their headquarters. There is nevertheless a trend underway to distribute innovation activities globally so as to take advantage of lower costs and special skills, and to be closer to important concentrations of customers. Foreign control does not automatically lead to low R&D activity in Canada. In fact, foreign subsidiaries in several sectors – e.g., pharmaceuticals and computers – have been major contributors to Canadian R&D. Moreover, if the foreign-controlled facilities were not here, there is no guarantee that Canada would have developed a "replacement set" of domestically owned R&D performers. *Canada's failure to develop a greater number of innovative Canadian-based multinationals has been a key contributor to the country's overall R&D weakness*.

Structure and ICT investment: Empirical studies suggest that only about 20% of the U.S.-Canada gap in ICT investment can be explained by structural characteristics related to sector mix and firm size distribution. Further study is needed to determine definitively the other factors that account for this perplexing gap. For now, it can only be said that relatively low ICT adoption is consistent with a view that *Canadian businesses on the whole, but always with notable exceptions, are technology followers, not leaders*.

Competitive Intensity

Competition stimulates innovation in most circumstances. In Canadian sectors that are well exposed to international trade (whether as exporters or competing against unconstrained imports), there do not appear to be significant innovation gaps, though many of Canada's export industries are either specialized at the upstream end of the value chain or dependent on technology and innovative practices in foreign-controlled firms.

The relatively small size of Canada's domestic market – made even smaller by regional fragmentation – tends to limit both competitive intensity and the returns to innovation in domestic sectors, which underlines the importance of increasing Canada's presence in global export markets for innovation-intensive goods and services. Innovation is needed to move from a domestic to a global growth strategy. Reciprocally, a heavy investment in innovation usually requires Canadian

businesses to go for the scale of global markets. Canadian businesses, on the whole, have so far failed to aggressively grasp the opportunities created by globalization, a shortcoming that is demonstrated by the relative lack of innovation-oriented Canadian-based multinationals.

The Climate for New Ventures

Despite some dynamic clusters – such as in Waterloo and in the largest Canadian cities – Canada needs to do better in creating the conditions to enable more of the country's impressive number of startups to become viable, growing businesses still based in Canada. The following three key conditions determine the quality of the environment in Canada for the support of such businesses.

Financing new ventures: A vibrant angel investor community is the key to bridging the "valley of death" that separates a promising idea from a viable startup business. (Angels are produced when innovative entrepreneurs succeed and thus generate both the financial resources and the experienced mentors to stimulate and guide a new generation of innovators.) The limited data available on "informal" investment sources in Canada suggest that they are much less extensive, in relative terms, than comparable sources in the United States. (Canada has produced a number of successful angel investors in several ICT subsectors, but relatively few in the life sciences.) Venture capital (VC) is the post-angel stage of funding when the basics of the business proposition have already been developed and larger sums are needed to ramp up to commercial scale. The generally weak performance of Canada's VC industry is due to the fact that the industry is still relatively young, and thus has not yet developed sufficient depth of experience to select and mentor the best potential investment candidates. It is also the case that several issues related to the VC activities of tax-advantaged Labour Sponsored Investment Funds (particularly outside Québec) have affected incentives and performance in the industry. While there is no quick or easy fix for Canada's VC industry, better performance depends on the industry maturing through competitive experience. Policy makers can positively influence the availability of risk capital funding, particularly at the earliest stage and also at the critical later (VC) stage of expansion and market growth.

Commercializing university research: Canada's record of university-based research activity is strong and ranks among the best of the OECD countries, but the commercialization of university research in Canada has been, on the whole, disappointing. The principal causes relate to (i) the shortage of commercial receptor capacity in Canada, due to the fact that relatively few established firms in this country are committed to research-based innovation (and would therefore be

in a position to transact with universities); (ii) the relative weakness of new venture financing in Canada at both the angel and later VC stages; and (iii) the inherent differences in the incentives and professional values of the university and the business firm, an issue not unique to Canada. The situation could be helped through better infrastructure for identifying and mobilizing potentially commercializable knowledge as it emerges from university-based research. In many cases this will involve well designed partnerships between universities and private sector businesses and/or government labs.

Supporting innovation clusters: Innovation is fostered by the close personal and supplier linkages that occur in certain geographic concentrations, creating local innovation "ecosystems". Public policies designed to create such clusters from scratch have yet to demonstrate much success in Canada or elsewhere, though continued learning from initiatives like MaRS in Toronto will aid the design of supportive policies. Some pre-existing advantages and a strong local catalyst appear to be critical factors. The Waterloo story is one good example and shows that cluster development may require both considerable time to mature and the convergence of several favourable features that are typically specific to the locality.

The Public Policy Environment

In broad terms, and over time, Canada has provided a progressively more encouraging environment for business innovation, at least in respect of those factors over which public policy has direct influence – for example, prudent fiscal and monetary policies, a trend of lower tax rates and support for university research. The business innovation problem nevertheless persists, so there is still much work to do.

Human capital: The continuing development of human resources is clearly necessary for innovation success and, in general, this is an area of relative Canadian strength. More specifically, the federal government's strong commitment since the mid-to-late 1990s in support of university research has increased the supply of leading-edge skills and research capacity and, other things being equal, made Canada a more attractive location for innovative business. On the other hand, Canadian business managers are, on average, not as well trained as those in the United States. This education gap may leave many Canadian managers less aware than their U.S. counterparts of developments at the leading edge of technology and business practice, and thus less likely to choose business strategies that emphasize innovation.

R&D incentives: The Scientific Research and Experimental Development tax incentive provides by far the largest direct financial support for business innovation in Canada – representing about $4 billion of federal tax foregone in 2007. While there is good evidence that the tax credit has a positive net benefit, many business leaders believe that the program should be improved – e.g., by extending the "refundability" of the credit beyond small businesses to R&D performers of any size. While Canada's total government support for business R&D (tax and direct spending combined) is somewhat larger, relative to GDP, than that of the United States and the United Kingdom, it is noteworthy that Canada's reliance on the tax assistance channel to stimulate R&D is unusually heavy. Although most countries have been increasing the use of tax credits in their R&D support programs, more evaluation is needed to determine the right mix.

Sector strategies: The ICT sector, among others such as aerospace, provides several examples of the government's catalytic role in enabling innovative activities to take root and build scale to the point where commercial viability emerges. This initiating influence has taken many forms – early procurement (for example, stimulating IBM's substantial presence in Canada); public-private commercial partnerships in support of a national mission (for example, creation of Telesat in 1969); and research support through targeted university funding and sector-oriented government facilities and programs.

Business Ambition

Are Canadian businesses good enough to compete in global markets, aggressive enough, willing to take risks, and sufficiently outward-looking beyond the huge and accessible U.S. market? Clearly, the many Canadians who have built successful global businesses have the necessary attributes. But the issue is whether there are enough of them to ensure the long-term prosperity of the entire economy. The panel's view is that today, there are not. This is not due to any lack of innate capacities of Canadian business people – it is not in the "DNA", so to speak.

Canadian business as a whole has been profitable despite its mediocre innovation record – pre-tax business profit in Canada, as a percentage of GDP, has exceeded that of the United States in most years since 1961. So the behaviour of Canadian business is unlikely to change unless its circumstances change. Those circumstances are, in fact, changing radically due not only to the current turmoil in the world economy but, more fundamentally in the long run, to a massive reallocation of the share of global economic activity as China and others become full participants in world commerce. The demographics of the Canadian business community

are also changing as immigrants and a younger generation of entrepreneurs, unencumbered by traditional attitudes, expand their presence. So whether by necessity or inclination, there is reason to expect that Canadian business will become more ambitious and innovative.

ADDRESSING CANADA'S BUSINESS INNOVATION CHALLENGE

Canada has a serious productivity growth problem. The statistical evidence is unambiguous and of long standing. The panel believes that Canadians should be concerned about the productivity of our export-oriented economy as competition from China and other emerging economies intensifies. Strong productivity growth is the way to remain internationally competitive with a rising standard of living. The panel also believes that Canadians should be concerned about the long-run consequences of continued weak productivity performance in the domestic economy as the population ages and competition intensifies among the mature economies for the best human skills, and particularly for entrepreneurial talent.

Because *Canada's productivity problem is actually a business innovation problem*, the discussion about what to do to improve productivity in Canada needs to focus on the factors that encourage, or discourage, the adoption of innovation-based business strategies. This is a complex challenge because the mix of relevant factors varies from sector to sector and requires a much broader conception of innovation than the conventional R&D-centred view which, while important, is too limiting.

There is no single cause of the innovation problem in Canada, nor is there any one-size-fits-all remedy. Public policy in respect of innovation therefore needs to be informed by a deep understanding of the factors that influence business decision makers, sector by sector, and this clearly requires extensive consultation with business people themselves as well as the further development of innovation surveys and other forms of micro-analysis of the innovation process. (The report provides several examples of industry-specific innovation challenges and strategies through short case studies of the automotive, life sciences, banking and ICT sectors.)

Overarching the sector-specific factors that influence innovation strategies are certain issues of pervasive influence identified in the panel's analysis that suggest the need for proactive public policies to:

- encourage investment in advanced M&E in general, and in ICT in particular (such incentives should be designed only in light of a more thorough understanding of the reasons for the relatively slow adoption of ICT in Canada to date);

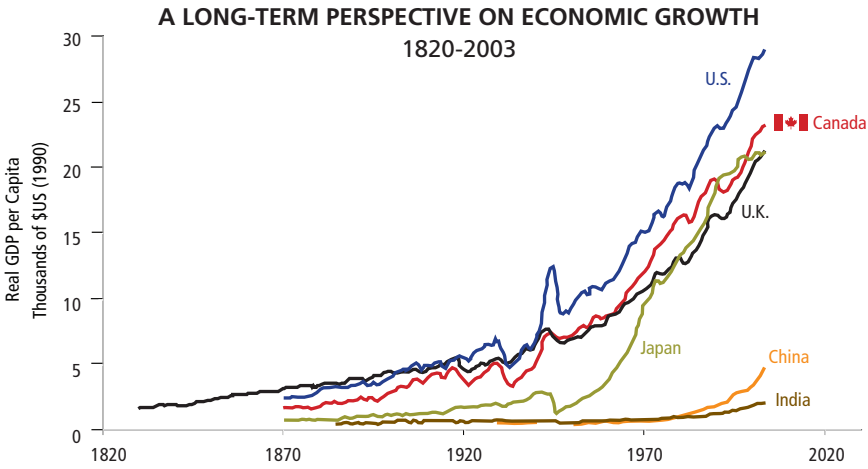
- sharpen the incentive for innovation-oriented business strategies by increasing exposure to competition and by promoting a stronger export orientation on the part of Canadian firms, particularly in goods and services that are downstream in the value chain and thus close to end-users;
- improve the climate for new ventures so as to better translate opportunities arising from Canada's university research excellence into viable Canadian-based growth businesses, bearing in mind that better early-stage financing and experienced mentorship hold the key; and
- support areas of particular Canadian strength and opportunity through focused, sector-oriented strategies, such as was done in the past in, for example, the automotive, aerospace and ICT industries.

The many successes of Canadian businesses in the hyper-competitive global marketplace show that there is nothing innate or inevitable in the national character that prevents Canada's businesses from being just as innovative and productive as those of other nations.

The panel has completed its analysis of business innovation in the shadow of the most severe global economic downturn in decades. The panel has nevertheless remained focused on the long term because Canada's innovation conundrum is deeply rooted and has little to do with the booms and busts of the economic cycle. As governments in Canada continue to take measures in the near term to mitigate the downturn, the panel's diagnosis of the nature and underlying causes of Canada's generally weak business innovation performance can help to target those measures so that they also strengthen the nation's economy for the long term.

Chapter 1 – Introduction and Charge to the Panel

Innovation – new or better ways of doing valued things – is the manifestation of creativity, the uniquely human capacity to transform the imagined into the real. The material progress of society, represented by the growing per capita output of goods and services, depends on the systematic generation and exploitation of innovation. For millennia, economic progress was exceedingly slow and halting as advances were soon offset by bouts of population growth, war and disease. Then, in the second half of the 19th century, and owing to a confluence of circumstances that are still debated, the Industrial Revolution took hold, first in Britain, and set in motion a process of sustained economic growth without precedent in recorded history (Figure 1.1). Innovations, including new political and institutional means to support innovation, spread rapidly through Europe and North America.



Data Sources: Conference Board & Groningen Growth and Development Centre, 2008; Maddison, 2008

Figure 1.1

A Long-Term Perspective on Economic Growth

The long-term trajectories of per capita economic growth are closely correlated for countries at comparable levels of development.

The pattern in Figure 1.1 suggests that once a society opens itself to reciprocal economic exchange with the technological leaders, a catch-up process ensues that is driven by the diffusion of leading-edge innovation and is extremely rapid from an historical perspective (Abramovitz, 1986).[1] China, with India close behind, is now undergoing a transition similar to that experienced by western countries and Japan over the past century and a half. The question remains whether the world's resources and the natural environment can support the almost vertical growth trajectory implied by Figure 1.1, this time involving several billion people who are still only at the foot of the development escalator. What is certain is that the innovative and adaptive resources of humanity will be challenged as never before.

Innovation matters enormously for society because it is the means by which problems are solved and new opportunities are created. Innovation is what gave us insulin, the telephone, movies, rock music, the microchip and the shopping mall, for better or worse. Innovation is also what gives rise to continuing improvement in goods and services and in the means by which they are produced.

Innovation matters for businesses, not only because great companies are often built on the success of a great innovation – for example, as Bombardier was on the basis of its founder's invention of the snowmobile – but also because novel products and more efficient processes are the principal means of making businesses more competitive. It is through innovation that businesses find ways to generate more value from existing resources. Innovation enables businesses sometimes to create entirely new markets, to expand share of existing markets, to improve profitability, or some combination of all three. When tastes shift, or major new challenges arise, innovation is usually necessary for businesses simply to survive.

As will be argued in this report, innovation is the main driver of productivity growth – the increased output of goods and services per hour worked. In the words of Paul Krugman (1990), the winner of the 2008 Nobel Prize in economics, "Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise output per worker" (p. 9). That is why innovation – which is, directly or indirectly, the principal engine of productivity growth – is the most important and fundamental source of economic progress and prosperity.

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1 Throughout the 19th century, Britain was the global technological leader in most fields of economic significance. The United States had largely caught up early in the 20th century. While Japan had a technical tradition of long standing in certain fields, it did not "take off" until after World War II when it acquired much greater access to U.S. know-how and to markets in the West.

Looking forward, we see a convergence of trends that make innovation more necessary than ever:

- Intensified global competition, particularly the exceptionally rapid emergence of China, India, Brazil and Russia as economic powers, is creating both growing challenges and opportunities for Canada.
- Less resource-intensive and environmentally damaging methods of production need to be developed through innovation to permit the continuation of economic growth and the realization of its benefits in the still-developing world.
- An aging population in Canada is making productivity growth imperative as the proportion of population that is of working age plateaus and then declines.
- Continuing revolutionary developments in the transformative technologies of information and communications, life sciences and advanced materials provide extraordinary opportunities to benefit from their innovative application.

We must therefore be concerned in the face of evidence suggesting that Canadian business on the whole, though with notable exceptions, is lagging in innovation relative not only to the United States, but also to many of our peer group of economically advanced countries in the Organisation for Economic Cooperation and Development (OECD). For example, business spending on research and development is relatively low, as is investment in advanced machinery and equipment – particularly in information and communications technologies. (These and many other indicators will be analyzed in depth later in this report.) Labour productivity growth in Canada has been lagging that of the United States and many other OECD countries for the past two decades. When combined with other measures that are linked to innovative business behaviour, where Canada also tends to lag, there is a presumptive case that the innovation performance of Canadian business is subpar.

THE CHARGE TO THE PANEL

The question is "why". *If innovation is good for business, why is Canadian business on the whole apparently less committed to innovation than analysts and policy makers believe it should be?* The question is all the more puzzling since it has been asked for decades, yet things have not changed much in relative terms. Moreover, Canada has tried many of the remedies that economists and policy analysts have recommended to promote innovation and improve productivity, though perhaps not always with sufficient vigour or persistence (OECD, 2003b, 2007c, 2008f). The causes of Canada's innovation deficiency must run deep in the nature of the economy, and perhaps in Canadian society as well.

To the extent that some of the causes might be mitigated by more appropriate public policies, it is important that governments have a sound diagnosis of what ails business innovation propensity in Canada. To this end, the federal Minister of Industry asked the Council of Canadian Academies "to work with the private sector and academic experts to deepen our understanding of the science and technology (S&T) investment constraints and opportunities facing Canadian firms. This will help the government better support an increased commitment to S&T by Canada's private sector" (Government of Canada, 2007, p. 28). Specifically, the charge to the Council was the following:

- *How should the innovation performance of Canadian firms be assessed?*
- *How innovative are Canadian firms, and what do we know about their innovation performance at a national, regional and sector level?*
- *Why is business demand for innovation inputs (for example, research and development, machinery and equipment, and skilled workers) weaker in Canada than in many other OECD countries?*
- *What are the contributing factors, and what is the relative importance of these contributing factors?*

In response to the charge, the Council of Canadian Academies assembled a panel of experts from the business, labour and academic sectors to provide answers to the four questions, drawing on their own extensive practical experience across many sectors of the economy and on the rich body of relevant domestic and international research. The panel benefited from written submissions from various individuals and organizations in response to a call for comment via the Council's website, as well as from a number of meetings between subgroups of the panel and invited experts who had extensive knowledge of specific sectors of the economy (Annex IV).

OUTLINE OF THE REPORT

Despite an outpouring of research and commentary over the years on the innovation behaviour of Canadian business, the understanding of it remains incomplete. The business innovation conundrum is therefore much in need of an objective, contemporary analysis. The principal aim of the panel's assessment is to provide this analysis. No new studies were undertaken. Moreover, the focus is on the *long run* and not on factors related to specific events or to the current severe downturn in the world economy. *The panel was not asked to provide policy recommendations, though much of its diagnosis of business innovation performance is of policy relevance*. Where findings have direct implications for policy, the panel has usually taken the opportunity to make the implications explicit.

The report is organized as follows:

- Chapter 2 defines the concept of innovation employed in the report and presents evidence of the impact of innovation on productivity growth in the context of Canada's long-run economic performance.
- Chapter 3 provides a quantitative description of the innovation activities of Canadian business, based primarily on national-level statistics relative to Canada's peer group of economically advanced countries. These data are the basis for the panel's conclusions as to the aggregate innovation performance of Canadian business against international benchmarks.
- In light of those data and conclusions, Chapter 4 establishes a framework for the panel's analysis by identifying the key factors that influence a firm's decision as to the emphasis to be placed on innovation in its business strategy. In this framework, the traditionally measured innovation "activities" discussed in Chapter 3 (e.g., research and development, hiring of highly skilled people, investment in advanced equipment) are actually the *consequences* of business choices to employ innovation as a strategic tool. The most important factors that influence the business decision as to whether or not to adopt an innovation-based strategy are (i) the structural characteristics of the Canadian economy – sector mix, foreign control and the distribution of firm size; (ii) the state of competition; (iii) the conditions that favour, or inhibit, the creation and growth of new innovative businesses; (iv) public policies that have significant impact on innovation; and (v) business ambition – for example, the extent to which business behaviour in Canada is, or is not, strongly growth-oriented. These factors are not independent of one another – for instance, if there is insufficient business ambition, the reasons may lie in some combination of the other factors.
- Chapters 5 through 9 address each of the foregoing factors, drawing on the experience of panel members and on academic literature as well as analyses by Statistics Canada, Industry Canada and the OECD, among others.
- Chapter 10 presents several short case studies of sectors of the Canadian economy – automotive, life sciences, banking, and information and communications technologies. These cases were chosen to complement the aggregated and rather abstract material in the rest of the report. The case studies do not attempt to comprehensively analyze the sectors; rather, they draw on the business experience of panel members, and of others consulted by the panel, to identify innovation-related issues and concerns that are specific to each sector. The cases contribute concreteness to the overall story and illustrate the great diversity and complexity of the innovation *problematique* in Canada.
- Chapter 11 ends the report with a statement of the panel's principal conclusions.

The full report is complemented by a digest version ("Report in Focus") that develops both the argument and main findings as an extended executive summary. The digest is made available as a stand-alone document for broad distribution and can be accessed from the Council's website (www.scienceadvice.ca).

Box 1 – Views on the Innovation Performance of Canadian Business

Government of Canada The scale of R&D effort by the Canadian private sector is far less than its international private sector competitors in many advanced economies. Only one Canadian firm was in the top 100 corporate R&D performers in the world, putting Canada at the bottom of the G7. Canadian firms also invest less than their counterparts in other countries in advanced machinery and equipment, ranking last among G7 countries. Low levels of investment by Canadian firms in information and communications technologies (ICT) compared with the US are of particular concern (2007).

TD Bank Financial Group The past decade has seen a declining trend in business sector investment intensity in Canada compared to other OECD and G7 countries. … The rapid growth in corporate profits over the past few years has not been accompanied by a matching increase in capital spending, with the result that machinery and equipment (M&E) as a share of GDP has declined – and this has happened during a period of rapid strengthening in the Canadian dollar that has reduced the cost of capital. This conservative behaviour … will not help to improve Canada's pitiful productivity performance. The main message is simple – the private sector, aided by the public sector, must put greater weight on productivity enhancing capital investment in the coming years (2007).

Bank of Canada Much uncertainty surrounds the root causes of Canada's failure in the past decade to follow in the footsteps of the US towards a higher growth rate in trend productivity. Canada appears to have taken less advantage of ICT and has also experienced few efficiency gains in the production of services and non-ICT goods… The persistently lagging performance in Canada with respect to innovative activity, adoption of new technologies, and investment in organizational capital seems to reflect less a deficiency in supply conditions than a lacklustre demand for innovation, which in turn could stem from less competition, few rewards for risk taking…In spite of the enormous research on productivity in the past decade, many issues need to be better understood in a Canadian context, [including] investigating the potential role of structural factors in holding back demand for innovation in Canada (2007).

Canadian Council of Chief Executives As a group, Canadian businesses have been too slow to invest in research and to adopt leading-edge technologies. … Too many business leaders – like too many Canadians in all walks of life – have been captured by a culture of complacency, by a sense that good is good enough (2008).

Canadian Auto Workers Manufacturing firms demonstrate much higher levels of commitment to R&D and other forms of innovation [than firms in other sectors]. The rapid decline of Canadian manufacturing implies that Canada's record in this regard will get worse, not better, in the years to come (2008).

Competition Policy Review Panel Much of Canada's poor productivity performance can be attributed to the comparatively poor performance of Canadian firms with respect to innovation. We rank poorly across almost all aspects of innovation: the creation of knowledge, the transformation of knowledge and the use of knowledge through commercialization (2008).

McKinsey & Company Much of the debate on Canada's economy has focused on productivity as the means to drive global competitiveness. Although productivity is important, McKinsey's research has found that innovation is much more important in driving competitiveness. It also found that Canada lags global competitors in its ability to innovate (2008).

Chapter 2 – The Nature and Importance of Innovation

This chapter defines the concept of innovation used throughout the report. It then sets the context for discussing the innovation performance of Canadian business by examining Canada's long-term economic performance relative to the United States and other economically advanced countries and, more specifically, by analyzing the Canada-U.S. productivity growth gap. The chapter concludes by assessing the significance of multifactor productivity growth as the principal indicator of the productivity-enhancing impact of innovation.

RADICAL VERSUS INCREMENTAL INNOVATION

Put simply and intuitively, *innovation is new or better ways of doing valued things*. Innovation occurs in the economy in two distinct but complementary ways – "radical" innovation and "incremental" innovation. Radical, paradigm-shifting innovations like the steam engine, canned food, the electric motor, the automobile, movies, television and the transistor are often science or engineering based, and create entirely *new markets* where innovation initially evolves rapidly and competitive races sort out the fit from the unfit.[2] This invention-driven form of innovation – which spans the range of significance from the hula hoop to the microchip – is what most people have in mind when they think of "innovation".

The ultimate economic benefits (jobs and income growth) of a blockbuster innovation usually diffuse broadly and relatively rapidly beyond the firm and location where the innovation originates. For instance, while the microchip and the personal computer may have been pioneered by a small number of companies in the United States (e.g., Apple, IBM and Intel), many of the resulting production jobs migrated elsewhere and, more important by far, the productivity benefits of the resulting information and communications technologies (ICT) revolution continue to accrue to users worldwide. This is a spectacular example of the "spillover" benefit of innovation generally, and of research and development (R&D) investment in particular. It is of course still the case that the originating location of a blockbuster innovation will usually benefit substantially – for example, as Silicon Valley has – and often becomes the focal point for an innovation cluster that takes on a life of its own.

Much more pervasive is incremental innovation in which goods and services, and their means of production, marketing and distribution, are being continuously

2 Many radical innovations also occur in other domains including the arts (e.g., impressionism in painting and jazz and rock 'n roll in modern music); organizations (e.g., the limited liability company, the assembly line, the department store); and public policy (e.g., unemployment insurance, publicly insured healthcare). Most of these have been of great economic and/or cultural significance.

improved.[3] Incremental innovation – in which developments are typically "new to the firm", or perhaps to a sector, but not "new to the world" – is what drives productivity growth and firm competitiveness in *established markets*. Since established markets constitute the great bulk of economic activity, incremental innovation is directly responsible for the vast majority of labour productivity growth.

The two varieties of innovation are complementary, with incremental innovation in established markets being the mature phase of the radical innovation that creates entirely new markets. Products, like people, have life cycles, and the progression from conception to expiry follows a kind of S-shaped curve where the phase of rapid development is followed, one hopes, by a long period of increasing maturity, but with slow continuing growth (Figure 2.1). The distinction between the two phases of innovation is significant because the policies and business strategies appropriate to each are quite different. For example, the style of management and the type of financing needed to launch and grow a "new market" innovation are not what are required to prosper in a mature market. Policies designed to encourage each type of innovation will also differ. One characterization of business innovation dynamics is described in Box 2 and Table 1.

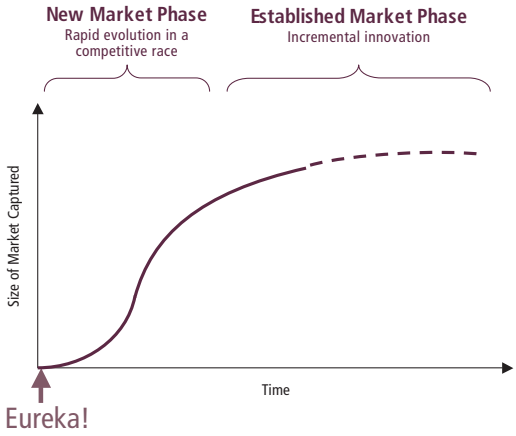

Figure 2.1
Lifecycle of Innovation – Schematic

A successful radical innovation creates a new market that develops rapidly (often in a competitive race), but eventually becomes established and grows slowly via continuous incremental innovation until decline inevitably sets in.

A further perspective on the central role of innovation is provided in Box 4 at the end of this chapter, which summarizes new trends in the organization and globalization of innovation. An overview of the modern "endogenous" models of economic growth – which give prominence to the role of innovation – is provided in Annex I.

3 Baumol (2002) argues that a great deal of innovation in business today is not the result of the lone, inspired entrepreneur, but rather due to the "routinized" activity of all successful large R&D-oriented companies: "This is not the realm of the unexpected, of the unrestricted exercise of imagination and boldness that is the essence of entrepreneurship. It is, rather, the domain of memorandums, rigid cost controls, and standardized procedures, which are the hallmark of trained management. Thus, corporate R&D has taken over a substantial portion of the field and has transformed it into a bureaucratized activity" (p. 36).

Table 1

The Faces of Innovation

	AUTONOMOUS INNOVATIONS	CLOSED SYSTEM INNOVATIONS	PLATFORM INNOVATIONS
MARKET-CREATING INNOVATIONS • New offerings, sometimes radically innovative, generating emulation and competitors • R&D intensive: 20% to 35% of sales Encountered in roughly 25% of the business economy	**- 1 -** **EUREKA!** • A new stand-alone product – e.g., new blockbuster drug • Science-based • Patents to fend off emulators and heavy focus on market development play critical roles *In 5% of the economy*	**- 2 -** **ENGINEERING BREAKTHROUGHS** • A major system component – e.g., SAP, CATIA, electric car battery • Often emerge from collaboration between an inventor and a demanding client *In 5% to 10% of the economy*	**- 3 –** **BATTLES OF ARCHITECTURE** • A new system takes hold – e.g., Microsoft O/S, Google, iPod • Success depends on vision, coalition building and network effects • Venture capital often key in early funding of visionaries *In 10% to 15% of the economy*
INNOVATIONS WITHIN EXISTING MARKETS • Improved value through incremental innovation for products and processes • Moderate R&D intensity: 4% to 6% of sales Encountered in roughly 75% of the economy	**- 4 -** **NEW AND IMPROVED** • Continuous improvements of products and processes – e.g., much of manufacturing • Constant focus on "routinized" innovating *In 35% to 40% of the economy*	**- 5 -** **PUSHING THE ENVELOPE** • Large clients improving their offering and systems, working with experts and suppliers – e.g., banks, airlines, utilities, airport buildings *In 15% of the economy*	**- 6 -** **MASS CUSTOMIZATION** • Battle of brands and systems through innovation in systems and in their elements – e.g., Toyota, IKEA, Wal-Mart, Microsoft • Managing global supply networks *In 20% to 25% of the economy*

Source: Adapted from Miller and Côté (2008a).

Box 2 – Business Innovation Dynamics

Based on a global survey of 1,000 firms, Miller and Côté (2008a, 2008b) have identified two characteristic innovation market types – "new" and "established", as described earlier in this chapter – and three categories of innovation that occur within each (see Table 1). When the two dimensions of the table are crossed, they define six "games" of innovation and particular patterns of competitive dynamics.

New versus established markets In a "new market", highly competitive innovation races occur as the product evolves rapidly through a combination of improvements in features and costs. New markets are characterized by 10 to 20 years of intense innovation until the market matures and becomes structured, as the personal computer market has, for example. The BlackBerry is currently an emblematic product that defines the relatively new "smartphone/digital assistant" market where there is an intense global race involving the BlackBerry, the iPhone and competing devices made by Ericsson-Sony, Nokia, Samsung and a few others. In a new market, all participants are innovative. The relevant public policy issue is how to set up conditions to have local firms participate as contenders in such markets, as these competitive races define the industries of tomorrow. In "established markets", the decision whether or not to innovate comes down to a choice among various competitive strategies. Although all markets are characterized by continuous improvements in costs and product features, firms can choose to be followers of innovation, and even outright laggards, and decide instead to compete on other terms. The choice will often depend on the intensity of competition in a particular market or on the demands of the firm's primary customers. These conditions will therefore strongly influence the level of innovation. Porter (1990), for example, emphasized the key role played by particularly demanding customers in stimulating a firm to innovate.

Product architecture The second set of characteristics is related to the architecture of the product that defines the market. The traditional view of innovation is the "better mouse trap" – a superior stand-alone product that trumps its competition. But increasingly, with the pervasive progress of information and communications technologies, new products tend to be parts of systems – either closed systems (e.g., a better jet engine that is inseparable from the rest of the plane) or open systems (e.g., software that enhances the capabilities of Windows, or the thousands of new applications being developed for smartphone platforms).

Product architecture will strongly influence the competitive dynamics, particularly as systems integration demands close co-operation among market actors and increases the importance of the "ecosystem" of supporting businesses that surround an innovative firm. Innovators surrounded by rich ecosystems are much stronger competitors in an innovation game as they typically have better access to relevant financial, technological and marketing resources (Porter, 1990). A key contribution of clusters, like the ICT cluster in Kitchener-Waterloo (see Chapter 7) or the video games cluster in Montréal, is to create exceptionally rich environments for innovative firms. These supportive ecosystems are much more important in new markets than in mature, established markets, since, in the latter case, innovators have more control of their innovation path and will rely more on internal resources or a few trusted partners. If Canada wants to succeed in new market innovation, a great deal of attention will have to be paid to the development of rich ecosystems in sectors of the economy where new markets are emerging.

INNOVATION DEFINED

From an analytical perspective, the OECD defines business innovation as "…the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD, 2005a, p. 46). This definition has been adopted by statistical agencies in most OECD countries and by many economic analysts worldwide. It implies that:

- *an innovation is not simply an invention, or even a practical prototype.* There must be implementation to a meaningful extent, though there is no required threshold of commercial success. It follows that there often is a considerable lag between the time of invention and the arrival of the related innovation, though the lag has tended to diminish over time (Table 2).
- *innovation is not limited to products and services, nor to the direct application of science and technology.* Innovation also includes business processes, marketing methods, business models and work practices. Indeed, many of the most far-reaching business innovations would fall into these categories – e.g., the factory assembly line, television advertising, just-in-time inventory management, the global supply chain and web-based commerce. Clearly, the concept of innovation is not limited to the traditional image of breakthrough products coming out of the lab, much less simply to the application of R&D or the grant of a patent.

Table 2

Invention to Innovation

Item	Year of invention	Year of commercialization	Time lag (years)
Radio	1887	1922	35
Insulin	1889	1922	33
Diesel-electric locomotive	1895	1925	30
Tungsten carbide	1900	1930	30
Automatic transmission	1904	1939	35
Kodachrome	1910	1935/36	25
Nylon	1927	1939	12
Xerography	1934	1950-55	16
Transistor	1940	1950	10

Source: Gerhard Mensch (1979) cited by Alexopoulos and Cohen (2009)

The concept of innovation used in this report is intentionally broad and encompasses not only the direct innovative activities initiated *within* a business but also the capital investment and knowledge acquisition by which the business captures and employs innovation that is generated elsewhere (Baldwin *et al.*, 2005; Baldwin *et al.*, 2009, forthcoming). That is because most of the innovation that is ultimately used in a particular business originates outside the business itself and is acquired through investment in machinery and equipment, and by adaptation of leading-edge knowledge that is circulating in business and academic environments (von Hippel, 2005). This knowledge may be conveyed by consultants, courses, conferences and other communications vehicles, as well as by the movement of people, either from other firms and organizations or as graduates of educational institutions.

The focus of this report is on innovation in the business sector, which accounts for about 85% of Canada's output. Of course, public-sector investments in infrastructure, education, R&D, health and social services are essential complements to private-sector innovation (Harchaoui & Tarkhani, 2003; Gu & MacDonald, 2009), but this report does not analyze these complementarities in depth.[4] Finally, there is much about innovation that is not captured in analytical definitions and statistics (Box 3).

WHY INNOVATION MATTERS

Innovation acquires its economic significance in two ways:

- Innovation responds to, and fulfils, human needs and desires, and thus creates entirely new possibilities and new sources of value in the marketplace.
- Innovation yields ever more efficient means to provide what people need or want.

In both these ways, innovation drives an economy's ability to create more economic value from an hour of work, thereby increasing economic output per capita. The resulting productivity growth creates the potential for rising wages and incomes, and thus for a higher standard of living (CSLS, 2008a).[5]

4 Gu and MacDonald (2009) estimate that public infrastructure capital (primarily roads, bridges, sewers and water treatment facilities) was responsible for about 9% of labour productivity growth in Canada from 1962 to 2006 with the majority of the contribution occurring prior to 1980.

5 Per capita output and "standard of living" are not synonymous, though they are often equated in economic discussion. A sharper distinction can be drawn between economic output and "quality of life" since the latter depends on many factors including environmental quality, leisure time, life expectancy in good health, personal security, social services and so forth. There is, nevertheless, a broad correlation between per capita output and many of the population-based measures of quality of life.

Box 3 – Innovation in a Phrase

"He who fails to adopt new remedies must expect new evils, for time is the greatest innovator." – Francis Bacon

"It is not the strongest species that survive, nor the most intelligent, but the ones who are most responsive to change." – Charles Darwin

"An important scientific innovation rarely makes its way by gradually winning over and converting its opponents. What does happen is that its opponents gradually die out, and that the growing generation is familiarized with the ideas from the beginning." – Max Planck

"Innovation is the specific instrument of entrepreneurship; the act that endows resources with a new capacity to create wealth." – Peter Drucker

"Innovation distinguishes between a leader and a follower." – Steve Jobs

"Being satisfied with the status quo means you are not making progress." – Katsuaki Watanabe

"If you're not failing every now and again, it's a sign you're not doing anything very innovative." – Woody Allen

Increasing the value created per hour of work is the only way in the long run for a business to pay growing wages and to survive economically. That is why innovation is the principal contributor to competitiveness, particularly for businesses in high-wage countries like Canada. It is also why the systematic promotion of innovation has become a primary preoccupation of business strategy in the most advanced economies (Baldwin & Johnson, 1995; Baumol *et al.*, 2007; McKinsey & Company, 2008).

It is evident from Canada's experience that natural resources can also make a region wealthy so long as supply lasts, prices are strong and the environmental costs are acceptable. But these favourable conditions may be unsustainable or out of a nation's control (as the latest economic downturn reminds us), and are thus no guarantee of continued prosperity (Brzustowski, 2008). Moreover, resource production itself requires continuous innovation to increase efficiency, extend supply and mitigate environmental impacts.

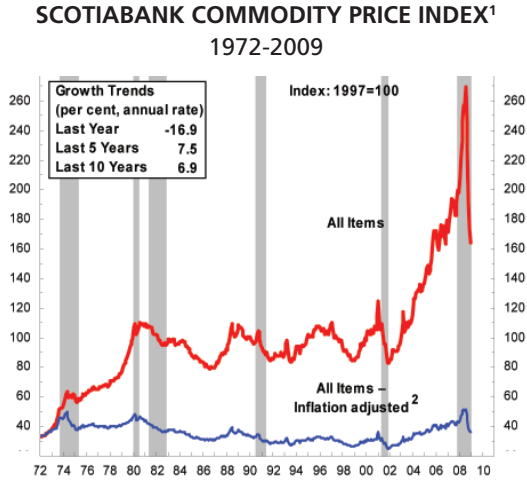

Figure 2.2

Scotiabank Commodity Price Index

The average price of Canada's commodity exports trended down in real terms for 30 years until the steep recovery beginning in 2002. Commodity prices are very sensitive to recession.

While resource price booms (Figure 2.2) may be welcomed, they invariably lead to appreciation of the exchange value of the Canadian dollar and thus undermine the cost competitiveness of Canada's non-resource sectors that are exposed to international competition. These sectors, which constitute a much larger share of Canada's workforce and total output than the primary resource industries, will survive only by becoming much more productive and, to that end, more innovative.[6] Even with some currency depreciation, many of Canada's traditional export strengths (other than resource commodities) will face increasing competition from China, India, Brazil and other rapidly industrializing economies. Technological upgrading and implementation of more effective business practices – in short, a commitment to continuous innovation – remain the principal ways to assure Canada's continued prosperity.

6 Manufacturing and the services sectors contributed almost 85% of GDP in 2007 while primary extractive industries (mining, oil and gas, agriculture, forestry and fishing) accounted for only 7% of GDP and a mere 4% of employment (Statistics Canada, 2008b, 2009). These statistics somewhat understate the importance of natural resources in Canada in view of the manufacturing and business services activities that depend on primary resources and the export revenue they generate, particularly in periods of buoyant commodity prices.

A LONG-TERM PERSPECTIVE ON CANADA'S ECONOMIC PERFORMANCE

To set the context for the discussion of the innovation performance of Canadian business, it is relevant first to compare Canada's overall economic performance to that of other economically advanced countries, and particularly to the United States, over a long period of time. If Canadian business has lagged seriously in terms of innovation, the consequences should show up in macroeconomic comparisons with peer countries, and in fact they do.

Canada's average living standard, measured as GDP per capita, has closely tracked behind that of the United States for as long as comparative estimates have been made (Figure 2.3). Output per person in the United States has always exceeded that of Canada, usually by about 20%, though with substantial fluctuations (Figure 2.4). This long-term perspective is exceptionally significant because it shows that the two economies are strongly coupled in a dynamic equilibrium, with the United States as persistent leader.[7] Canadian society, and Canadian business in particular, has become well adapted to this situation. When Canada has fallen too far behind, implicit forces – economic, attitudinal and political – have always eventually come into play to restore the balance. But history is not destiny. Indeed, the restorative forces that keep the relative gap from widening indefinitely are brought to bear only through the conscious actions of business and political leaders, and of Canadians themselves (Howitt, 2007).

Per capita output (GDP divided by total population) is, by definition, output per hour worked (labour productivity) multiplied by hours worked per capita (a measure of overall labour utilization in the economy).[8] Hours worked per capita have trended up in recent years in Canada and in 2007 exceeded the comparable measure in the United States by about 4% (CSLS, 2008b, 2008c). Thus the roughly 20% gap between the United States and Canada in respect of per capita output today is due entirely to a lower level of labour productivity in Canada. Moreover, since the demographics of Canada's aging population will constrain the future increase of hours worked per capita, the growth of output per person in Canada will depend increasingly, if not entirely, on productivity growth.

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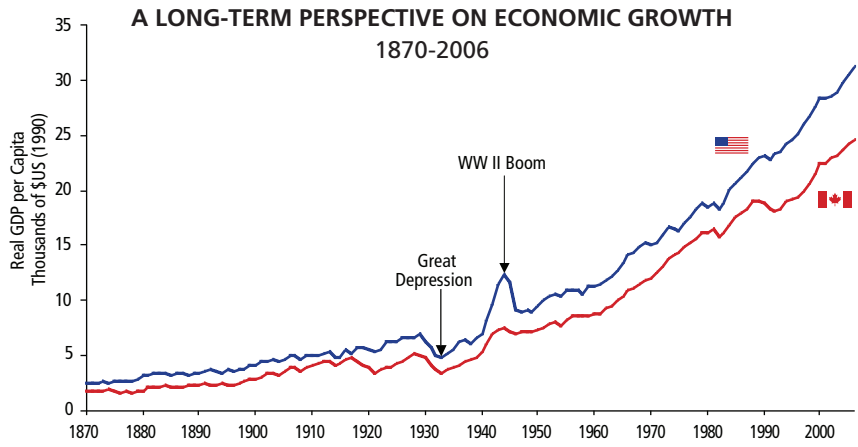
7 The U.S-Canada output gap in any given year can also be characterized by the time needed for Canada to catch up to where the United States was in that year. For example, if real output per capita in Canada grows by 2.3% per year, and if Canada's output per capita is 80% of that of the United States at some particular time, then eight years later, Canada will be where the United States had been eight years earlier. Under these assumptions, the output gap of 20% is equivalent to a "time gap" of eight years. If Canada were to grow faster (slower) than 2.3%, the time gap would shrink (grow).

8 Hours worked per capita can be broken down as the product of four factors: (i) average hours worked per worker; (ii) the fraction of the population that is of labour force age (usually aged 15 to 65); (iii) the fraction of the labour force age population that is working or seeking work (the "participation rate"); and (iv) one minus the unemployment rate – e.g., if the unemployment rate were 7% (0.07), then factor (iv) is 0.93.

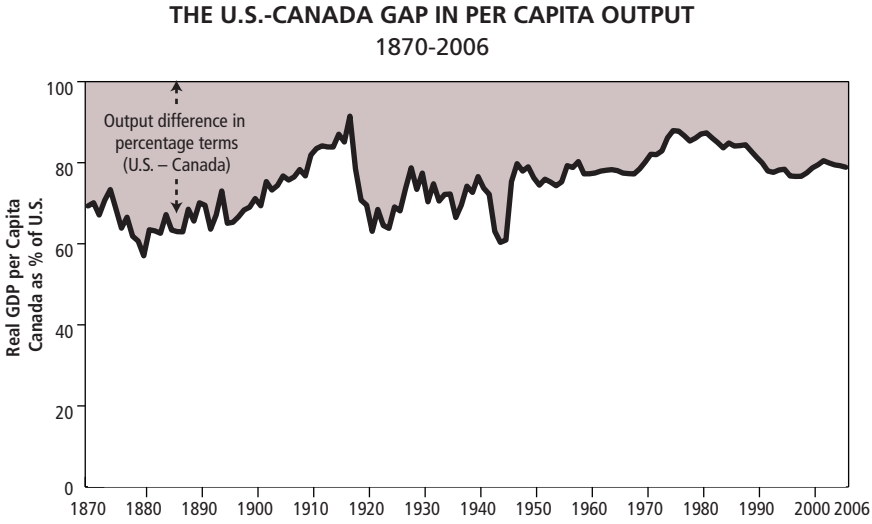


Data Sources: Conference Board & Groningen Growth and Development Centre, 2008; Maddison, 2008

Figure 2.3

A Long-Term Perspective on Economic Growth

Per capita output in the U.S. and Canada evolves almost in lock-step.



Data Sources: Conference Board & Groningen Growth and Development Centre, 2008; Maddison, 2008

Figure 2.4

The U.S.-Canada Gap in per Capita Output

The volatility in the ratio of Canada's per capita output to that of the U.S. has decreased markedly since WWII. Canada's relative decline since the early 1980s reflects weak productivity growth, mitigated by strong job growth. Figure is derived from Figure 2.3 by dividing the Canadian series by the U.S. series.

U.S.–CANADA RELATIVE PRODUCTIVITY TREND

Canada was rapidly closing the labour productivity gap with the United States until the early 1980s (Figure 2.5).[9] The reasons are complex in detail but the convergence trend reflects the well-established empirical pattern that economies that are productivity laggards tend to experience more rapid productivity growth than the leader (in this case, the United States) provided there is considerable sharing of technology and know-how, as there certainly has been between Canada and the United States (Abramovitz, 1986; Howitt, 2000).

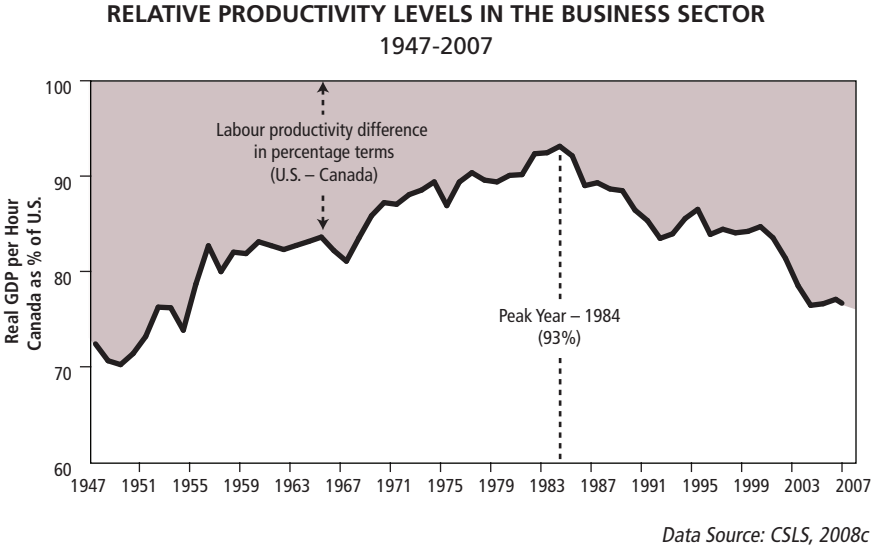


Figure 2.5

Relative Productivity Levels in the Business Sector

Canada was rapidly closing the productivity gap with the U.S. until the early 1980s. The strength of U.S. productivity growth since the mid-1990s is primarily associated with the production and use of information and communications technologies.

Productivity growth in the United States began to outpace that in Canada after the deep recession of the early 1980s, and particularly after the mid-1990s. Since 1984, relative productivity in Canada's business sector has fallen from more than 90% of the U.S. level to about 76% in 2007. (The most recent preliminary data indicate that the gap widened in 2008 as business sector productivity increased by

9 Figure 2.5 refers to productivity in the business sector of the economy. The productivity gap with respect to the total economy – including the public and not-for-profit sectors – has deteriorated by a smaller amount since the mid-1980s. In 2007, total output per hour in Canada was 81% of the U.S. level, down from 91% in 1984 and 89% in 1995 (CSLS, 2008a).

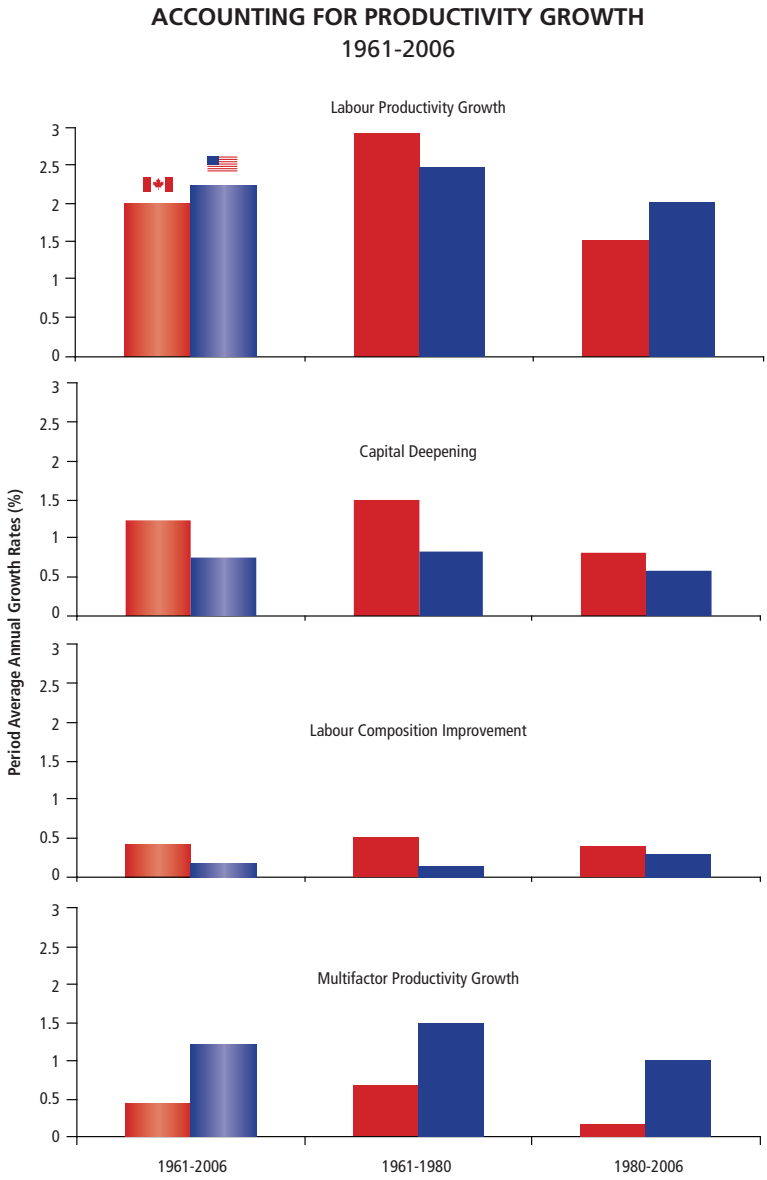
2.7% in the United States while decreasing by 1.2% in Canada.) Dion and Fay (2008) provide an excellent review of studies that have analyzed the long-term developments. The surge in U.S. productivity since 1995 has been due to U.S. leadership, first in the production of goods and services associated with ICT and, after 2000, owing to the broad application of ICT throughout the U.S. economy and to adjustments by businesses to downward pressure on profitability (Oliner *et al.*, 2007; Arsenault & Sharpe, 2008; Jorgenson *et al.*, 2008).

Although Canadian businesses, on average, have lagged considerably behind the United States in the application of ICT (as described in Chapter 3), it is reasonable to expect that there will be a move to catch up because competitive pressures almost inevitably ensure that Canadian firms will not allow themselves to fall too far behind the technological leaders. Prior to the full benefits of ICT investment being realized, however, there is a period of reduced productivity as adjustments are made in employee training and business process reorganization to take full advantage of the productivity-enhancing potential of the new technologies (Helpman & Rangel, 1999; Gordon, 2003; Baily, 2004; Leung, 2004).

ACCOUNTING FOR PRODUCTIVITY GROWTH

Statistics Canada (2007b) has analyzed the differences in labour productivity growth between the business sectors of Canada and the United States over the 45-year period, 1961-2006, and identified the relative contributions due to (i) upgrading of the labour force, (ii) "deepening" of the capital stock, and (iii) increases in multifactor productivity.[10] Multifactor productivity – which is described more fully below – reflects, among other things, the contribution to productivity from aspects of innovation not already embodied in the capital stock. The results of the productivity growth comparison are summarized in Figure 2.6 where the breakdown of the time interval reflects the period during which Canada was closing the labour productivity gap (roughly 1961-80) and the period since then when the gap has been widening (roughly 1980-2006). The precise end-points were chosen based on the data as presented in Baldwin & Gu (2007) and Statistics Canada (2007b). The "growth accounting" methodology employed in the study is outlined in Annex II.

10 This study is particularly significant both for the length of the time period covered and for the sophistication of the statistical procedures employed. For example, the study reconciles most of the methodological differences that have often plagued Canada-U.S. productivity comparisons in the past. It also isolates changes in labour "quality" (e.g., rising education levels and increased experience) and employs a sophisticated measure of capital "services" that, in particular, takes into account the very large performance-to-cost improvement in ICT. The study is thus able to provide the most reliable estimates yet of the growth of multifactor productivity in Canada.



Data Source: Statistics Canada, 2007b

Figure 2.6

Accounting for Productivity Growth

Labour productivity growth can be accounted for by increasing capital intensity, improvement in workforce skills, and a residual called multifactor productivity (which broadly reflects the effectiveness with which labour and capital are used). Growth rates in the top panel are the sum of growth contributions of the factors in the bottom three panels. The time periods cover the total 45-year interval (leftmost bars) and two subperiods; one when Canada was closing the productivity gap (roughly 1961 to 1980) and the other when Canada was falling behind (roughly 1980 to 2006).

The conclusions of the analysis, in summary, are as follows:

- As the left side of the top panel in Figure 2.6 shows, over the entire 45-year period from 1961 through 2006, average annual labour productivity growth in Canada (2.1%) lagged only slightly behind that of the United States (2.3%). During that long period, greater capital deepening in Canada took place – i.e., more rapid growth of productivity-enhancing capital per hour worked – as well as a greater contribution to productivity growth in Canada owing to improvement in the composition of the workforce – measured primarily by changes in average educational attainment and years of work experience. These factors favouring labour productivity growth in Canada were more than offset by significantly lower multifactor productivity (MFP) growth in Canada (0.4% per year) compared to the United States (1.2%) – the bottom panel in the figure.
- The 45-year perspective conceals significant differences between the periods when Canada was closing the productivity gap and when, from the early 1980s on, it was falling behind. Between 1961 and 1980, average annual labour productivity growth in Canada was very strong (2.9%) and exceeded the U.S. average (2.5%), thus narrowing the gap as shown in Figure 2.5. Canada's much stronger growth of capital intensity and more rapid improvement in workforce skills were responsible, since the average annual rate of MFP growth in Canada (0.7%) was less than half that of the United States (1.5%).
- In the period since 1980 (the right hand side of Figure 2.6), average productivity growth in the United States (2.2%) has significantly outpaced that of Canada (1.5%), particularly since 2000. The rate of growth of capital intensity and improvement in workforce skills has been roughly similar, on average, in both countries, but the rate of MFP growth in the United States has averaged about five times that of Canada.
- In the most recent 10-year subperiod, 1996-2006 (not shown separately in Figure 2.6), productivity growth increased in Canada (averaging 1.8% per year), but not nearly to the extent seen in the United States (2.8%). Again the difference reflects, almost entirely, much slower MFP growth in Canada. There was a sharp rally of Canadian productivity growth in 1996-2000, averaging about 3.2% and slightly exceeding the U.S. metric over that period. But this appears to have been a cyclical phenomenon reflecting the strong economic recovery in Canada following the stagnation of the mid-1990s (Dion & Fay, 2008). In sharp contrast with the United States – which sustained strong productivity growth even after the cyclical peak in 2000 – Canadian productivity growth then slumped in the 2000-06 period as MFP actually declined. It is believed that this was caused in part by (i) the boom in energy and mineral prices, which induced production from lower-grade sources; and (ii) reduced output in

certain sectors as human and capital resources were being shifted between manufacturing and primary resource industries in response to the sharp rise of the Canadian dollar and of commodity prices (Arsenault & Sharpe, 2008).[11]

THE SIGNIFICANCE AND MEANING OF MULTIFACTOR PRODUCTIVITY

For a time – between 1961 and the mid-1980s – Canada's strong growth in capital intensity and more rapid improvement in the composition of the workforce were able to offset persistently weak MFP growth. But that has long since ceased to be the case with the effect that Canada's average labour productivity growth has lagged behind that of the United States and most other economically advanced countries, for the past 20 to 25 years. Over the 1985-2006 period, Canada's average labour productivity growth ranked 15th out of 18 comparator countries (Figure 2.7).[12] *To reverse that dismal trend is the core economic challenge facing Canada.*

Since lagging MFP growth has been primarily responsible for the weak trend of labour productivity, it is important to examine what MFP actually measures. Intuitively, changes in MFP measure that portion of labour productivity growth that can not be accounted for by measured growth of capital intensity and the quality of the workforce. MFP is what is left over, or, in the famous words of one economist, MFP is "a measure of our ignorance" (Abramovitz, 1956). Most significant for this discussion is that *MFP growth contains the macroeconomic signature of aggregate business innovation* – the extraction of increasing value from inputs of capital and labour through inventive activity, the more efficient organization of work, new marketing practices and business models, the payoff from performing R&D, the capture of the benefits of innovation originating elsewhere and particularly the insights of entrepreneurs. A few examples will illustrate:

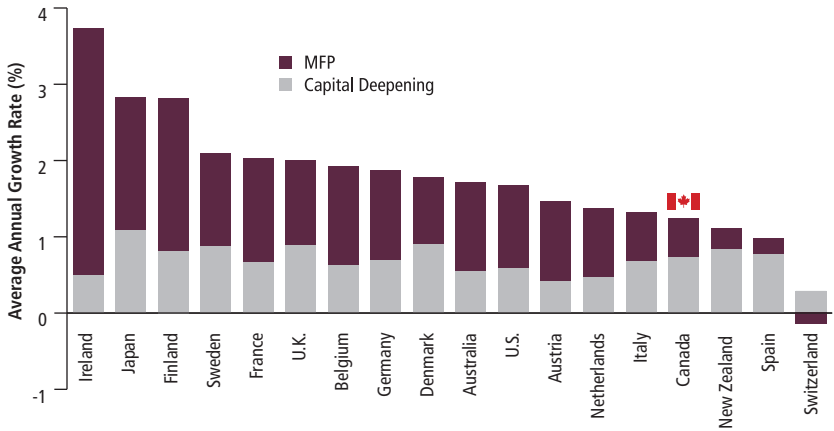
- Consider moving shipping containers by rail. With a very small modification in design, they can be double-stacked and thus, without adding any significant amount either of capital (the train) or of labour (the train crew), the output (containers transported in a given time) can be doubled. This would show up in a productivity analysis as an increase in MFP.

11 This illustrates how productivity growth in the relatively short run can be affected significantly by many subtle and temporary factors. The analysis of innovation and of the fundamentals of Canada's economic performance requires a perspective of decades and throughout several turns of the business cycle.

12 Switzerland's exceptionally poor productivity growth revealed in Figure 2.7 – with a negative average MFP growth – is puzzling. At least part of the explanation may be found in the underlying measurement methodology — in particular, the fact that national MFP measurement, as reported by the Swiss Federal Statistical Office, includes residential assets in the capital stock. These "unproductive" assets are excluded from the OECD data for other countries (OECD, 2008e).

- Consider the addition of a drive-through window in a fast food outlet. A small amount of construction and one or two extra servers could substantially increase sales volume by expanding the effective "seating capacity" of the restaurant, and, more importantly, by increasing service convenience and thereby attracting more customers. After accounting for the modest capital cost of installing the drive-through window and some extra labour, the remainder of the increased output is chalked up to MFP growth.
- Consider a sales force in the field (or a team of customer service representatives) before the advent of the cellphone or, better yet, the BlackBerry. Today's relatively inexpensive wireless capital equipment has amplified greatly the value of each field employee, not only through more efficient allocation of time but also through more timely and co-ordinated service for customers. While some of the added value comes from new investment in equipment, most is measured as an increase in MFP.

CONTRIBUTIONS OF MFP AND CAPITAL DEEPENING TO LABOUR PRODUCTIVITY GROWTH
1985-2006*



*Data for some countries are for shorter periods – refer to original source for details.

Source: OECD, 2008d

Figure 2.7

Contributions of MFP and Capital Deepening to Labour Productivity Growth

The OECD's decomposition of productivity growth into components reflecting MFP and capital intensity employs a less sophisticated methodology than the Canada-U.S. comparison in Figure 2.6 owing to less complete and consistent data across OECD countries. (The Swiss data are not fully comparable with the rest – see footnote 12 in the text.)

Micro-examples like these can be multiplied endlessly. In each case, we see an innovation that may be based on science and technology (e.g., the BlackBerry) or on some very simple engineering combined with entrepreneurial insight (e.g., the drive-through window and double-stacked containers). The economic impact of thousands upon thousands of such innovations, large and small, is huge.

There is an important interaction between new capital investment (which embodies prior innovation) and MFP since successive generations of capital induce complementary, and often highly innovative, changes in the organization of work and the training of employees. Rao *et al.* (2008) have analyzed the Canada-U.S. labour productivity gap from 1987 to 2006 and found that (i) about 90% of the gap is due to lower MFP growth in Canada, and (ii) the dominant source of the MFP gap is Canada's lower investment per worker in machinery and equipment. MFP growth and investment in new capital are very often linked. Thus the distinction between the component of productivity growth ascribed to more and better capital, and the component ascribed to MFP, can be somewhat artificial. The impact of technological innovation on productivity growth enters jointly through both channels (Helpman, 2004; Rao *et al.*, 2008).

In the examples given above, the double stacking of shipping containers may require investment in new overpasses to accommodate the taller loads, the drive-through windows require investment both in structures and communications equipment, and the mobile sales force depends on investment in wireless networks and handsets. The direction of *causation* between an innovation and complementary capital investment depends on the case – e.g., the "idea" of container stacking or of a drive-through window induces capital spending, whereas prior investment to create wireless networks and to develop BlackBerries was needed to enable MFP-generating innovation in sales force organization.

The importance of capital investment, especially in machinery and equipment, is underestimated by growth accounting models if they only take into account changes in the actual *quantity* of capital employed. In practice, the qualitative improvements that are embodied in successive generations ("vintages") of capital as technology advances are also crucially important for innovation and productivity. The sophisticated growth accounting methodology that is now being employed by Statistics Canada and several other national statistical agencies incorporates estimates of technological improvement in measures of the contribution of capital (particularly ICT capital) to productivity growth and thus yields more accurate estimates of MFP growth (Baldwin & Gu, 2007).

Since MFP is the residual after improvements in labour quality and capital intensity have been accounted for, it reflects all other factors that affect labour productivity. So the innovation signal in MFP growth comes mixed with a lot of "noise". These other confounding factors include prominently:

- changes in capacity utilization and other cyclical influences
- changes in economies of scale
- influence of still other factors besides innovation
- improper measurement of changes in capital and workforce quality, and
- improper specification of the growth accounting model.

There are good reasons to believe that these factors, for reasons discussed below, would not account for any significant amount of the MFP *growth* differences identified in Figures 2.6 and 2.7.

Changes in Capacity Utilization and Other Cyclical Influences

When the economy slows, capital and workers may be underutilized yet much of their cost continues to be registered; thus some of the decline in output shows up as a (temporary) decrease in MFP. (The opposite effect occurs early in a recovery.) This business cycle effect can significantly distort the estimation of MFP growth rates over different stages of the cycle, or differences in MFP growth rates between Canada and the United States if the cycles in the two countries are substantially out of phase. But the data in Figure 2.6 cover sufficiently long periods that this cyclical effect averages out.

Business decisions regarding the use of productive inputs (including labour of varying quality, capital equipment and innovation inputs) will reflect the broader macroeconomic environment in which they occur. These influences may be considerably more subtle than those associated simply with booms and recessions. For example, the labour market in Canada was persistently and significantly weaker than in the United States throughout most of the 1990s due to the more severe downturn experienced in Canada at the beginning of the decade, which reflected the adjustment to free trade, high interest rates and a fiscal retrenchment. With labour more abundantly available – and thus relatively cheap compared to capital – Canadian firms (by contrast with their U.S. counterparts) were more willing and able to pursue "low-value" opportunities for expanding output, relying more on sheer increases in the quantity of labour employed, rather than on improvements in productivity, to generate incremental output (Harris, 2005).

Movements in the Canada-U.S. exchange rate can have complex and contradictory impacts on business innovation. A low exchange rate (such as prevailed during most of the 1990s) increases the Canadian dollar cost of imported capital equipment, while making Canadian labour look "cheap" in international terms. This may reduce the imperative for innovation and capital investment. At the same time, however, the enhanced cost competitiveness enjoyed in tradable industries as a result of a low dollar might induce more capital investment in Canada, which would support innovation and productivity growth. (Investment data are discussed in Chapter 3.)

Comparison of MFP growth rates over several decades, as reported in Figure 2.6, can largely average out the impact of these cyclical macroeconomic factors on our understanding of Canada's relative innovation and productivity performance.

Changes in Economies of Scale

The effect on productivity of efficiencies derived through economies of scale shows up as MFP. Such effects may arise from growing markets, as would typically occur after trade liberalization. Alternatively, an innovation will often increase the size of the market for a good or service and thus give rise to scale-related MFP growth due to longer and thus more efficient production runs. Because trade liberalization (for example, the North American Free Trade Agreement and World Trade Organization rounds) has facilitated Canada's access to much larger markets, Canadian MFP should have benefited from increased scale to a greater extent than the United States since the late 1980s. Thus changes in scale economies can not explain slower MFP growth in Canada than in the United States – in fact, the effect of scale economies since the 1980s would be expected to be the opposite.

Influence of Factors Other than Innovation

The level of MFP is influenced by a host of factors including climate and geography, institutional elements such as property rights, government policy and social forces. However, the *growth rate* of MFP is affected only by those influences that are measurably changing over time. For example, although geography may explain a portion of the difference in the *level* of MFP between Canada and the United States, geography cannot account for differences in the growth of MFP between these countries because geography is a constant (or very slowly varying) factor. In other words, productivity changes are driven by the dynamic components of MFP – such as product and process innovation – that evolve over time, and not by the static components of MFP that contribute to its level. Of course, relatively static features of a country – e.g., culture, political institutions, resource endowment – can strongly influence the propensity to innovate and thus indirectly affect the MFP growth rate over long periods.

Growth accounting analyses almost always include only inputs from the business sector and fail to measure the contribution to business sector productivity growth of public-sector capital investment. The productivity benefit (for the business sector) of public infrastructure therefore shows up in the residual as MFP growth. A recent Statistics Canada analysis by Gu and MacDonald (2009) estimates that public infrastructure investment can in fact account for about half of the conventionally estimated MFP growth in Canada over the 1962-2006 period – i.e., if public capital were included with private capital in a growth accounting exercise, the residual MFP growth rate would be cut in half. The great majority of this effect occurred prior to 1980 during the era of heavy public infrastructure investment in Canada (and in the United States as well).

The new work by Gu and MacDonald suggests that the omission of public capital investment can lead to a significant overestimate of the MFP growth rate, but it would likely have much less effect on differences in MFP growth between the United States and Canada since public infrastructure has also been omitted from the U.S. estimates of capital stock in Figure 2.6. More generally, when the focus of analysis is on differences in MFP growth rates between two countries – as between the United States and Canada, for example – other factors that may influence MFP growth rate, but are relatively similar between the countries, tend to wash out in the estimation of the MFP growth rate differences. Cross-country comparison of MFP growth rates also avoids the difficulty of estimating the appropriate currency exchange rate that would otherwise be required if comparisons of MFP levels were to be made among countries.

Baldwin *et al.* (2008) estimated the difference in the level of MFP between the United States and Canada in 1999. They found that Canada's MFP levels in both the business services and goods (primarily manufacturing) sectors were about 20% below U.S. levels in 1999 while the gap in the "engineering" sector (e.g., primary resources, utilities, construction, transportation) was about 15%. Because the service sector has such a large weight in both employment and output, the gap in MFP in business services accounted for most of the overall U.S.-Canada difference in MFP level in 1999. The significantly higher growth of U.S. MFP since 2000 implies that the overall gap in MFP level between the United States and Canada will have widened substantially.

Improper Measurement of Changes in Capital and Workforce Quality

Estimation errors in these factors, which may occur for conceptual or statistical reasons, induce errors of opposite sign in MFP estimation – e.g., if the contribution of capital to labour productivity growth is underestimated then MFP growth will be overestimated. Statistics Canada has done a great deal of work to improve both the statistical and conceptual accuracy of its MFP estimates and to achieve the best possible comparability with U.S. methodology.

Improper Specification of the Growth Accounting Model

Departures in the real world from perfect competition and from "constant returns to scale" will invalidate, to some extent, the assumptions on which many MFP estimations are based (Dion & Fay, 2008). In particular, traditional growth accounting models are based on the assumption that competitive markets for capital and labour ensure that each input to production is paid according to its marginal productivity; hence they use factor prices derived from empirical data as proxies for that marginal productivity (see Annex II). To the extent that factor prices deviate from productivities in the real world, then the model's residual (which is interpreted as MFP) will be affected accordingly. The errors arising can sometimes be roughly estimated and more complex growth accounting models can be employed (Aghion & Howitt, 2007). Moreover, these effects are unlikely to have a significant impact on the estimated differences in the growth rate of MFP between the United States and Canada.

MFP AS AN INDICATOR OF INNOVATION

While acknowledging the foregoing caveats, the panel believes that the rate of MFP growth over suitably long periods is primarily due to business innovation, broadly interpreted as including better organization of work, improved business models, the efficient incorporation of new technology, and the payoff from R&D and the insights of entrepreneurs.[13]

Detailed comparative analysis of Canadian productivity performance usually focuses on the gap relative to the United States because of Canada's close link to the U.S. economy and the availability of more readily comparable data. It is nevertheless revealing to compare Canada with a much broader peer group of economically advanced OECD countries: the story is the same as told by comparisons with the United States (recall Figure 2.7). Significantly slower MFP growth has been the factor principally responsible for lower productivity performance in Canada.

Something appears to have gone seriously amiss in the Canadian economy since the mid-1980s, and the evidence points to some combination of the factors that contribute to MFP growth as the culprit. Note moreover that relatively weak MFP growth is of much longer standing and antedates the 1980s.[14] The panel therefore concludes that *Canada's weak productivity growth over the past two decades is largely due to weak business innovation performance.*

The next chapter develops a great deal of further quantitative evidence of Canada's subpar innovation performance relative to peer countries. The analysis that follows uses innovation indicators that are more conventional than MFP, but the pattern is consistent with the foregoing diagnosis based on Canada's lagging MFP growth.

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13 Analysis of 16 OECD countries (1980-98) showed that investment in innovation was positively associated with MFP growth. Business R&D had a significant positive impact on MFP and the impact increased over the period (Guellec & van Pottelsberghe de la Potterie, 2001).

14 As will be seen in Figure 3.19, a (statistically smoothed) estimate of Canada's MFP growth rate has continuously lagged behind that of the United States for as long as the difference has been measured by Statistics Canada.

Box 4 – Open Innovation and the Globalization of Innovation

"Open innovation" is a broad concept that can encompass everything from collaboration across organizations to user-led and "open source" innovation. As discussed in the case study on life sciences in Chapter 10, the development of biotechnology innovation, particularly biopharmaceuticals, is highly dependent on university research and small, innovative firms that feed new technologies into the large pharmaceutical companies. This collaborative model of innovation is only one example of the open innovation phenomenon.

Chesbrough (2003) argued that various forms of open innovation are increasingly important for businesses of many types. The opening up of innovation is closely related to the de-integration of corporations in other areas, where it has been found that outsourcing some functions to specialist firms can be a more efficient means of operation than the vertically integrated firm. Coase (1937) showed that the set of functions included within the boundaries of a firm was determined by the structure of transaction costs. Firms would outsource if the costs of co-ordination and performance monitoring, and other transactional activities, were sufficiently low. If so, the benefit that could be derived from using an outside specialist would more than offset the extra cost of going outside the firm. Information and communications technologies have dramatically lowered the costs of co-ordination and monitoring, and therefore diminished the range of functions that need to be kept integrated within a single firm, but these same technologies have also allowed many firms to grow to global scale. The result is a trend to larger, but more specialized, firms.

This process of "horizontalization and globalization" – the outsourcing of specific functions to specialists that serve global markets – began with manufacturing, but is now having an impact on services and business innovation activity. Friedman (2005) described this as the "flattening" of the world, with the effect that competition shifts from something between vertically integrated firms in a local market to something between individual functions (or employees) spread around the globe. There is already evidence that this change is taking place in innovation activities. Automotive manufacturers have begun to move R&D outside their home countries, although the process is still in its early stages. Complex manufacturing industries, such as automotive and aerospace, are seeing original equipment manufacturers pass segments of the value chain – from parts to large components – to their suppliers, who consequently play an increasing role in the design and development of the components.

Chapter 3 – The Innovation Performance of Canadian Business

The main purpose of this chapter is to answer the first two questions in the charge to the panel:

- *How should the innovation performance of Canadian firms be assessed?*
- *How innovative are Canadian firms, and what do we know about their innovation performance at a national, regional and sector level?*

This chapter establishes a number of basic facts about business innovation in Canada. It examines the principal indicators of the aspects of business innovation in Canada that are typically measured – the inputs, outputs and outcomes – and compares them with those of Canada's peer group of economically advanced countries including, in particular, the United States. This discussion complements, at a more disaggregated level, the preceding analysis of innovation as reflected in MFP growth, which, in the panel's view, is the most appropriate high-level indicator of the ultimate economic *outcome* of innovation.

HOW SHOULD INNOVATION PERFORMANCE BE ASSESSED?

Innovation activity occurs in many guises – innovation in the design of products, the improvement of processes, the successful use of advanced technology, and the structure and behaviour of organizations. It is impossible to fully measure innovation simply as a set of quantitative indicators (Box 5). Only certain aspects of the phenomenon are directly observable – for example:

- *Inputs* like R&D; investment in advanced equipment, or purchased science and engineering services; the fraction of the business sector workforce with advanced degrees in science and engineering; or venture capital financing for new businesses.
- *Outputs* like the fraction of sales contributed by products introduced within, say, the past three years; or intellectual property protected and managed by legal instruments such as patents, copyrights and trademarks.[15]

15 A patent is not itself necessarily an innovation output because a patented "invention" may or may not become an innovation. A patent will often be an output of R&D activity and, in this sense, may be regarded as an "intermediate input" in the entire innovation process. Thus, patent statistics do not measure innovation directly, but they have been shown to correlate with innovation in sectors that are R&D-intensive and are therefore often cited as indicators of innovation in such sectors.

- *Outcomes* like market share or export growth in sectors that are considered to be technologically dynamic and for which a firm must presumably be innovative to keep up. At the level of the entire economy, or for major sectors, the outcome of innovation – other than the innovation that is embodied in capital equipment – is perhaps best indicated by the longer-term growth of MFP.

Each of the foregoing groups of metrics has limitations and captures only a portion of the total innovation process. The input measures implicitly assume a causal, though not necessarily linear, link with innovation outputs, the precise nature of which can only be inferred indirectly. The output measures (e.g., sales from new products) are often hard to capture and, in the case of new product sales, require a somewhat arbitrary criterion for what should qualify as "new". Outcome measures like market share, profitability and MFP growth are influenced by many things other than innovation, particularly in the short run.

Box 5 – Innovation as a Corporate Mission

The corporate mission statement of Philips, the Netherlands-based electronics giant, is built upon a broad and customer-focused concept of innovation that illustrates well the view of many contemporary technological leaders. In its 2007 Annual Report Philips states that its mission "is to improve the quality of people's lives through the timely introduction of meaningful innovations" (p. 16).

Philips notes that this mission does not explicitly mention technology, because innovation does not necessarily need to involve new technology. In fact the company states that "…innovation is integral to everything we do. But to ensure it is relevant and meaningful, we take end-user insights as its starting point" (p. 18).

The concept of innovation embodied in the Philips mission statement cannot be encompassed by any set of quantitative indicators, much less aggregated across thousands of innovating companies to arrive at national indices of innovation that fully reflect the concept as described by Philips. One may nevertheless examine an array of indicators of inputs, outputs and outcomes of the innovation process and seek evidence from firm-based innovation surveys and macroeconomic trends like productivity growth to make meaningful inferences about national innovation performance.

Individual firm performance (productivity, profitability and market share) can be correlated with measures of innovation from formal innovation surveys conducted by national statistical agencies. These, together with surveys of advanced technology use, have been carried out for many years by Statistics Canada and produce valuable micro-level data on firm behaviour (Box 6). Meanwhile, debates

about survey methodology continue, and the lack of U.S. innovation surveys, comparable to those undertaken in Canada and the European Union (EU), limits comparative analysis. A recent panel report to the U.S. government recommends that a great deal more effort go into measuring innovation in the United States and notes that Canada's use of innovation surveys provides valuable experience to be drawn upon (Advisory Committee on Measuring Innovation, 2008). In view of the need to gain a much deeper understanding of innovation, it is essential that Statistics Canada continues to build on its leading capabilities to conduct deeper and more extensive innovation surveys and analysis.

HOW INNOVATIVE IS CANADIAN BUSINESS?

The second question addressed to the panel asks: *How innovative are Canadian firms, and what do we know about their innovation performance at a national, regional and sector level?*[16] The following sections address this question by presenting the principal input, output and outcome measures of innovation drawing on international comparisons with a peer group of economically advanced OECD countries and, more specifically, with the United States. Although Canada is not strictly comparable with the United States in view of the vast difference in size and industrial structure, the close proximity and economic links between the two countries make comparison both inevitable and instructive. This is particularly the case if the primary focus is on the convergence or divergence of longer-term trends such as productivity, investment, and R&D ratios. The Canada-U.S. comparisons that follow are also placed in the context of comparisons with a broad spectrum of about 20 OECD countries (see Figure 3.3), which, by virtue of their size and stage of economic development, are appropriate comparators for Canada. Thus the panel's conclusions are not based on contrasting Canada with the United States alone.

The diagnostic data that follow are organized around a set of conventional indicators that reflect inputs to, as well as outputs and outcomes of, the innovation process. Although no single indicator provides an adequate measure of the innovation performance of Canadian business, the constellation of indicators do yield, in the panel's view, a consistent and reliable picture.

16 Unfortunately, there are very limited data, other than provincial R&D statistics (see Figure 3.4), on which to comprehensively analyze business innovation regionally in Canada. In particular, Statistics Canada has not produced provincial estimates of MFP growth, despite the availability of the basic data from which such estimates could be developed if funds were allocated. The Centre for the Study of Living Standards is currently working with the Government of Alberta and Statistics Canada to produce MFP estimates for Alberta. Some regional conclusions can be inferred from industry sector analysis combined with the known geographic concentrations of certain industries.

Box 6 – Innovation Surveys in Canada

Statistics Canada's Survey of Innovation is part of an ongoing program to measure innovation in Canada. The surveys provide information on innovation activities including, for example, co-operative and collaborative arrangements, business success factors, intellectual property protection, use of government support programs and reported obstacles to innovation. The survey is compulsory, though compliance is not rigidly enforced. Innovation surveys are conducted for a sample of industries every three to four years, and cover a three-year reference period. Estimates produced from the survey are used by firms for market analysis, by trade associations to study performance of their industries as well as by government policy makers.

Industries covered typically vary from survey to survey. For example, the most recent survey (Statistics Canada, 2006b) surveyed the manufacturing and logging industries for the reference period 2002-04 and asked establishments to identify which of five different types of innovation were introduced during the period. The innovations had to have been new to the establishment and, in the case of product innovations, the simple resale of new goods purchased from other plants and changes of a solely aesthetic nature were excluded. Innovations cover goods, services and processes (the latter including, for example, new or significantly improved logistics or distribution methods, operations for purchasing and accounting).

Some findings from the 2005 survey (Statistics Canada, 2006b, 2008c, 2008d) illustrate the kind of micro-level insight that only innovation surveys can provide:

- Two-thirds (65%) of surveyed manufacturing establishments indicated they had implemented at least one of five categories of innovation in 2002-04.
- Among ICT manufacturers, the proportion of innovators exceeded 80%.
- Among reasons given not to innovate, lack of market demand was the main response. Examination of responses showed that some non-innovators may actually be innovative although they do not perceive themselves to be.
- In 2004, more than half of all manufacturing plants participated in a global supply chain. Of these, 30% sold goods or services to global customers, while 34% purchased raw materials and components from global suppliers. Among the nearly two-thirds of plants that purchased new machinery or equipment, one-quarter did so from a global supplier. Of the one-tenth of manufacturing plants that contracted out for R&D services, 11% did so from global suppliers.
- Almost 80% of large manufacturing plants (those with at least 250 employees) were part of a global supply chain, compared with 64% of medium-sized plants (100-249 employees) and less than half of small plants (20 to 99 employees).

- Slightly more than 60% of innovative plants participated in a global supply chain in 2004 compared with slightly more than one-third of non-innovative plants.
- Innovative plants that were part of a global supply chain were about three times more likely to have a world-first innovation (16%) than those that were not part of a global supply chain (6%). Moreover, an innovative plant was three and a half times more likely to have a "world-first" innovation if it had sales to a global client than if sales were entirely domestic.
- Factors influencing the decision to co-operate in order to access external knowledge are very similar to those influencing cost-sharing motives. Public funding also leads firms to co-operate in order to access external knowledge and R&D.
- Firms surveyed use strategic methods (e.g., lead-time advantage on competitors, secrecy and complexity of design) more than patents for intellectual property protection.

MEASURES OF INNOVATION INPUTS

The following sections describe the principal statistical facts regarding Canada's performance in respect of:

- research and development
- employment of highly skilled people, and
- investment in machinery and equipment.

Most of this material is well known but is nevertheless an important part of the story. Other key input resources, which include technology partnerships, licensing arrangements, outsourcing contracts and consulting relationships, are increasingly important as part of an innovation ecosystem but are not readily captured in aggregate statistical measures – see, however, Baldwin *et al.* (2005) and Baldwin *et al.* (2009, forthcoming). It is important to encourage work by Statistics Canada and the OECD to assemble a more complete picture of innovation activity. In the meantime, discussion is necessarily limited largely to the conventional indicators for which a great deal of reasonably reliable and internationally comparable data exist.

Research & Development

R&D spending has emerged over many years as the most widely cited proxy for business innovation, partly because it can be measured with reasonable, though still imperfect, consistency over time and across countries, but more importantly because it signals a firm's commitment to the systematic generation and com-

mercial application of new ideas. The definition of "research and development" used by OECD countries and their statistical agencies is set out in the *Frascati Manual* (OECD, 2002), which describes procedures that seek to ensure comparable measurement of R&D activities across countries. The overarching definition of 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" (p. 30).

Business expenditure on research and development (BERD) is a particularly relevant indicator because it has been found to correlate closely with other indicators of innovation activity, including micro-data collected through innovation surveys. The various stages of the creation process – R&D, patenting and commercial applications – have also been shown empirically to be positively linked (Trajtenberg, 2002; Jaumotte & Pain, 2005a), reflecting their common connection to discovery-based innovation as a business strategy.

About 80% of R&D in Canada is performed in sectors that make up a little more than one-quarter of the economy. Most sectors do little or no R&D. Innovation is not absent in these sectors, but is likely to manifest as improved management practices and organization of work, and through employment of new capital equipment (Baldwin *et al.*, 2005). The firms that produced the advanced equipment in the first place would likely have performed considerable R&D in the course of doing so. Machinery and equipment is thus primarily the embodiment of R&D, which is therefore a critical link in the chain of economic value creation, whether it is performed directly by a business firm or acquired indirectly via partnerships, licensing of intellectual property, or by investment in advanced machinery and equipment.

R&D spending by business is of particular interest to policy makers in view of strong evidence that R&D has powerful spillover benefits that cause its social return usually to exceed its private return (Box 7).

The policy relevance of R&D is also supported by academic studies that point to a causal connection between business R&D and productivity growth, though the econometric results are sensitive to assumptions and measurement issues (Griliches, 1998). A major long-term, cross-national study by the OECD suggested that a sustained increase of 0.1 percentage point in a nation's BERD to GDP ratio would eventually translate to a 1.2% higher GDP per capita, other things being equal (OECD, 2003b).[17]

17 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.

Box 7 – R&D Spillovers and MFP Growth

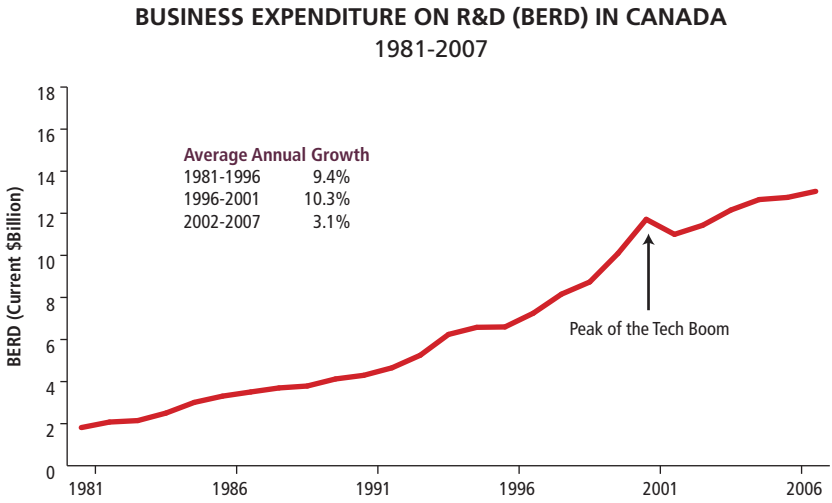
A key insight of endogenous growth theory (see Annex I) is that knowledge spillovers – one form of which results from R&D – provide a way to avoid the limits of diminishing returns and thus generate constant or increasing rates of long-term economic growth. Whether spillovers, in fact, allow an economy to escape the fate of diminishing returns depends crucially on their empirical magnitude.

The agriculture and manufacturing industry studies reviewed by Griliches (1992) generally conclude that the magnitude of R&D spillovers is quite large and social rates of return are significantly above private returns. From these studies Griliches concluded that R&D expenditure can account for roughly 75% of MFP growth with "most of the explanatory effect coming from the spillover effect, which is large, in part, because it is the *source* of increasing returns" (p. 44). Parsons and Phillips (2007) reviewed a number of estimates of the domestic "external" rate of return to R&D in Canada (i.e., the domestic spillover effect), the median of which was 56% with a range from 9% to 138%.

Coe and Helpman (1995) estimated cross-country MFP levels for 22 countries as a function of domestic R&D capital stock and foreign R&D capital stock over the 1971-90 period. They concluded that domestic and foreign R&D capital are the key long-run determinants of MFP and that foreign R&D capital stocks have stronger effects on domestic productivity the larger the share of imports in GDP. This is certainly Canada's circumstance. Specifically, Coe and Helpman found that in 1990 the average "own" rate of return from investment in R&D in the G7 countries was 123%, and the worldwide rate of return was 155%. More specifically, the elasticity of Canadian MFP with respect to foreign R&D was 0.075, implying that an increase of 1% in the R&D capital stock outside of Canada raises Canadian MFP by roughly 0.08 %. Coe *et al.* (2008) confirmed these results and provided evidence that countries where the ease of doing business, quality of tertiary education and patent protection are relatively high tend to benefit more from international R&D spillovers.

Business R&D in Canada

BERD in Canada reached $15.8 billion in 2007 (Figure 3.1 and Table 3). In the 1980s and 1990s, BERD grew more rapidly than the total economy, particularly during the technology boom from 1996 to 2001 when business R&D spending in Canada almost doubled, driven by the surge in the ICT sector, led by Nortel. Since the collapse of the technology boom in 2001, BERD has remained roughly flat after taking account of inflation, and has *declined* by one-fifth as a share of GDP (Figure 3.2).



Data Source: OECD, 2008d

Figure 3.1

Business Expenditure on R&D in Canada

The expenditure data refer to R&D funded and performed by businesses. A standardized definition of R&D has been developed by the OECD to facilitate cross-country comparison (OECD, 2002).

Table 3

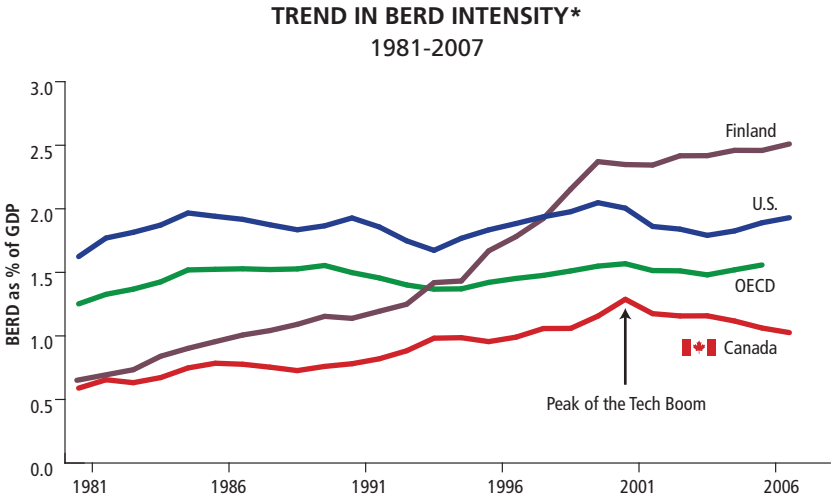
Distribution of Business Expenditure on R&D (BERD) in Canada, 2007

Business Sector	SHARE OF BERD (%)	SHARE OF TOTAL GDP (%)	BERD INTENSITY*(%)
MANUFACTURING	**52.7**	**15.1**	**3.59**
Computer and electronic products	18.5	0.6	31.72
Pharmaceutical and medicine	7.3	0.3	25.03
Aerospace products and parts	6.5	0.5	13.37
Machinery	3.6	1.1	3.37
Chemical, plastic and hydrocarbon products	3.3	1.2	2.83
Motor vehicles and parts	3.3	2.0	1.70
Wood products, paper and printing	2.9	2.2	1.36
Fabricated metal products	1.4	1.2	1.20
Primary metals	1.3	1.0	1.34
Electrical equipment, appliances and components	0.9	0.3	3.09
Food, beverage and tobacco	0.9	1.9	0.49
Non-metallic mineral products	0.4	0.5	0.82
All other manufacturing	2.4	2.3	1.07
SERVICES	**42.3**	**69.2**	**0.63**
Information and cultural industries	10.6	3.6	3.03
Computer systems design and related services	8.0	1.1	7.48
Scientific research and development	8.0	1.2	6.86
Wholesale and retail trade	5.2	11.8	0.45
Architectural, engineering and related services	2.7	1.0	2.78
Finance, insurance and real estate	2.3	19.9	0.12
All other services	5.5	31.8	0.18
ALL OTHER INDUSTRIES (primary, utilities, construction)	**5.0**	**15.8**	**0.33**
TOTAL ($ BN)	**$15.8**	**$1,536**	**1.03%**

*Business expenditure on R&D as a % of value added (GDP) in the relevant sector.

Source: Statistics Canada, 2008b, 2008c

Particular significance is attached to international comparisons of BERD *intensity* (BERD as a percentage of GDP) because empirical evidence suggests that R&D performed by business, rather than by universities and governments, most directly contributes to productivity growth (OECD, 2004). Canada's BERD intensity has consistently remained below the OECD average and well below BERD intensity in the United States (Figure 3.2).



*BERD Intensity = Business Expenditure on R&D as a percentage of GDP.

Data Source: OECD, 2008g

Figure 3.2

Trend in BERD Intensity

BERD intensity in Canada declined by 20% between 2001 and 2007 reflecting the pullback in Canada's large telecom equipment sector. The commitment of Finland to innovation-led growth accelerated sharply in the wake of a severe banking crisis in 1991, exacerbated by weakness in Finland's traditional exports following the collapse of the USSR.

While the U.S.-Canada BERD intensity gap diminished in the 1990s – and narrowed to 0.7 percentage points relative to the United States in 2001[18] – the gap opened up to 0.9 percentage points by 2007. BERD intensity in Canada actually declined from 1.30% in 2001 to 1.03% in 2007, which was only a little more than half the U.S. level (1.93%). Finland, meanwhile, achieved an exceptionally rapid increase in BERD intensity during the 1990s, reflecting that country's concerted effort to become one of the world's technological leaders (Box 8).

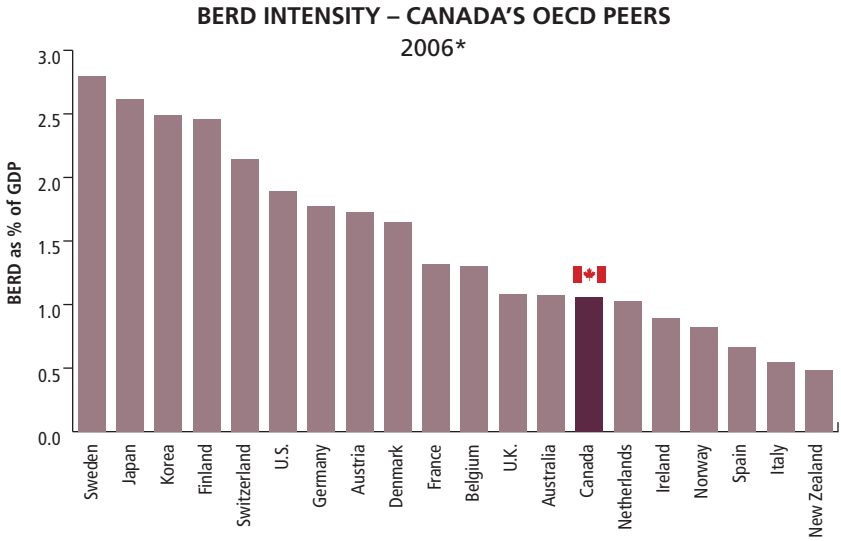
Box 8 – Finland's Innovation Strategy

The stimulus for Finland's commitment to an innovation-led economic strategy appears to have come in large part from the severe economic crisis of 1991 when the Finnish economy was devastated by the simultaneous impact of a near collapse of the domestic banking system and a massive export market disruption due to the disintegration of the USSR (Honkapohja & Koskela, 1999). Through the concerted effort of the government and the business sector, Finland committed to transform its economy into one of the most technologically advanced in the world. While the ICT sector has been responsible for a great deal of Finland's remarkable R&D growth, the country also stepped up its innovation performance in traditional resource sectors like forestry. Finland's success was also due to the fact that it was much less affected than Canada by the communications sector pullback after 2001. This is because the Finnish ICT industry, and notably Nokia, was more heavily oriented to the rapidly expanding mobile communications segment and to the global consumer market.

In Finland's case, a national crisis was the "necessity" that gave birth to invention and galvanized the nation's commitment to innovation as an economic strategy. Finland's experience shows that a concerted strategy to focus resources on innovative activity and investments, and to nurture globally oriented national companies and sectors, can transform a national economy from laggard to leader in a remarkably short period of time. It must be acknowledged that Finland's relatively small size (population of 5.3 million) and cohesive culture make for a significant difference compared with a much larger and highly diverse and regionalized country like Canada.

18 Narrowing of the BERD intensity gap by 2001 was principally due to robust growth of spending in the ICT sector, an area of relative Canadian strength.

Canada's BERD intensity has consistently remained near the back of its peer group, ranking 14th out of 20 economically advanced OECD countries in 2006 (Figure 3.3).[19] Canada's ranking has been essentially unchanged over the past 25 years despite repeated calls and policy initiatives aimed at stimulating much greater R&D effort by Canadian businesses (CMA, 1987; OECD, 1995; CCCE, 2006).



*Data for New Zealand are for 2005, and data for Switzerland are for 2004.

Data Source: OECD, 2008g

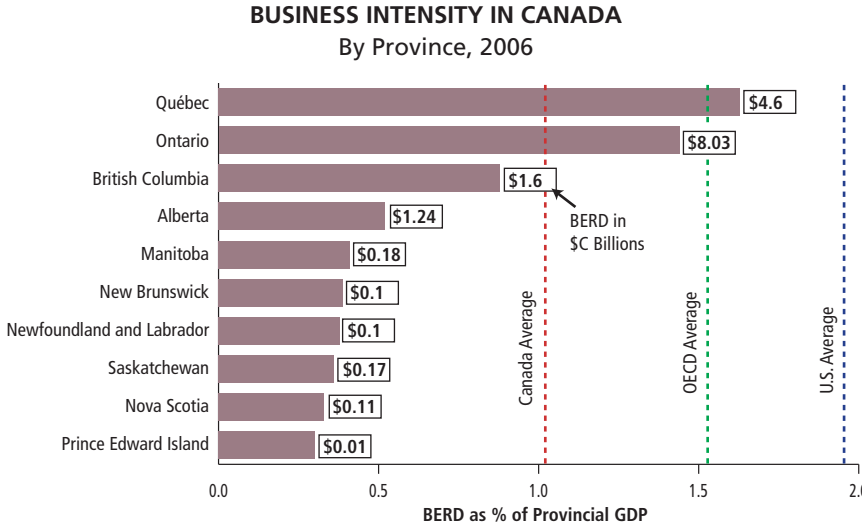
Figure 3.3
BERD Intensity

In 2006, Canada's BERD as a percentage of GDP ranked 14th in a 20-country peer group and sixth in the G7. Canada's relative position has changed little over the years.

Within Canada there is considerable provincial variation of BERD intensity (Figure 3.4). Only Québec and Ontario have levels at or near the OECD average, reflecting the relatively heavy weight of manufacturing and certain R&D-intensive industries, such as pharmaceuticals and ICT, in those provincial economies. Moreover, the BERD ratio has increased more significantly (1991-2005) in Québec and Ontario than in the other provinces. BERD has also grown rapidly in Nova

19 The usual peer group in this report will be 20 of the 30 OECD countries – i.e., excluding most of the newer members as well as the very small members (Luxembourg and Iceland), thus restricting comparisons to larger countries at a level of development roughly comparable with Canada (i.e., the group in Figure 3.3). Occasionally, data are not available for all 20 peer group countries (e.g., as in Figure 2.7).

Scotia and Prince Edward Island, though from a very low base, and also in British Columbia since the late 1990s. The other western provinces, New Brunswick, and Newfoundland & Labrador experienced very little growth in the BERD ratio between 1991 and 2005 (Institut de la statistique du Québec, 2008).



Data Source: Institut de la statistique du Québec, 2008

Figure 3.4

BERD Intensity in Canada

About 80% of business R&D spending takes place in Ontario and Québec, and the top three provinces (Ontario, Québec and British Columbia) account for 90%. The exceptionally low BERD intensities in other provinces reflect the prominence of primary resources and the services sectors in many parts of Canada.

Total R&D in Canada

Canada's total R&D intensity – including business, higher education, and governments – was 1.9% in 2006, placing Canada 11th in its OECD peer group. Weakness in BERD intensity has been partly offset by a sharp increase in higher education R&D (HERD) since the late 1990s (Figure 3.5). Canada's HERD intensity was second only to Sweden in 2006 (OECD, 2007e). This reflects a very significant allocation, particularly of federal government funds over the past decade or so, to support university- and hospital-based research via major new initiatives including the Canada Foundation for Innovation, Genome Canada, the Canada Research Chairs and the research granting councils. Business enterprises meanwhile funded 8% of Canadian university-based research in 2006/07 (Statistics Canada, 2008e). In the United States, the comparable business-funded portion was only about 5% (NSF, 2007a).

GOVERD intensity has meanwhile declined more or less steadily since the early 1980s. By 2007, Canada's GOVERD intensity had fallen to 0.17%, and ranked 13th in the peer group. In first place was South Korea with GOVERD intensity of 0.37%, while the United States stood fifth at 0.30% (OECD, 2007d). Note that GOVERD refers to R&D *performed* by government – in public-sector laboratories and by agencies with regulatory mandates – and is less than the total R&D that is *funded* by government. In the United States, for example, a great deal of defence-related R&D is performed outside government-owned facilities. In fact, as Figure 3.6 shows, U.S. defence-related R&D is about 0.6% of GDP, by far the largest proportion among OECD countries (OECD, 2007e). This public expenditure, while nominally for military purposes, is of significant benefit to many U.S. commercial firms and sectors as well as to university-based researchers.

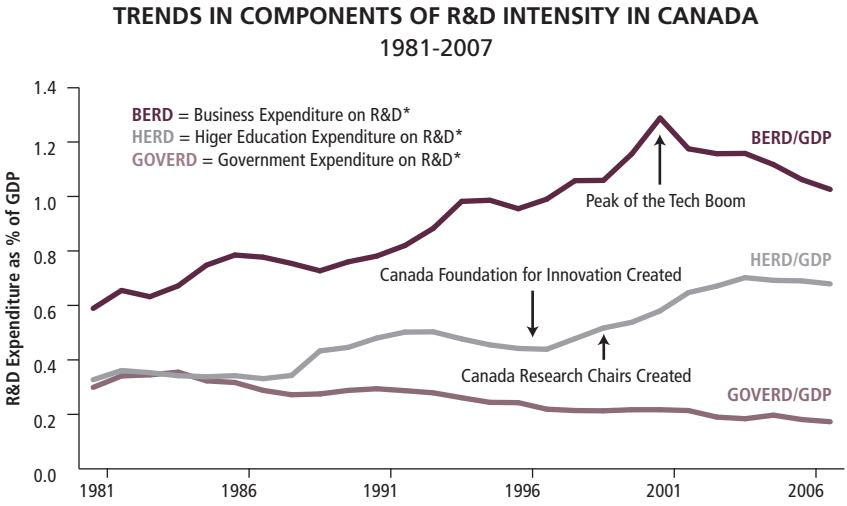
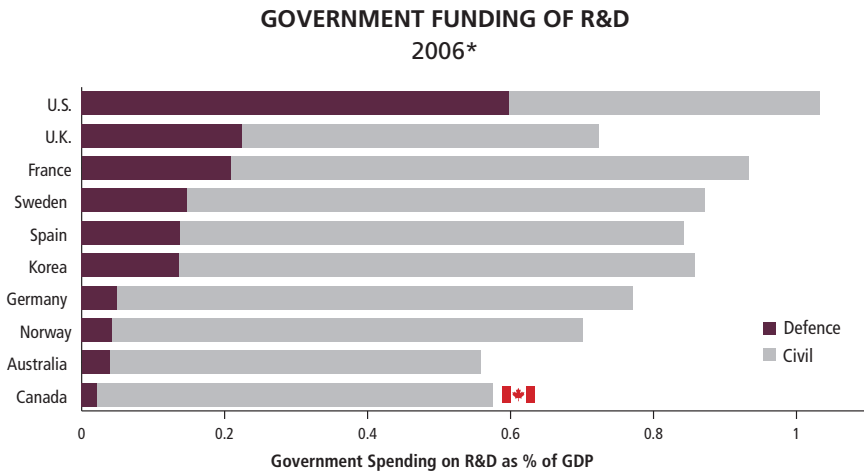


Figure 3.5

Trends in Components of R&D Intensity in Canada

Heavy investment in university R&D (HERD) – led by the federal government once budgets swung into surplus in the late 1990s – boosted Canada's HERD intensity to second place in the OECD (behind Sweden) in 2007. In recent years, however, all three major categories of R&D intensity have been flat or declining.



*Data are for 2006 or latest available year.

Data Source: OECD, 2007e

Figure 3.6

Government Funding of R&D

The U.S. is by far the world's largest spender on defence R&D, both in absolute terms and as a proportion of GDP. Much of this publicly funded R&D is performed by businesses and in universities, and often has had important civilian applications.

There are potentially significant complementarities among R&D performed by businesses (more "D" than "R"), in universities (more "R" than "D") and in government laboratories (R&D applied in support of policy objectives, including intermediation between basic and applied knowledge). In view of its large public investment in university research, Canada could further benefit from improved R&D co-operation between universities, businesses and, in many cases, government scientific establishments. (Transfer mechanisms between universities and businesses are discussed in Chapter 7.) While Canadian investment in university research has paid off well in terms of the internationally recognized quality of Canadian academic science, and the graduates that have been trained, the payoff in terms of new businesses created has been comparatively meagre (Brzustowski, 2008). The relative weakness of business R&D and the disappointing level of university research commercialization appear to be two symptoms of the same underlying condition – a lack of orientation by Canadian business, on the whole, to the commercial exploitation of opportunities at the leading edge of science and technology. There are notable exceptions – Research in Motion (RIM) being the most prominent recent example, among several – but they are not the rule. Even RIM has looked to research universities primarily for trained graduates and not as partners in commercialization.

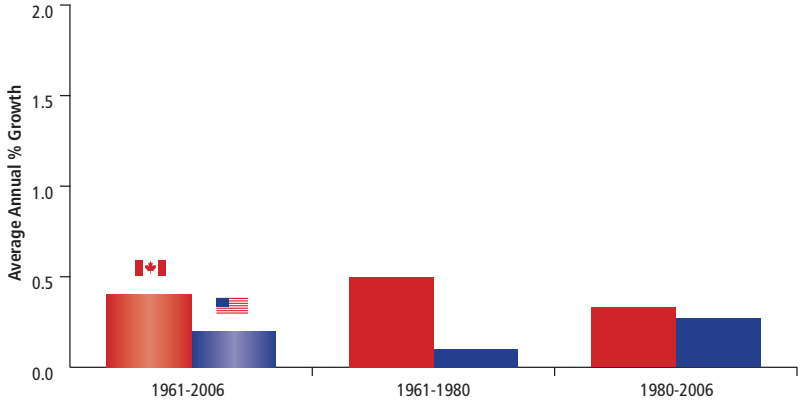
Highly Qualified People

Productivity growth is enhanced by continuous improvement in the skills possessed by working people. Figure 3.7 (derived from Figure 2.6) shows that improvements in the composition (or productive "quality") of the workforce have, on balance, contributed more to productivity growth in Canada than in the United States since 1961, though there has been very little difference between the two since 1980 (Statistics Canada, 2007b).[20]

The productivity gap that has opened up between Canada and the United States since the mid-1980s has not been due to any measured relative deterioration in Canada's workforce. Indeed, among OECD countries, Canada has the highest proportion of workers who have completed post-secondary education – 46% in 2005. Although only about 39% of U.S. workers had post-secondary credentials in that year, among these there is a higher proportion with university degrees than in Canada, where community college diplomas are much more prevalent (OECD, 2006a, 2007b). This pattern is reflected across all major sectors of the Canadian and U.S. economies – i.e., a larger proportion of workers with university degrees are employed in U.S. businesses, but a higher overall proportion of workers with tertiary credentials (university or college) are employed by Canadian businesses (Figure 3.8). There is also a higher proportion of U.S. workers with advanced graduate degrees (Figure 3.9), indicating greater demand for the most technically sophisticated skills. The demand by business for research-level skills is in fact closely correlated with BERD intensity across OECD countries. Part of the correlation is due to the fact that about half of business R&D spending is for employee compensation (Jaumotte & Pain, 2005a).

20 The measure of workforce "quality" depends on compositional changes in employment – e.g., increasing experience (as the baby boom cohort has moved through its working years) and educational attainment – weighted by estimates of the productivity of various education and experience categories. (Refer to the discussion of growth accounting in Annex II.)

CONTRIBUTION OF WORKFORCE COMPOSITION TO PRODUCTIVITY GROWTH
1961-2006



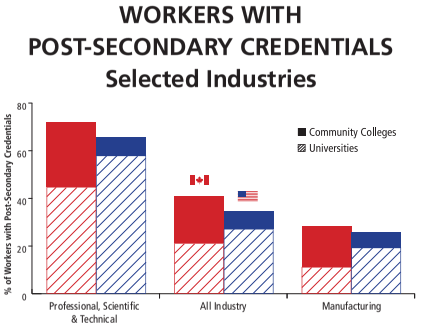
Data Source: "Long-term Productivity Growth in Canada and the United States – 1961 to 2006"; Baldwin and Gu, 2007

Figure 3.7

Contribution of Workforce Composition to Productivity Growth

Improvement in the average skill level of the workforce can be estimated by taking account of: (i) progressively higher average levels of educational attainment and (ii) the increasing average number of years in the workforce as the baby boom cohort has aged. The contribution to productivity growth is estimated by relative wages as a function of education and experience. The bars reflect the rate of change of workforce skills, not the absolute level of the skills in the two countries. The contribution of workforce upgrading to productivity growth is relatively modest overall, but has been greater in Canada than in the U.S., though the difference has diminished steadily over time.

The innovative capability of a business depends at least as much on the quality of management as on the technical skills of workers. A significantly higher proportion of managerial employees in the United States, relative to Canada, has university degrees, and the proportion of those with business degrees appears to be more than double (Figure 3.10). This gap would be expected to translate to a difference between U.S. and Canadian businesses, on average, in the propensity to be aware of, and to adopt, leading-edge technology and business practices. The gap in managerial education levels is most pronounced among small and medium-sized enterprises (SMEs), which would be consistent with surveys that have consistently documented lower adoption rates of advanced technologies by Canadian SMEs as compared with their U.S. counterparts, though not relative to those in most other advanced OECD countries (Baldwin & Sabourin, 1998; Sharpe, 2005).

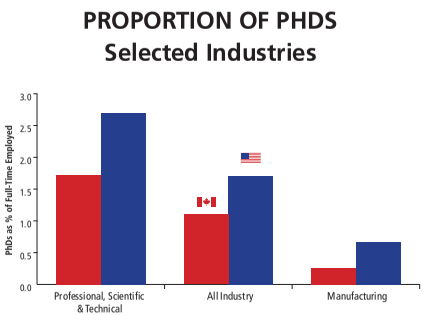


Data Sources: United States Census Bureau, 2000; Statistics Canada, 2001

Figure 3.8

Post-secondary Graduate Workers

The bars indicate the percentage of workers in selected industries with post-secondary credentials – either from a university or a community college. Although Canada has a higher proportion overall, its workers have relatively fewer university degrees than in the U.S.

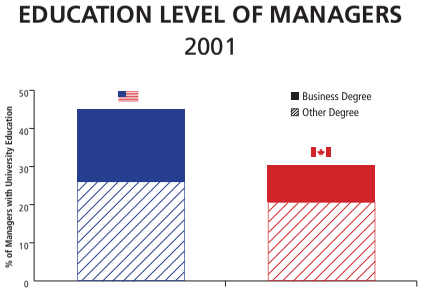


Data Sources: United States Census Bureau, 2000; Statistics Canada, 2001

Figure 3.9

Proportion of PhDs

The U.S. economy employs a significantly higher proportion of workers with the most advanced education. This reflects the relatively large number of U.S. businesses heavily committed to innovation based on science and technology. The demand for workers with graduate degrees is strongly correlated with BERD intensity.



Data Sources: Statistics Canada, 2001; United States Census Bureau, 2005

Figure 3.10

Education Level of Managers

A larger proportion of U.S. business managers is university educated and the difference relative to Canada is particularly noteworthy for business degrees.

There is also a great deal of anecdotal evidence that technology-based startups in Canada (predominantly in the ICT and biotech fields) suffer from deficient business management skills, particularly compared with the United States where the pool of experienced technology executives is exceptionally deep. This is a "chicken or egg" problem because the lack of seasoned managers impairs the prospects of new companies while the resulting low success rate reduces the supply of experienced management. Business school programs focused on technology entrepreneurship can provide important help in solving the new venture management problem. Formal training in this regard needs to be complemented with practical experience, which is often gained in the United States or with the coaching of the small but growing number of senior technology executives and investors in Canada (see also Chapter 7).

Investment in Machinery and Equipment

Investment in leading-edge machinery and equipment (M&E) is the key driver of technological upgrading. Econometric studies demonstrate a robust correlation between M&E investment per worker and R&D spending intensity (Rao *et al.*, 2008). Investment in advanced M&E is a principal source of productivity growth, both through its direct labour-augmenting effect and through its induced impact on innovation, including innovations in the business reorganization required to fully exploit new M&E (David, 1990; Helpman, 1998).[21] The latter is captured statistically as part of MFP growth.

Canadian industries have largely relied on leading-edge capital equipment provided first from the United Kingdom, and later primarily from the United States, but also from Germany, Finland, Japan and Taiwan, among others. Canadian innovation was therefore more likely to be manifested as *adaptation* of technical equipment than as the development of sector-leading capital goods industries. This has been particularly notable and puzzling in the resource sector where, despite a strong comparative advantage in resource endowment, Canada did not develop leading global firms in machinery for forest products, mining or fisheries. Canadian companies chose instead to purchase advanced equipment from countries like Finland, Germany and Norway. The nuclear energy industry is a notable exception, but it has not been able to sustain its former leadership. The failure of Canada to

21 In his celebrated paper, *The Dynamo and the Computer*, Professor Paul David describes how the replacement of mechanical power with electric motors in factory production completely changed the architecture of factories and patterns of workflow. This transition took decades to complete as old capital and work methods were only gradually replaced, and thus significantly delayed realization of the productivity benefits of electrification. David and others have noted that an analogous adjustment to the contemporary ICT paradigm appears to have delayed the productivity payoff from the computer revolution that began in earnest in the 1960s. A great deal of the productivity revival in the United States between 1995 and 2006 has been identified with the production, and then the widespread efficient use of ICT (Jorgenson *et al.*, 2008).

develop global export leaders in advanced M&E for the resource sector is one particularly telling indicator of the country's innovation shortcomings.

Total capital investment by businesses includes both M&E and investment in "structures" – i.e., buildings and various types of engineering structures such as pipelines and power-generating facilities. Canadian investment in structures substantially exceeds that of the United States on a per worker basis, reflecting the relatively heavy role in the Canadian economy of structure-intensive sectors such as mining, energy and utilities (Figure 3.11). And while structures are obviously essential to most businesses, they are usually not directly linked to advanced technology and play a much smaller role than M&E investment in the innovation process.

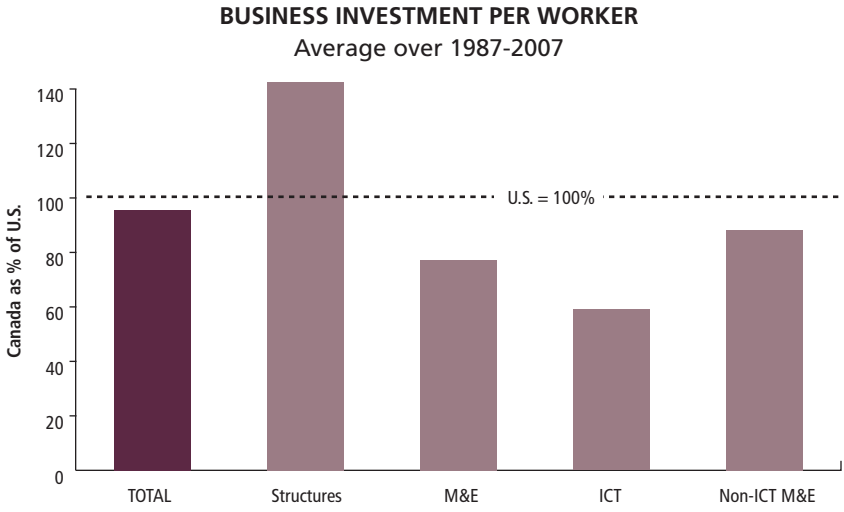
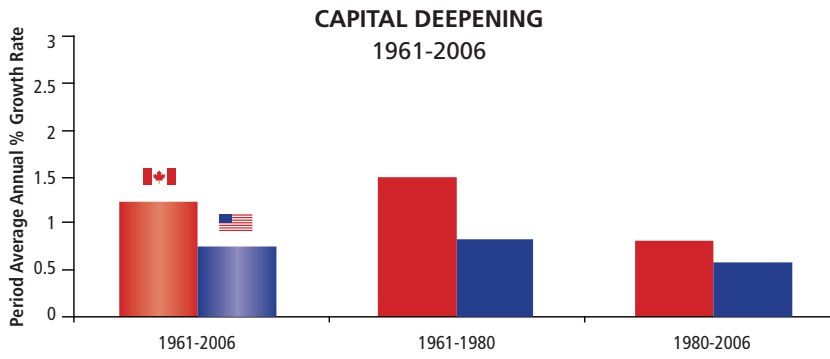


Figure 3.11

Business Investment per Worker

Canada's total capital per worker is only slightly less than the U.S. metric. But Canada's business capital stock is heavily weighted to structures – roads, pipelines, generating facilities, etc. – whereas the U.S. has much more machinery and equipment per worker, especially in ICT. This reflects more innovation-oriented business strategies and results in greater MFP growth.

Viewed in a longer-term perspective, business capital investment overall (structures plus M&E) has actually contributed more to productivity growth in Canada than in the United States, particularly from the early 1960s to the early 1980s (Figure 3.12). Since the mid-1980s, capital deepening – which measures the increase of the productive output of a nation's capital stock per hour worked – has been responsible for only a small part of the widening productivity gap between Canada and the United States.



Data Source: Statistics Canada, 2007b

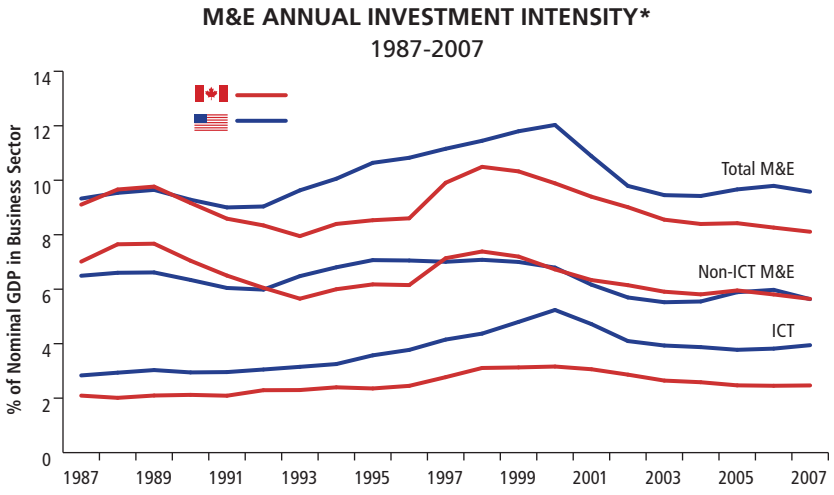
Figure 3.12
Capital Deepening

Capital deepening measures the annual percentage increase in the flow of capital services per hour worked (see Annex II). The data encompass all business capital, not just M&E, and are based on 28 capital asset categories, and calculations of the rates of return and depreciation in each category.

Investment in M&E by Canadian business has not persistently lagged the United States as has been the case with R&D, though a gap has opened up since the early 1990s. The elements of the gap are traced over time in Figures 3.13 and 3.14.[22] They show that Canada's M&E investment – whether expressed per worker or relative to GDP – began to fall behind that of the United States in about 1990. *The gap, relative to GDP, has been almost entirely due to Canada's persistently weaker investment in ICT.* Expressed as annual investment per worker (Figure 3.14), there is also a U.S.-Canada gap, on average, of about $US500 in non-ICT machinery and equipment, but since the mid-1990s the ICT gap is more than twice as large. Investment in ICT was particularly strong in the United States until the collapse of the "tech bubble" in 2001 and still remains well above the level prior to the mid-1990s.

Although overall M&E investment intensity in Canada lagged behind that of the United States for more than 15 years, the non-ICT component held up well despite (i) the prolonged weakness of the Canadian dollar, which increased the cost of the large proportion of M&E that was imported; and (ii) the relative slack in the Canadian labour market during much of that period, which reduced the incentive for capital-labour substitution (Leung & Yuen, 2005; Rao *et al.*, 2007).

22 Note that these data are *annual* new investments. The total M&E capital stock per worker – which is the relevant factor for the analysis of productivity growth – accumulates annual increments and subtracts the effect of wear and tear and ultimate replacement. By displaying annual investment intensities over an extended period, the trend of capital stock can also be roughly inferred.



*M&E investment intensity is measured as a percentage of GDP.

Data Source: CSLS, 2008b

Figure 3.13

M&E Annual Investment Intensity

This chart traces annual investment in nominal terms (i.e., using current prices) as a percentage of nominal GDP. Since ICT prices, per unit of performance, have fallen substantially (especially for microelectronics and optical communications), the performance-adjusted "volume" of ICT investment would be much greater than the chart suggests. Note that Canada's non-ICT investment ratio increased from 1993 to 1998, despite Canadian dollar weakness, (which increased the cost of imported capital goods), and has been flat to declining since 2002 even as the dollar strengthened.

Meanwhile, the apparently favourable investment conditions in Canada from 2002 through 2007 – i.e., strong currency appreciation, a tighter labour market and healthy corporate profitability overall – actually produced a declining-to-flat M&E investment ratio (Figure 3.13). This counter-intuitive pattern can be explained by the fact that during the time when the Canadian dollar was weak and labour costs were relatively low, export-oriented facilities in Canada were exceptionally cost-competitive and thus attracted heavy investment. When those conditions reversed, especially for many manufacturers, M&E investment weakened despite the falling Canadian dollar cost of many capital goods.[23]

23 Looking forward, the federal government has provided encouragement for M&E investment by manufacturers by allowing a two-year tax write-off for investments made through 2011. To address the ICT gap, the 2009 federal budget proposed a two-year measure to allow businesses to fully expense investment in computers in the year the investment is made. The government also projected that by 2010 Canada will have the lowest "marginal effective tax rate" on new business investment among G7 countries (Finance Canada, 2009, p. 261).

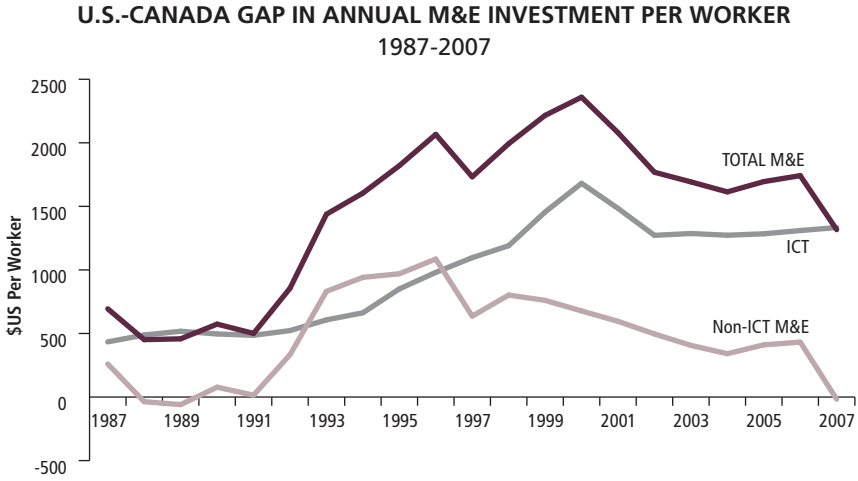


Figure 3.14

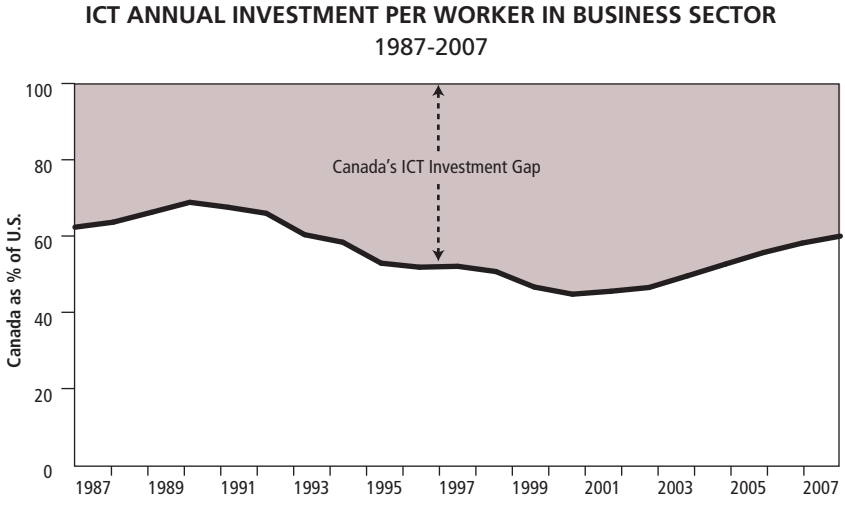
U.S.-Canada Gap in Annual M&E Investment Per Worker

In 2007, U.S. businesses invested about US$1,400 per worker more in ICT than did Canadian businesses. A similar annual gap has persisted for a decade.

The ICT Investment Gap

The most significant, and puzzling, component of the M&E gap between Canada and the United States is obviously the large disparity in investment intensity in ICT, which includes both hardware and software (Figure 3.15). In fact, OECD data for 2002 indicate that ICT investment per worker in Canada has also lagged well behind Australia, Finland and Sweden, among others (Figure 3.16).

The sectoral breakdown of ICT investment in Figure 3.17 shows that the U.S.-Canada gap is widespread and very large in many important industries. While the gap has persisted over time, it has shown some sign of narrowing since the Canadian dollar began to appreciate in 2002 (Figure 3.15). Figure 3.18 compares ICT investment per worker in the United States and Canada over the period 1997-2006 in manufacturing, finance and insurance, and professional, scientific and technical services. Each sector includes a pair of charts for ICT and non-ICT investment per worker. The overall pattern is common throughout the economy – ICT investment per worker has invariably trended higher in the United States than in Canada and usually by a substantial margin. The pattern of non-ICT investment per worker (in M&E) is somewhat mixed, but, in most cases, the level in the United States exceeds that in Canada, though the "finance and insurance" sector is a significant counter-case.



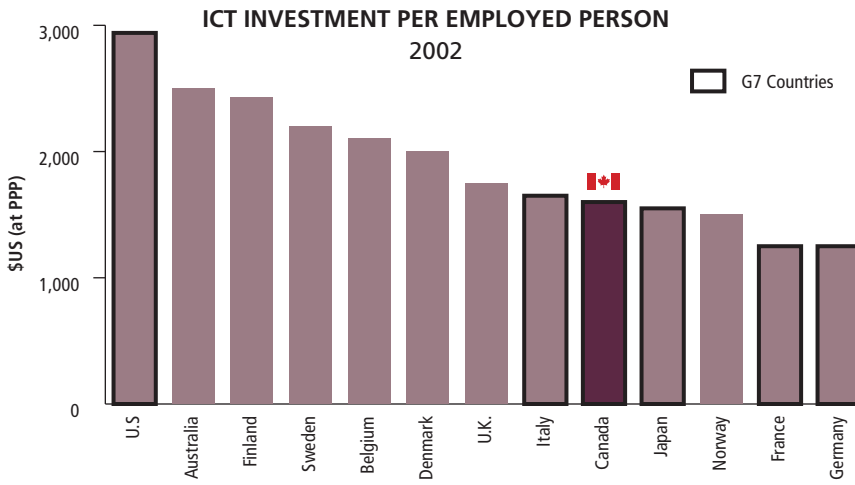
Data Source: CSLS, 2008b

Figure 3.15

ICT Annual Investment per Worker in Business Sector

This figure presents a different view of the data in Figure 3.14. Canada's ICT investment per worker in 2007 was only 60% that of the U.S. The trend is very similar to the Canada- U.S. exchange rate (Figure 8.1), which suggests that Canada's relative pickup after 2002 was influenced by the stronger Canadian dollar.

There is a substantial consensus among economists that the ICT-producing sector was the principal driver of the productivity revival in the United States during the 1990s (Oliner *et al.*, 2007; Jorgenson *et al.*, 2008). Since then, the influence of ICT has been primarily due to productivity growth in sectors that use ICT intensively. The impact has been particularly strong in various service industries (OECD, 2000; Brynjolfsson & Hitt, 2003; OECD, 2007c; Sapprasert, 2007). Studies of the introduction of ICT in a wide range of industries show that ICT by itself will not boost aggregate productivity growth (Pilat & Lee, 2001). Investments complementary to ICT such as training, business process reorganization and managerial innovation all appear to be essential to realization of the full benefits of ICT investment (Brynjolfsson & Hitt, 2000). The importance of complementary investment is typical when general purpose technologies such as computers are introduced into the economy. The full productivity benefit is delayed until the effects of the complementary investments have had time to work their way thoroughly into business practices (David, 1990; Helpman, 1998).

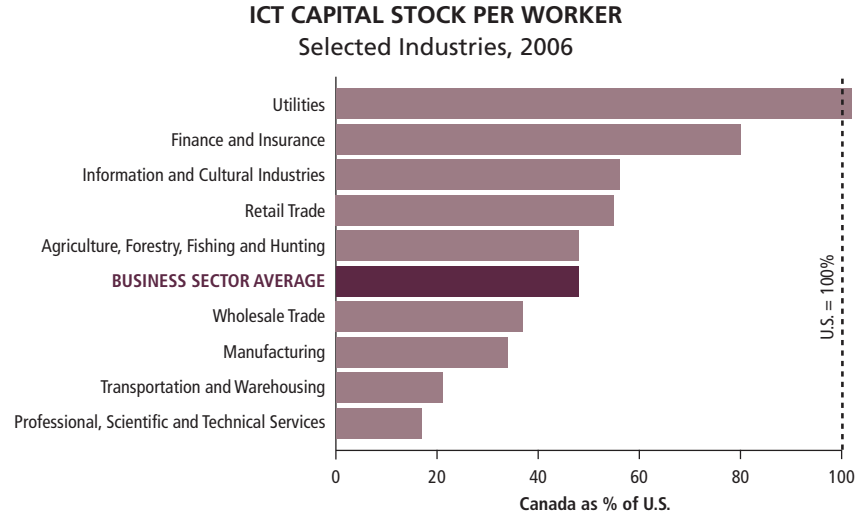


Data Source: OECD, 2005b

Figure 3.16

ICT Investment per Employed Person

Canada's ICT investment deficit is not only relative to the U.S. Finland and Sweden are in their customary high-ranking positions, but Australia also invested considerably more than Canada (at least in 2002). On the other hand, Canada was investing somewhat more per worker than Japan, France, and Germany.

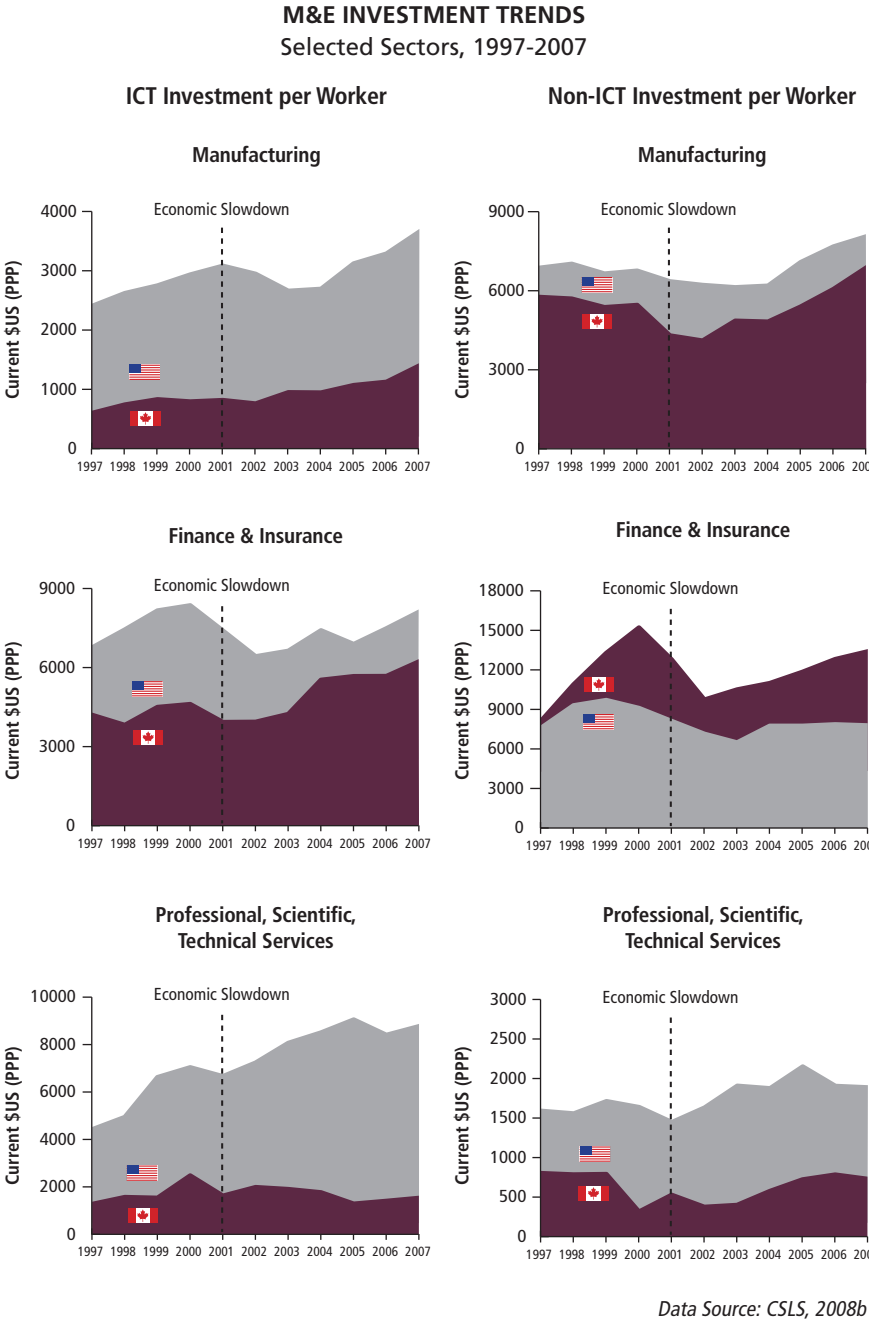


Data Source: CSLS, 2008b

Figure 3.17

ICT Capital Stock per Worker

The ICT capital stock is the accumulated value of annual investment less depreciation and retirements. Labour productivity depends on capital stock, not simply on annual increments. With the exception of utilities and the financial sector (two areas of particular strength in Canada), ICT capital per worker in Canadian industries lags very far behind that of the U.S.



Data Source: CSLS, 2008b

Figure 3.18

M&E Investment Trends in Selected Sectors

Only in the finance & insurance sector has Canadian ICT investment tended to close the gap with the U.S.

Canadian research also points to the benefits of ICT investment for firm performance, again noting the importance of complementary investments (Baldwin & Sabourin, 2001; Baldwin & Gu, 2004). Within the manufacturing sector, Gu and Gera (2004) find that Canadian firms that invest in ICT perform better than those that do not, and firms that invest in ICT and adopt new organizational practices perform even better. The direction of causation is less clear. While ICT may indeed improve performance, it is also true that firms that are better managed in the first place are more likely to invest in leading-edge equipment and methods.

These findings regarding the benefit of ICT investment have intuitive appeal but they only sharpen the question as to why the gap between Canada and the United States has remained so large. The Centre for the Study of Living Standards (CSLS) analyzed this question extensively in 2005. The study found that about 20% of the Canada-U.S. gap in ICT investment as a share of GDP in 2004 was due to industry structure differences – e.g., Canada has a smaller share of output in ICT-intensive industries and a slightly higher proportion of small firms, which tend to invest less in ICT. The study identified the following contributing factors but was not able to quantify their impact on the ICT investment gap (Sharpe, 2005).

- The weakness of the Canadian dollar prior to 2002 and relatively low labour compensation costs in Canada appear to have militated against ICT investment in Canada compared with the United States.
- Since many aspects of ICT capital investment can be located in the home country of a multinational and accessed via communications facilities by subsidiaries, Canada's unusual preponderance of large foreign-controlled activity would lead to less ICT investment intensity, other things being equal.
- The proportion of managers with university education is significantly greater in the United States than in Canada (recall Figure 3.10). More highly trained managers would be expected to have greater appreciation for the benefits of ICT and thus would be more likely to make an investment.
- Marginal effective tax rates on ICT capital were, by 2005, about equal in Canada and the United States and thus do not explain the current investment gap; but they may have been a factor in the past and might explain some of the Canada-U.S. gap in the stock of ICT capital per worker.[24]

The CSLS study was not able to account definitively for the majority of the ICT investment gap and noted: "There is much anecdotal evidence that there are cul-

24 Most ICT assets depreciate rapidly, and thus the investment of several years ago would not contribute much to the present stock of ICT capital. It is capital stock, and not annual increments of investment, that enters into the growth accounting analysis of productivity increases.

tural differences in the operations of businesses between Canada and the United States and that these differences account for the ICT investment gap. The report found no hard data to support this view, although it may still be valid and may indeed account for part of the gap… Lower ICT investment in Canada may also reflect the lower intensity of competition in this country, but again the evidence… is inconclusive at this stage" (Sharpe, 2005, p. 9).

While recognizing that the evidence base is anecdotal rather than systematically quantified, the panel believes that the ICT investment picture is consistent with the view that *Canadian businesses on the whole – but always with notable exceptions – are technology followers, not leaders*, and are less willing to adopt new practices until they have been well proven south of the border. In today's fast-paced world, that strategy is unlikely to work as well as it once did.

MEASURES OF INNOVATION OUTPUTS

Patenting

The intensity of patenting is one of very few readily compiled and internationally comparable indicators of innovation activity. Unfortunately, this indicator is limited to specific types of innovation. Moreover, patents are intended to protect the intellectual property of an *invention*, whereas only a very small proportion of patents are implemented as *innovations*. Thus patents are more properly regarded as "intermediate inputs", rather than strictly as outputs of innovation. Furthermore, simply counting patents does not capture which ones are important. While it is possible to use citations in later patent applications as a good indicator of the importance of a patent, it takes years to develop a significant base (Hall *et al.*, 2005).

Notwithstanding the limitations of patent data, they can be significant as components of a constellation of several indicators of national innovative orientation. As with R&D and M&E/ICT investment measures, Canada is well back in the international pack, ranking 14th within its 20-country peer group in terms of triadic patent families per capita in 2005 (OECD, 2007d).[25] There is also quite a tight correlation between patent intensity and BERD intensity since businesses conduct R&D in part to develop patentable goods and services. The correlation is of course only relevant in those R&D-performing industries that also tend to use patents to protect intellectual property. It is also the case that the propensity to patent differs among countries and has changed over time in response to

25 Counts of triadic patent families – made up of a set of patents filed at the European Patent Office, the United States Patent and Trademark Office and the Japan Patent Office for the same invention – provide the most internationally comparable metric.

globalization and the 1994 Agreement on Trade-Related Aspects of Intellectual Property Rights.

Innovation Output Indicators at the Firm Level

The innovation surveys of Statistics Canada provide information on inputs and outputs of innovation derived from survey data at the firm level in selected sectors (recall Box 6). Similar surveys in Europe, based on the common methodologies set out in the OECD's *Oslo Manual*, permit some international comparisons but not yet with the United States, which is only beginning to conduct trial surveys. The results of innovation surveys indicate generally that Canada ranks ahead of most European countries in terms of the proportion of manufacturing firms reported to be innovative. But the proportion of sales derived from innovative products is reported to be consistently lower for Canadian businesses than for their European counterparts (Therrien & Mohnen, 2001). These results have been broadly confirmed in a recent OECD paper on firm-level innovation indicators, which presents a broad range of results from country innovation surveys (OECD, 2007c, 2009 forthcoming). Canada's statistics, covering the manufacturing sector only, compare very favourably within a group of 16 countries including Germany, Finland, Sweden and Japan.

Survey data of this type promise eventually to yield much deeper insight into innovation behaviour than can be conveyed by aggregates like national R&D spending. But the coverage and methodology have not yet reached the point where firm conclusions can be drawn. The continuation of innovation surveys and the further development of their methodology appear to hold great promise and may be the best way to improve both the understanding of business innovation and the design of policies to foster innovation.

MEASURES OF INNOVATION OUTCOMES

Reliable and internationally comparable measures of innovation outcomes are even more elusive than measures of innovation output. For the individual firm, the most relevant outcome indicators are growth, market share and/or profitability, whereas, for the economy as a whole, productivity growth – and more particularly MFP growth – is the most significant indicator of the aggregate outcome of business innovation.

Profitability

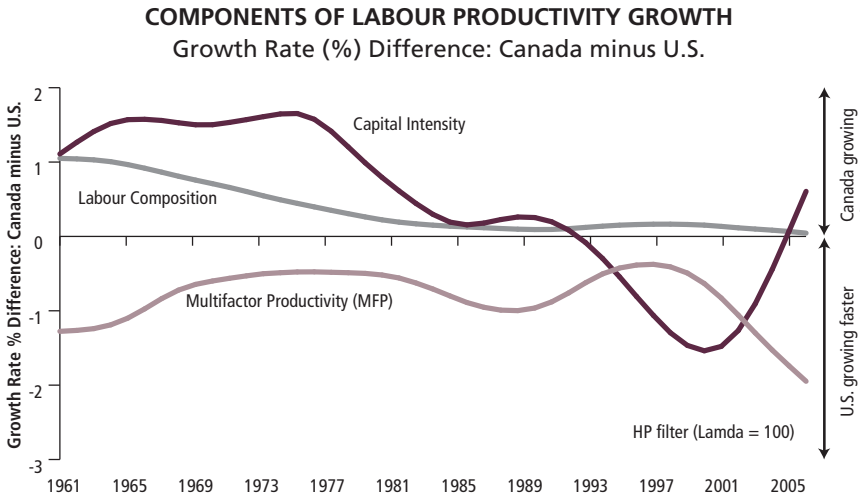
Although strong profitability is one potential outcome of innovation, business profit is also dependent on a great many other factors. Particularly significant is the intensity of competition, the broad effects of which are to constrain profit ratios while creating,

in most cases, an incentive to innovate (Arsenault & Sharpe, 2008). Low profitability may be consistent with high innovation intensity, with the poor innovators simply disappearing. It should be noted that aggregate business profit (as a percentage of GDP) in Canada has usually exceeded the profit ratio in the United States throughout at least the past 40 years (Figure 6.2).

On the other hand, superior innovation can also produce exceptional financial results because (i) blockbuster innovations like the BlackBerry or iPod will confer effectively a monopoly advantage for some period, the outcome of which is more often rapid sales growth than very high profit margins; or (ii) an ongoing sequence of more incremental innovations – as typified by firms like Toyota, GE, IBM, and Procter & Gamble – can keep a business perpetually ahead of the competition with the advantage showing up as industry-leading margins and/or steadily increasing market share. Given the many uncertainties and distorting factors that cloud any empirical relationship between innovation and profitability metrics, no clear conclusions regarding innovation performance can be drawn from national-level data on corporate profitability.

Multifactor Productivity

For reasons explained in Chapter 2, the growth rate of MFP is the best overall indicator of the outcome of innovation at the aggregate level. It is particularly significant, therefore, that MFP growth in Canada has consistently and substantially lagged behind that in the United States since at least the early 1960s (Figure 3.19) and in most peer group countries (recall Figure 2.7). The smoothed data in Figure 3.19 trace the difference in growth rates between Canada and the United States of the principal contributors to labour productivity. From the early 1960s through the early-1980s, capital intensity was increasing much more rapidly in Canada than in the United States, as was the average education and experience of the workforce. During this period, Canada's MFP growth consistently lagged behind that of the United States, but the shortfall was more than offset by Canada's strength in capital intensity and labour composition improvement. Thus the U.S.-Canada gap in labour productivity was shrinking until the mid-1980s (recall Figure 2.5). Since then, MFP growth in the U.S. has continued to outpace that of Canada, and Canada has ceased to have an advantage in respect of labour composition improvement or increasing capital intensity – in fact quite the opposite in the latter case due to the much slower pace of ICT investment in Canada during the 1990s. The net effect is that Canada's labour productivity has been falling farther behind that of the United States for the past 20 years, with the one consistent feature being Canada's significantly slower rate of MFP growth. *Sustained weakness in MFP growth is the most compelling indicator that Canada has a business innovation problem, and that this problem is the primary source of Canada's lagging labour productivity growth.*



Data Source: Statistics Canada, 2007b

Figure 3.19

Components of Labour Productivity Growth

This chart is another view of the data in Figure 2.6 and is based on a smoothing ("filtering") of the "noisy" annual estimates of the growth accounting decomposition of labour productivity growth in Canada and the U.S. The curves measure the differences in the growth rates of the variables, and not the differences in their levels. Most significant is that Canada's (smoothed) MFP growth has substantially trailed that of the U.S. for at least the past 45 years, and has fallen even farther behind since the late 1990s.

COMPOSITE INDICATORS OF INNOVATION

The foregoing discussion has addressed the typical collection of innovation indicators, most of which are subject to relatively objective statistical measures over long periods of time. Recently, the European Commission (EC) has developed a systematic methodology to rank the innovation performance of EU members as well as a group of non-EU comparator countries, including Canada. The latest ranking placed Canada 17th of 37 countries surveyed in terms of the Summary Innovation Index (Box 9). Sweden ranked first, and the United States, ninth.

The business media also publicize various global rankings that purport to give integrated assessments of business competitiveness and innovation performance across countries, primarily based on surveys of executives and other stakeholders. While the rankings may include certain objective data, the weights that are used to construct single indicators from such data are necessarily somewhat arbitrary. If the sample of opinion is nevertheless sufficiently large, and if a consistent survey methodology is employed over several years and across countries, the results of these survey-based rankings are meaningful.

The World Economic Forum (WEF), which has tracked and refined its criteria over many years, appears to provide the most reliable of such rankings. The overall message is consistent with the objective statistics – i.e., Canada is a mid-to-low performer among peer group countries in terms of business innovation (Table 4). Canada's ranking and mean score, on the six tabulated questions used by the WEF to gauge "innovation fitness" in 2008, are remarkably consistent with the picture painted by the suite of quantitative indicators reviewed in previous sections (WEF, 2008). The quality of Canada's research institutions is considered to be world class, and there appears to be an ample supply of scientists and engineers. On the other hand, university-industry collaboration is seen as quite weak in Canada as is the perception of Canada's "capacity for innovation" (see definition in Table 4).

The WEF has created an omnibus *Innovation Index* as a weighted combination of the scores on the various component questions. Figure 3.20 shows that the index correlates closely with BERD intensity and Canada lies near the simple regression line. The correlation with BERD intensity is not surprising since the questions on which the index was based were oriented toward a concept of innovation that is linked to the application of advanced science and technology. The remarkable tightness of the correlation nevertheless shows that BERD intensity is a reasonably good predictor of the results of more impressionistic assessments of the relative innovation strength of countries.

Box 9 – European Innovation Scoreboard

The European Innovation Scoreboard (EIS) was developed at the initiative of the EC to provide a comparative assessment of the innovation performance of EU members. The EIS 2007 (EC, 2008), released in February 2008, includes, for the first time, innovation indicators and trend analyses for Canada (among 37 countries).

The EIS uses 25 innovation indicators, classified into five dimensions, to capture the various aspects of the innovation process.

- *Innovation drivers* measures the structural conditions required for innovation potential.
- *Knowledge creation* measures the investments in R&D activities.
- *Innovation & entrepreneurship* measures the efforts toward innovation at the firm level.
- *Applications* measures the performance expressed in terms of labour and business activities and their value added in innovative sectors.
- *Intellectual property* measures the achieved results in terms of successful know-how.

The EIS Summary Innovation Index (SII) provides an overview of aggregate national innovation performance boiled down to a single number. (The weights of various sub-indicators in the final index introduce some arbitrariness.) The SII of certain countries, including Canada, is based on a more limited set of subindicators; thus the relative position of those countries in the overall SII ranking is not strictly comparable with the ranking of EU countries. Canada, with a score of 0.44, ranked 17th in 2007, while the United States ranked ninth with a score of 0.55. Sweden topped the list with a score of 0.73.

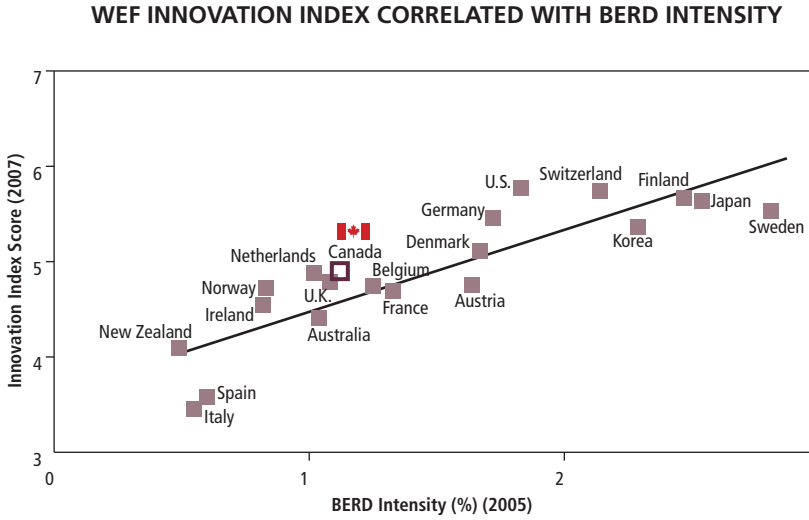
The countries that made up the *innovation leaders* list in 2007 were, in descending order: Sweden, Switzerland, Finland, Israel, Denmark, Japan, Germany, the United Kingdom and the United States. Innovation leaders are those that are among the best performers in all five dimensions mentioned above. Countries in the *innovation followers* list are, in descending order: Luxembourg, Iceland, Ireland, Austria, the Netherlands, France, Belgium and Canada. These are above average performers in almost all cases. The other two groupings are the *moderate innovators* (eight countries), which are close to, or below, average across the dimensions; and the *catching-up countries* (11 in number), which are below the EU average in all of the dimensions.

Table 4

World Economic Forum 2008: Business Executives' Opinion of Innovation Fitness[26]

COUNTRY	MEAN SCORE	RANK	COUNTRY	MEAN SCORE	RANK	COUNTRY	MEAN SCORE	RANK
1. Capacity for innovation – Companies obtain technology (1=exclusively from licensing or imitating foreign companies, 7=by conducting formal research and pioneering their own new products and processes)			**2. Company spending on R&D** – Companies in your country (1=do not spend money on R&D, 7=spend heavily on R&D relative to international peers)			**3. Government procurement of advanced technology products** – Government purchase decisions for the procurement of advanced technology products are (1 = based solely on price, 7 = based on technical performance and innovativeness)		
Germany	6.0	1	Switzerland	6.0	1	Singapore	5.5	1
Japan	5.9	2	Japan	5.8	2	Korea	5.1	2
Switzerland	5.9	3	United States	5.8	3	Tunisia	5.1	3
Sweden	5.8	4	Sweden	5.8	4	United States	4.9	4
Finland	5.6	5	Germany	5.8	5	Israel	4.8	5
United States	5.5	6	Finland	5.3	9	Finland	4.7	7
CANADA	**4.5**	**18**	**CANADA**	**4.4**	**22**	**CANADA**	**4.1**	**29**
4. Availability of scientists and engineers – Scientists and engineers in your country are (1=nonexistent or rare, 7=widely available)			**5. Quality of scientific research institutions** – Scientific research institutions in your country (e.g., university laboratories, government laboratories) are (1= nonexistent, 7 = the best in their fields internationally)			**6. University-industry research collaboration** – In its R&D activity, business collaboration with local universities is (1 = minimal or nonexistent, 7 = intensive and ongoing)		
Finland	5.9	1	United States	6.3	1	United States	5.8	1
Japan	5.9	2	Switzerland	6.2	2	Switzerland	5.6	2
India	5.7	3	Israel	5.9	3	Sweden	5.6	3
Sweden	5.6	4	**CANADA**	**5.9**	**4**	Finland	5.5	4
France	5.6	5	Belgium	5.8	5	Singapore	5.5	5
United States	5.5	6	Finland	5.7	9	**CANADA**	**5.0**	**14**
CANADA	**5.5**	**7**						

26 The table shows the top five countries, plus United States, Finland and CANADA (if not already in the top five), for each survey question based on the mean value of ratings on a seven-point scale. Higher mean scores indicate a perceived greater fitness for business sector innovation. The country rankings for each question are based on surveys of business people working in those countries. The 2008 survey included 134 countries.



Data Sources: OECD, 2007e; WEF, 2008

Figure 3.20

WEF Innovation Index Correlated with BERD Intensity

The World Economic Forum's *Innovation Index* is constructed from a number of indicators derived from surveys of business people in each country. The correlation suggests that BERD intensity can be a rough proxy for more impressionistic indicators of innovation performance.

CANADA'S SUBPAR INNOVATION PERFORMANCE

The suite of quantitative indicators presented in this chapter provide compelling evidence that the innovation performance of Canadian business is, on the whole, subpar by the standards of Canada's peer group of industrially advanced countries. It may nevertheless be argued that the aspects of innovation measured by indicators such as R&D, M&E/ICT and patents address only certain components of innovation that, moreover, are significant only in those sectors where science-based product development or the application of advanced technologies are critically important. (These sectors comprise about a quarter of Canada's economy.)

It is true that R&D is limited in scope and concentrated in specific sectors (recall Table 3) and is therefore not an omnibus indicator of business innovation. On the other hand, it is difficult to be innovative in any sector today without investing, especially in ICT; and the ICT investment gap, relative to the United States and several other countries, appears to be even greater than the R&D gap.

Given the unimpressive long-term trend in the level and growth of business sector productivity in Canada, there is no reason to believe that Canada excels in the areas of innovation that are not captured by conventional metrics such as R&D and M&E investment. Indeed, the gap in the education level between Canadian and U.S. business managers suggests, if anything, that Canadians would likely be slower to adopt the newest ideas and methods in business processes, marketing and so forth. Weaknesses in these less easily quantified dimensions of innovation would be expected to show up in subpar growth of Canada's MFP, and this has emphatically been the case. The lagging adoption of ICT in virtually every sector of the Canadian economy suggests that Canadian businesses, on the whole, are followers and not innovators in the sort of business reorganization that ICT implementation demands. Canada's relative lack of export aggressiveness outside the North American market, despite the burgeoning opportunities in Asia, also implies a degree of complacency incompatible with attitudes needed to excel in the *non-technological* aspects of business innovation.

On the positive side, and as Statistics Canada's innovation surveys attest, many Canadian businesses have been successful process innovators on the plant floor and in important complementary areas such as labour-management relations. Canadian-based auto plants for example – thanks to very effective use of innovative production techniques and state-of-the-art equipment from the United States and Japan – are disproportionately represented among the North American leaders in productivity and quality (see the automotive case study in Chapter 10). Four Ontario auto plants rank in the top 10 in North America – including the plants that are in second and third places – in terms of fewest labour hours per vehicle (Harbour Consulting, 2008). It is also the case that labour agreements in the Canadian sector of the industry have demonstrated an innovative response to current competitive realities.

Notwithstanding many examples of successful innovation by Canadian firms, the weight of evidence from the benchmark indicators reviewed in this chapter establishes that *the innovation performance of Canadian business, taken as a whole, is significantly weaker than the innovation performance of the U.S. business sector, and in fact weaker than that of many of Canada's peers among OECD countries.*

Chapter 4 – Innovation as a Business Strategy

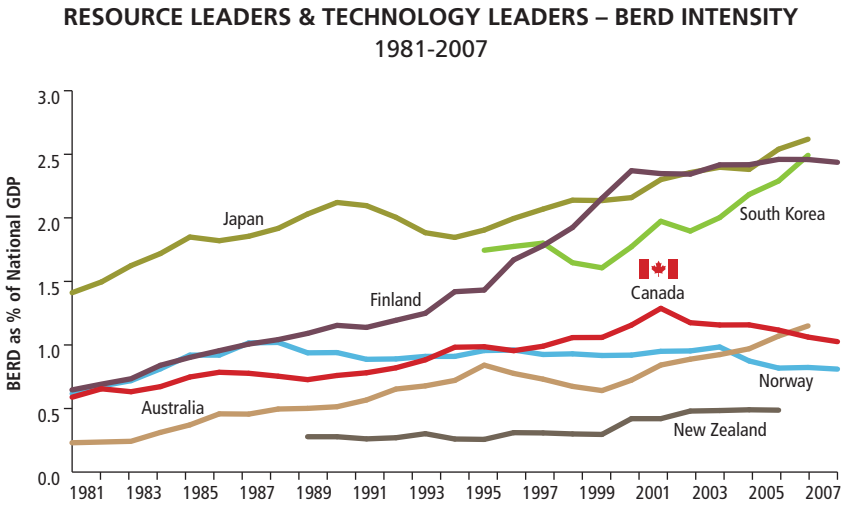
This chapter addresses the third question in the charge to the panel: *Why is business demand for innovation inputs (for example, research and development and skilled workers) weaker in Canada than in many other OECD countries?*

The evidence presented in Chapter 3 shows conclusively not only that Canadian business invests less in innovation inputs than many peer group countries, but also that Canada's innovation outcomes are subpar and there has been a persistent drag on labour productivity growth as a consequence. The relative weakness of business innovation in Canada is not due to irrational behaviour of firms as a whole, nor to any collective failure of business to recognize that innovation could be the best strategy under the right circumstances. While an individual firm may get its strategy wrong, the same cannot be said for the entire business sector in Canada, and particularly not over decades. It follows that the strategic choices of Canadian firms regarding the emphasis to be placed on innovation reflect the particular circumstances prevailing in this country, and those circumstances include the attitudes toward growth and risk-taking of business people themselves.

Business strategy drives innovative behaviour – some companies have strategies based heavily on innovation and some do not. *Explaining business innovation performance in Canada therefore comes down to explaining the business strategy choices of Canadian firms*. Why, for example, is an innovation-focused strategy more common in the United States, Finland, Sweden, Switzerland, Germany, South Korea and Japan, than it is in Canada? Why, moreover, is an innovation-focused business strategy more common in Finland than in Norway, and more common in Japan and Korea than in Australia and New Zealand (Figure 4.1)?[27] Natural resource endowment, and other aspects of industry structure, would certainly appear to play a significant role; though, as Finland's example shows, a resource-based tradition can be shifted deliberately and rapidly to a knowledge-based focus (recall Box 8).

Little has been accomplished over the years simply by exhorting the business sector to spend more on R&D, commercialize more university research, invest more in ICT or simply be more "innovative". If the innovation performance of Canadian business is to be changed, then the factors that influence the choice of business strategy must change in ways that make increased emphasis on innovation a better business decision than sticking with the status quo.

27 Although Figure 4.1 uses R&D as a proxy for innovation-based business strategy, other broad indicators, as noted in Chapter 3, are consistent with the pattern of inter-country differences exhibited by R&D intensity.



Data Source: OECD, 2008g

Figure 4.1

Resource Leaders & Technology Leaders – BERD Intensity

Finland broke from the resource-intensive peer group after an economic crisis in the early 1990s. Similarly, Australian business has made a concerted attempt to sustain increasing BERD intensity since the late 1990s. On the other hand Canada's traditionally heavy focus on communications sector R&D has not found a replacement since the collapse of the technology bubble in 2001.

It follows that to understand why Canadian business as a whole has not invested more in innovation, one must shift the perspective of analysis from innovation activities themselves – e.g., inputs such as R&D and M&E investment – and focus instead on the factors that influence the choice of business strategy. Since the shortcomings in the innovation performance of Canadian business are of very long standing, the causes cannot be explained by transient factors such as the business cycle or the particular political stripe of successive governments, much less by the day-to-day economic news that is the staple of the media and pundits. Instead, the causes must derive from deep and persistent features of the Canadian economy.[28]

28 There is a large literature of long standing as to the causes of Canada's subpar innovation performance. McFetridge (2008) provides an excellent overview. The literature has not explicitly emphasized the central role played by the business strategy decision, which is the organizing focus of the analysis in this report.

FACTORS INFLUENCING THE CHOICE OF INNOVATION AS A BUSINESS STRATEGY

What are the factors that principally influence firms in Canada to choose, or not to choose, business strategies based around innovation? The influencing factors that are, in the panel's view, of greatest importance are depicted schematically in Figure 4.2. This figure emphasizes the central role played by the choice of business strategy and distinguishes between (i) those factors that influence the strategic choice, and (ii) particular activities like R&D and investment in advanced technologies that are consequences of the chosen strategy. The logic flow depicted in Figure 4.2 is thus a reframing of the analytical approach to understanding innovation – a shift from a focus on innovation activities to a focus on what determines a firm's choice to employ innovation as a business strategy. This will serve as the conceptual framework for analysis throughout the remainder of the report.

The decision as to the emphasis to be placed on innovation in a firm's strategy will be primarily influenced – to varying degrees depending on the circumstances of the individual firm – by the following:

- *Structural characteristics* – For example, is the firm in a sector of the economy that typically does little in-house innovation, relying instead on technology embodied in capital equipment and/or on production of relatively standard goods or services? Or is the firm foreign controlled with most innovation originating in the home country? In many cases, Canadian firms occupy "upstream" positions in North American industries, providing specified inputs to U.S.-based businesses that serve end-user markets. These conditions would tend to discourage a primarily innovation-based strategy in favour of greater focus on cost reduction and supplier reliability. Different structural conditions – for example, a vibrant ICT sector – would promote innovation, not only within the sector but also in ICT-using businesses.
- *Competitive intensity* – For example, is the pressure from competitors so intense that innovation is needed to maintain profitability and/or market share? This would be the case in many export markets, and particularly in those where technology, or customer requirements or tastes are changing. Alternatively, is the nature of the competition such that innovation would provide little or no competitive advantage – for example, if any one firm's attempt to break from the pack could quickly be copied by the other competitors, in which case is there the incentive to stay put? This may be the case in a technologically mature market with just a few well-established players, and is more likely to occur in domestic markets than in export markets.

- *Climate for new ventures* – For example, is sophisticated early-stage venture financing available? Are there research universities nearby to provide potential innovation partners and highly trained graduates? Is there an ecosystem of complementary skills and supplier firms to help carry an innovation from concept to success in the market?
- *Public policies* – For example, are government policies in respect of tax, regulations, intellectual property rules, targeted assistance programs, public procurement, and fiscal and monetary policies favourable to innovation, or not?
- *Business ambition* – For example, is the business dedicated to market expansion (either geographically or via new offerings) and prepared to take the required risks? Business ambition, in this context, reflects the extent of entrepreneurship and drive. Clearly, entrepreneurs are critically important agents of innovation because they are, by temperament, pioneers and builders. But even in large, bureaucratically organized companies, the board and management may be ambitious and expansionist, or cautious and perhaps complacent. A business strategy that emphasizes innovation is far more likely to be adopted by the former.

Once a firm has decided on an innovation strategy, it assembles the enabling inputs. These include the appropriate mix of highly qualified employees; investment in the necessary capital equipment and training; an R&D program if needed; and retention of consultants and various external suppliers, including licensing arrangements and partnerships with other firms.[29] While these inputs, and R&D spending in particular, can be regarded as indicators of innovation, they are more fundamentally the *consequences* of a commitment to innovation as a business strategy.

To the extent that Canadian business, on the whole, lags in respect of innovation, the reasons must lie primarily in some combination of the primarily influencing factors outlined above. Business ambition will always be a factor, even for businesses in well-established markets – for example, is the firm prepared to break out of its comfort zone and go for growth?

Certain of these factors will have more or less relevance depending on the market circumstances of the firm as illustrated, for example, in the sector case studies in Chapter 10. For would-be radical innovators in new markets, there is no choice

29 Statistics Canada has begun to develop a consistent body of statistics on business investment in "intangibles" that support innovation. Baldwin *et al.* (2009, forthcoming) show that in 2001 intangible investments totaled $144 billion including investments in (a) science (comprising R&D, purchased science and engineering, software and "own account other science"); (b) advertising; and (c) mineral exploration (predevelopment stage). Remarkably, this was about twice the business investment in M&E and four times the investment in buildings and structures. About 78% of the intangible investment was in "science" activity and two-thirds of the latter was investment in other than R&D.

but to make innovation the core of a firm's strategy. For these businesses, the most significant influencing factors will be the climate for new ventures – for example, the availability of smart financing and the presence of an ecosystem of innovation supports, including good marketing resources and access to the relevant advanced technologies and talent – and supportive public policies. The supply of entrepreneurship will also determine the number prepared to come forward with great ideas, or to invest in these ideas during their earliest and riskiest stages.

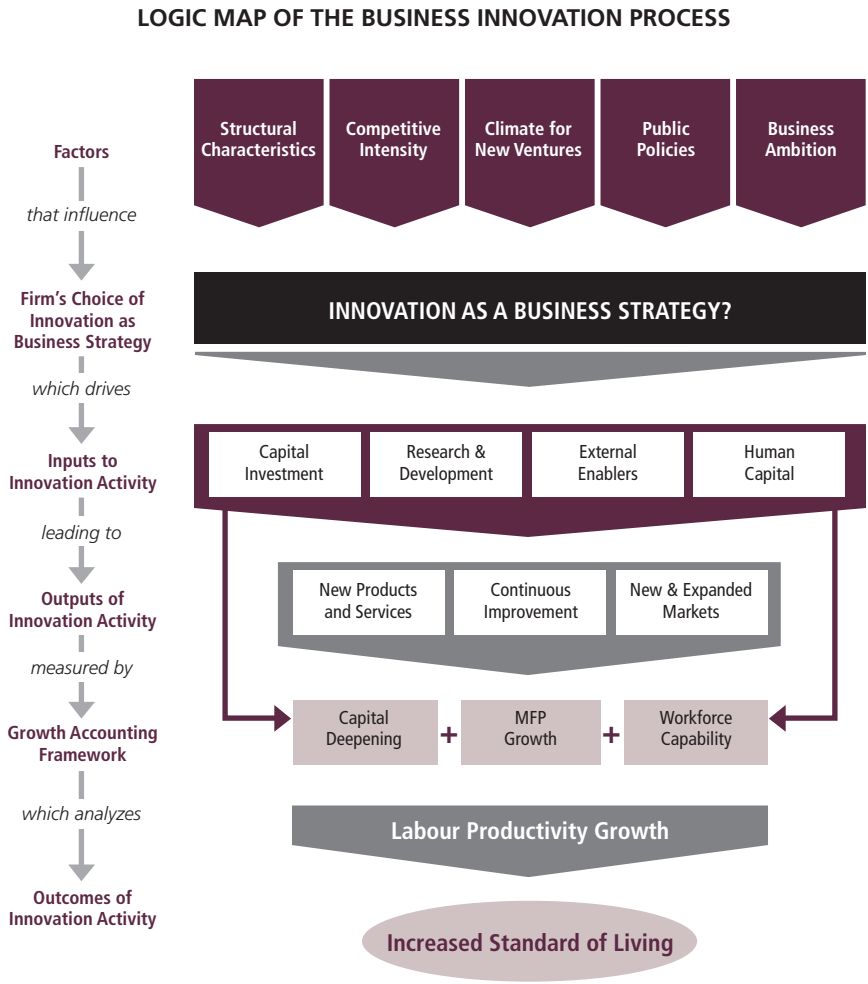


Figure 4.2
Logic Map of the Business Innovation Process

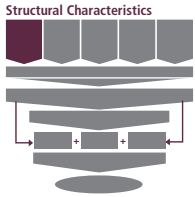
For firms in established markets, on the other hand, the innovation strategy choice is likely to be most influenced by the state of competition, by specific features of the public policy environment (e.g., tax-related), or by some industry characteristic such as the firm's sector or its domicile of control. The specific context can have a major influence on innovation strategy – e.g., whether the firm is a stand-alone innovator or part of a network where it must operate within the constraint of alliance (Box 2).

For policy makers, the concern is the extent to which the factors that influence innovation strategy can be affected by public policy. Clearly some will, for example, taxes, regulations, assistance programs, government procurement, foreign investment rules and certain aspects of competition. Since the state of competition can have an extremely important impact on the propensity to innovate in established markets, policies to facilitate competitive access to markets may be quite effective though, in some cases, the Canadian market will simply be too small to attract innovative competitors, or at least to attract them during the early stages of the roll-out of an innovation.

Policy will have much less impact, at least in the near to midterm, on factors such as industry structure and the inherent ambition of business leaders. The structural conditions in the Canadian economy – industry mix, foreign control and distribution of firm size – reflect a combination of comparative advantage and history, including past policies. While not immutable, these overall conditions change slowly and are taken as given by individual businesses, though not necessarily by policy makers with a view to the long run. Attitudinal factors are even tougher to address though business attitude can certainly be affected by competitive intensity, which is amenable to policy influence.

The final question in the charge to the panel asks: *What are the contributing factors [responsible for the weak business demand in Canada for innovation inputs], and what is the relative importance of these factors?* In the panel's view, the five factors identified in Figure 4.2 are the key factors that influence the decision as to the emphasis to be placed on innovation in a business's strategy. The next five chapters address each of these factors, the relative importance of which will vary from sector to sector (as illustrated in the examples in Chapter 10) and across the life cycle of individual businesses.

Chapter 5 – Structural Characteristics



This chapter focuses on the three principal structural characteristics that are thought to contribute to Canada's innovation input gaps – i.e., industry sector mix, foreign control and firm size. These features of the economy potentially have a strong influence on the choice of business strategy and represent significant differences between Canada and many of its peer group of economically advanced countries including, in particular, the United States.

Structural issues are most readily analyzed in the limited context of R&D spending because a long series of internationally comparable sectoral data is available from the OECD. The evidence described in Chapter 3 showed that several other innovation indicators correlate closely with business R&D spending intensity.[30] An investigation of the structural factors affecting R&D intensity could therefore be expected to apply roughly to many other national-level innovation indicators. The focus on R&D as an innovation indicator nevertheless limits the direct relevance of the analysis to a subset of the economy and to a particular type of innovation activity. On the other hand, the influence of sector mix (e.g., the relatively heavy weight of resource-based industries in Canada) and of foreign control is most pronounced in the subsets of the economy that perform at least some R&D. The analysis of the effect of sector mix and foreign control through the lens of R&D intensity is therefore appropriate as long as one bears in mind that R&D is only one indicator of innovation as a business strategy.

This chapter also considers very briefly the potential influence of structural characteristics on investment in M&E and ICT. This applies more generally than analysis of R&D since investment in advanced equipment, and particularly in ICT, are hallmarks of an innovation orientation in virtually any sector or type of firm.

The chapter concludes by introducing a less conventional structural perspective on the issue: the "upstream" position of many Canadian firms in integrated North American value chains and the implications for innovation-based strategies of limited interaction with end-user customers.

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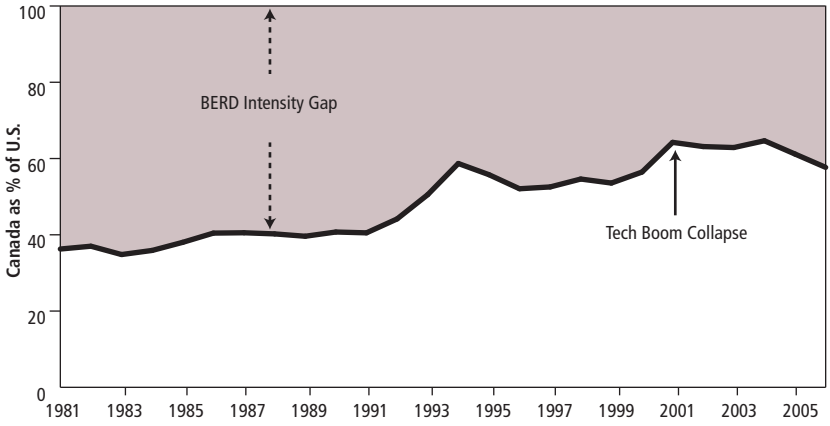
30 Jaumotte and Pain (2005a, p. 31) have presented a table that includes the correlation (based on rank ordering) between R&D intensity and several other innovation indicators across 20 OECD countries in 2001. The correlation coefficients relative to total R&D intensity were BERD (0.99), R&D employment share in total employment (0.94), scientists' share in total employment (0.85) and triadic patents (0.87). Canada ranked 14th out of 20 countries on a composite indicator based on an average of the foregoing components.

THE EFFECT OF SECTOR MIX ON R&D EXPENDITURE

To what extent do differences in industry sector mix account for the large gap between Canada and the United States in business expenditure on R&D as a percentage of GDP (BERD intensity)? A similar analysis could be undertaken to compare Canada with other high-intensity R&D spenders like Sweden, Finland, Switzerland and Japan, but comparison with the United States is most relevant in view of its close integration with the Canadian economy.

The R&D intensity gap between the United States and Canada has narrowed somewhat over time (Figure 5.1). In 1981, Canada's BERD intensity was only 36% of the U.S. level; by 1994 it had increased to 58%, and in 2001, at the height of the tech sector boom, Canada's BERD intensity peaked at about 63% of the U.S. level. Since then, the gap has returned to its 1994 level, as the downturn in the communications equipment sector (and particularly in Nortel's R&D expenditure) has had a relatively larger impact on Canada's ratio than on that of the United States.

EVOLUTION OF THE U.S.-CANADA GAP IN BERD INTENSITY
1981-2006



Data Source: OECD, 2008g

Figure 5.1
Evolution of the U.S.-Canada Gap in Business R&D (BERD) Intensity

Canada was closing the gap in BERD intensity (business R&D as a percentage of GDP) until the collapse of the technology boom. The sharp falloff in ICT R&D in Canada has caused the gap to widen again.

Part of the BERD intensity gap is due to the relatively large portion of Canada's economy that consists of industries that, by their nature, tend not to employ innovation strategies based on heavy investment in R&D. The primary resource sector, for example, does not perform much R&D in the United States or in Canada, though it is a large investor in M&E that embodies R&D performed by capital goods producers. To get a feel for the size of the industry mix effect, the overall BERD-to-GDP ratio can be expressed as the sum of sectoral BERD intensities weighted by each sector's share of GDP.[31] The U.S.-Canada BERD intensity gap can thus be expressed as a sum of individual sector gaps.[32] The more sectors that can be included in such an analysis the better, but the level of detail is limited in practice by availability of comparable sectoral data for the United States and Canada. The OECD has compiled an extensive database of business R&D expenditure and GDP (i.e., value added) that covers some 16 manufacturing subsectors and a more limited number of subsectors of the services industry (Table 5). These data are reasonably complete for Canada and the United States, covering 23 subsectors from 1987 through 2002. Some later data are available, but comparable U.S.-Canada coverage is incomplete. Nevertheless, 16 years of comparable data through 2002 are enough to tell the story.

Table 5 presents a sectoral decomposition of the U.S.-Canada BERD intensity gap in 2002.[33] A similar analysis has been undertaken by ab Iowerth (2005) using 1999 data. The last column in Table 5 shows that the gap in 2002 was about 1.03 percentage points — the difference between a U.S. intensity of 2.90% and a Canadian intensity of 1.87%. The manufacturing sector contributed 0.63 percentage points to the gap; business services added 0.46 percentage points; whereas mining, utilities and construction all *diminished* the gap by a total

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31 This can be seen as follows:

$$BI = BERD/GDP = \sum_{K=1}^{N} [(BERD_K/GDP_K) \times (GDP_K/GDP)] = \sum_{K=1}^{N} BI_K \times S_K$$

where BI is BERD intensity, $BERD_K$, BI_K and S_K refer to the Kth sector's BERD; BERD intensity; and share of GDP respectively and the summation ($\sum$) is taken over "N" sectors that cover the entire economy. The number of sectors will depend on how fine-grained one intends the analysis to be, always subject to availability of sectoral data.

32 The contribution of a particular sector to the overall U.S.-Canada BI gap is:

$$\text{Contribution to Gap} = BI_{US} \times S_{US} - BI_{Can} \times S_{Can}$$

where "BI" and "S" are the BERD intensities and shares in GDP of the given sector in the U.S. and Canada. Thus each sector gap arises from a mix of an "intensity effect" (BI) and a "structure effect" (S).

33 Table 5 is based on the business sectors of the two economies – excluding agriculture, hunting and fishing and "real estate services" (largely imputed rent in owner-occupied premises). Thus the BERD intensities, and sector shares, are larger than those cited elsewhere in this report, which are, in most cases, calculated relative to the GDP of the entire economy.

of 0.06 percentage points. (The weight of these sectors in the Canadian economy and/or their BERD intensity exceeded that of the United States.)[34]

Table 5

BERD Intensity Gap by Sector, U.S. and Canada, 2002

	SECTOR SHARE OF BUSINESS GDP (%)		BERD INTENSITY (%)		CONTRIBUTION TO BI GAP (U.S.-CANADA)
	CANADA	U.S.	CANADA	U.S.	Gap[2]
BUSINESS SECTOR[1]	100.0	100.0	1.87	2.90	1.034
MANUFACTURING	**27.0**	**21.9**	**4.16**	**8.03**	**0.634**
Motor vehicles and parts	3.4	1.7	1.88	13.41	0.166
Pharmaceuticals	0.5	1.0	27.17	21.16	0.066
Chemicals (excl. pharmaceuticals)	1.5	1.5	2.01	6.45	0.066
Office accounting and computing machinery	0.1	0.4	65.01	32.80	0.053
Machinery and equipment n.e.c.[3]	1.8	1.5	2.70	6.59	0.048
Food, beverages and tobacco	3.3	2.6	0.45	1.28	0.018
Aircraft and spacecraft	0.8	0.8	15.41	18.49	0.018
Rubber and plastics products	1.4	1.0	0.73	2.32	0.013
Other non-metallic mineral products	0.7	0.6	0.29	0.98	0.004
Electrical machinery & apparatus n.e.c	0.4	0.6	7.20	5.46	(0.001)
Pulp & paper, paper products printing and publishing	4.1	3.2	1.29	1.52	(0.004)
Textiles, leather and footwear	0.9	0.7	1.44	0.53	(0.010)
Fabricated metal products	2.0	1.6	1.61	1.24	(0.011)
Basic metals	1.6	0.6	2.04	1.14	(0.025)
Radio, TV & communication equipment	0.7	1.1	53.67	29.52	(0.054)
Other manufacturing[4]	3.8	3.0	1.88	11.80	0.288

34 The fact that a low R&D sector like mining and quarrying is shown in Table 5 as *reducing* the R&D intensity gap is counter-intuitive. Since a sector's contribution to the overall gap is the U.S.-Canada difference in "the sector's R&D intensity multiplied by the sector's share of GDP", a sufficiently large sector share (as Canada has in mining and quarrying) can reduce the Canada-U.S. gap even though the sector has low R&D intensity and in fact has slightly lower intensity in Canada than in the United States. The mix of structure and intensity in Table 5 requires careful interpretation.

Table 5 (continued)

	SECTOR SHARE OF BUSINESS GDP (%)		BERD INTENSITY (%)		CONTRIBUTION TO BI GAP (U.S.-CANADA)
BUSINESS SERVICES	**53.4**	**66.2**	**1.26**	**1.71**	**0.457**
Wholesale and retail trade	17.1	20.5	0.53	1.83	0.285
Other business services	19.0	28.9	2.85	2.49	0.181
Transport and storage	6.2	4.6	0.10	0.11	(0.001)
Financial intermediation	11.0	12.3	0.33	0.23	(0.007)
MINING & QUARRYING	**7.5**	**1.6**	**0.64**	**0.68**	**(0.037)**
UTILITIES	**4.0**	**3.2**	**0.46**	**0.06**	**(0.016)**
CONSTRUCTION	**8.1**	**7.2**	**0.08**	**0.03**	**(0.004)**

Data Source: Panel's calculation based on OECD STAN database

1 Excludes agriculture, primary forestry and fishing and real estate services (largely the imputed value of owner-occupied housing). The OECD definition of Business GDP ($715 billion in 2002) differs from the Statistics Canada breakout for that sector ($873 billion in 2002), which the panel believes to be largely due to real estate services.

2 The contribution to the gap is calculated as: "Sector share of BERD intensity times sector share of GDP" for the United States, minus the analogous product for Canada. For example, for manufacturing the contribution is: (8.03 x .219)-(4.16 x .27)=0.634. Negative contributions to the BI gap – i.e., those numbers in parentheses in the final column of the table – are associated with sectors where the ratio of Canada's BERD to total GDP exceeds that of the United States – i.e., sectors that reduce the gap.

3 n.e.c. = not elsewhere classified.

4 An omnibus group of subsectors (including precision instruments among others) that is not further broken down in the OECD database.

Manufacturing

Within manufacturing, the auto industry (vehicles and parts) was the largest contributor to the gap. It was responsible for 0.17 percentage points, or more than a quarter of the manufacturing gap. The BERD intensity of the U.S auto industry in 2002 was 13.4%, more than seven times the Canadian intensity of 1.9%. This reflects the overwhelming concentration of R&D activity in parent companies based primarily in the United States and Japan. The chemicals industry, M&E, and "other" manufacturing (for which a detailed sectoral breakdown is not available in the OECD database) contributed a further 0.40 points to the gap, owing to the much higher U.S. BERD intensity in these sectors. This also likely reflects the extent of foreign control, leading in these particular sectors – certainly the case for chemicals – to small R&D mandates for the Canadian subsidiaries.[35]

It must be emphasized that foreign control does not necessarily imply a lower BERD intensity in Canada than in the United States. For example, Canada's R&D intensity in the pharmaceutical and computing machinery sectors, despite extensive foreign control, exceeded U.S. intensity in 2002. But since both of these sectors had a much larger weight in the U.S. economy than in Canada, they contributed a further 0.12 percentage points to the overall U.S.-Canada gap.

A rough pattern, apparent in Table 5, is that Canada tends to have a relatively low R&D intensity in those manufacturing sectors where it has a relatively large presence (e.g., autos, M&E, and "other" manufacturing) and, conversely, a relatively small presence in sectors where it has a high R&D intensity (e.g., pharmaceuticals, computing machinery, electrical machinery and communications equipment) though aerospace is an important exception. This is the interaction of "structure" with "intensity" that accounts for the BERD gap. The 11 sectors in Table 5 that *reduce* the overall gap tend to be those that are either resource based or highly mature – e.g., pulp and paper, basic metals, fabricated metal products, textiles and footwear, and mining and quarrying. Canada has both higher R&D intensity and greater weight in the economy for most of these sectors than is the case in the United States; however, they are neither particularly dynamic nor innovative growth sectors.[36]

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35 A study of individual establishments would be needed to identify the R&D performed in Canadian and foreign-owned facilities and thus to estimate the precise extent to which relatively low Canadian R&D intensity was due to the majority of R&D being performed in the parent country. Such a detailed study is beyond the scope of the panel's work.

36 These sectors may nevertheless employ sophisticated technology acquired by investment in (usually imported) machinery and equipment. The clothing sector, for example, has used advanced technology to remain internationally competitive in certain niches.

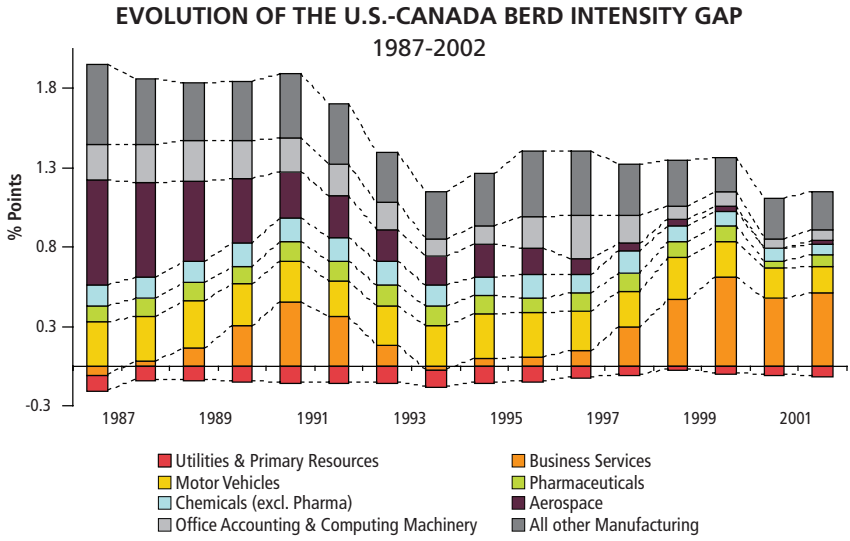
Services

Many of the most dynamic subsectors in today's economy are in business services, which in 2002 constituted a much heavier weight in U.S. business GDP (66%) than in Canada (53%). This, combined with a higher BERD intensity in services in the United States (1.71%) than in Canada (1.26%), added 0.46 percentage points to the U.S.-Canada gap overall in 2002. The major subsectoral contributor was "wholesale and retail trade" where U.S. BERD intensity was more than three times the Canadian ratio, and that sector's contribution (0.29 points) to the overall U.S.-Canada gap was almost twice that of the auto industry. Perhaps surprisingly, the financial intermediation sector slightly favoured Canada in 2002, though data in this, and several other components of business services, appear to be far less reliable than data for manufacturing subsectors. (See the case study on banking in Chapter 10.)

Evolution of the R&D Gap

Table 5, based on 2002 data, is a snapshot in time. Figure 5.2 traces the evolution of the sectoral U.S.-Canada BERD intensity gap over 16 years from 1987 through 2002. The total gap diminished from about 1.7 percentage points in the 1988-91 period to about 1 percentage point in 2001-02, though it has increased somewhat since then (recall Figure 5.1). The most significant drivers of the trend have been (i) the sharp reduction in the manufacturing sector's contribution to the gap, and (ii) the increasing share of the gap accounted for by business services since the mid-1990s. The broad shift of output and employment toward services has been occurring more rapidly in the United States than in Canada, and the location of innovative dynamism in the U.S. economy is increasingly to be found in the service sector. The strong investment trend in ICT described in Chapter 3 is consistent with such a shift. Based on data available to date, Canadian business has been lagging the trend significantly. Further evidence in this regard is provided by Baldwin *et al.* (2008) who estimate that the majority of the difference in MFP *levels* between the U.S. and Canada in 1999 was due to the MFP gap in business services.

The detailed sectoral data underlying the trend in Figure 5.2 are compiled in Annex III and constitute a remarkable portrait of the sector dynamics of R&D intensity and output shares in the United States and Canada over a 16-year period. Of particular note is the virtual disappearance of the R&D gap in aerospace, which in fact represents by far the biggest contribution to the reduction of the overall gap. This has not been due to strong Canadian R&D growth, but rather to the decline of the aerospace share of U.S. output and its reduced R&D intensity after 1991, reflecting in part the end of the Cold War and the competition for global market share with Airbus.



Data Source: Panel calculations based on OECD's STAN database

Figure 5.2

Evolution of the U.S.-Canada BERD Intensity Gap

This chart traces the evolution of the most important sectoral components of the R&D intensity gap. The narrowing of the manufacturing gap (at least through 2002) has been due entirely to the disappearance of the gap in the aerospace sector as the U.S. industry downsized after the Cold War and due to commercial competition from Airbus. The business services gap has meanwhile widened since the mid-1990s. Much more work is needed to improve data on subsectors of business services.

Unfortunately, data for subcomponents of the service sector are limited, particularly for the United States prior to the mid-1990s.[37] The trend is nevertheless clear – service sector R&D intensity in the United States has been increasing strongly, especially in the large wholesale and retail trade sector that accounts for one-fifth of U.S. business GDP and where the pace of innovation in logistics, supply-chain management and "big box" retailing has been feverish. There is evidently a need for much more extensive work to develop productivity and innovation statistics for subgroups of services. The distinction between manufacturing and services has moreover become increasingly outdated as much of the value added in sophisticated products is now being contributed by a bundle of technical and professional services – e.g., design, process and software engineering, marketing, finance and legal services.

37 Care must be taken in interpreting these data because of classification issues. In the United States, for example, Dell is treated as a wholesaler and this inflates the R&D figures for the sector, while in Canada, some companies often regarded as pharmaceutical firms and technical equipment producers are included in the trade classification because they engage in selling.

In fact, even the robots that have become ubiquitous in many manufacturing plants are largely the embodiment of R&D and engineering design "services".[38]

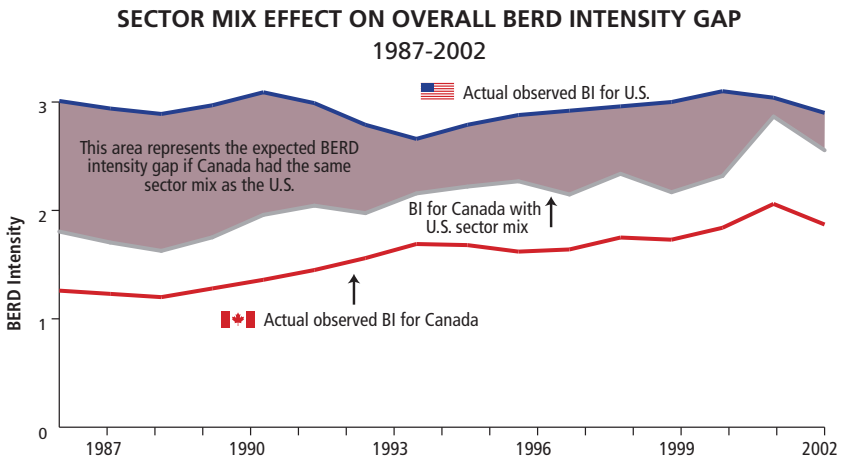
Mix versus Intensity

The sectoral decomposition of the U.S.-Canada BERD intensity gap (Table 5 and Figure 5.2) begs two further questions: precisely what portion of the gap is due to sectoral composition differences, and what portion is due to lower R&D intensities in individual sectors in Canada as compared with U.S. intensities in the same sectors? Figure 5.3 shows (in the dark shaded area) what the overall R&D gap would have been if Canada's economy were to have had the same sectoral composition (i.e., same sector shares of GDP) as the U.S. economy, while Canadian sectoral R&D intensities remained as they were. Figure 5.4 shows, conversely, what the overall gap would have been if Canada were to have had the same sectoral BERD intensities as the United States while sectoral composition remained as it was. The pattern in Figures 5.3 and 5.4 roughly support an intuition that lower R&D intensities in individual sectors in Canada have been more responsible than sectoral composition for the U.S.-Canada gap in overall BERD intensity. While Figure 5.3 shows that adjusting for sector mix does narrow the gap (substantially in 2001 and 2002), Figure 5.4 shows that if Canadian firms acted like those in the United States – that is, had the same R&D intensity in each sector as the United States – the gap would largely be eliminated even with no sectoral shifts.

Thus, low R&D intensity within Canadian sectors is more important than an adverse sector mix in accounting for the overall BERD intensity gap between the United States and Canada. The precise quantitative results are sensitive to the granularity of the sectoral breakdown and to the choice of decomposition methodology.[39]

38 There is a new concept in international trade called manufacturing services. For example, if a Canadian company ships components to China for assembly, it is exporting goods, but the return of the finished product is treated as an import of a manufacturing service – i.e., the assembly process. This will make it difficult to study differences between manufacturing and services when Canadian companies are outsourcing parts of their manufacturing chain to other countries. In short, issues arising from data interpretation and comparability over time and cross-nationally require continued research and international co-operation to ensure harmonization of concepts in data collection.

39 A more sophisticated decomposition would apportion a sector mix effect and an intensity effect so that the two added precisely to equal the overall gap. (This involves equally apportioning the cross-effect of sector and intensity combined.) Other decompositions are also possible, but all are sensitive to the fineness of sectoral breakdown and to the method of decomposition.

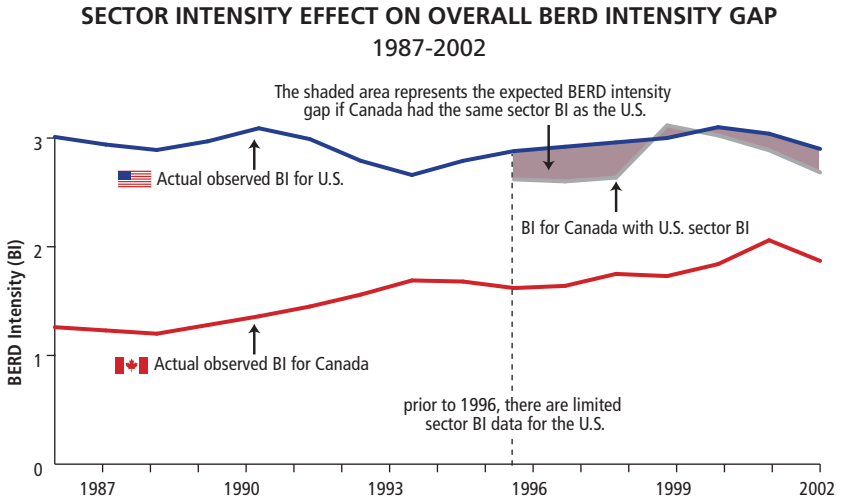


Data Source: Panel calculations based on OECD's STAN database

Figure 5.3

Sector Mix Effect on Overall BERD Intensity Gap

Is the R&D gap due primarily to Canada's industry mix – i.e., a specialization in sectors that are not heavy R&D spenders in any country? If the U.S. sector mix is applied to Canada's BERD intensity in each sector, the gap shrinks (shaded area). Under this scenario the near closure in 2001 reflects the heavy U.S. weight in ICT applied to Canada's very high BERD intensity in telecom equipment at that time.



Data Source: Panel calculations based on OECD's STAN database

Figure 5.4

Sector Intensity Effect on Overall BERD Intensity Gap

This chart, which is the converse of Figure 5.3, shows the effect of applying U.S. BERD intensities, sector by sector, to Canada's sector mix. The shaded area is the resulting simulated gap. The reduction in the gap is generally greater than in Figure 5.3, which suggests that the actual R&D gap is due more to lower sectoral R&D spending in Canada than to Canada's adverse sector mix.

It is therefore not particularly meaningful to ascribe a specific percentage of the BERD intensity gap to either sector mix or to intensity. Moreover, any such allocation would vary somewhat from year to year.[40]

The sector mix analysis of R&D spending in the United States and Canada, when combined with the charts in Annex III, effectively shows "where" the differences lie, but the numbers themselves do not explain "why" large BERD intensity differences between the two countries often exist within the same sectors. It remains to examine other possible structural factors, specifically foreign control and the distribution of firm size.

THE EFFECT OF FOREIGN CONTROL ON R&D EXPENDITURE

The foreign control of Canadian industry is often cited as an explanation for Canada's low R&D spending in view of the fact that Canada has a disproportionate share, relative to most OECD countries, of facilities that are subsidiaries of foreign companies. Cross-country comparisons of R&D intensity confirm that the R&D intensity of domestically-controlled firms substantially exceeds, on average, that of foreign-controlled firms in most countries (Figure 5.5). This is because the majority of R&D is managed out of the corporate headquarters.[41] Canadian facilities nevertheless benefit from parent company R&D embodied in advanced equipment and business processes. Moreover, foreign-controlled firms are substantial contributors to R&D in Canada, accounting for about one-third of the total (Figure 5.6).

The R&D strategies of foreign-controlled firms in Canada vary from sector to sector. For example, while there is some R&D spending by foreign auto firms in Canada, and there has been growth over time, the vast majority of automotive R&D takes place in the United States and Japan. The chemicals industry (Figure 5.7) is similar. Much of the Canadian industry consists of manufacturing plants supplying basic chemicals as inputs to final products, with R&D spending taking place at the corporate headquarters, usually in the United States. The pharmaceuticals industry presents a very different story as described more fully in the case study in Chapter 10.

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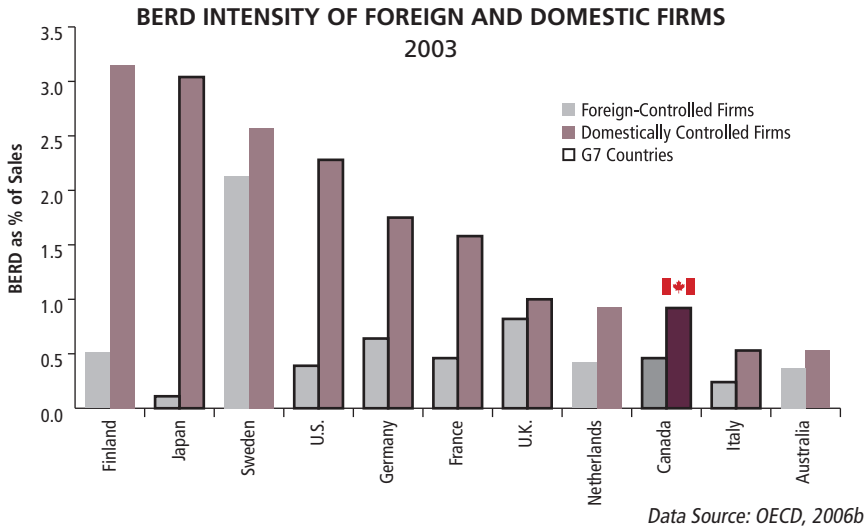
40 The near closing of the R&D gap in 2001 when the U.S. sector mix is used (Figure 5.3) reflects the large U.S. share in ICT sectors weighted by the extremely high Canadian BERD intensity in those sectors at the peak of the technology boom. This shows how short-run phenomena can strongly affect the estimate of the "mix versus intensity" contribution.

41 This traditional behaviour is changing as multinationals seek the best locations worldwide to perform R&D. China and India have become particularly attractive in terms of both cost and talent. There is also a trend to undertake more R&D in large markets so as to better adapt products to local tastes and conditions.

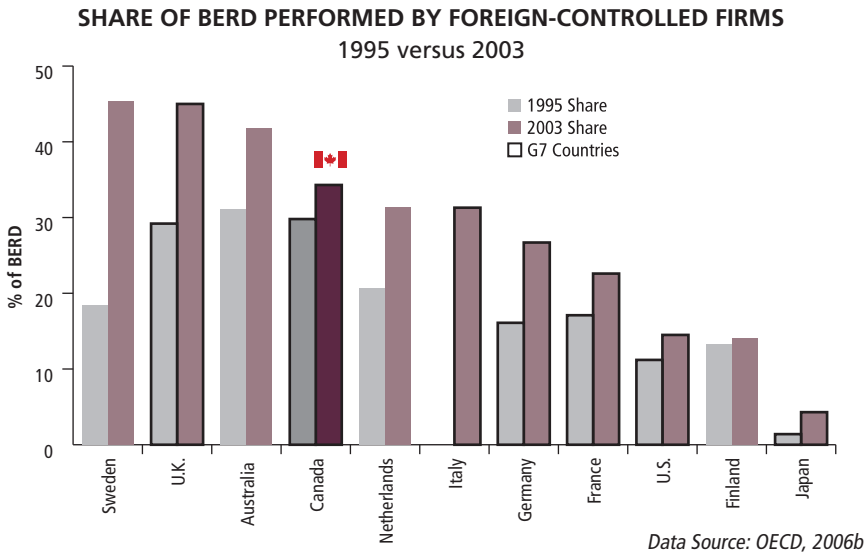


Data Source: OECD, 2006b

Figure 5.5

BERD Intensity of Foreign and Domestic Firms

Here R&D intensity is defined relative to sales volume, rather than to the more usual denominator of value added. The effect is to yield lower intensity ratios. Domestic R&D performers in advanced countries invariably have higher R&D-to-sales ratios (on average) than foreign-controlled R&D performers.



Data Source: OECD, 2006b

Figure 5.6

Share of BERD Performed by Foreign-Controlled Firms

Between 1995 and 2003 the share of business R&D performed by foreign firms increased in every country, consistent with an overall trend to diversify R&D from the home country. In some cases, this could also reflect the foreign takeover of a major domestic R&D performer.

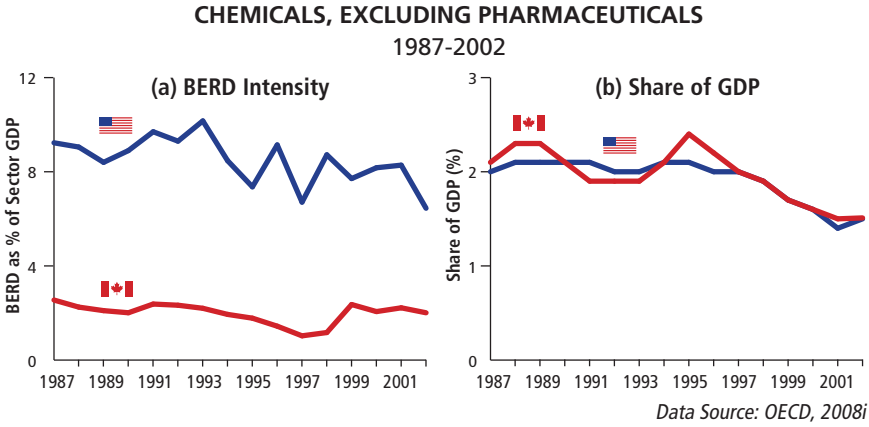


Figure 5.7

Chemicals, excluding Pharmaceuticals

Industrial chemicals has a similar weight in the two economies, but BERD intensity is far greater in the U.S. where most R&D is concentrated near headquarters.

Large, foreign-owned pharmaceutical firms generate relatively high R&D spending in Canada with the effect that the BERD intensity of the Canadian industry actually exceeded that of the United States between 1997 and 2002 (Figure 5.8(a)). However, this investment in R&D has not been reflected in the growth of the overall industry. The share of pharmaceutical output in the Canadian economy has remained essentially flat since the early 1990s, though with some rebound from the trough in 1998 (Figure 5.8(b)).

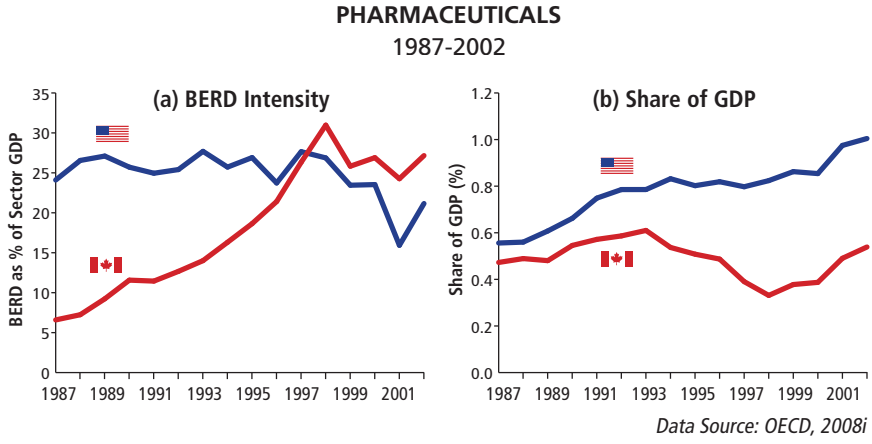


Figure 5.8

Pharmaceuticals

The R&D intensity of the pharma industry in Canada actually exceeded that of the U.S. after the late 1990s – the result of industry undertakings in the context of tightening Canadian patent laws. But the size of the sector in Canada did not grow and in 2002 was much smaller relative to the U.S. than it had been in 1987.

The service sector presents an unusual pattern – one where Canadian-based, foreign-controlled firms, on average, have *higher* R&D intensity than Canadian-controlled firms. At least through 1999, the gap was widening (Figure 5.9). This trend would be consistent with the greater dynamism of U.S.-owned business services firms as noted earlier and is a case where foreign control actually appears to have *reduced* the R&D intensity gap between the United States and Canada. Nevertheless, it will be recalled from Table 5 and Figure 5.2 that both the relative size and BERD intensity of the U.S. (business) services sector considerably exceed the comparable metrics in Canada. The sector as a whole therefore contributed to the overall R&D gap, but the cause is not related to foreign control. More up-to-date and disaggregated data for the service sector are needed to understand the microeconomic sources of the gap.

It is important to emphasize that there is no invariable link between the amount of R&D spending in a particular industry by foreign firms in Canada and that industry's growth and productivity in this country. Consider again the case of the automotive sector, which has provided many opportunities for innovation in process efficiency and workplace practices that are not reflected in R&D spending. Both the automotive and chemicals sectors show how the purchase of embedded R&D (in manufacturing equipment, intellectual property and technology), as well as advanced business practices conveyed from the parent company, can enable substantial employment, productivity and output benefits to accrue in Canada.

A comparison of the automotive and pharmaceutical sectors provides a revealing contrast of the domestic economic impact of government policies on R&D spending by foreign firms. The negotiation of the Canada-U.S. Auto Pact in 1965 focused on offering tariff-free market access in exchange for guarantees of manufacturing jobs and Canadian content. While concerns about R&D spending had been identified even before the Auto Pact was negotiated, the agreement nevertheless did not address the issue (Bladen, 1961; Acheson, 1989). With pharmaceuticals, the trade-off was quite different. In recognition of changes in Canada's patent legislation, the industry committed to spend 10% of sales on R&D (see Chapter 10). In both cases, the Canadian government traded market access for a specific commitment from a foreign-owned industry operating in Canada, and in both cases the industry delivered what was promised. However, the impact on R&D intensity, and on jobs in Canada, has been entirely different in the two situations. In the case of pharmaceuticals, the R&D ratios have been impressive but the scale of the industry in Canada in terms of jobs and income has been much less so (recall Figure 5.8). The opposite has been the case for the auto industry.

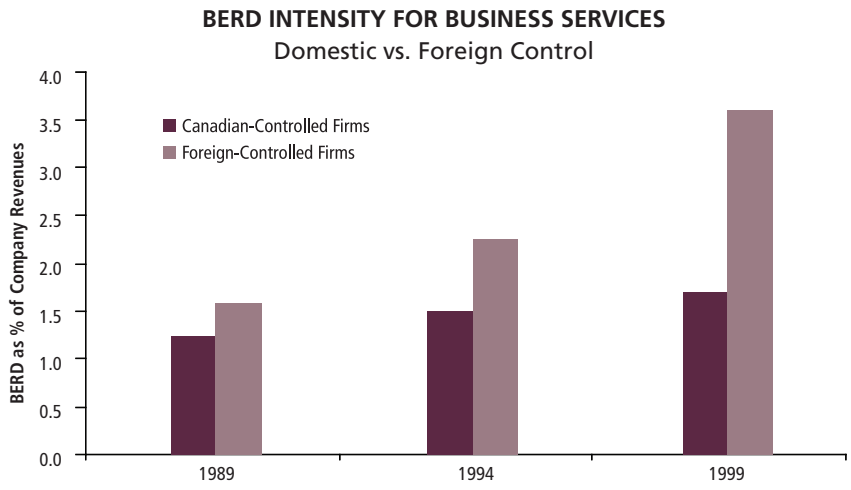


Figure 5.9

BERD Intensity for Business Services

The pattern of BERD intensity in business services as a whole is unusual – foreign-controlled firms in Canada have higher R&D ratios than domestic firms and the gap was growing at least through 1999. This is consistent with the greater innovative dynamism of U.S. firms in some service subsectors, especially in wholesale and retail trade.

While foreign control is part of the *explanation* for low R&D intensity in Canada, it is not necessarily the *cause* in the sense that were the foreign-controlled facilities not here, there is no guarantee that Canada would have had a "replacement set" of domestically owned R&D performers (McFetridge, 2005). In the motor vehicle industry, for example, it is far more likely that the alternative to the *status quo* would not have been a domestically owned assembly industry, with associated heavy R&D investment, but rather a situation where both assembly and R&D took place outside Canada and all vehicles were simply imported.

A number of studies have used both R&D data and innovation surveys to understand how foreign-controlled firms behave in Canada (Tang & Rao, 2001; Baldwin & Hanel, 2003; Baldwin & Gu, 2004; McFetridge, 2005). Macro-level assessments of the behaviour of foreign firms can be distorted by two factors: (i) multinational firms with Canadian subsidiaries tend to be large, and size, as discussed below, correlates positively with R&D spending; and (ii) many foreign subsidiaries operate in R&D-intensive industries such as ICT, chemicals, aerospace and pharmaceuticals. This is another form of structural effect – i.e., foreign subsidiaries operating in Canada can have lower R&D intensity than their Canadian counterparts, yet because their intensities are still well above average for the economy as a whole, their

presence actually improves Canada's overall BERD intensity. Analyses of individual firms, based on R&D spending data and innovation surveys, reveal a common pattern and produce a three-tiered structure of R&D and innovation behaviour in Canada (Baldwin & Gu, 2005; Criscuolo *et al.*, 2005).

- Canadian-owned multinationals are the most likely to engage in product innovation and R&D spending.
- Canadian subsidiaries of foreign multinationals are second, with generally lower R&D intensity than Canadian-owned multinationals, but higher than purely domestic Canadian firms.
- Canadian firms with only domestic operations have both the lowest incidence of R&D spending and the lowest BERD intensity.

The conclusion is that foreign control does have a significant negative influence on Canada's BERD intensity because integrated North American value chains in industries such as automotive and chemical manufacturing are dominated by foreign firms that conduct relatively little R&D in Canada. It is nevertheless the case that Canada is quite strong in process-focused aspects of innovation in those sectors. Moreover, it cannot be concluded that were it not for the foreign control of these firms, Canada's BERD intensity would be greater. This underlines the fact that *Canada's failure to develop a greater number of innovative Canadian-based multinationals has been a key contributor to the country's overall R&D weakness.*

THE EFFECT OF FIRM SIZE ON R&D EXPENDITURE

Smaller firms, on the whole, are less likely to invest in R&D than large firms (Cohen & Klepper, 1996a, 1996b). It might follow that Canada's comparatively small average firm size (Table 6), and higher proportion of very small firms (those with fewer than 20 employees), would explain some of the BERD intensity gap relative to the United States.

Boothby *et al.* (2008) have summarized the available Canadian and U.S. data on R&D behaviour as a function of firm size. The overall conclusion is that Canada's greater proportion of small firms does *not* explain a meaningful proportion of the BERD intensity gap. To the extent there is a size effect, it is within the category of largest firms – those with 500 or more employees – where the proportion of R&D performers is relatively high and where Canada's share of such firms is relatively low. The analysis is based on (i) R&D incidence, or the proportion of firms in various size classes that engage in R&D – Figure 5.10; and (ii) the R&D intensity of those that do – Figure 5.11.

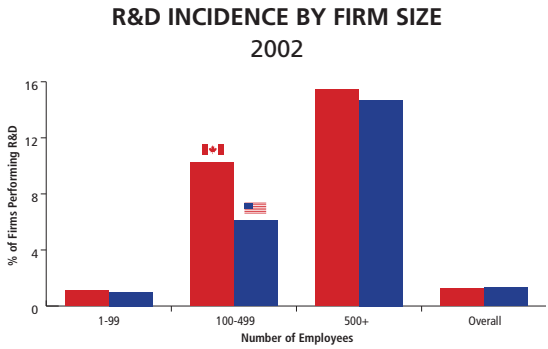
Table 6

Firm Size Distribution – Canada and United States, 2002

	CANADA		U.S.	
EMPLOYEES PER FIRM	AVG. EMPLOYEES	% OF FIRMS	AVG. EMPLOYEES	% OF FIRMS
1-19	3	92.0	4	89.3
20-99	40	6.6	39	8.9
100-499	191	1.1	193	1.4
500+	2,398	0.2	3,326	0.3
Average Overall	13	100.0	20	100.0

Source: Boothby et al., 2008

The data in Figure 5.10 demonstrate a strong correlation between firm size and the likelihood of performing R&D. Only about 1% of firms with fewer than 100 employees engage in R&D, compared to about 15% of those with 500 or more employees. The proportion of R&D-performing firms in each size category is comparable in the United States and Canada, and those in the 100-499 employee group in Canada, are in fact more likely to invest in R&D. This may be a byproduct of the value of the Scientific Research and Experimental Development tax credit, which encourages firms to report any spending that could be classified as R&D (see Box 17 in Chapter 8).



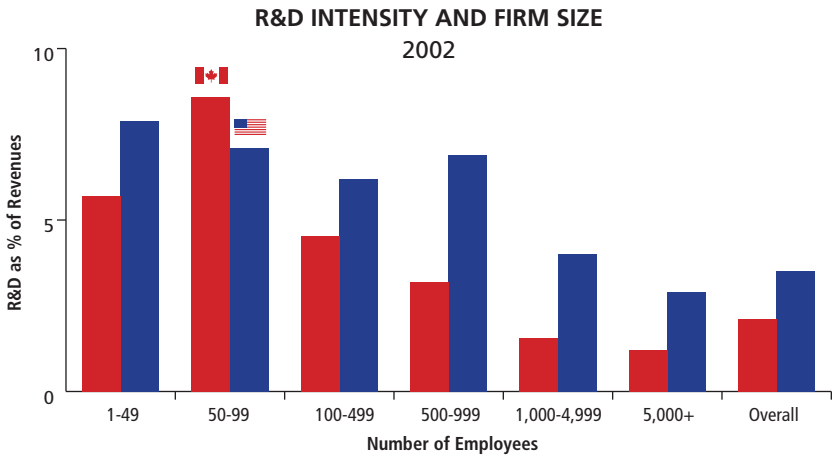
Data Sources: Statistics Canada, 2005; NSF, 2006; U.S. SBA, 2006

Figure 5.10

R&D Incidence by Firm Size

This figure shows, for Canada and the U.S., the percentage of firms within three size classes that perform at least some R&D. That percentage is very low for firms with under 100 employees, and increases the larger the company. The overall likelihood that a firm – small, medium or large – will perform some R&D is about the same in Canada and the U.S.

R&D *intensity* is less intuitive. Smaller firms that do perform R&D actually have higher BERD intensity on average than larger firms (Figure 5.11). These businesses are almost always early-stage innovation-focused firms that must spend a disproportionate amount on R&D relative to their typically meagre sales revenue. They are aiming to grow into large firms. There is a systematic R&D intensity difference between Canadian and U.S. firms within the same size class. With the exception of firms with 50 to 99 employees, U.S. R&D performers have a significantly higher intensity than Canadian R&D performers throughout the size spectrum. This gap is most significant for the largest firms, those with 500 or more employees.



Data Sources: Statistics Canada, 2005; NSF, 2006; U.S. SBA, 2006

Figure 5.11
R&D Intensity and Firm Size

Among firms that perform R&D, the intensity is almost uniformly greater in the U.S. across all size categories except in firms of 50 to 100 employees. The biggest difference is in firms with more than 500 employees; the effect of firm size on the U.S.-Canada R&D gap is at the large end, not the small.

When these results are put together, the conclusion is that small to medium-size Canadian firms appear to perform R&D about as intensively as their U.S. counterparts. Canada's higher proportion of small firms (fewer than 20 employees) cannot, however, explain more than a very small part of the overall R&D intensity gap since the great bulk of R&D is performed in companies with 20 or more employees. In fact, the R&D intensity gap is concentrated in the set of largest firms in both countries.[42] This means that size is a factor in accounting for the gap,

42 In 2005, U.S. firms with 500 or more employees accounted for about 82% of total R&D expenditure in that country, while Canadian firms in that size category generated only about 57% (NSF, 2007b; Statistics Canada, 2008c).

just not in the manner generally supposed. The most that can be said is that to the extent that firm size matters, it is manifested in the R&D behaviour of very large firms where, in Canada's case, foreign control also plays a role – i.e., many of the large firms in Canada in the more R&D-intensive sectors are foreign controlled, and there is generally, but not always, a bias in such cases to perform most R&D outside Canada.

The foregoing analysis of the impact on R&D of sector mix, foreign control and firm size shows that these three contributing factors are interrelated in complex ways that vary from sector to sector. Attempts to account for the U.S.-Canada R&D gap by analyzing the effect of only a single factor at a time therefore miss much of what is really going on.

EFFECT OF STRUCTURAL FACTORS ON INVESTMENT IN M&E

To what extent might industry sector mix, foreign control or firm size contribute to the U.S.-Canada gap in M&E investment (recall Figure 3.13)? Rao *et al.* (2008) and Fisher and Rodriguez (2006) have concluded, on the basis of econometric analysis, that sector mix explains *none* of the overall M&E gap. In fact, Canada's sectoral composition actually favours higher M&E intensity. With respect to the large gap in ICT investment, Sharpe (2005) found, as described in Chapter 3, that sectoral composition and firm size together could account for only about one-fifth of the difference. Foreign control probably has some effect because subsidiaries in Canada are able to use headquarters-based ICT assets for certain purposes but the implications for the U.S.-Canada investment gap have not been evaluated quantitatively.

THE POSITION OF CANADIAN FIRMS IN NORTH AMERICAN VALUE CHAINS

This chapter has focused on the structural characteristics that are most generally cited in accounting for Canada's lagging innovation performance – sector mix, foreign control and distribution of firm size. A less conventional structural perspective is based on (i) the position of many Canadian firms in integrated North American value chains; and (ii) the implications for interaction of Canadian firms with end-user customers, in view of the stimulus for innovation that frequently results from such interaction.

Canadian firms, reflecting the nation's traditional areas of specialization, have often chosen, or been relegated to, an *upstream* position as providers of commodities or other intermediate goods in many North American value chains, with most

product innovation taking place elsewhere.[43] In some sectors – automobiles and chemicals, for example – foreign ownership may be the proximate reason, but a commodity orientation appears to be a characteristic that cuts across many sectors and includes a great many Canadian-owned firms. For example, the relative lack of upgrading of natural resources by Canadian producers has often been ascribed to a "commodity mentality" on the part of Canadian business. The virtual absence of Canadian firms in global consumer products is also evidence of the country's specialization in primary and intermediate goods (this is discussed further in Chapter 9).

Successful innovation, especially in respect of goods and services, is most likely to come from businesses that have direct contact with end-users and, as a result, develop a deep understanding of what those ultimate customers need or want. (Recall Philips mission statement in Box 5.) While every business has customers, not every business has end-users as customers. The many Canadian firms and industries that occupy upstream positions in integrated North American value chains do not have a day-to-day interface with the ultimate market of end-users, and instead supply the companies that do. It is also the case that firms at the upstream end of the value chain are often removed from the leading edge of business decision making regarding innovation, especially in respect of product development, marketing and new business models.

In many export-oriented sectors, Canada's commodity or intermediate goods specialization has made cost efficiency and dependability a more important focus of competitive strategy than innovation, *per se*. While this may be very profitable, a failure to emphasize innovation can leave a business vulnerable to new competitors or to innovative substitute products that may be just as dependable but more attractive for any number of reasons.

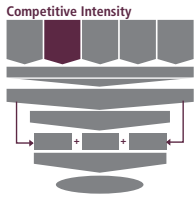
It has been noted – for example, by Barber and Crelinsten (2005) – that Canadian businesses on the whole, but always with many exceptions, appear to be less customer focused than those in the United States. This difference in attitude would be expected if the reference is to the end-user customer and the Canadian business is an intermediate supplier, and particularly if it is a supplier of commodities or a foreign-controlled branch producer for export, often to the United States. Since Canada's economy is relatively heavily weighted toward such upstream industries, the (end-user) customer focus would be relatively less pronounced in Canada than is typical in the United States, for example. The motivation to adopt innovation-oriented business strategies would, as a result, also be relatively less pronounced in Canada.

43 A value chain is the sequence of activities and inter-firm relationships involved in the production and marketing of particular goods and services.

The implications for Canada looking forward are challenging. Reviewing changes in global competitiveness from 1990 to 2008, Macher and Mowery (2008) have emphasized the rise of new regions – particularly, China, India, Taiwan and South Korea – first in manufacturing, but then in innovation and, possibly more importantly, as consumers: "Consumer markets for wireless and digital devices in countries such a South Korea, for example, are growing more rapidly than are similar markets in the United States. Equally important is the fact that many consumers in these markets (including firms producing advanced electronic-systems products) demand more advanced applications than is true of consumers elsewhere in the global economy" (p. 11). Bhidé (2006) has made a similar argument that the U.S. market has excelled in supporting vibrant innovation because of the "venturesome" nature of its consumers. As the leading edge of customer adoption and performance demand in more and more sectors shift towards Asia, so too will the leading edge of product innovation.

These trends are troubling for Canada. As a small market, Canada does not naturally attract early deployments of new technologies or new products. However, as markets globalize and increasingly innovation is being driven by the interaction between global leaders – that is, between firms leading technology development and customers leading technology adoption – any country whose businesses and citizens do not participate at the leading edge risks falling farther behind.

Chapter 6 – The Role of Competition



Competition is among the most potent incentives for innovation, both because of the benefits innovation can provide in terms of greater market success and the threats that can be averted if innovation keeps a firm running ahead of its competitors. The state of competition in a firm's market will thus often be the deciding influence on its choice as to whether or not to employ innovation as a core strategy. This chapter examines the dynamic interplay between competition and innovation in general, and then specifically in the Canadian market, noting that Canada's relatively small domestic market provides weaker incentives for business innovation than is typically the case in large markets like the United States.

EVOLVING THEORIES OF COMPETITION AND INNOVATION

The influence of competition on firms' propensity to innovate was analyzed initially in the context of firm size and the extent of market power possessed by the potential innovator. Joseph Schumpeter (1942) argued that large firms with market power were more likely to innovate than small firms. He believed that large firms could better tolerate the risk of innovation, and that market power would increase the likelihood that the rewards from innovation activities could be fully captured. Thus Schumpeter concluded that a market consisting of a small number of large firms with market power was likely to generate the most innovation. Evidence of this effect is to be found in the extraordinary amount of product innovation that came out of companies like AT&T (Bell Labs), IBM, General Electric, Boeing, Xerox and others in the heyday of the giant in-house company labs. These gave rise to such radical innovations as the transistor, the laser, the 747 aircraft, the mainframe computer and the personal computer, among several mega-inventions that have changed the world.[44]

Almost all of the recent empirical analysis has shown that the situation is more complicated than Schumpeter supposed. Too much concentration – with monopoly representing the extreme case – inhibits innovation by removing the incentive created by competitive rivalry. Nickell's analysis of U.K. data (1996) showed that the greater the number of competitors, the faster the rate of MFP growth, both

44 The traditional corporate R&D model had a relatively short life span – from the rise of Menlo Park in New Jersey in the 1880s, where Thomas Edison worked, to the rise of Menlo Park in California in the 1970s – but was effective during much of the 20th century when vertically integrated corporations dominated many markets. This model eventually broke down as technology enabled new competitors, backed by venture capital, to enter and disrupt existing markets.

economy-wide and within industries. Geroski (1990) made an important contribution by using several indicators of competitive intensity and concluding that "actual monopoly has an unambiguously inhibiting effect, and that rivalry has an unambiguously stimulating effect on innovativeness" (p. 599).

Based on estimations from U.K. data, Aghion *et al.* (2005) found robust evidence of an "inverted-U shaped" relationship between competition and innovation: greater competition initially increases, and then decreases, the rate of innovation. Firms have little incentive to innovate if they are not stimulated by competition; however, too much competition discourages innovation because both incumbent and entrant firms cannot fully capture the benefits of their research effort (Sharpe & Currie, 2008). Innovation will be most rapid at some intermediate degree of competition where firms are operating at similar technological levels and thus innovate to "escape competition". Howitt (2007) implicitly cautioned that policy makers should not push this theory too far: "To the extent competition policy authorities (…) might have shrunk from promoting competition for fear that innovation-promoting profits might erode, the new growth theory suggests they should take a more aggressive stand in favour of more competitive markets (p. 6)."

The relationship between firm size and innovation is also more complex than Schumpeter theorized. Small firms that undertake R&D have been shown to be at least as innovative as their larger counterparts (Sharpe & Currie, 2008), and are in fact increasingly relied upon to generate the new product ideas that are brought to market by large, often multinational, companies. Indeed, competition and the declining productivity of in-house R&D have forced even the largest corporations to outsource more and more inventive activity to smaller specialized firms. This trend is particularly evident in the pharmaceutical and information technology industries.

Research on firm dynamics supports the view that competition is a significant factor in productivity growth. Baldwin and Gu (2006) assessed the impact of changing market shares of individual firms over two 10-year periods to estimate what proportion of productivity growth derives from within-firm improvements and what derives from between-firm changes (i.e., more productive firms increasing market share at the expense of the less productive). They concluded that "for Canadian manufacturing industries, about 70% of overall labour productivity growth is due to changes in market share across firms in the periods from 1979 to 1989, and from 1989 to 1999 (around 50% if the effect of mergers is removed)" (p. 7). Thus the inter-firm reallocation of resources that results from competition – with the winners typically being those that are the most innovative

in ways that confer competitive advantage – is a principal source of productivity growth, at least in the manufacturing sector.

INNOVATION AND THE DYNAMICS OF COMPETITION

The challenge facing studies of the impact of competition on innovation is to employ measures of competitive intensity that are relevant and robust. Most empirical analyses focus on static measures of competition, and particularly measures of market concentration.[45] But it is the interaction of static and dynamic factors that really drives the effect of competitive intensity on innovation. Figure 6.1 is a highly simplified, schematic illustration of how two key factors – existing market concentration and barriers to entry – can influence the propensity of firms to innovate. In the lower left and upper right quadrants, the incentive to innovate is muted. In other cases – on the main diagonal in the figure – there can be a strong incentive to innovate.

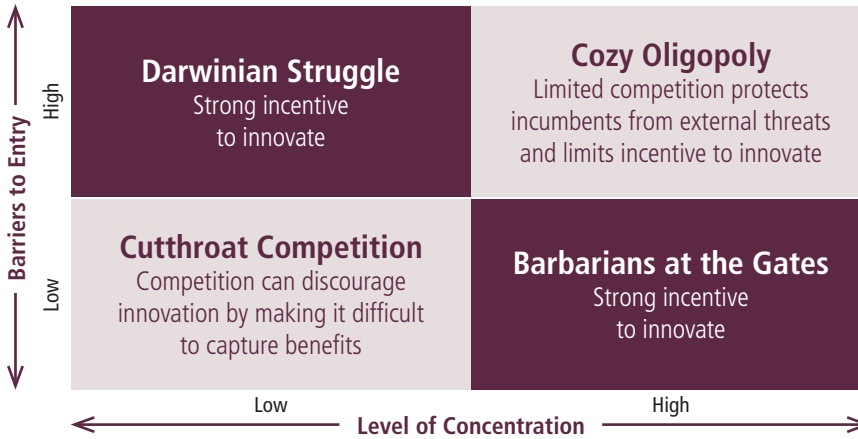


Figure 6.1
Illustration of Competitive Dynamics – Schematic

45 These include the Herfindahl-Hirschman Index (a measure of the size of firms in relation to the industry as an indicator of the amount of competition among them) and concentration ratios (i.e., the share of the market held by the top "N" firms). These measures are difficult to determine in practice because the relevant market can vary geographically, from local to global, and can be dependent on a complex set of partial substitutes. Another theoretically attractive measure is the price-cost margin (PCM) – the difference between the price of a product and its marginal cost. In theory, a purely competitive market would drive the price down to the marginal cost. However, marginal cost cannot be directly measured, so most attempts to assess this measure focus on average costs, which can seriously distort the metric.

- In the lower left quadrant (Cutthroat Competition) firms cannot capture the benefits of innovation because competition is too intense due to many players and low barriers to entry. This is typically the case with small retailers. Retail chains, on the other hand, can acquire the scale to innovate and tend to find themselves in the lower right quadrant.
- Firms in the upper right quadrant (Cozy Oligopoly) can be too complacent because there are only a few players and entry barriers are high. In industries with this structure, firms may be reluctant to introduce innovations intended to gain market share because they know that the innovation will be quickly copied by the competition, market shares will stay pretty much as they were, but the cost of innovation will have been incurred.
- In the lower right quadrant (Barbarians at the Gates), even though market concentration is high, the few incumbents will be threatened by new entrants that face low barriers to entry and have little to lose and much to gain. This is the situation when, for example, foreign competitors are first allowed to enter a market. It is also where what is called "disruptive innovation" often occurs. In this case, a new and often insignificant competitor enters a segment of the market that is considered to be unimportant by the dominant competitors – e.g., a low-margin, unsophisticated product niche. But once the new player establishes a foothold, it can continue to improve its technology or business model and colonize increasingly lucrative segments. When the dominant competitor(s) wake up, it may be too late to respond effectively because the disruptive entrant is already too far down the learning curve of a superior technology or business model. The disk drive industry is a classic example, as described by Clayton Christensen (1997), a professor at the Harvard Business School. But the pattern applies potentially to any sector undergoing rapid and fundamental change.[46]
- In the upper left quadrant (Darwinian Struggle), even though barriers to new entrants are high, the large number of existing competitors can improve their position through innovative behaviour. This would be the case in the early stages of development of a new market – such as the "smartphone" market today – when competition is a fight to determine the few survivors. The survivors might then form a cozy oligopoly – i.e., drift toward the upper right quadrant. But this may be an unstable state if, for example, further technological innovation reduces entry barriers, causing the industry to migrate into the lower right quadrant where the tempo of innovation remains high.

46 Gladwell (2008) describes how, in the 1970s, some start-up law firms in New York began to specialize in advising on hostile corporate takeovers. This was business that the established Wall Street law firms shunned as unseemly. The disruptive startups (epitomized by Skadden, Arps, now among the world's largest law firms) perfected their craft, established their specialist reputation and ended up dominating the Wall Street legal sector as the market for corporate control developed, and then boomed.

The message of these examples is that innovation and competition create a highly dynamic interplay in which innovation enables new competition, and then that competition motivates further innovation. The lessons for market structure and innovation are less clear. Neither economic theories nor empirical studies have been able to determine what degree of market concentration, or contestability, faced by which types of firms produces the most innovation (OECD, 2008a).

INTERPLAY BETWEEN COMPETITION AND INNOVATION IN CANADA

Is the state of competition in Canada a significant cause of the country's weak productivity and innovation performance? The evidence does not permit a definitive answer in view of (i) the difficulty of measuring the intensity of competition; and (ii) the great variety of market situations throughout the economy, some of which are intensely competitive and others not. The following general observations are germane.

Sectors Exposed to International Trade

For some sectors, particularly technology-intensive industries and many parts of manufacturing, the market for the product is North American or global. In these cases, the competitive intensity faced by Canadian firms is essentially identical to that faced by competitors in other countries, and most indicators suggest that Canadian firms achieve comparable levels of innovation and competitiveness. For example, the ICT sector consistently demonstrates R&D intensity levels similar to those elsewhere. Assessments of innovation activity at the firm level demonstrate that exporting firms are more likely to invest in R&D and to manifest innovative behaviour (Baldwin & Gu, 2004).

The Domestic Market

An insufficient level of competitive intensity is most likely to persist in industries that are domestically focused, particularly in those where barriers to entry limit the number or nationality of competitors or where the relatively small size of the market means that Canada is not a priority for potential foreign competitors. The existence of the border matters. Even though Canada and the provinces have relatively few "bureaucratic" barriers that would deter a foreign firm from establishing here (apart from in a small number of sectors), there nevertheless are the inevitable legal and regulatory formalities. Perhaps more important, a would-be competitor from abroad must learn cultural habits and business practices and create new networks of suppliers. The benefit has to exceed the cost, and the potential benefit to be gained in Canada may be limited by a relatively small and fragmented market. While the competitors often do arrive eventually, it is often

after a delay as expansion strategies focus first on larger prizes. In this regard, the burgeoning opportunities in Asia can be expected to make smaller markets relatively much less attractive in the years to come.

The retail sector is a case in point. As Sharpe and Smith (2004) have described, retail trade accounted for 15% of Canada's labour productivity gap relative to the United States in 1999. It also accounted, together with wholesale trade, for a significant share of Canada's BERD intensity gap (recall Table 5). While productivity in the U.S. retail sector accelerated rapidly in the late 1990s – due to what the McKinsey Global Institute (2001) called the "Wal-Mart effect" – no similar improvement was seen in Canada. Wal-Mart has been the industry leader in adopting new technologies and inventory management systems to reduce costs. These reduced costs, which were also supported by Wal-Mart's scale, created intense pressure on other firms in the retail industry to innovate. This heated competition had two effects. First, several other firms were forced to adopt the same technologies, eventually reaping similar productivity benefits and cost reductions. Second, many smaller firms that were unable to innovate went out of business, leading to a "composition effect" away from lower-productivity firms and thereby increasing productivity growth in the overall industry (Sharpe & Smith, 2004). Although Wal-Mart entered the Canadian market in the mid-1990s, the effect of its entry on competitors was not immediate. But there is now abundant anecdotal evidence that Canadian retailers are responding to this increased level of competition. For example, Canadian grocery chains have all developed strategies to respond to the introduction of Wal-Mart's Supercentres.

Sectors Where Competition is Curtailed

There are some important sectors in Canada – e.g., telecommunications services, air transport, and certain agri-foods – where regulations impede foreign entrants, thus sustaining protected niches where competition is limited.[47] Innovation tends to be dampened in those situations than might otherwise be the case because there is little incentive for well-established incumbents to compete for domestic market share via innovation. This is because it is easy for their competitors to follow suit, thus nullifying the potential benefit. But if the market were opened to foreign competitors that have already borne the cost of developing a particular innovation elsewhere, the new competitor has no market share in Canada to lose and only profit to gain by bringing the innovation to a whole new group of potential

47 In sectors with limitations on foreign entry, there is of course opportunity for "upstart" domestic competitors with innovative service models to make inroads, as is occurring, for example, in airlines and telecommunications. Regulatory limitations on competition in Canada are rarely absolute – other than for a few government-sanctioned monopolies (e.g., liquor commissions in some provinces). The issue is the extent to which regulation reduces competition and the cost of such reduction relative to the public benefit that the regulation was designed to create.

customers. Examples of this kind of competition and the resulting diffusion of certain innovations in the financial services sector are described in Box 10.

Market Regulation

Canada has among the fewest policy-related restraints on product market competition overall according to work by the OECD, which has developed sophisticated measures of product market regulation based on 16 indicators (Conway *et al.*, 2005). On the other hand, Canada was ranked worst out of its 20-country peer group in 2003 in respect of foreign ownership barriers. Many Canadian authorities consider this to be too harsh a judgment (Competition Policy Review Panel, 2008). It may have stemmed from the fact that Canada's restrictions, such as the foreign investment review provisions under the *Investment Canada Act*, are simply more explicit and transparent than those of many other countries. In practice, and apart from sectors where there are formal restrictions on foreign ownership, Canada's treatment of foreign investment does not appear to be more restrictive than that of most industrialized countries (Competition Policy Review Panel, 2008). Notwithstanding the competition-limiting ownership restrictions in certain key sectors, the substantial openness of the Canadian economy to trade implies that many sectors are fully exposed to global competition, either to gain export share or to defend against loss of domestic market share to imports.

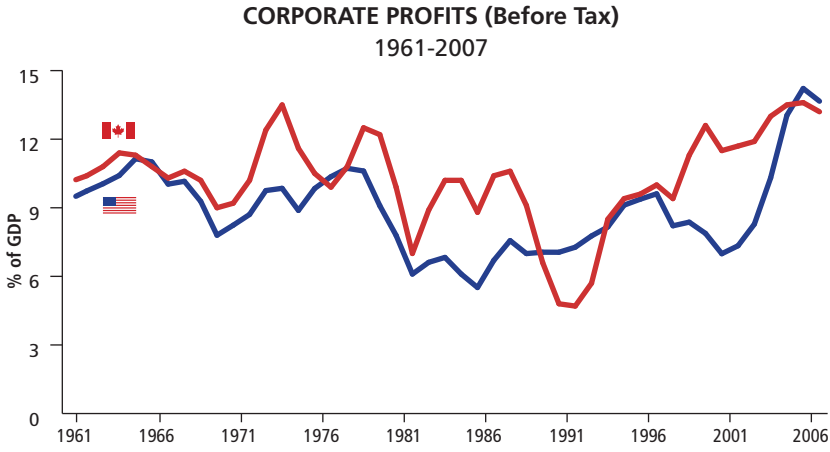
Internal Barriers

Canada still has internal barriers to trade that limit competition, though their impact is most evident in only a few high-profile industries like beer and wine. Government procurement policies may pose the bigger barrier to competition in several industries. Governments sometimes also impose conditions on their suppliers in the form of preferences in favour of local firms in the case of provincial governments, or, in the case of major federal purchases (of defence equipment, for example), requirements that foreign suppliers buy a specific percentage of parts or other inputs from Canadian firms. While such policies support certain public objectives, they nevertheless reduce competition and may thus diminish the incentive to innovate.

Indirect Evidence of Competitive Intensity

There is a great deal of anecdotal evidence that the intensity of competition in the U.S. domestic market is far greater than in comparable sectors in Canada. The slowness with which many Canadian prices fell toward U.S. price levels for identical goods when the Canadian dollar suddenly appreciated sharply in late 2007 suggests

that, at least in these markets, competition is not particularly intense.[48] The difficulty experienced by Canadian firms that have tried to penetrate consumer and local markets in the United States – as contrasted with the widespread success of U.S. firms in many consumer sectors in Canada – is also suggestive evidence of greater competition and innovation in the U.S. domestic economy.[49] Further indirect evidence is provided by the generally lower level of business profit (relative to the size of the economy) in the United States as compared with Canada (Figure 6.2). During the period since 1961, the pre-tax profit ratio in Canada exceeded that in the United States in more than 80% of the years. Other things being roughly equal, more intense competition would lead to a lower relative level of business profitability.



Data Source: Statistics Canada, 2007

Figure 6.2

Corporate Profits (Before Tax)

Aggregate corporate profit (before tax) as a percentage of GDP has generally been higher in Canada than in the U.S., with the Canadian ratio higher in 39 of the 47 years (83%) from 1961 to 2007. The only time when the profit ratio in Canada was significantly below that of the U.S. was in the 1990-93 period, reflecting the deeper recession in Canada.

48 There is no established standard by which to judge objectively the speed at which prices in a particular market segment "should" decline following a cut in price of a significant input factor. But when margins expand due to reduction of a significant cost element, firms in highly competitive markets usually cut prices and sacrifice some of the windfall margin in order to gain market share. The alternative where everyone simply stays put and enjoys quasi-permanent above-normal profit is not a stable state when competition is vigorous.

49 Other factors play a role. Many U.S. firms that establish in Canada also benefit from scale economies both in production and marketing as well as from brand identity. By contrast, it is common for Canadian firms in the United States to "disguise" their national identity.

THE EFFECT OF CANADA'S MARKET SIZE ON COMPETITION AND INNOVATION

The data presented in earlier chapters indicate that the relative weakness of business innovation in Canada is of very long standing – for example, Canada's MFP growth has lagged that of the United States throughout the 45 years over which rigorous statistical comparisons have been made. It is therefore almost certainly the case that at least some of the factors responsible for the innovation weakness are also of long standing and thus are probably linked to fundamental characteristics of Canada's economy. One example, noted earlier, would be the relatively large number of Canadian businesses that are "upstream" in North American value chains.

A second important factor is the comparatively small size and geographic fragmentation of the Canadian market, particularly when compared with the enormous scale of the U.S. market. As a general rule, a larger market promotes innovation via two principal channels. First, larger markets attract and support more competitors, and the resulting competitive intensity stimulates innovation; and second, larger markets increase the size of the potential reward for innovation and thus improve the likelihood that the upfront cost and risk of innovation will be recouped (Helpman, 2004). Since Canada starts with the limitation of a relatively small domestic market – made even smaller by interprovincial and regulatory barriers in some sectors– measures to increase the "effective size" of the market by reducing internal barriers and increasing access to markets abroad would increase the incentive for Canadian businesses to adopt innovation-based strategies. The innovation orientation and success of countries like Sweden and Finland proves that small market size is not an insuperable barrier provided businesses are aggressive in seeking global markets for innovative products.

Box 10 – Entrants Versus Incumbents: Competitive Challenge and Response

E-TRADE Canadian banks have run discount brokerages since the 1990s. Until fairly recently, the standard price for a stock transaction was $29.95 for most traders and $15 for active traders. In 2006, *E*TRADE* Canada introduced new pricing that offered a $15 transaction price for all traders, forcing the Canadian banks to follow. A year later, *E*TRADE* took its price down to $9.99 for active traders; again, the Canadian banks followed. TD Waterhouse subsequently created a new "hyperactive trader" category with transactions priced at $7. The other banks and *E*TRADE* Canada (acquired from its U.S. parent by Scotiabank in September 2008) matched the move.

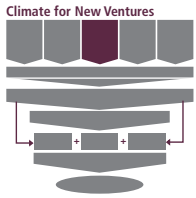
There are two lessons here. First, the Canadian banks were happy to sit on their higher prices, confident that their established domestic competitors would not upset this profitable arrangement. But second, when faced with a competitive threat from outside, they were able to respond with both innovation and efficiencies to meet the new lower price point and remain profitable. Thus they had the capability, but moved only when threatened. In a protected environment, the banks changed only when they had to.

ING Direct Canada's domestic banks also found themselves with a new competitor when ING, a Dutch bank, entered the Canadian market in 1997. With strong financial support from its parent, ING Direct targeted high-wealth Canadians with savings accounts by offering much higher interest rates than the Canadian banks on the cash accounts of those clients (3% to 4%, rather than, say, 0.5%). The company also aimed at a broader customer base by offering these rates on all cash balances rather than requiring large minimums.

The domestic Canadian banks had two options. First, they could raise their own interest rates on cash deposits, but because they would have to make the same offer to their vastly larger clientele, such a move would be costly. Second, they could leave their rates unchanged and accept the inevitable loss of what they hoped and assumed would be only a small share of the market to ING. They chose the latter and lost somewhere between 3% and 5% of the market to the newcomer, as ING skimmed the deposits of higher-income people. Once ING had a foothold in Canada, it was able to use its capital base to begin offering mortgages, mutual funds, and other credit and investment products.[50]

50 This type of competition is closely analogous to the "disruptive technology" model described by Clayton Christensen (1997).

Chapter 7 – The Climate for New Ventures



Small entrepreneurial businesses and large incumbent firms play different roles in innovation. While large firms are critical to routinized, incremental innovation, which often generates significant productivity improvement, entrepreneurial firms are typically the source of radical innovations (Baumol, 2002). New ventures are thus the "green shoots" of the innovation system, bringing new ideas to market and creating new competition.

Entrepreneurial firms – rather than small businesses in general – tend to be focused on innovation and play an important role in economic growth. That is why the Competition Policy Review Panel (2008) recommended that government policies in respect of small and medium-sized enterprises should "focus on those firms that demonstrate the desire and capacity to grow to become large enterprises" (p. 75). While Canada has a particularly strong record of new business creation (OECD, 2003b; Global Entrepreneurship Monitor, 2007), only a small minority of new businesses contribute to generation of economic growth. The innovation strategy for these new ventures, on the whole, is quite different from that of large incumbent firms (Table 7).

The distinctions highlighted in Table 7 are not hard and fast since new businesses, if they succeed and grow, gradually take on the characteristics of established firms. At the same time, it is becoming necessary even for large firms to adapt themselves to the new venture model of innovation to improve performance (Hamel, 2007). Because the more radical, new-market-creating innovations usually start within smaller entrepreneurial ventures, it is important to understand the features of Canada's business environment that affect the quality of the breeding ground for such enterprises. The key enabling conditions can be grouped into three broad categories:

- *Venture financing and acquisition of commercial skills* – the sources and availability of risk capital and mentorship to support the development of new companies from concept to sustainable business, including access to mentoring, business experience and commercial networks to develop entrepreneurial commercial skills.
- *Technology transfer* – the mechanisms to take research and intellectual property, developed within universities and government laboratories, to commercial realization.
- *Clusters* – the development of a local innovation ecosystem that supports and sustains the creation and growth of new ventures.

The purpose of this chapter is to outline the extent to which each of these support factors contributes to Canada's environment for the creation and growth of new businesses that have innovation-focused strategies.

Table 7

Innovation Strategies – Incumbents versus New Ventures

	INCUMBENTS	NEW VENTURES
TARGET MARKET	*Existing markets* – Incumbent firms tend to focus on existing markets and products. Some, but not all, of the investment in innovation targets improvements in existing businesses.	*New markets* – New ventures are more likely to seek out new markets (those without an incumbent competitor), but even existing markets are new to the firm.
STYLE OF INNOVATION	*Incremental innovation* – Existing products and markets create demands for incremental innovations, both in the products and in the associated processes. (A small number of incumbents do manage to sustain more radical innovation strategies.)	*Radical innovation* – Gaining entry to an existing market, or creating a new market, usually requires some form of radical innovation.
ALLOCATION OF RESOURCES	*Balanced priorities* – Large businesses must allocate resources across multiple products and corporate priorities, with investments in innovation allocated in competition with many other demands.	*Single priority* – New entrants are much more likely to be focused on a single product or service.
SOURCE OF FUNDING	*Internal funding* – Incumbent firms are more likely to fund innovation from internally generated resources.	*External funding* – New ventures, usually with little or no sales revenue, are heavily dependent on external financing to support innovation and growth.
MANAGEMENT INCENTIVE TO INNOVATE	*Mixed incentives* – Management bonuses (whether cash or equity) are generally spread across the multiple objectives of the firm.	*Strong incentives* – Equity and stock options typically provide key contributors with significant opportunities for wealth creation.

VENTURE FINANCING AND ACQUISITION OF COMMERCIAL SKILLS

Innovation-oriented new ventures require a particular form of risk capital because investing in startups (i) entails an unusually high degree of risk; (ii) places limitations on the liquidity of the investment; and (iii) in the case of S&T-based initiatives,

requires the investor's acceptance of the "information asymmetry" that arises from the specialized technical knowledge of the investee. The most successful forms of risk capital have originated from specialized private groups focused on raising funds from investors comfortable with the associated risks and timeframes for success and possessing the special business skills needed to effectively manage such an investment. Therefore, successful venture investing demands much more than financial capital. Operational and business experience is a key ingredient needed to monitor and manage these investments. It follows that traditional capital markets for public equity or commercial debt do not play a significant role at the early stage of new technology ventures.[51]

Venture funding is critical for new business creation, but its precise nature changes as companies evolve from seed or early-stage investment, through commercial validation, to later-stage growth and expansion (Table 8). The focus of this chapter is on the initial funding stages outlined in the table – "Getting Started" and "Commercial Validation". These are particularly critical stages, needed to bridge the new venture across the so-called "valley of death" that separates a promising business idea from a sustainable commercial enterprise.

Table 8
Evolution of New Business Financing

	STAGE	USE OF FUNDS	SOURCE OF FUNDING
INITIAL FUNDING	**Getting Started** *Pre-seed, Seed & Early-Stage Funding*	• Proof of concept for a potentially profitable business opportunity • Complete product development and conduct initial marketing • Use initial capital to initiate commercial-scale business activities	• Family and friends • Angels
	Commercial Validation	• Expand production and support growing accounts receivable and inventories (Although potential is there, company may or may not be profitable at this stage.)	• Venture capital
GROWTH & EXPANSION	**Later Stage** *Expansion Stage*	• Increase sales and profitability • Significantly expand capacity, marketing and working capital • Develop new product and technology	• Equity and debt funding

51 This may be changing. Special Purpose Acquisition Corporations (SPACs) have been growing in popularity in the United States, and the Toronto Stock Exchange is reviewing its current policy for Venture Capital Pool Companies to possibly permit larger pools of such capital in Canada.

Getting Started

Support from family and friends ("love money") is often needed for new firms to get started, but is usually limited. Angels – investors that are independent of the firm but knowledgeable in its business sector – are typically needed to enable a startup to proceed to the next level. Angel investors behave much like venture capitalists, except they usually invest their own money rather than acting as investment managers on behalf of other providers of funds.

Based on the limited available data on "informal" investment sources – i.e., friends and family plus angels – it appears that this important source of startup capital is not as extensive as it needs to be in Canada. The 2001 *Global Entrepreneurship Monitor* (Peterson *et al.*, 2001) estimated that angel investment in Canada is slightly more than half that in the United States on a per capita basis, a finding that is roughly consistent with the estimate that about 7% of Americans invest in new businesses compared with fewer than 3% of Canadians. The estimates from Industry Canada's *Survey on the Financing of Small and Medium-sized Enterprises* suggest that angel investors are responsible for $3.5 billion of the total annual investment of $11 billion in Canadian SMEs by informal investors (Riding, 2005).[52] However, the $11 billion figure includes funding for all small businesses, and so goes well beyond the scope of innovative growth businesses.

The relative weakness of early-stage investing in Canada is of concern because the angel and venture capital communities are linked and complementary. Successful entrepreneurs are valuable as angel investors not only for the funds they bring (a byproduct of their own past success), but particularly for the valuable experience and mentorship they can offer to new entrepreneurs, often providing business contacts as well as specialized market knowledge. This support helps new firms bridge the gap between funding available from friends and family and from venture capital, and better prepares the company to receive venture capital support.

Canadian governments have sought to address the early-stage gap in financing through various initiatives. For example, since 2001, the Business Development Bank of Canada has been directing a growing share of its resources to seed-stage and startup companies. Less directly, the investing constraints imposed on Labour Sponsored Investment Funds (discussed below) have served to channel investments to early-stage companies. While both of these programs improve the availability of capital for startup companies, they do not address the other critically important aspects of the role of angel investors – experience, contacts and mentorship.

52 According to the National Angel Organization, in 2008 angel investment in Canada was twice that of venture capital, or about $3.2 billion (Research Money, 2008).

To address that gap, a number of incubation centres have been created to assist small companies in their earliest stages of growth.[53] One example of a direct effort to generate additional angel investment is a component of the Regional Economic Intervention Fund (FIER) established by the Québec government. The "Support Funds" within FIER provide regionally managed capital pools that combine public and private money.[54] This model is well designed to attract experienced angel investors who benefit from the additional leverage provided by the FIER co-investment.

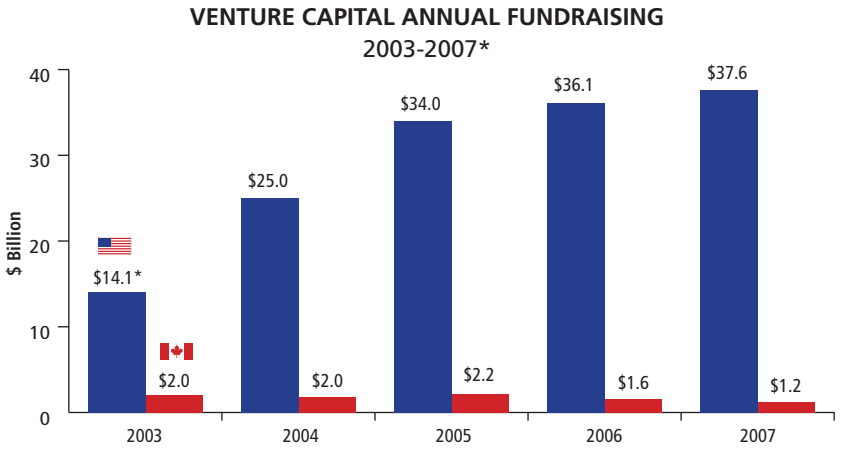
Commercial Validation (Venture Capital)

Venture capital is provided primarily by professionally managed funds that pool assets from multiple investors. Venture capital (VC) has played a significant role in the establishment of most large information technology and biotechnology firms, as well as other innovative firms, such as Federal Express and Home Depot (Kenney *et al.*, 2008). While VC investment is substantially smaller than the total pool of informal investment – in Canada it has ranged from $1.5 to $2 billion per year over the last five years (CVCA, 2008a) – it is concentrated in those firms with the greatest potential to eventually become public, or to grow into large companies.

There are reasons to be concerned about the state of venture capital in Canada. Fundraising for Canadian VC firms – i.e., the capital raised or committed from investors for subsequent VC investments – has been falling with 2007 marking the fifth decline in the previous six years. By contrast, there were five consecutive years of growth in the United States. In 2007 fundraising in Canada dropped to $1.2 billion, about 3% of the $37 billion raised in the United States, or 30% on a per capita basis (Figure 7.1). While there has been a U.S.-Canada per capita gap for as long as venture capital has been measured, that gap has grown. Fundraising by VC firms in Canada declined by 27% between 2006 and 2007, and is now 40% below the 2003 level. Over the same four-year period, annual U.S. fundraising was up by over 150% and increased each year (CVCA, 2007).

53 Examples of incubation centres include the Québec Biotechnology Innovation Centre and the Centre for Drug Research and Development in British Columbia, both supporting new life sciences firms (see Box 14). The Waterloo Accelerator Centre (see Box 16) is similar, but more focused on ICT startups.

54 These funds, the first of which were created in 2005, align the interests of private investors with the public policy goal. Investors can obtain a return only by investing the money (which includes their own) well and generating a profit from the investment. The individual funds receive $2 of government money for each dollar raised by the community. As an incentive, the government waives its share of any gains generated for the first five years. Individual investments are limited to $250,000 per company and are constrained to either startups or local firms that require a turnaround.



*U.S. data converted to $C at market exchange rate.

Data Source: CVCA, 2007

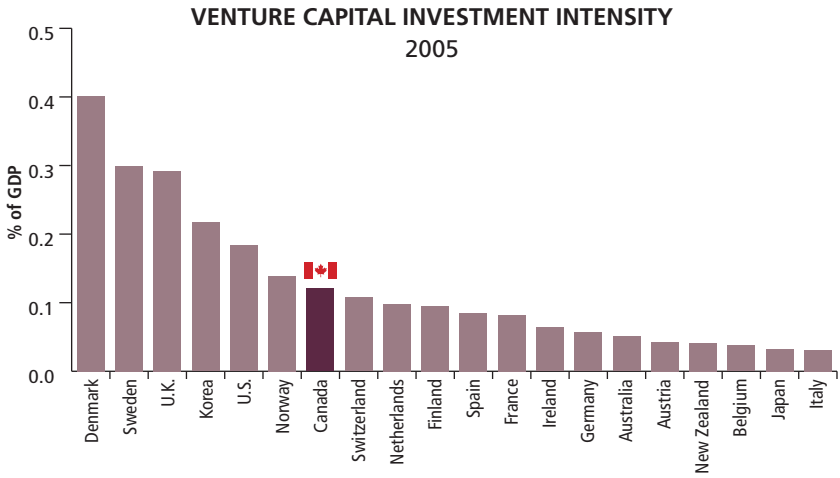
Figure 7.1

Venture Capital Annual Fundraising

This chart shows the annual funds obtained by VC firms for subsequent investment in companies. Amounts committed to U.S. VC firms have been increasing while Canadian commitments have fallen. New funds obtained by VCs in Canada have been only 3% to 6% of the U.S. level since 2005.

The fundraising difficulties of the VC industry in Canada present serious issues for the immediate future but have not yet been reflected in the size of annual new investments. The legacy of large funds raised during the technology boom in the late 1990s, and increasing investments from foreign funds (primarily U.S.-based), produced total new investments in Canada of approximately $2.1 billion in 2007 (CVCA, 2007).[55] VC investment relative to GDP placed Canada seventh in the group of 20 comparator nations in 2005 (Figure 7.2). Canadian VC firms are significantly smaller than their U.S. counterparts, raise smaller funds and make smaller investments – by late 2008, the average size of a Canadian VC investment was a little less than 40% of the U.S. average (CVCA, 2008a). The one area where Canada could be considered a leader is in the relative number of firms receiving investments: Canada is well ahead of the United States and second in the comparator group of OECD countries (OECD, 2007e).

55 It is important to distinguish between capital raised annually by venture funds (e.g., $1.2 billion in 2007) and venture funds invested annually in businesses ($2 billion in 2007). This difference is due to (i) the presence of foreign funds in the investing total that are not captured in the Canadian fundraising data, and (ii) the timing differences between the raising of funds by VC firms and their ultimate investments in businesses.



Data Source: OECD, 2007e

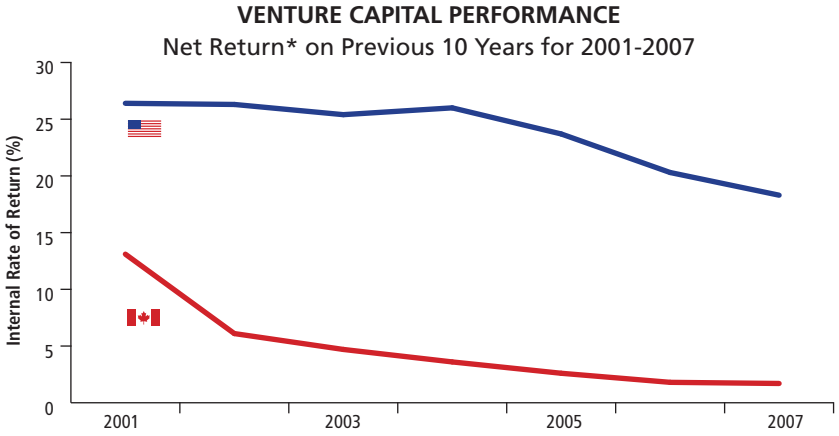
Figure 7.2

Venture Capital Investment Intensity

Venture capital is provided by specialized financial firms and also by "angels" – usually wealthy individuals experienced in both business and finance. The investment by U.S. angels is not included in the data above and international comparison may be affected since angels in the U.S. tend to invest more in new firms than VC funds do.

The relatively weak state of the Canadian VC industry mirrors a large U.S.-Canada performance gap. Canadian funds have significantly lagged their U.S. counterparts across virtually every time period for as long as the data have been tracked. Figure 7.3, tracks the 10-year rate of return performance in Canada and the United States since 2001. The fundamental questions regarding the weak state of the Canadian VC industry are the following:

- Are there too few attractive opportunities for investment relative to the amount of venture capital potentially available in Canada?
- Alternatively, is there too little supply of venture capital in Canada – due perhaps to excessive risk aversion or other reasons – to support the development of the skills base needed for a healthy VC industry?
- Are there deficiencies in the structure and skills base of the Canadian VC industry itself that have depressed investment performance as well as the contribution of venture capital to new venture growth in Canada?



*The first three values for Canada are for 1995-2001 (seven years), 1995-2002 (eight years), and 1995-2003 (nine years), respectively.

Data Source: CVCA, 2007; NVCA, 2008

Figure 7.3

Venture Capital Performance

The financial underperformance of aggregate VC investment in Canada is clear. (Some individual funds may of course perform well.) There has been a decline in the 10-year rate of return for VC funds in both the U.S. and Canada following the end of the tech boom, but the fall-off was steeper in Canada and from a much lower level to begin.

Quality of Opportunities for Venture Capital Investment in Canada

It might be argued that if there were a sufficient number of quality companies in Canada that were attractive for VC funding, the money would be forthcoming, whether from Canadian investors or from those in other countries.[56] There is a perception that there are too few Canadian entrepreneurs with the experience needed to successfully develop startup firms in S&T-based sectors. If so, this may be attributed to self-selection. The United States provides a readily accessible magnet for entrepreneurial talent eager to launch new ventures. The people with the most get-up-and-go attitude may therefore have left Canada to pursue opportunities elsewhere. Canada also appears intolerant of failure among entrepreneurs, whereas in the United States an early failure is more often seen as a learning experience for the next try. Whatever the effect of these considerations, there is also a "chicken or egg" problem – a shortage of venture financing (for whatever reason) reduces the opportunities for startups to succeed in Canada, and thus limits the number of experienced and successful entrepreneurs, which then constrains the creation of good investment opportunities. However, there are no pertinent data to effectively measure demand for venture capital categorized by quality of opportunity, which would be the relevant correlate.

56 Evidence reported in an OECD study suggests that a lack of good projects may be a prime constraint on VC activity (OECD, 2003a).

The Supply of Venture Capital

To the extent that there is a supply constraint on VC funding, it is believed to be due to the low level of institutional VC investment in Canada. More than a third of funds raised by the U.S. VC industry in 2004 derived from pension funds and foundation endowments, while Canada generated only 15% from those sources (Thomson Financial, 2005; CVCA, 2007). Contributing to the gap is the fact that, prior to 1995, many of Canada's current largest institutional investors either did not exist (e.g., Canada Pension Plan Investment Board) or were more constrained in their investment options (e.g., Ontario Teachers' Pension Plan only began making private equity investments after 1990). These constraints have been loosened, but institutional investors in Canada are still less likely than their U.S. counterparts to support private equity. When they do, they are likely to choose the broader U.S. market as a more conservative investment bet.[57] Canadian institutions would presumably be more inclined to invest in Canadian venture capital if the sector produced better investment performance. On the other hand, a lack of stable investment support from Canadian institutions makes it more difficult for the domestic VC industry to reach sustainable scale and, most importantly, to develop the team skills and expertise necessary for success.

Performance obviously matters for VC firms because they are competing for capital against both foreign VC firms (primarily in the United States) and other forms of private equity. It is significant that "buyout funds" – those that target more mature businesses than does venture capital – have generally performed well in Canada and have not experienced the fundraising issues that have afflicted venture capital (Figure 7.4 and Box 11).

Governments have played an important role in shaping the venture capital industry to date by designing policies to improve the supply of funding. Until recently, the most significant policy initiative has been the creation of Labour Sponsored Investment Funds (LSIFs). As a contrasting approach, a number of provincial governments have recently moved in the direction of creating a "fund of funds", which combines public and private investment but focuses on supporting private VC firms that will then grow, or not, based solely on their performance.[58]

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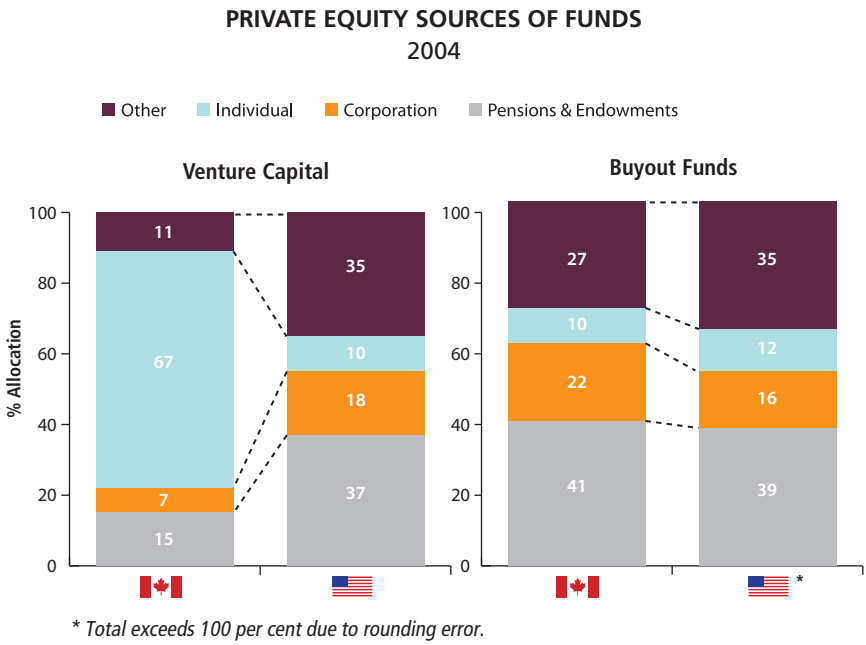
57 In 2007, only 22% of the Ontario Teachers' Pension Plan's private equity investments were in Canada, down from 40% in 2005, albeit on a larger base of total investments (Ontario Teachers' Pension Plan, 2005, 2007). They do not report what proportion of the investment is venture capital.

58 A "fund of funds" is a capital pool that invests primarily in other, professionally managed venture capital funds, rather than investing in new firms directly. One example is the Ontario Venture Capital Fund, which includes $90 million of public funding in a $205 million fund. The Ontario government has decided to phase out its LSIF tax advantage beginning in 2010. Other provinces have made analogous investments, but all of these funds are too new to have any performance track record.



** Total exceeds 100 per cent due to rounding error.*

Data Source: Thomson Financial, 2005

Figure 7.4

Private Equity Sources of Funds

Sources of funds and the proportion for "buyouts" (of established companies) are similarly distributed in Canada and the U.S. On the other hand, the sources for Canadian VC funds are heavily weighted to individual contributions, reflecting the dominant role of tax-advantaged funds (LSIFs) and the comparatively minor role of institutional investment Canadian venture capital.

Box 11 – Venture Capital Versus Buyouts

The problems of the VC industry in Canada cannot be explained simply by the small size of the Canadian market or by a failure of investors to support Canadian money managers in general. In fact, none of the issues that afflict venture capital in Canada are problems in the other main class of private equity investment, the buyout fund. Buyout funds – those that target more mature businesses than does VC – have demonstrated performance in Canada that exceeds that of U.S. buyout funds. As a result, they have recently attracted much more new investment than VC funds in Canada – $13.3 billion vs. $2.8 billion in 2006 and 2007 combined (McKinsey & Company and Thomson Reuters, 2008). These results, and the accompanying investment, have been achieved without significant government programs to encourage investment in buyout funds or to promote the industry. The characteristics of buyout investments are very different from venture investments and involve, for example, established businesses, more readily available business talent for established companies, and more options for further financing and investor liquidity.

The question of whether buyouts promote innovation, or not, is controversial. Since the ultimate goal of the buyout investor is to recoup its investment at a substantial profit, there is a powerful incentive to boost the performance of the investee business. This may require innovation in business model, organization and marketing. It may also involve a reduction of the workforce to increase a firm's productivity, thus releasing people to potentially be re-employed more productively. Buyout investors will make new investments to sustain innovation – e.g., the purchase of the Bombardier Recreational Products Division by private equity interests – if they believe such investments will increase the value of the enterprise for a future public offering or further sale to realize their investment return. A review of the performance of buyout firms by Canada's Venture Capital & Private Equity Association (CVCA, 2008b) concludes that all of these approaches are relevant, and that added growth from market expansion or new products is critical to the firms' success.

The buyout investor and the new venture investor are both agents in the process of "creative destruction" by which capitalist economies evolve more productive businesses. The extent that one predominates over the other in Canada is due to the nature of Canadian market conditions, and not the result of faulty investment judgments made by private equity investors.

Structural Deficiencies of the Venture Capital Industry in Canada

Problems concerning the sustainable supply of capital to the VC industry in Canada appear to be rooted primarily within the industry itself and its poor performance. If the performance were strong, the supply of funds for VC investment would not be an issue.

For a brief period during the technology boom in the 1990s, the Canadian VC industry was able to raise significant funds for investment. These amounts helped carry the industry for a number of years, but are not being replaced. While the United States went through the same boom and bust cycle, fundraising by VC firms began to recover in 2003 and steadily increased through 2007. This divergence appears to be caused by the poor performance of the Canadian VC industry as an investment class. There are two main contributors: (i) Canada's VC industry is still relatively young, and therefore has not fully developed the necessary skills for success; and (ii) there are structural issues related to the historical predominance of tax-advantaged LSIFs.

The "Age Effect" and Skills Deficiencies

Compared with the United States, the Canadian VC industry is very young, with the great majority of firms dating only from the mid-1990s (Macdonald & Associates, 2005). While there had been a small industry during the 1960s and 1970s, most of those funds were wiped out after the 1987 stock market crash. These early firms had also been more focused on non-technology sectors as compared with the U.S. industry. More than 80% of existing Canadian firms were created during the expansion of the technology bubble between 1995 and 2001. The industry doubled in size between 1998 and 2001 (Duruflé, 2006).[59]

The big maturity gap between the U.S. and Canadian VC industries is important because it takes time for the VC sector to learn the lessons of successful investing, and to winnow out weak firms and reallocate resources to the strong ones (Box 12). For example, while U.S. assets are more heavily concentrated in top-quartile-performing VC firms, the opposite is true in Canada where the top quartile firms have the smallest share of assets under management (Duruflé, 2006).

Over time, the performance issue could be expected to work itself out. The successful VC firms would raise additional funds and continue to invest; others would fail to do so and exit the business. Unfortunately, the timing of the boom in the

59 While the U.S. industry had a similar boom during the late 1990s, almost 20% of firms have been operating since before 1985. In Canada, by contrast, less than 2% of the current industry existed in 1985.

Canadian industry has complicated this evolutionary process. The quantity of funds raised late in the boom years (1998 to 2001) and the predominance of first-time firms have contributed to the continuing poor performance of the industry. Even the top quartile firms in Canada have a 10-year return of only 19.3%, which is barely competitive with the overall *average* returns in both the U.S. VC industry (20.4%) and other private equity asset classes in Canada – e.g., buyout firms at 20.3% (Duruflé, 2006, 2007).

The performance issues of the VC industry are linked to certain management characteristics. Fund managers in Canada have less operational experience than their U.S. counterparts and appear to make less use of advisory groups of experienced entrepreneurs and technology experts. This lack of operating expertise has led them to take a more passive role in investments; whereas it is through active management that the investee firms are made more valuable.

Box 12 – Development of the U.S. Venture Capital Industry

Gompers and Lerner (2001) have described the evolution of the U.S. VC industry, usually dated back to 1946 with the formation of the American Research and Development Corporation, the first firm dedicated to professionally managed investment targeting new ventures. This nascent industry received a dramatic boost in 1958 when the U.S. government created the Small Business Investment Company (SBIC) program. These funds, which peaked at more than 700 during the 1960s, helped build the industry and enabled venture capitalists to gain the experience necessary to eventually create wholly private funds.

After significant declines during the economic downturn of the 1970s when the number of SBICs contracted to 250, changes to pension regulations created a new source of funding by enabling pension funds to invest in private equity. The impact was dramatic – fundraising jumped from US$39 million to US$570 million between 1977 and 1978. Pension funds and endowments are now the largest source of funds for venture capital in the United States.

The combination of a new capital source and economic growth during the 1980s allowed the industry to take its current shape. While the boom and bust of the tech bubble had an effect on the U.S. industry, the trauma was less significant than was the case in Canada, reflecting the far greater depth and maturity of the sector in the United States.

Canadian VC firms invest a larger share of their funds in early-stage companies, do too many deals and tend to underinvest in each one. Moreover, according to at least one leading industry expert in human capital assessment, the Canadian VC industry has invested in a larger proportion of companies with underperforming management teams than has been the case in the United States.[60] This finding does not answer the question as to whether the problem is primarily due to a lack of entrepreneurial expertise in Canada, or due to a tendency of Canadian VC firms to be more tolerant of weaker management performance, or both. It would be helpful to examine incentives to increase the available talent pool within the country, including ways to attract back to Canada the many Canadians that have acquired valuable experience abroad.

Labour Sponsored Investment Funds

A significant component of the Canadian VC industry, LSIFs (Box 13), have used the availability of personal tax credits as an incentive to draw significant amounts of capital into the industry. But LSIFs have also been strongly criticized as contributing to an unhealthy environment for other private VC firms, particularly during the 1990 to 2005 period. In those years, LSIFs dominated the VC industry and arguably adopted different investment objectives than purely market-based players. The major presence of LSIFs in Canada makes it hard to compare Canada's VC sector with that of other countries because (i) only the United Kingdom has adopted a similar structure (Cumming, 2005), and (ii) LSIF statistics have historically included a significant amount of investment that is not actually in venture capital. This is particularly the case in Québec where LSIF assets are concentrated in only two funds that are, in fact, broader private equity investors that have been classified as VC firms for statistical purposes.

The LSIF model has been criticized for its suboptimal use of tax-subsidized capital. From 1992 to 2000, according to the Canadian Retail Venture Capital Association, the tax subsidy accruing to LSIFs and their investors was close to $1 billion. This access to lower-cost funds and a focus on an annual funding cycle favoured LSIFs in the competition for funds with other non-subsidized VC firms, and allowed them to satisfy investors, despite lower performance, given the reduced

60 Duruflé (2006) cites research by ghSmart & Company, the leading firm performing assessments of management for the private equity industry, that shows that only 22% of Canadian VC investments were in "A" teams in 2006, compared to 75% of U.S. VC-backed firms. These gaps are most significant for the Chief Financial Officer and the Vice President, Sales. Duruflé (2008) reports that more effort is now going into the assessment of management teams, with the selection of "A" teams increasing to 55%. While still below the level in the United States, the improvement is significant and indicates that it is possible to find higher quality management in Canada.

cost of investment after tax credits. A task force set up by the Québec government in 2003 concluded that taxpayer-supported VC firms had crowded out private venture capital, particularly at the lower end of the market (investments of less than $5 million), while at the same time showing poorer performance (Le groupe de travail, 2003). That analysis led the *Fonds de solidarité* to exit direct early-stage VC investments in 2006 and to channel its technological VC investments through the private VC firms in which it invested. Other tax-subsidized VC firms were liquidated as the Québec government chose to focus its support for venture capital through the FIER structure described earlier.

LSIFs outside Québec, which collectively invest close to 60% of their funds in venture capital, have also had relatively poor performance. Cumming and MacIntosh (2006) cite a number of flaws in the design of LSIFs. In separate studies, both Cumming and MacIntosh (2003, 2006) and Brander *et al.* (2008) conclude that LSIFs have crowded out private sector investment. The evidence is thus strong that LSIFs across Canada have contributed to weaker performance of the VC industry, essentially by accumulating significant capital in a vehicle that is poorly designed for new venture investments, particularly in high-risk technological innovation domains. Both Ontario and Québec have now addressed that issue, and that should provide healthier competitive conditions for the Canadian VC industry in the future.

The message of the foregoing discussion regarding the state of Canadian VC industry is that there is no quick or easy fix. Attracting sufficient capital to become self sustaining will require VC firms to demonstrate they have the skills and experience to generate acceptable returns. The dilemma is that the industry requires access to sustainable pools of investment capital to develop a critical mass of investing skills. It is encouraging that recent government policy initiatives at both the provincial and federal levels have been designed to support the growth of market-based venture capital firms that will be judged, and will succeed or not, based solely on their performance.

Box 13 – Labour Sponsored Investment Funds

LSIFs are intended to pool small investments from retail investors and to invest the funds in small businesses or startups. The legislation requires the funds to be endorsed by a labour union though in many cases (apart from the broad LSIFs in Québec) the involvement of the union does not go beyond "renting" its name to the fund manager.

The first LSIF, the *Fonds de solidarité de la Fédération des travailleurs du Québec*, was created in 1983, spurred by a Québec tax credit for individual investments in the *Fonds*. Over the following decade, the model spread across Canada and was adopted by the federal government and most provinces.

Individual investments in a LSIF receive a tax credit – generally, 30% when the provincial and federal credits are combined – and are eligible for Registered Retirement Savings Plans (RRSPs), allowing, at the limit, up to an 80% tax deduction for investments up to $5,000 per year. An LSIF is required to keep 40% of the funds it raises in liquid investments to ensure liquidity and to generate sufficient revenue to cover operating expenses. The rest has to be invested in private equity, but not necessarily in venture capital.

At the peak of the LSIF movement in 2000, there were about 25 LSIFs in Canada, with over $10 billion in assets. The *Fonds de solidarité* currently has assets of $7.3 billion, and has always represented close to 60% of the industry. Because of its size and actual control by a union, its investment policies differ significantly from non-Québec LSIFs, and should be analyzed separately. (This also applies to the second much smaller Québec LSIF, *Fonds d'action*, also controlled by a union.)

Fonds de solidarité de la Fédération des travailleurs du Québec The *Fonds de solidarité* can best be described as a broad private equity fund. It raises its investible funds mainly through payroll deduction programs. About 60% of its assets are in *investissements* – i.e., equity of private and public companies where it has a say on the board – and 40% in *placements* – i.e., securities such as equities, bonds and money market. Contrary to other LSIFs and to VC firms with five-year investing horizons, the *Fonds de solidarité* tends to hold its investments, resulting in a very low churn, which is one of the major criticisms of its investment policies. Its VC investments amount to $600 million according to one definition, or only about half of its amount of $1.2 billion *placements* in bonds. As such, its portfolio has more in common with other large institutional investors or pension funds than with VC firms.

LSIFs outside Québec Outside Québec, LSIFs, while viewed as a form of venture capital, have a structure much closer to that of a mutual fund – i.e., marketed to retail investors through distribution by investment advisers, with no fixed life span, and the ability of investors to withdraw or add investments over time. While there are slight variations across the country, 60% of the funds must be invested in private companies within one to three years. In comparison, traditional private equity and VC firms have a longer timeframe in which to invest and do not call for funds from investors until needed. While LSIFs outside Québec are described as VC firms, and belong to the Canadian Retail Venture Capital Association, their investment behaviour does not always fit this description. Their investment rules do not require targeting ventures or growth companies and they must invest a large proportion of their assets in fixed income and public equities.

LSIFs and the VC market Although LSIFs have been major players in the Canadian VC sector, trade statistics tend to overstate their importance. For example, VC industry statistics state that LSIFs raised $1.2 billion in Canada in 2007, but almost two-thirds of that was raised by Québec LSIFs, and probably less than one-quarter of that amount will be eventually invested in the VC market. As a result, the fundraising statistics, as unimpressive as they are, appear to substantially overstate the availability of venture capital in Canada.

TECHNOLOGY TRANSFER

Research that takes place in universities and government labs is a potentially important source of ideas and new technologies particularly for startup businesses. Given Canada's heavy investment in university-led R&D (recall Figure 3.5), the effective transfer of technology from university research labs to commercial practice is an opportunity to be seized. This issue is particularly important for biotechnology, which strongly relies on academic research (Hermans *et al.*, 2008).

Technology transfer in the context of this discussion involves formal transfer of intellectual property (IP) from the originating institution to either an existing or new business. It would thus not include the transfer of general knowledge and capabilities from universities to the private sector through the movement of highly qualified people with advanced training or through the diffusion of new knowledge via academic literature, conferences and consulting. These channels – and particularly the knowledge transferred via trained graduates – are by far the most significant ways through which universities provide human and intellectual capital to business.

The effective commercial implementation of university research requires (i) researchers with the right mindset to identify and exploit commercial opportunities, and (ii) an "ecosystem" of institutions and infrastructure that can support these commercialization efforts. Three broad issues arise as to the right environment for successful technology transfer from public research. These include:

- research support philosophy including the incentive and recognition systems in universities
- institutional support for technology transfer and IP ownership, and
- business receptors of publicly funded research.

Research Support Philosophy and Incentives

Research funding for university faculty is allocated primarily by peer review committees whose criteria are focused on the research significance of the proposed effort and not on commercial potential. There are strong reasons to believe that public support for *basic research* should not be allocated according to commercial criteria since neither governments nor funding committees are well positioned to judge the future commercial value of curiosity-driven research.

Meanwhile, in areas of directed research, such as that funded by the Canadian Institutes of Health Research to cover specific therapeutic fields, there is a concern that funding is not as strategically allocated as it could be to optimize Canada's strengths and commercial potential. On the other hand, it is very difficult to establish objective measures of "commercializability" for the type of research typically undertaken in universities. Arguably, the most effective way to increase support for research that is likely to find commercial application is through programs that require partnerships between universities and private-sector businesses and/or certain government labs.

Research commercialization may be inhibited by the particular incentives and professional recognition embedded in university practice and culture. The priority usually given to the quick publication of university research militates against both the commercialization of discoveries and, by extension, implementation of a patent strategy to protect commercially promising IP. To apply for a patent for a (potentially) valuable discovery, it may be necessary to delay publication; and since patents are typically given little weight in tenure and promotion decisions, there is little incentive to pursue the commercial value of the research.[61] Furthermore,

61 There is a widespread view, based more on anecdotal than systematic evidence, that the Canadian academic environment is less conducive to commercial development than in the United States. But any difference is likely to be a matter of degree and reflect a much larger proportion of businesses in the United States that are at the leading edge of science and technology, and thus more capable of interacting with university researchers

discoveries are released into the public domain through publications and, as a result, they are at least as likely to be picked up internationally as in Canada.

There is a debate internationally about the relative merits of "open science" regimes versus those in which IP rights are strongly asserted. The balance has shifted in favour of the view that an open science model leads to more rapid technological advances overall than the alternative approach (Mowery, 1998; Jaffe & Lerner, 2004). Although the issues involving the effect on research commercialization of university practices and incentives will continue to be debated, the panel believes there is an unambiguous case for putting more emphasis on building up and improving the critical infrastructure for identifying and mobilizing potentially commercializable knowledge as it emerges from university-based research.

Institutional Support for Technology Transfer and IP Ownership

Even when researchers identify discoveries with commercial potential and wish to see them commercialized, the challenge of technology transfer remains. Most Canadian universities support this process through a technology transfer office (TTO) that is tasked with the responsibility of facilitating the transfer of discoveries to the private sector. These are increasingly assisted by external organizations that seek to support incubation and development of new businesses (Box 14).

University Technology Transfer

The overall performance of university technology transfer in Canada has not been strong.[62] While data collected by the Association of University Technology Managers (AUTM) indicate a steady increase over the last decade in all aspects of technology transfer in Canada, almost no TTO is self-sustaining and licensing revenue is generally insufficient to pay the full costs of an office.

Funding limitations may leave a TTO without sufficient scale and expertise to effectively manage the technology transfer segment of the commercialization process. The requirements related to patenting are illustrative. While preliminary work on filing a patent can be done for a few thousand dollars, full filings, especially in multiple countries, increase the cost by an order of magnitude. Without a private-sector receptor, few potentially valuable patents can be funded by universities on their own. As a result, IP with significant potential, but without a clear path to commercialization, can be lost because the skills to select the truly promising ideas, and the resources to protect them, are not available.

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62 Research expenditure in Canadian universities and hospitals has grown from $1.2 billion in 1996 to $4.7 billion in 2006, and staff at TTOs has more than doubled since 2000. While these have led to rapid increases in both new discoveries reported and new patents filed, Canada still appears to lag the United States. For example, the number of new patents filed per million dollars of research expenditure is only about 60% of the U.S. level (AUTM, 2007a, 2007b).

A particular challenge facing the Canadian technology transfer system is therefore to generate sufficiently specialized expertise in appraising the commercial potential of university-generated IP and facilitating the commercialization process. A recent organizational innovation in this regard is the MaRS Innovation initiative, funded through the federal government's CECR program.[63] The idea underlying this approach is to pool the science and IP of 16 institutions in Toronto to create

Box 14 – Raising Healthy Life Sciences Companies

The Québec Biotechnology Innovation Centre (QBIC) has been working to incubate startups and bridge the early-stage financing gap. It provides promising new startups a physical location conducive to both additional lab work and a business environment. In addition, it provides help with business plan development and funding. A very stringent selection process is a key component in the success of QBIC, which has supported 25 companies, 14 of which have been spun out as stand-alone entities. Twelve of them are still operating and growing.

In British Columbia, the Centre for Drug Research and Development (CDRD) has been set up to bridge the commercialization gap by reducing the risk associated with early-stage technologies. It provides expertise and infrastructure to advance therapeutic discoveries to the proof-of-concept stage. CDRD was founded by scientific and business leaders that have successfully navigated this space.

The MaRS Centre in Toronto was founded in 2000 by a group of local business leaders working with academic and government partners to foster commercialization of local research by connecting science, business and capital. MaRS has been operational since 2005 and launched a full suite of programs and services in 2006. It is a particularly ambitious initiative encompassing some 16 institutional participants and is designed to provide facilities and mentorship for new ventures (not limited to life sciences). In addition, MaRS intends to serve as the physical hub of a developing cluster of innovation based around the major research hospitals in the downtown core. Such physical proximity matters, particularly in large cities, because a big part of the innovative "chemistry" of a cluster is the frequency of serendipitous encounters and the opportunity for casual contact with peers.

63 The Centres of Excellence for Commercialization and Research (CECR) is the government's recently created program that aims to strengthen Canada's ability to attract the world's top researchers and develop ambitious research programs (Finance Canada, 2007, pp. 199-200). "MaRS" originally stood for "Medical and Related Sciences" but the mandate of the organization has evolved to encompass a broad spectrum of innovation-intensive fields and thus the name MaRS is no longer an acronym.

sufficient "deal flow" to support the development of a team of commercialization and entrepreneurship professionals that is large enough to accommodate specialized expertise in a wide range of scientific and engineering fields. No single member institution could afford to develop this kind of in-house team. By joining forces, MaRS Innovation hopes to make possible the creation of a vital new piece of knowledge mobilization infrastructure.

IP Ownership Policies

Canadian universities exhibit a wide range of policies as to the ownership and commercialization of IP. For example, the University of Waterloo places no restrictions on faculty seeking to commercialize the products of their research. The University of British Columbia, on the other hand, allows a researcher to own the IP and to decide whether to pursue its commercialization though the IP rights must be assigned to the university.[64] Most universities fall between these two models, with many allowing inventors to choose between commercializing new technologies on their own or assigning them to the university's TTO to act on their behalf. Almost all universities, with the exception of the University of Waterloo, claim some interest in revenue generated from technology that is developed using university resources, whether or not the university is involved directly in its commercialization.

Through the course of consultations, the panel heard a range of views regarding what constitutes the most effective IP policy. Those in the Waterloo region strongly support the *laissez-faire* policy of the University of Waterloo, which has helped to attract more entrepreneurial faculty to the university and has returned large dividends through the philanthropy of former students and faculty who have gone on to success as entrepreneurs. Others argue that the Waterloo model would not translate as well to other institutions. In the Waterloo case, most of the local new ventures have been ICT-related, with a particular focus on software. For these sectors, the importance of IP protection, particularly in the form of patents, is much less than the knowledge transfer that occurs as students and faculty migrate from the university to business.[65] For other sectors, especially life sciences, where patents and the ability to assemble complementary patents from various institutional sources may be a critical component of the technology's value, a centralized model through a TTO could be the most effective. Beyond the potential

64 If the researcher seeks commercialization, the university then manages the commercialization process (whether licensing the technology or creating a spin-off company). Any revenue generated is split between the institution and the inventor.

65 Even in this case, there are significant exceptions. The most successful technology licensing program in Canada, measured in revenue terms, is at the University of Sherbrooke and is almost entirely due to a single set of patents for voice compression software used in digital telephony.

benefit to the university, a TTO can provide outside businesses with a single window into various related activities within the institution, as well as cleaner title to relevant IP by performing some due diligence and ensuring that credit for invention has been properly attributed.

The design of IP-sharing policies is of course not the only determinant of the success of university technology transfer, and may not be the most important factor. For example, Stanford University and the University of California at Berkeley are both advanced research universities, have very similar IP policies and operate within the same general geographic area, but Stanford has spun off a great deal more commercial activity. This shows that "micro-geography" can matter. The Stanford campus is surrounded by big technology firms like Intel, IBM, Oracle, HP and Apple, among others, whereas there is much less presence of comparable companies in Berkeley's immediate neighbourhood only a few tens of kilometres away. The small difference in proximity has produced a big difference in outcome.

Business Receptors for Research

The two examples, Stanford and Berkeley, demonstrate that the university is only one side of the technology transfer equation. Niosi (2008) emphasizes the need for a *demand-pull* model of technology transfer. Neither university researchers nor a TTO alone are well equipped to assess the commercial value of new technology. Therefore, to complement the *supply-push* perspective of the universities, there must be a business – either an established firm or a startup – that can receive the technology and commercialize it. (Box 15 describes important trends in the commercialization of R&D and their implications for technology transfer from universities.)

Research originating in universities is most readily commercialized by businesses that are oriented strategically toward the development and marketing of opportunities at the leading edge of science and engineering. Almost inevitably, these are businesses that do a lot of R&D. The low BERD intensity of the Canadian business sector, as documented in Chapters 3 and 5, would therefore tend to correlate with subpar commercialization of university research, though the direction of causality is more subtle. A firm invests in R&D because its particular business strategy requires it. The implication is that commercialization of university research is more likely to occur if the surrounding business environment is rich in firms that are committed to S&T-based innovation as a major business objective – i.e., more "market pull" is needed in Canada to complement "research push".

The alternative to established businesses that are keen to adopt new technologies is a healthy crop of new ventures that can commercialize the discoveries that emerge from research. In this regard, Niosi (2008) argues that Canada lags the United States. While the National Research Council's Industrial Research Assistance Program is very well regarded by technology-oriented smaller firms in Canada, a broader range of policies operate in the United States, including the Small Business Innovation Research program, the Small Business Technology Transfer program and the Advanced Technology Program. Each of these combines public funding with private capital to enable early-stage and commercial development of new technologies that, in combination, represent considerably more support for new ventures than the equivalent programs in Canada (Cumming, 2005).

In summary, it would appear that the best way to foster commercial success from publicly funded research is to enhance the depth and frequency of interaction with the commercial world. This can be done by:

- creating opportunities for academics and students to be in co-operative contact with commercial enterprises
- providing TTOs with the resources to adequately catalogue, protect and showcase the research developments that are occurring, and
- encouraging the private sector to collaborate with university and government research groups.[66]

These measures will be effective to the extent that more businesses in Canada become strongly committed to innovation. Greater success in commercializing university and government research depends therefore on strengthening the factors that encourage companies in Canada to adopt innovation-based business strategies.

66 This objective was explored by an expert panel (chaired by Dr. Arnold Naimark) reporting to the Treasury Board of Canada on inter-sectoral S&T integration (Independent Panel of Experts, 2008). A further example is the creation of iNovia Capital, a private manager of seed and ultimately venture capital funds with university sponsorship and collaboration partnerships. Founding partners include McGill University, University of Sherbrooke and Bishop's University. They have since been joined by Université de Montréal, University of Alberta and University of Calgary.

Box 15 – Business R&D and Technology Transfer

Business R&D is fusing into a continuum where it is no longer meaningful to distinguish between research and development as sequentially separate activities: "Old-fashioned R&D is losing its ampersand" (The Economist, 2007). In fact, decades have passed since companies like AT&T, IBM and Xerox operated stand-alone research facilities that were the equal of the best universities. The leading pharmaceutical companies still retain features of the classic R&D model but, there too, the productivity of the pure research function has declined substantially.

The paradigm that is coming to dominate today – in which R&D form a continuum that is merged with the marketplace – has significant implications for policies that seek to encourage the transfer of technology from universities and government laboratories to commercial enterprises. Even inside corporations themselves, the transfer of technology from the corporate lab to the engineering and marketing divisions has proven to be a problem. Instead, research teams stay with their ideas all the way through to manufacturing (The Economist, 2007).

This model of "RD", as distinct from "R&D", appears to have taken firm hold at least in manufacturing and the ICT sectors. Biotechnology presents some different challenges – e.g., in biotech the basic science is often less developed and the lead times from lab to market are typically long. But even in the life sciences, the incentive to link research agendas closely to market objectives has become stronger.

This presents a conundrum for policies intended to promote technology transfer from universities and government labs. If the transfer process – in the sense of a formal handoff from a lab to an engineering department and then to a marketing division – is being abandoned even inside corporations, then how much tougher it is to encourage technology transfer from entities that are outside the corporation, and particularly from those, like universities, whose incentive structures do not usually fit easily with commercial objectives. The relative lack of success of many university technology transfer programs should therefore come as no surprise. This entails the following implications:

- The primary role of universities is to produce highly trained people who, once they are in the commercial sector, will have the ability to adapt research results and advanced techniques from around the world to meet market demands. These employees then create the demand-pull necessary to make technology transfer effective.

- There is still an important role for policies and programs that foster technology diffusion, particularly to small and medium-size enterprises. The National Research Council (NRC) institutes and programs like the Industrial Research Assistance Program have continuing value. Internship programs that place graduate students in real business environments can also be effective as a means of technology transfer and in educating the interns about the realities of business. The University of Waterloo's internship programs have been particularly successful.

- The continuing withdrawal of business from the "research" end of the R&D continuum creates a growing void that can only be filled by universities and specialized institutes and revitalized government laboratories, perhaps acting in partnership. The public support of research has thus become even more important.

CLUSTERS

While technological advances have substantially increased opportunities for firm location, geographic concentration remains a feature of virtually every national economy in the OECD. Development of innovative activity usually takes place in a small number of regions with highly inventive regions tending to cluster together (OECD, 2008c). Social structure is an important component of economic development because new information and novel ideas are efficiently diffused through "weak ties", or acquaintances, within a community of interest. Geographic clusters of innovation activity represent such communities of interest through the links that naturally develop among a large group of people working in related fields and in close physical proximity (Granovetter, 1973, 1983; Porter, 1990).

There are several successful technology clusters in Canada. Among them, the Waterloo region stands out in the Canadian innovation system as an area that has developed a cluster of successful startup firms with a particular focus on information technologies (Box 16). There are several others across the country: for example, Ottawa has a leading cluster in communications technologies; Montréal has developed a digital media and computer graphics cluster; and Saskatoon has an agricultural biotechnology cluster. In every case, a local community has developed a sufficient critical mass of resources – from people to new ventures to financing and support services – to enable a self-sustaining ecosystem that nurtures innovation and growth.

While it is easy, after the fact, to identify successful clusters and to analyze what led to their success, public policies designed to create a cluster from whole cloth have

yet to demonstrate much success, though continued learning from initiatives like MaRS will aid the design of supportive policies. A recent review of regional innovation by the OECD highlighted that evaluation of current cluster approaches remains inadequate (OECD, 2007a). A significant component of this challenge is the "path dependency" of cluster development (Wolfe & Gertler, 2006). Experience has shown that highly individualized, and often essentially random, factors can influence the development of a local cluster or region. For example, the consent decree between the U.S. Justice Department and AT&T that separated Northern Electric from Western Electric (Box 20 in Chapter 9) was a critical catalyst in the evolution of the Ottawa ICT cluster. The U.S. decision had the collateral effect of cutting off Northern Electric from its traditional source of technology. This led to the creation of Bell Northern Research and its location in Ottawa, and planted the seed from which the Nortel-centred telecommunications cluster developed.

The Waterloo Experience

Although there is no sure-fire formula for cluster formation, a strong local catalyst and some pre-existing advantages appear to be the critical success factors. In Waterloo's case, without the anchor of the university and co-op training, the initial set of spin-off companies might never have happened. Without strong community cohesion, the region may not have been able to respond so successfully to the decline of its traditional industrial base. The development also owes much to the inspiration, drive and steadfastness of individual leaders within the university and the community. Individuals matter and are inevitably a unique and unpredictable element in any social process. One key lesson of the Waterloo experience is that this type of development takes time. While the university was founded in 1957, it took almost 25 years before the first wave of startups emerged. It has since taken almost another 25 years to reach the point that a sustainable ecosystem has emerged.

The combination of qualities that has made the Waterloo region such a successful cluster is difficult to replicate. Other regions that have developed technology clusters have often done so very differently. The development of a cluster is an organic process that typically depends on the fortuitous confluence of factors that self-reinforce, often in unpredictable ways.

San Diego's CONNECT Initiative

San Diego's reinvention as an innovation hotbed provides another instructive example of the combination of special circumstances with extraordinary local vision and drive. That city's economy had traditionally been heavily reliant on the military, and defence cutbacks after the end of the Cold War left it scrambling to

find economic alternatives. Necessity being so often the mother of innovation, a local political decision was taken to target life sciences as a new focus for economic development despite the fact that the city did not have a strong pre-existing base in the sector. San Diego has nevertheless been able to build a very successful life sciences cluster during the past 15 years with the help of CONNECT – a public benefits organization fostering entrepreneurship in the region by catalyzing and supporting the growth of the most promising life sciences and other technology-intensive businesses. San Diego now boasts a vibrant cluster of research-based commercial and publicly financed activity.

Toronto's MaRS Centre

A more recent effort to catalyze a research-based cluster is MaRS in Toronto (see also Box 14). MaRS includes a physical facility to bring multiple parties together with new ventures so as to foster the "weak ties" that can stimulate a local cluster. It provides incubation for startups and is expanding to support the technology transfer process for discoveries arising from local research institutions. This ongoing initiative by local business leaders and leading research institutions to create a global-scale innovation cluster in Toronto merits close attention for the lessons that will be learned from its comprehensive and ambitious model.

Box 16 – What's In the Water In Waterloo?

The region surrounding Waterloo, Ontario has evolved into one of the most successful innovation clusters in North America. The development of the region has owed much to the industrial tradition in the Kitchener-Waterloo area, which is home to many family-owned businesses rooted in the applied technical tradition of the German immigrant population. When the University of Waterloo (UW) was founded in 1957, its purpose was to support education and training in applied sciences – essentially, engineering. Local companies like Electrohome saw the need to develop local talent to meet their technical needs. From the beginning, UW's program was based on co-operative education that explicitly tied undergraduate education to experience working with industry. These roots are seen as a significant factor in the development of both UW and the region.

This base was reinforced with the growth of a leading program in mathematics and computer science at the university. Innovative developments, particularly the WATFOR and WATFIV compilers, enabled UW to offer computing access to all undergraduate students during the 1960s and eventually to build a world-leading program. Software developed at UW became the international standard for scientific computing and,

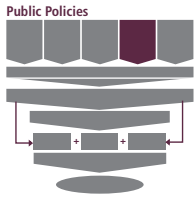
quite inadvertently, led to the creation of a business that sold and supported the software, but operated inside the university. During the 1970s, this leading-edge position enabled UW to attract eminent faculty to the region who were encouraged to engage in some industry-related work because it helped the co-op program and was seen as enhancing teaching.

After 20 years of development, the first wave of startup companies emerged from UW in the early 1980s. These were assisted by the creation of the Waterloo Research Institute and the Canadian Industrial Innovation Centre (CIIC), the first of their kind at a North American university. The CIIC supported inventors (as technology transfer offices often do today) and helped startup companies get off the ground with office space, training and assistance to obtain funding. Many of the leading firms in the region today emerged in this period, including RIM, Open Text and DALSA.

The 1990s saw a decline in the traditional industrial base of the Waterloo region – particularly, rubber/tires, chemicals and furniture – which convinced community leaders of the urgent need to develop alternatives. The local governments thus took steps to support new businesses – developing and servicing land provided at low cost to growing companies, and forming Communitech as a local technology association for the entire region. RIM has become the symbol of the region's success, but there were almost a thousand local technology companies identified in 2001, at the time of the last thorough attempt to catalogue them all. Eighty per cent of the technology companies in the Waterloo area are headquartered there and only one outside firm, Toyota, did not enter the local market by acquiring a local firm. Most of these companies continue to be led by UW graduates.

The latest development in the infrastructure to support startups in Waterloo is the Accelerator Centre. The goal of the centre, which is supported by UW, local businesses, and the federal and provincial governments, is to incubate new businesses developed by students and faculty from local universities and the surrounding community. The Accelerator Centre provides office space and facilities to approximately 20 companies at a time. It only accepts companies that have funding (e.g., they must pay rent for their space) and a viable business plan, and that are prepared to accept mentoring. In exchange, they receive support from business mentors (human resources, sales and marketing, etc.), an advisory board of local entrepreneurs and access to training programs focused on developing business skills. The centre opened in 2006, so the first wave of companies is just reaching the point where they can "graduate" to stand-alone facilities, making room for the next crop to move in.

Chapter 8 – The Influence of Public Policy



This chapter addresses the influence of several areas of public policy on the decisions of businesses in Canada to adopt innovation-based strategies. It is complementary to the foregoing treatment of structural characteristics, competitive intensity and the climate for new ventures, each of which is also amenable, in varying degrees, to policy influence. The present chapter addresses: broad macroeconomic conditions, international trade, education, regulation, taxation, and programs of direct support for business innovation. It was beyond the panel's scope to treat these subjects except in a highly selective and summarized way. Each could be the subject of a thorough study in itself.

MACROECONOMIC CONDITIONS

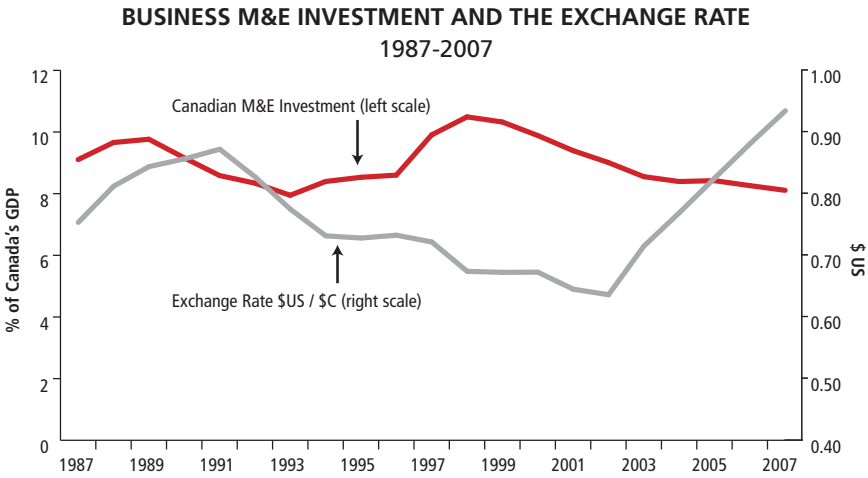
Prudent and stable macroeconomic management in Canada for the past decade-and-a-half, represents a remarkable turnaround following a quarter-century of public-sector deficits and volatile inflation. Since 1992, the Bank of Canada has kept the annual consumer price inflation rate within a target band of 1% to 3% almost continuously. Since the mid-1990s, and until the current global economic downturn, federal and provincial governments have restored budgets to balance, or surplus, making Canada one of very few OECD countries to do so consistently. Public debt has been reduced sharply as a percentage of GDP.[67] Taxes, particularly at the federal level, have been progressively lowered. These conditions have signalled an extraordinary commitment by governments in Canada to macroeconomic stability, the effect of which has been to bolster business confidence and thus to improve the environment for innovation-based strategies (OECD, 2009 forthcoming).

The current turmoil in world financial markets and the uncertain prospects for future economic growth have validated Canada's prudent policy making, but at the same time underlined the country's vulnerability to global macroeconomic conditions. So far (early 2009), Canada has fared better than many countries, but has still felt the effects on jobs and growth of sharply reduced export demand and lower commodity prices. As a relatively small open economy, Canada is particularly exposed to the vicissitudes of global markets and especially to conditions in the United States. While prudent macroeconomic policy provides some capacity to

67 Total public debt in Canada (on a National Accounts basis) had decreased to 22.6% of GDP in 2008, from 70.7% in 1995. Public debt in the United States had grown to 48% of GDP in 2008 (OECD, 2008c) and is on course to increase substantially. The response of governments everywhere to the current worldwide economic downturn will tend to increase public-sector debt ratios, perhaps substantially. In view of Canada's commitment, since the mid-1990s, to fiscal prudence, the country is better placed than most to keep its debt ratio below a level that might create alarm in global financial markets.

absorb shocks, further insulation depends on building a base of export industries at the leading edge of innovation in order to be among the last to lose market share if customers retrench.

The reduction of macroeconomic risk in Canada, by lessening one important source of uncertainty, would tend to increase the willingness of businesses to invest in innovation, other things being equal. Of course, other things are never equal. Between 1991 and 2002, the substantial depreciation of the Canadian dollar and relative slack in Canada's labour market combined to affect business incentives regarding the substitution of capital for labour. As noted in Chapter 3, while the weak Canadian dollar made imported capital expensive, it also made many export-oriented manufacturing businesses very cost competitive and thus stimulated rising M&E investment to facilitate growth. The subsequent commodity-induced rise of the Canadian dollar (through mid-2008) squeezed firms, particularly manufacturers, with the net effect that overall M&E investment ratios remained flat to declining despite lower Canadian dollar prices for many investment goods and a tighter labour market (Figure 8.1).[68]



Data Source: CSLS, 2008b

Figure 8.1

Business M&E Investment and the Exchange Rate

After the deep recession of the early 1990s, Canadian M&E investment (as a percentage of GDP) increased sharply even as the Canadian dollar weakened, increasing the average cost of M&E, much of which is imported to Canada. The technology boom – which collapsed in 2001 – was a factor but non-ICT investment intensity also strengthened in response to improved manufacturing cost-competitiveness as the Canadian dollar weakened.

68 Canada's unemployment rate was 11.3% in 1993 and had fallen only to 9.1% by 1997. By early 2008, unemployment was down to 5.8%, the lowest national rate in many decades, but by early 2009 had risen above 7% as the global slowdown began to be strongly felt in Canada.

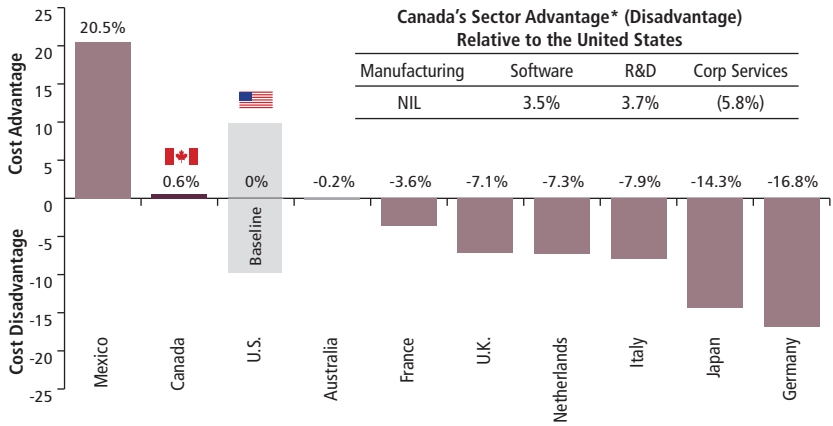
The depreciation of the Canadian dollar through early 2009 would, if sustained, increase Canada's manufacturing competitiveness; but by far the dominant factor now is weak demand globally, and particularly in the United States. When demand eventually recovers, commodity prices will increase and the Canadian dollar will almost certainly appreciate, once again putting competitive pressure on non-commodity exports. For Canadian firms in these sectors, innovation-based business strategies will be required to remain competitive once strong global growth resumes.

The Cost of Doing Business in Canada

International surveys of the overall cost of doing business invariably show Canada to be one of the most attractive locations among highly developed countries. The key results of the most recent assessment by KPMG (2008) are summarized in Figure 8.2. Although Canada's cost attractiveness has declined since 2006 as the dollar appreciated, Canadian locations generally remained cost competitive with the United States, both overall and in three of four major sectors, including the performance of R&D.[69]

BUSINESS LOCATIONS

Cost Advantage and Disadvantage Relative to U.S.



*$C assumed at par with $US in calculations.

Data Source: KPMG, 2008

Figure 8.2

Business Locations

The annual business cost analysis conducted by KPMG examines four key cost factors across 10 countries, relative to the U.S. benchmark. This figure shows a blended indicator of overall cost-competitiveness. Compared to other countries and despite assuming the Canadian dollar at par with the U.S. dollar (2007-early 2008), Canada retained a slight cost advantage over the U.S., though far less than Mexico.

69 The specific R&D activities analyzed by KPMG were biomedical R&D, clinical trials management, and electronic systems development and testing.

While Canadian business conditions overall have been very favourable, particularly since the mid-1990s, they may not have encouraged a growing commitment to innovation in view of (i) healthy profit growth (recall Figure 6.2 which shows that in Canada corporate profit as a percentage of GDP has generally exceeded that in the United States); and (ii) a relatively weak incentive environment for M&E/ICT investment. The current severe downturn in the world economy is now putting extraordinary pressure on manufacturing including key sectors like the global auto industry. This pressure can be expected to induce innovation in processes and plant-level organization; however, many management teams will need to be focused primarily on survival strategies. The more fundamental benefits of innovation accrue only in the mid-to-longer term and depend on a continuous commitment to innovation as a strategy.

INTERNATIONAL TRADE

The global expansion of markets has been a powerful driver of innovation and productivity gains. Openness to trade increases the scale of markets while facilitating the spread of knowledge, technologies, new businesses practices and competition (OECD, 2003b).

The general liberalizing trend of trade policy – until very recently at least – has thus encouraged innovation strategies. Still, Canada maintains substantial barriers, notably to the import of some agri-food goods and to imports or foreign investment in some services – for example, in sensitive sectors such as culture, health care, transportation and telecommunications. As discussed in Chapter 6, Canada's remaining foreign investment restrictions in a few key sectors have negatively affected innovation incentives by reducing competition, but the restrictions have not worsened over time. Indeed, the liberalizing trend of global and regional trade policies over the past several decades has provided an increasing incentive for Canadian businesses to place greater emphasis on innovation in their competitive strategies.

The concern looking forward – particularly in view of the severe economic stress worldwide – is of increased protectionism, or in fact any development that would impede Canada's access to the United States and other markets. A curtailment of export markets would reduce the size of the addressable market for many Canadian businesses and thus the potential return from an investment in innovation.

EDUCATION IN CANADA

Overall, education and the quality of human capital are Canada's most significant strengths and therefore offer little by way of explanation for long-term relative weakness in productivity growth or business innovation.[70] Consider, for example, the following indicators.

- Based on results from the Program for International Student Assessment, Canadian 15-year olds are consistently among the world's top performers in international evaluations of proficiency in mathematics, science and reading (OECD, 2007d).
- The Canadian labour force has the world's highest proportion of people with post-secondary education, though the share of university graduates (as distinguished from those with college or other post-secondary certifications) is somewhat below that of the United States (OECD, 2007b).
- The federal government's commitment to the support of university research – particularly in areas related to science and technology – has been strong since the mid-to-late 1990s (recall Figure 3.5), and the quality of Canadian academic research in most fields is highly rated according to international bibliometric analysis (Council of Canadian Academies, 2006). This has increased the supply of leading-edge R&D skills and, other things being equal, made Canada a more attractive location for innovative businesses. The competition from China and India, among others, for knowledge-intensive activity has meanwhile increased sharply as those countries have also succeeded in rapidly expanding their production of skilled people.

Of considerable significance for innovation performance, despite the foregoing advantages, is the fact that Canadian business managers are, on average, not as well trained as those in the United States. A smaller proportion of Canadian managers has business degrees, and there is a significantly lower percentage of Canadian business employees with advanced degrees than in the United States (recall Figures 3.9 and 3.10). This education gap may leave many Canadian managers less aware than their U.S. counterparts of developments at the leading edge of technology and business practice, or less comfortable adopting these developments, and thus less likely to choose business strategies that emphasize innovation. Moreover, the disadvantage can be self-sustaining because less innovation-oriented businesses may be disinclined to seek out highly educated managers or to encourage employees to take leading-edge management training. Eventually, pressure from the market can bring about change, but clearly it would be better to be proactive than reactive.

70 Recall from Chapter 2 (Figure 2.6) that improvement in the composition of the workforce has contributed more to productivity growth in Canada than in the United States since at least the early 1960s. This particular measure involves years of experience in the workforce as well as educational attainment.

REGULATION

The impact of regulatory policies is usually sector specific, thus few generalizations can be made. Moreover, the effect of regulation on business innovation may either be stultifying or encouraging. Regulations often inspire innovation either to meet the rules (e.g., auto emission limits and fuel efficiency standards) or to design around them (e.g., refrigerant substitutes for CFCs to avoid ozone depletion).

Environmental Regulation and Innovation

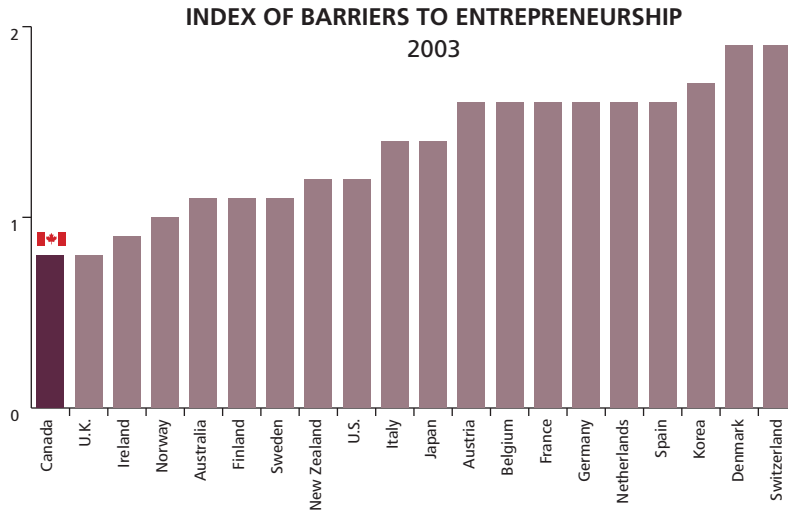
The intensifying pressure on virtually all aspects of the natural environment due to population and economic growth in general, and energy use in particular, requires an unprecedented innovative response, elements of which will need to be encouraged by well-designed regulation in all countries (OECD, 2008b). This is both an enormous challenge and opportunity for government and business, and will be one of the world's main arenas of innovation for decades to come. While Canada has some companies that have been successful innovators in various fields of environmental technology (e.g., fuel cells and wastewater treatment), it has not generally been an area of comparative global strength for Canada despite this country's outstanding research competence in many fields of environmental science (Council of Canadian Academies, 2006).

Market Regulation and Innovation

The OECD has developed a quantitative index of product market regulation (as distinct from labour market regulation). The index is used to rank countries on the basis of 16 indicators that are ultimately aggregated to a single number (Conway *et al.*, 2005). Subindexes permit countries to be ranked in respect of the degree of state control of business, barriers to trade and investment, and barriers to entrepreneurship. Statistical analysis demonstrates a link between the restrictiveness of regulation on the one hand, and lower investment and productivity growth on the other. The trend over the years has been for market regulation to decline in most OECD countries. By 2003, Canada ranked as the seventh least restrictive overall among its 20-country peer group, whereas Australia had the lowest index value. More specifically, Canada was judged, together with the United Kingdom, to be the least restrictive in respect of barriers to entrepreneurship (Figure 8.3) (Conway *et al.*, 2005).

On the other hand, Conway and Nicoletti (2007) have presented evidence that Canada's relatively restrictive regulations in several ICT-intensive sectors – particularly electricity, retail distribution, air transport and professional services – have contributed to Canada's weak ICT investment numbers. Their empirical work suggests that the main payoff from further regulatory reform in Canada would be

to increase the contribution of ICT-using sectors to productivity growth. They estimated that the improvement might be very significant – a potential increase in the rate of labour productivity growth of between 0.5 and 1 full percentage point – if Canada were to reform its remaining anti-competitive regulations to the standard of the most liberalized OECD country in each sector. Although an effect of this magnitude is unlikely to be achieved in practice, there nevertheless appears to be considerable potential for targeted regulatory reform to increase the incentives for innovation in many service sector industries in Canada, and particularly the incentive for ICT adoption and use.



Data Source: Conway et al., 2005

Figure 8.3

Index of Barriers to Entrepreneurship

The OECD has developed a methodology to estimate quantitatively the extent of regulatory barriers of various kinds. In 2003, Canada was judged to have the lowest measure of barriers facing entrepreneurs. (Lower numbers imply fewer barriers.)

There are other cases where regulation or government-endorsed monopolies inhibit innovation, either directly or indirectly. For example, many have claimed that farm product marketing boards, and associated protection from import competition, have curbed the development of the food products industry in Canada. It is also the case that the provision of health care, despite being one of the largest single economic activities in Canada, has not been designed and managed to foster innovation. On the contrary, a combination of bureaucratic control and an aversion to private-sector delivery, while serving certain public objectives, has inhibited innovation and thus diminished the economic development potential of the health sector and perhaps, in some respects, the quality of care that is available.

Intellectual Property Rights

Intellectual property rights (IPRs) – e.g., patents, copyrights, trademarks, trade secrets – play an important role in innovation strategies in certain industries. Patents, for example, are widely employed in pharmaceuticals, medical instruments and chemicals. Elsewhere, firms rely more on secrecy, time to market and customer service to protect their return on investment (OECD, 2008a). The design of IPRs must seek to balance the incentive to innovate with the spillover benefits to society of relatively unencumbered access to knowledge and innovative ideas. While Canada's IPR regime is generally considered to comply with global best practice, there is concern that efforts to thwart various forms of IP theft have been inadequate.[71] Moreover, the new challenges facing IPR protection in light of the Internet and other manifestations of information technology call for innovation and vigilance to keep Canada's IPR regulation on the leading edge.

TAXATION

Many studies over the years have pointed to a relatively high rate of business taxation in Canada, particularly as it affects the after-tax cost of investment in M&E (McKenzie, 2006). This would reduce the incentive for firms to accumulate M&E and, because of the strong linkages among M&E, R&D and innovation generally, would explain some part of Canada's weak productivity performance.

Marginal Effective Tax Rate

One theoretically relevant tax concept in respect of capital investment is the marginal effective tax rate (METR) though, in practice, statutory and average corporate tax rates are often used in investment decision making.[72] According to estimates by the C.D. Howe Institute (Mintz *et al.*, 2005; Chen & Mintz, 2008), Canada's METR for medium and large companies was the highest in the OECD in 2005 and 2006, though the comparable rate in the United States was only slightly below that of Canada. The federal government has meanwhile been steadily reducing corporate tax rates of various kinds, and in Budget 2009 committed to continue with measures that would give Canada the lowest overall tax

71 The *Global Competitiveness Report* in 2008 ranked Canada 15th in its 20-country OECD peer group, just behind the United States but with the same "score" of 5.6 out of 7.0. Switzerland, the Nordic countries, Austria and Germany ranked at the top with scores of 6.0 to 6.3 (WEF, 2008).

72 The METR seeks to measure the full economic impact of the tax regime on a business's evaluation of investment choices – specifically, it is the extra return that an investment would need to earn over and above the return needed to make the investment worthwhile if there were no taxes to be paid. It combines all applicable federal and provincial taxes and deductions and credits.

rate on new investment in the G7 by 2010 (Finance Canada, 2009).[73] Of course other countries are not standing still, so prospective comparisons might not materialize as forecast. Canada's rate would come down further if all provinces eliminated remaining capital taxes and harmonized sales taxes with the federal regime as some have. This is a large opportunity to substantially improve the incentive for business investment in Canada.

There are very large intersector and interprovincial differences in investment tax rates in Canada, and these would be expected to have a significant influence on business investment behaviour and, less directly, on innovation strategy. Canada's 2008 average METR of 29.1%, as estimated by Chen and Mintz (2008), masks large variations – for example, 11% for the forestry industry; 19.3% in manufacturing; and between 33% and 40% in retail and wholesale trade, construction and communications. Provincially, average rates vary from 22% in Alberta to 33.6% in Prince Edward Island. And within provinces, different industries are taxed differently. Comparisons with the United States also look different on a sectoral basis. For 2008, Canada's 19.3% METR for manufacturing was below the 25.4% rate in the United States, but the picture was reversed in the service sector, where Canada's 35.5% rate was well above the United States at 27.8%.

Preferential corporate income tax rates for small business might be an indirect impediment to corporate growth. Canadian-controlled private corporations pay a federal tax rate of 11% on their first $400,000 of income (a threshold that Budget 2009 proposed be increased to $500,000) and varying provincial rates that bring the total to between 13% and 19%. In 2008, income over $400,000 was taxed at almost double the rate levied on income up to the threshold. This has the unintended consequence of reducing, at least to some extent, the incentive for small businesses to grow beyond a certain size.

Viewed from a broader perspective, the overall trend of business tax rates in Canada in recent years has been downward, and that trend is expected to continue. In fact, on broad measures of corporate taxation, Canada now appears to be internationally competitive. A detailed study of effective corporate income tax rates in 10 countries[74] ranked Canadian rates to be among the lowest in three broad activity classes – manufacturing, R&D and corporate services (Table 9).

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73 Canada's general statutory corporate income tax rate (federal and provincial average) was 34.1% in 2007, the second lowest among the G7 countries. The rate is projected to drop to 27.2% by 2012, which, based on current projections, would be the lowest in the G7. The U.S. general corporate rate is projected to be 39.3% in 2012 (Finance Canada, 2009).

74 The 10 countries were Canada, United States, Mexico, Australia, Japan, United Kingdom, France, Germany, Italy and the Netherlands.

Table 9
Effective Combined Corporate Income Tax Rate*

	MANUFACTURING AVERAGE (%)	R&D AVERAGE (%)	CORPORATE SERVICES AVERAGE (%)
CANADA	24.0 (2)	– 4.4 (4)	29.6 (3)
UNITED STATES	33.2 (7)	36.0 (8)	38.4 (8)

*Percentage of net profit before tax for representative operations. The rates are calculated net of government grants and incentives.

Figures in brackets are rankings out of the 10 countries. The negative tax rate for Canada in respect of R&D activities reflects tax-based (refundable) incentives.

Source: KPMG, 2008

The economic effect of taxes depends on more than tax rates. Predictability matters as well. A tax system that is stable over long periods of time will do more to encourage investment in innovation than one in which tax incentives are turned on and off for various reasons. Firms need to plan for the long term, and there are enough uncertainties about future returns on investment without worrying that an adverse change in tax policies will suddenly change the economics of a given project.

The Scientific Research and Experimental Development Tax Incentive

In the specific context of innovation, the centrepiece of Canada's tax regime is the Scientific Research and Experimental Development (SR&ED) incentive (Box 17). This program, with an estimated annual tax expenditure (i.e., foregone revenue) of $4 billion in 2007 (Finance Canada, 2008, p. 285), is by far the most significant government-provided support for business R&D in Canada. The policy rationale, as noted earlier, rests on the belief – for which there is substantial empirical support – that the spillover benefits to the economy flowing from R&D-based innovation are usually much greater than the benefits that can be captured by the private performers of R&D. Thus a public incentive to induce more private R&D is justified. Delivering the incentive via the tax system avoids the need to target particular sectors, though, in the case of SR&ED, the benefit is designed to be greatest for small enterprises. A recent and rigorous cost-benefit analysis of the SR&ED by Parsons and Phillips (2007) estimated a net economic benefit for the Canadian economy of 11 cents per dollar of tax expenditure, or a benefit of about $400 million annually. Others argue that the tax benefit would have greater overall return if it were allocated instead to a reform of several aspects of the corporate tax system (McKenzie, 2006).

The impact of the SR&ED tax reduction is amplified by various other deductions and particularly by R&D credits provided by the provinces. An integrated analysis by Lester *et al.* (2007) estimated that the METR on investment in R&D by large

firms in Canada, based on 2011 projected rates, would be the second lowest in the OECD, only slightly higher than Spain and well below the METR on R&D activity in the United States. This, of course, assumes no further reduction in METRs for other countries.

Although Canada's tax-based incentives for R&D, and the SR&ED program in particular, are generally popular with businesses, there has also been persistent criticism of its design, primarily for the following reasons:

- The discrimination in favour of very small R&D performers – via the higher 35% credit and the refundability condition (Box 17) – blunts the potential benefit that could be induced if the more generous parameters were available to large firms, and might even have the unintended consequence of encouraging some firms to stay small (Wensley & Warda, 2007).[75]
- The SR&ED incentive is of much less benefit for large firms when tough economic conditions reduce or eliminate taxable income and there is pressure to delay R&D spending. A refundable SR&ED credit would strengthen the incentive to sustain the pace and continuity of R&D through downturns.
- Assistance via tax credits is untargeted and thus fails to direct limited public funds to R&D-based innovation activities that have the highest spillover effects. (On the other hand spillovers are extremely difficult to measure and it is virtually impossible to do so at the firm level.)
- The SR&ED incentive has induced firms to seek to define as much of their activity as possible as "R&D". A minor industry of consultants has arisen to assist firms in this regard. This type of behaviour does not produce incremental R&D-based innovation and thus reduces the net benefit of the program (Freedman, 2008).

The SR&ED and related incentives have also been criticized on the grounds that they have not closed Canada's gap in business R&D spending. But this is a specious line of reasoning since the real test is whether the incentive confers a net positive benefit to the economy. It is also the case that business R&D intensity has increased significantly in Canada (but also in other countries), and the gap might have been wider without the SR&ED incentive.

75 The system is acknowledged to be very generous for companies that qualify. For other business taxpayers, however, the Information Technology Association of Canada (ITAC) believes that the credits are at best a windfall at some future date when they can make use of them (but too late to have affected a firm's budgeting decisions on R&D spending when the credits were generated) and at worst a compliance exercise with no payback (ITAC, 2007).

Box 17 – Canada's SR&ED Tax Incentive

The SR&ED tax incentive is the federal government's single largest program supporting business research and development. Roughly 18,000 companies earned SR&ED tax credits in 2004 on allowable expenditure of $14.4 billion (Statistics Canada, 2007).

To qualify for the SR&ED program, work must advance the understanding of scientific relations or technologies, address scientific or technological uncertainty, and incorporate a systematic investigation by qualified personnel. This includes, for example:

- experimental development to create new products, or processes, or improve existing ones;
- applied research to advance scientific knowledge with a specific practical application in view;
- basic research without a specific practical application in view; and
- support for work in, for example, engineering, design, data collection, testing or psychological research, but only if the work directly contributes to the eligible experimental development, or applied or basic research.

The SR&ED program does not apply to, for example, social science research, commercial production of a new or improved product, market research, routine testing, routine data collection, exploring for minerals or development based solely on routine engineering practice, because these activities generate few spillovers.

The earliest tax support for business-performed R&D in Canada dates from 1944 but the SR&ED program in roughly its current form was introduced in 1983. The program supports SR&ED in all industrial sectors, with additional benefits for small firms. There are two forms of incentive: (i) an income tax deduction allows companies to expense immediately all allowable expenditures; and (ii) an investment tax credit – generally 20%, but up to 35% for small Canadian-controlled firms – is applied to income taxes otherwise payable. (Unused credits can be carried forward 20 years and back three years.) The tax credit is partially or fully refundable for smaller businesses in recognition of the fact that many R&D-intensive small companies are in their early stages and have little or no tax payable, and need cash to finance continued operations.

A detailed cost-benefit analysis (Parsons & Phillips, 2007) estimated that the SR&ED incentive produced a "net welfare" improvement of 11 cents per dollar of tax expenditure. This analysis employed a vast amount of empirical data from Canadian and international sources. Parsons and Phillips based their calculation of net benefit on (i) an estimate that the SR&ED incentive generates an additional 86 cents of R&D per

dollar of tax expenditure; and (ii) an assumption that the social rate of return to R&D expenditure – i.e., the spillover benefit that accrues in the Canadian economy – is 56%, being the median of eight separate Canadian estimates. The estimated cost of the SR&ED subsidy includes the opportunity cost of funding the program – the marginal cost of public funds – as well as administration and compliance costs. Parsons and Phillips estimated that the incrementality ratio would need to fall from their estimate of 86 cents to 71 cents, or the spillover rate would need to decline from 56% to 45%, before the net benefit of the program was reduced to zero. The majority of empirical estimates of these parameters exceed those thresholds.

A more germane question relates to the design and ultimate intent of the SR&ED incentive. This report has emphasized that R&D activity is undertaken as a means to implement the innovation strategy of a firm. By lowering the cost of a key activity like R&D, Canada's R&D tax incentives would be expected to (i) induce some Canadian firms to adopt more innovation-intensive business strategies, and (ii) attract firms from outside Canada to shift some of their R&D activity to Canada. These two channels of influence would largely account for the significant incrementality of the SR&ED program estimated by Parsons and Phillips (see Box 17). Despite the evidence that the SR&ED incentive has a positive net benefit, it cannot be concluded that the design is optimal, in part for some of the critical reasons noted above. It is also the case that the data are not available to estimate the SR&ED parameters that would maximize the net social benefit.[76] The SR&ED incentive can always be improved, so policy development concerning its design and range of application should continue.

DIRECT GOVERNMENT SUPPORT FOR INNOVATION

Governments can provide incentives to business directly rather than through the tax system. They can support desired business activity through grants, co-investments, government laboratories (via mandates that are important to business) and, less transparently, by various forms of favoured public-sector procurement. To the extent that such support mechanisms can be shown to subsidize export activity, they have been increasingly limited by international trade rules.

76 The calculation of maximum benefit requires equating marginal (social) benefit with the marginal cost of the program. The data used by Parsons and Phillips (2007) are based on average or constant parameters and therefore shed no light on the issue of optimality. They estimate simply that the net welfare benefit of the program is positive – i.e., 11 cents per dollar of tax foregone.

Direct forms of support are, almost by definition, targeted to specific sectors – e.g., aerospace and defence (Box 18). Their benefits and costs reflect many specific circumstances, so it is well beyond the scope of this report to survey, even at a high level, the effectiveness of the many innovation-promoting programs and institutions implemented by governments in Canada over the decades (Martin & Milway, 2008). Based on the evidence regarding Canada's innovation and productivity performance presented in earlier chapters, the cumulative effect of all this activity has not solved the problem. Even so, as was argued in respect of the SR&ED tax incentive, the net benefit of many programs may still be positive and there might have been even less innovation without them. The formal evaluation of government programs should ideally include a full cost-benefit calculation based on methodologies of equivalent rigour to that used by Parsons and Phillips (2007) in their evaluation of the SR&ED incentive.

Box 18 – Aerospace & Defence: Role of Government Support

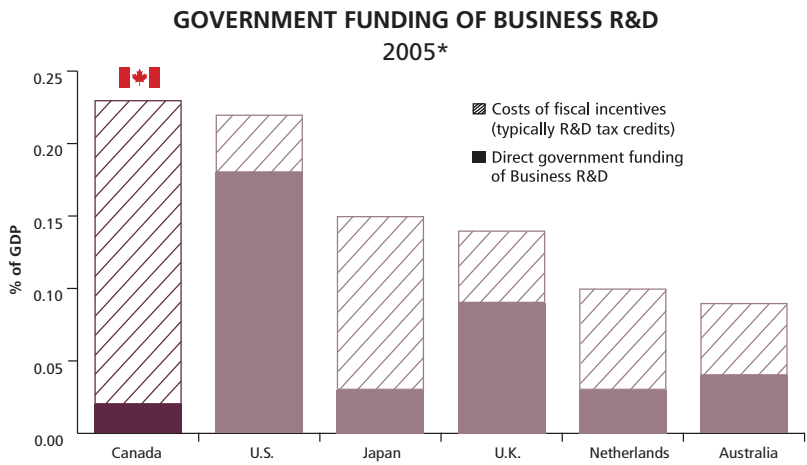
The aerospace and defence sectors stand out for the importance of government policy and procurement in their operations. Federal support for the sector has been a key factor in making Montréal a centre of excellence (a "cluster") for aerospace, much as Toulouse and Seattle have become in France and the United States. Industry Canada, through various programs over time, has participated in the development of anchor companies like Bell Helicopter Textron, Bombardier, CAE and Pratt & Whitney Canada. These companies have played a key role in developing a full industry, offering high-paying jobs and undertaking R&D individually, with other companies and organizations, as well as with universities. In fact, the R&D intensity of the Canadian aerospace industry is comparable to that of the United States, contributing about the same share in the economies of both countries (see charts in Annex III).

Since the demise of the Avro Arrow, Canada has largely abandoned the goal of developing major weapons systems domestically. Instead, military aircraft have been acquired from abroad, although with a requirement for some "benefits" spending in Canada to support related industries. As a result, Canada has some strength in training, in-service support and maintenance of equipment, and as a supplier of parts and components. Canada has not been a lead developer of new technology or systems, though some companies have become leaders in their sphere of expertise. For example, CAE is a world leader in flight simulators and training; Pratt & Whitney Canada is renowned for its engines; and Bombardier is one of a very small number of global suppliers of corporate and regional jets.

Beyond comments on sector-specific programs in certain case studies presented in Chapter 10, the discussion in this report is limited to some general principles based on empirical evidence from cross-country studies. The case for public support of business innovation (whether direct or tax-based) should be judged in terms of:

- *incrementality* – does the public subsidy simply substitute for work the recipient would have done anyway ("crowding out") or does it induce extra investment by the business ("crowding in")?
- *spillovers* – to what extent does the "social return" arising from the innovation activity induced by the public expenditure exceed the full economic cost of public funds?

This framework can, in principle, also be used to determine the most effective way to deliver a given amount of public support – i.e., whether via the tax system or directly. Canada's total government support for business R&D (tax and direct spending combined) is somewhat larger, relative to GDP, than that of the United States and the United Kingdom. It is noteworthy that Canada's heavy reliance on the tax assistance channel makes it virtually an outlier (Figure 8.4). This invites close analysis as to why Canada has chosen such an extreme mix of assistance delivery mechanisms and whether such a tax-heavy emphasis is appropriate.



Data Source: OECD, 2008h

Figure 8.4

Government Funding of Business R&D

Government funding of business R&D, whether through direct grants or tax credits, is a relatively small proportion of BERD in most OECD countries (e.g., about 20% in Canada). The use of tax-based incentives has been increasing in the OECD group, but Canada is unusual in its almost exclusive reliance on the SR&ED incentive.

The use of direct grants to firms has become less important in most economies with greater emphasis on both tax measures and the targeting of funds toward specific projects put out to tender (Jaumotte & Pain, 2005b). In 2007, 21 OECD countries offered an R&D tax credit compared to 12 countries in 1995. Parsons and Phillips (2007) have reviewed the extensive literature seeking to estimate the impact of different mixes of direct and tax-based support for business research and conclude that "…there is presently *no evidence-based reason* to choose between tax credits, grants and publicly-performed R&D as alternative ways to deliver support for R&D" (p. 34). This is a good starting point but is probably not the last word. For example, tax credits, as opposed to direct upfront subsidies, encourage different types of R&D by different types of companies. Subsidies are likely to be more effective in motivating firms to take bigger risks and are attractive to companies that are constrained for funds. Tax credits – unless they are refundable – benefit only profitable firms. Thus a policy based largely on (non-refundable) tax credits would tend to bias the innovation process toward established companies conducting less risky projects. Because of Canada's SR&ED credit is refundable for small R&D performers, riskier projects, for these companies at least, should not be discouraged by the nature of the tax incentive.

The OECD has extensively analyzed the impact on business R&D of government support, whether in the form of transfers to business, tax incentives, or publicly funded research in government labs and universities. Based on econometric analysis of data from 17 countries, including Canada, over two decades, Guellec and van Pottelsberghe (2000) have drawn the following broad policy-relevant conclusions:

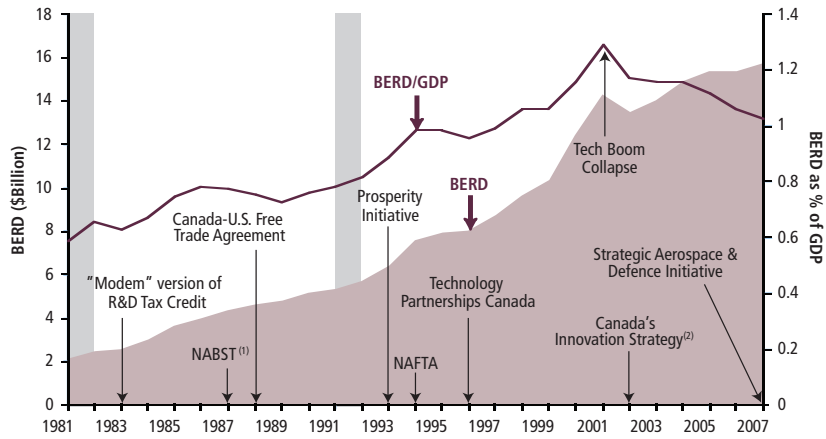
- Direct government funding of business R&D, as well as tax breaks, have a positive impact on business spending on R&D – i.e., there is incrementality.
- The impact of direct support is lessened if the amount, as a percentage of the activity being stimulated, is either too low or too high, since incrementality is found to decrease at both the low and high ends. (Specific circumstances would need to be investigated to determine the approximate optimum.)
- Both direct and tax-based support are more effective when stable over time. This is a significant conclusion and speaks to the importance of maintaining consistent support that is integrated into a stable cross-government framework. This principle was also emphasized by several business people interviewed by the panel.

Although the foregoing appear to be the more robust findings of the OECD work, even these conclusions need to be treated with some caution because they are based on multi-country data aggregated over time and thus may apply with more or less force in individual countries going forward.

A LONG-TERM PERSPECTIVE ON INNOVATION POLICY IN CANADA

It is instructive to revisit the long-term trend of business R&D spending in Canada (1981-2007), superimposing on it a number of key policy initiatives and factors – such as North American recessions and trade agreements – that might have been expected to influence the expenditure pattern (Figure 8.5). Nothing appears to have had a material impact on the gradual upward-sloping trend other than the Internet/telecom boom between the mid-1990s and 2001, and the aftermath of the bubble's collapse. While the aggregate impact of targeted support for business innovation is hard to discern in Figure 8.5, it can be decisively important at the scale of individual firms and sectors. The impact will be amplified if targeted support is integrated to reinforce a comprehensive policy framework that also promotes competition, new venture financing, encouragement for M&E/ICT investment and top-notch research universities.

THE MACRO CONTEXT FOR BUSINESS EXPENDITURE ON R&D
1981-2007



(1) NABST = Prime Minister's National Advisory Board on S&T.
(2) Included a target for Canada to be among the OECD's top five in R&D intensity by 2010.
- Shaded areas indicate recessions in North America.

Data Source: OECD, 2008g

Figure 8.5

The Macro Context for Business Expenditure on R&D

This figure shows the growth of BERD since 1981 (in current dollars and as a percentage of GDP) with a number of relevant economic and policy developments superimposed. The inflation and collapse of the tech bubble has had by far the largest impact on the aggregate trend.

A recent OECD paper (Box, 2009) has reviewed a decade of its research on innovation policy; the results are consistent with many themes in this report (Box 19). In broad terms, and over time, Canada has provided a progressively more encouraging environment for business innovation, at least in respect of those factors over which public policy has direct influence. But the generally weak innovation performance of Canadian business persists, so there is still a great deal of policy work to do – for example to:

- foster competition
- enhance the supply of finance for new ventures
- encourage the transformation of university and government research into innovation
- reform regulations that may be inhibiting ICT investment in certain service sectors
- continue to improve the design of tax incentives, and
- design ways to encourage innovation-based business strategies in sectors where Canada has demonstrated strengths or significant opportunities.

While the overall trend in innovation-promoting policy in Canada has been in the right direction, Canada's other benchmark competitors are not standing still. Globalization and ICT are changing the way in which a great deal of business innovation is conducted, and Canada's innovation performance is still far from where it needs to be.

Box 19 – Stimulating Innovation: Insights from a Decade of OECD Research

In 2007, the OECD launched concerted work on innovation strategy for presentation to its Ministerial Council in 2010. The *OECD Work on Innovation – A Stocktaking of Existing Work*, released in February 2009 (Box, 2009), provides a broad overview of OECD research over the past decade on good policy practices for innovation. A selection of findings from the paper that are of particular relevance for issues addressed in this report are summarized below.

Policy conditions that generally create a favourable environment for innovation include:

- macroeconomic stability, openness to trade and investment, deep financial systems, competitive markets, and regulation that is proportionate and appropriate
- flatter, lower and more predictable taxes, and

- labour markets that allow mobility and adjustment, assist workers to retrain and allow firms to undertake organizational change.

OECD research supports the following general propositions of relevance for policies to foster innovation:

- Access to secondary "high risk" capital markets, in addition to generally deep financial markets, is useful for young innovative firms.
- Intellectual property rights require a balance between rewarding risk-takers and diffusing new knowledge.
- Supporting management training appears to be beneficial.
- The role of government in clusters is mainly as a catalyst and broker for strengthening their formation.

The following areas were noted as in particular need of further investigation:

- More research is needed to appropriately measure human capital as an input to innovation. Especially important would be a better understanding of "soft skills" such as teamwork.
- Tax subsidies are increasingly used (relative to direct grants) to support firms. More evaluation is needed to determine the efficiency and effectiveness of this support since it is unclear whether the social benefits outweigh the costs.
- Since innovation is closely linked to demand from users, government as a large-scale purchaser can promote innovation by being a demanding buyer. More work is needed to better understand the linkages and policy responses to support innovation through procurement.
- Evaluation is sparse in many areas of innovation policy and much more work is needed to assess the return on government investment in the innovation activities of firms.
- Further work on the measurement of innovation is likely to yield benefits, particularly in understanding innovation in the service sector and better capturing the increasingly international nature of innovation activity.
- Indicator and related econometric research must move forward from innovation inputs and activities to include the outputs and impacts. A marked improvement in the policy relevance of innovation research is required in order to create a "science of science policy".

Chapter 9 – Business Ambition

This chapter addresses the intangibles that make up Canada's business culture – the attitudes that many believe have reduced the supply of entrepreneurial talent, the appetite for risk, the urge to grow and the propensity to innovate. The relevance of "business ambition" to an explanation of Canada's lagging innovation performance is a matter for debate based on evidence that is largely anecdotal. Business culture is almost by definition the residual explanation once all the other more tangible factors have been assessed.

THE INFLUENCE OF HISTORY

History matters. Canada's particular colonial history, its specialization in natural resources and its proximity to the U.S. colossus have had a powerful shaping influence on Canada's path of economic development and on the nation's values and the attitudes of its business people. Canada's early economic history was almost entirely a story of exploiting natural resources for overseas markets. The "staples thesis" first advanced in 1930 by Harold Innis provided a framework that not only fit Canada, but was readily adapted to other resource-rich countries like Australia. Innis argued that reliance on natural resource products for export to industrially advanced nations left Canada persistently vulnerable to shifts in world demand and decisively affected the country's culture and politics (Innis, 1930, 1940). Smardon (2006), in an extensively documented doctoral dissertation, argued that the Canadian economy is weaker, in terms of innovation, than other advanced economies because it has systematically relied on imported technologies in key manufacturing sectors. During two key periods of rapid growth (1870-1914 and 1945-73), imported technology allowed Canadians to enjoy high income and productivity growth without developing indigenous technology.

V.O. Marquez, when CEO of Northern Electric (later to become Nortel), put forward broadly similar arguments in 1972 (Box 20). Marquez drew on his extensive experience to conclude that foreign ownership and an abnormal degree of dependence on imported innovation and technology were key characteristics of the Canadian manufacturing economy. As a result, "…the lack of need to make risk decisions in Canada and the consequent stunting of experience in making such decisions have conditioned the managers of manufacturing enterprises in Canada into becoming inexperienced, diffident and reluctant risk-takers" (p. 40).

Canada's small size was no excuse, Marquez argued, noting that other small countries had followed different paths. His prime example, LM Ericsson of Sweden, was founded at about the same time as Northern Electric. Whereas Northern took U.S. design and technology from AT&T and simply manufactured for the Canadian market, Ericsson developed its own designs and sold globally because Sweden's domestic market alone was far too small to support the required R&D investment.

Box 20 – "Wanted: Small Catastrophes"

Excerpts from an article by V.O. Marquez in the Business Quarterly, Winter 1972. Mr. Marquez was, at the time, CEO of Northern Electric, later to become Nortel Inc. His views, based on practical experience on the front lines of the technology industry, give a particularly vivid account of the factors that have shaped the innovation behaviour of Canadian business. Thirty-seven years later, Marquez's observations are still relevant.

"Canada's problem is that technology and innovation from parent corporations, but also from other easily accessible foreign sources, have been so readily available, so economically attractive in the short term, that the growth of systematic, broad-based, indigenous innovative and technological capability has been severely inhibited.

When Northern was cut off from the source of technology on which it had depended for 75 years (as part of an anti-monopoly agreement struck between AT&T and the U.S. government in 1956) … [it] encountered obstacles and problems of which it had never been aware. It learned, for instance, that Canadians, in general, unlike the English, the Dutch, the Swedes, have developed little expectation of being asked to work for long periods of time in foreign fields. Most of Northern's people were reluctant to do so. Northern learned too, that when a company depends completely on imported technology, its history unknowingly insulates it from failure. Because the technology it uses is representative only of the R&D successes of its source, the recipient corporation has no real awareness of the fact that not all R&D explorations and costs result in success. Moreover, it is alarming to discover, at first hand, how much time and how substantial a commitment of resources have to be invested before a marketable product emerges which can make a return on the investment.…

We lack, above all, the entrepreneurial initiative achieved by others, not because their people have greater potential than Canadians, but because their corporations and their countries have been forced to develop more vigorous responses by exposure to severe conditions from which we have been insulated… Technology is not a prime mover; entrepreneurship is. Seeking by incentive to lure our present industries into

generating more of their own technology, or to seek foreign markets with vigor, will continue to meet with indifference and spotty success until and unless these activities are preceded by a greater proliferation of native entrepreneurial talent.

If progress and increasing self-reliance come from making a virtue of necessity and if we, in Canada, seek to be virtuous, we must somehow see to it that we create the necessity, but in a controlled way, so that we do not destroy our industries in the process. The generation of indigenous technology, and the relentless search for expanding markets, did not come about in Sweden and similar countries, or even in Northern Electric, because our government provided incentives for appropriate behaviour. They developed as natural and instinctive survival responses to demands from the environment.

Northern has benefited materially from the federal plans to stimulate innovation. But it is still uncertain whether any incentive plan to stimulate the growth of domestic technology and innovation, or to make corporations expand aggressively into foreign markets, can achieve significant success when it is applied to companies in which the drive to do these things has not already been forced to emerge because of exposure to a real stimulus from the economic environment. What we seem to need in Canada are 'small catastrophes'."

History tells a great deal about how Canada got to where it is today, but less about where it can go in the future. While Canada's colonial history and economic dependence on the United States have shaped the attitudes of previous generations, and of older native-born Canadians today, this history should be less a barrier tomorrow. Almost one-quarter of Canada's current adult population was born abroad, including a remarkable 55% in Toronto and 47% in Vancouver (Statistics Canada, 2006a). Canada's increasingly multicultural character is a significant potential advantage in a global economy where the greatest growth opportunities are in markets other than the United States and western Europe. Members of Canada's immigrant communities are increasingly moving into positions of business leadership that will allow them to exploit advantages of language, contact networks and deep cultural understanding to succeed in new export markets. Moreover, with each new generation, Canadian business people – whether born in Canada or abroad – will have an increasingly global mindset and be further removed psychologically from the more limiting conceptions that shaped the nation's past.

SOME EMPIRICAL EVIDENCE

The question of business culture is frequently the subject of surveys and commentaries in which there are two contradictory threads. One is pessimistic and reflects a widespread view among Canadian business people that too many of their number simply do not measure up to the standards needed for global success. While acknowledging plenty of exceptions, it is claimed that Canadian business people lack a sufficiently aggressive and entrepreneurial spirit, at least when compared with their counterparts in the United States.[77] The contrary view, based on surveys of the broader population – e.g., the World Values Survey conducted periodically in a large number of countries – contends that Canadians are not that much different from Americans when it comes to attitudes regarding risk and entrepreneurship, and therefore any explanation of innovation shortcomings based on public attitude and "business culture" is a red herring.

The more critical attitude was expressed characteristically in a 1999 report by the federal government's Advisory Council on Science and Technology which concluded that if Canadians "want to maintain our ranking as the world's number one country in which to live… We must become much more accepting of risk, more willing to celebrate and reward successful innovators and risk takers (and encourage those who fail, to try again)…" (section 5).

Similar views emerged in the *Global Entrepreneurship Monitor* (1999), which surveyed 1,000 people and about 40 "key informants" in each of 10 countries on different aspects of entrepreneurship. The broad public segment of the survey ranked Canada very high, second only to the United States on things like the proportion of adults trying to start a new business and perception of good opportunities for a startup.[78] But the 40 Canadian key informants – leading members of the business community – were much more critical. They regarded Canadians as less hard working, less ambitious and more dependent on government, mainly because of the social safety net. They thought that educators, because they did not understand entrepreneurs, failed to teach students the right skills. They were also critical of other business people. Too many family businesses aim too low; once the owners get the cottage in Muskoka or the place in Florida or a boat, they turn into a

77 In the words of Don Drummond, Chief Economist of the TD Bank Financial Group, "our machinery and equipment per hour worked is 55% of what it is in the United States… I think that there is a milder business attitude in Canada. We're not as driven or as entrepreneurial as the United States…" (Economist Intelligence Unit, 2007).

78 A much higher proportion of the U.S. public sample nevertheless perceived "good opportunities for a startup" – 57% versus 37% of the Canadian sample. As usual, Canadian attitudes lie somewhere between those of the United States and of other highly developed countries.

"lifestyle business" with no growth ambitions. The study's general conclusion was that although Canadian entrepreneurs were good at starting companies, the typical owner-manager was guided by the principle of financial and managerial self-sufficiency, with little or no reliance on external sources, and thus with less opportunity to grow to a significant size.

There is a widespread conviction in the Canadian business community, usually based on direct experience, that there is an inbred propensity among U.S. business people to maximize the economic heft of their enterprise – to always go for growth. In Canada and Europe, "good enough" appears more often to be reached at a lower level. In other words, there appears to be a deficiency of business ambition in Canada. Too many successful Canadian businesses would rather behave like an "income trust" than like a "venture capitalist".[79]

On the other hand, Canadians have been bold and entrepreneurial in domains where the country has had long experience and deep knowledge flowing from the particular opportunities and challenges the country has faced – mineral exploration and project engineering being good examples. Canadian business, on the whole, has acquired much less experience at the frontiers of science and technology, and has thus been less able to gauge the risks and opportunities in many of these domains. Fewer Canadian companies have therefore been prepared to adopt strategies based on technological innovation. Similarly, as described in Chapter 7, Canadian suppliers of risk capital have been much less skilled than their U.S. counterparts in financing technology-based new ventures. This is now changing, but it will take time.

To go beyond the anecdotal evidence regarding attitudes toward competitiveness, innovation, risk-taking and business, the Institute for Competitiveness and Prosperity commissioned a survey in 2003 to compare the views of the general public and business people in both Ontario and a "peer group" of American states.[80] To the surprise of the study's authors, the survey showed remarkable similarities in most of the attitudes in Ontario and the peer group: "…In contrast to the likely prevailing view, we differ very little from our counterparts in how we view business and business leaders, risk and success, and competition and competitiveness" (p. 8). This finding differs from the experience of many business

79 The contrast with the business ambition of the United States is clear in the words of Walt Whitman's essay, "Democratic Vistas". While acknowledging the occasional vulgarity of the American success drive, he accepted his country's "extreme business energy", and its "almost maniacal appetite for wealth". He believed that America's spirit of commercial optimism would always prevail (Brooks, 2009).

80 The U.S. survey covered Massachusetts, New Jersey, New York, Illinois, Virginia, North Carolina, Pennsylvania, Ohio, Michigan and Indiana.

people, including several panel members who, having worked extensively in both Canada and the United States, believe that there are real and significant differences, at least, in business attitude and behaviour, if not in the attitudes of the general population. Additional survey research would be needed to probe more deeply into the nature and determinants of business behaviour in Canada and the United States, and to determine whether these differences may be diminishing.

Further light was recently shed on certain aspects of the issue by the Information Technology Association of Canada (ITAC), which carried out focus group discussions with some of its members who had extensive experience in the United States and Canada. They concluded that there is a greater depth of management talent in the United States, especially in the ability to expand companies to a larger scale and to better exploit global markets. Because the U.S. market is so much larger than Canada's, U.S. managers have greater incentive to undertake disruptive change and reap the resulting rewards of growth and competitiveness (ITAC, 2008). This process is self-reinforcing since, as described in Chapter 7, it induces competitors to similarly pursue transformational innovation more aggressively. Business people in the United States inhabit a market with many more potential competitors, a daily reality that forces them to be more competitive than their Canadian counterparts. A U.S. CEO who fails to focus on winning, and therefore to focus on growth, will usually find that his or her company gets swallowed up with the CEO ending up regarded as a loser. Avoiding that stigma is a powerful psychological incentive.

INNOVATION AND GLOBAL GROWTH STRATEGIES

Innovation is needed to move from a domestic to a global growth strategy. Reciprocally, a heavy investment in innovation usually requires Canadian businesses to go for the scale of global markets. Global market strategies and innovation strategies are therefore interlinked. The ability, or willingness, of Canadians to compete in the global market has recently come under increasing scrutiny (Competition Policy Review Panel, 2008). While there is almost nothing in the way of hard data to measure characteristics like entrepreneurship, leadership, boldness, imagination or sheer moxie, there is a plethora of anecdotal material that points to a growing disquiet on the part of Canadian business people – especially those with a strong international perspective – over the reluctance of too many of their compatriots to move vigorously into world markets.

Canadian businesses, on the whole, have so far failed to aggressively grasp the opportunities created by globalization. Canada has never had a single global brand in consumer products, though the BlackBerry has become a contender.

Molson, for example, was about the same size in the 1980s as Heineken in the Netherlands; today, the Heineken brand ranks fifth in the world, selling 12 times the volume Molson does. Mexico's Corona is fourth (Mandel-Campbell, 2007). In other consumer products, Sweden has IKEA, Finland has Nokia, Italy has Armani, Gucci and Prada, and Switzerland has Nestlé and Rolex, among others. Of course consumer product manufacturing and marketing has never been an area of Canadian specialization, but neither was it of Finland or Sweden.

The picture is little different in the resource sector. Canada has no "super-major" energy multinationals and, notwithstanding Canada's vast forest tracts, no domestically owned forest company to rival those of Scandinavia. Despite a strong tradition in mining, only very few major players – e.g., Barrick Gold, Teck Cominco, and Sherritt International – have Canadian head offices. Inco and Falconbridge, having failed to merge into a new mining giant with a rich Canadian history, were sold to companies from, respectively, Brazil (CVRD) and Switzerland (Xstrata). Alcan's 2003 acquisition of Pechiney, the French aluminum giant, appeared at first to be a notable exception, but Alcan was itself taken over by U.K.-based Rio Tinto. Even when Canadians develop something new, we often fail to maximize its potential: IMAX languished until acquired by a U.S. company; and insulin, a Canadian discovery, was commercialized by Danes in 1923 through a company, Novo Nordisk, that now employs 25,000 people in 78 countries.

On the positive side of the ledger, Canada has produced companies like RIM, Cirque du soleil, SNC-Lavalin (an international engineering and construction firm), Bombardier (the world's third-largest aircraft maker), and CAE, all of which are still controlled by Canadians. Less well known are companies like Methanex, which won a quarter of the world market for methanol, a commodity, through service so good it could charge much higher than commodity prices; and Alimentation Couche-Tard, whose success with convenience stores in Canada was the springboard for a $1.1 billion takeover of 2,290 Circle K stores in the United States. High-profile losses like Alcan, the Hudson's Bay Company and Molson tend to attract much more media play than acquisitions of foreign firms by Canadian companies – e.g., Manulife's purchase of John Hancock Financial Services, TD Bank's acquisition of Commerce Bancorp (as a result of which TD now has more branches in the United States than in Canada) or Thomson's takeover of Reuters, a global company with deep historical roots.

Comprehensive research suggests that recurring fears of the hollowing out of Canadian industry through foreign takeover are probably exaggerated. Between 1994 and 2007, Canadian merger and acquisition (M&A) activity abroad exceeded foreign M&A in Canada, and the number of billion-dollar-plus deals was about

the same on both sides of the ledger (Thériault & Beckman, 2008). A study by the Institute for Competitiveness and Prosperity (2008) compiled a list of Canadian companies with more than $1 billion in annual sales and that also rank among the top five globally in their specific market segment. In March 2008, there were 40 such companies compared with 15 in 1985. The ICAP study identified only four Canadian companies, acquired between 1985 and 2008, that were deemed by the study's authors to be both innovative and globally competitive – Intrawest, Masonite, ATI Technologies and Alcan. And of these, only ATI and Alcan, the study said, represented cases of globally competitive and innovative companies whose new foreign owners turned them effectively into branch plants.

At the same time, there has been persistent concern that too many innovative startups fail to mature in Canada with the most promising often acquired and eventually relocated to the United States. The greater supply and sophistication of venture capital investors in the United States and immediate proximity to a larger market can be irresistible attractions for young, technology-based firms. Because these businesses are small they attract far less media attention than major takeovers but their disappearance saps the long-run innovation capacity of the Canadian economy. This underlines the importance of improving the climate for new ventures as discussed in Chapter 7.

THE IMPERATIVE FOR CANADIAN BUSINESS TO BECOME MORE AMBITIOUS

Are Canadian businesses good enough to compete in global markets, aggressive enough, willing to take risks, and sufficiently outward-looking beyond the huge and accessible U.S. market? Clearly, the many Canadians who have built successful global businesses have the necessary attributes. But the issue is whether there are enough of them to ensure the long-term prosperity of Canada's economy. The panel's view is that today, there are not. This is not due to any lack of innate capacities of Canadian business people – it is not in the "DNA", so to speak. Rather, 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 relatively subdued domestic competition, there are fewer market incentives to push toward the kind of competitiveness that can survive in larger world markets. As a small country, Canada offers a limited field on which business people can test themselves. Finally, the country is rich and business has been profitable – so why change?

The truth is that the behaviour of Canadian business will not change unless its circumstances change. Those circumstances are, in fact, changing radically due not only to the current turmoil in the world economy but, more fundamentally in the long run, to a massive reallocation of the share of global economic activity as China and others become full participants in world commerce. The demographics of the Canadian business community are also changing as immigrants and a younger generation of entrepreneurs, unencumbered by traditional attitudes, expand their presence. So whether by necessity or inclination, there is reason to expect that Canadian business will become more ambitious.

Chapter 10 – Case Studies: Sectoral Perspectives on Innovation

The big picture story of Canada's innovation performance described in the previous chapters has limitations. By averaging across widely disparate industries, a macro perspective conceals essential detail. No one industry is "average" and there is no one-size-fits-all explanation for Canada's innovation shortcomings. The strategic issues facing business leaders in each sector flow from the unique features of that sector's competitive environment. Individual sectors are also important when considering the nation's objectives for innovation. As a small country, Canada cannot expect to compete globally across all sectors and should focus instead on a limited number in which it can be among the world leaders.

The four sectors addressed in this chapter were chosen as examples because innovation tends to be an important business strategy in each and, taken together, they illustrate most of the innovation issues that arise in the economy. They are: automotive, life sciences, banking services, and information and communications technologies.

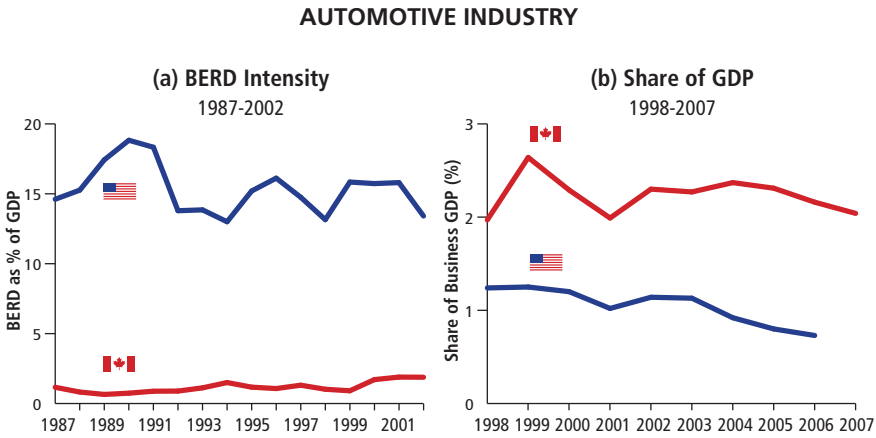
Innovation of course also occurs in Canada's resource-based sectors, which constitute an important source of export earnings and economic activity in many of Canada's smaller communities. Much of the innovation in the resource industries relates to process improvements, the adaptation of foreign-sourced M&E and techniques to Canadian circumstances, mineral exploration, and the financing and engineering of resource initiatives at all scales. But with very few exceptions, Canadian firms have not been at the forefront of innovation in capital equipment for resource sectors or in the development of the most sophisticated materials and products derived from the nation's resources – further evidence of Canada's characteristic "upstream" position in North American and global value chains.

The following four sectoral mini-studies have a common structure: first, some salient aspects of Canada's performance; then, a set of challenges related to innovation; and finally, some lessons for business innovation strategy drawing on the relevant factors discussed in Chapters 5 through 9. These mini-studies make no pretence to completeness and are intended as illustrations of the complexity and diversity of the innovation challenge.

THE AUTOMOTIVE INDUSTRY: WEAK R&D BUT STRONG PRODUCTIVITY

The Canadian automotive sector presents an innovation paradox – low R&D intensity accompanied by strong productivity growth and, until recently at least, significant success in export trade.

Canada's R&D intensity in the motor vehicles and parts sector is about one-seventh that of the United States (1.9% of value added vs. 13.4% in 2002). This gap (Figure 10.1(a)) has persisted for many years and, as discussed in Chapter 5, is a significant contributor to the overall U.S.-Canada R&D intensity gap. Nonetheless, Canada has for decades maintained a vibrant automotive sector that has gradually, and until recently, increased its share of total Canadian business sector output (Figure 10.1(b)). It is one of the country's largest employers and in 2007 had exports of $77 billion, almost 17% of Canada's merchandise total.



Data Source: OECD, 2008i

Figure 10.1
Automotive Industry

The auto industry performs a great deal of R&D in the U.S. and very little in Canada. Yet the industry actually makes up a much larger share of Canada's business sector, thus making Canada relatively more vulnerable to the industry's current crisis.

The low level of automotive R&D spending in Canada has not translated into poor productivity performance. For example, in 2008 the *Harbour Report* (the leading industry review of plant-level productivity performance) listed four Canadian

plants in the top 10 in North America on the basis of hours required per vehicle.[81] Average labour productivity in the Canadian auto industry has exceeded U.S. levels by a margin of 10% or more in recent years, making this one of the few manufacturing industries in which Canada enjoys a productivity advantage (CAW, 2008).

Between 2002 and mid-2008, the rapid ascent of the Canadian dollar undermined the cost competitiveness of the entire sector in Canada. Canadian plants cannot afford to be merely as efficient as those in other countries, but must continue to be more productive to maintain and attract investment in a relatively high-cost environment. The unprecedented decline in customer demand for motor vehicles since mid-2008 has now overshadowed considerations related to Canada-U.S. cost differences and left the industry in crisis in both countries. The discussion that follows is therefore relevant as and when the North American industry returns to a sustainable state, one condition of which will be a recommitment to innovation by the major U.S.-based firms.

Canada's Performance in Automotive Innovation

Innovation in the automotive industry generally takes place in one of three main forms. Each is handled differently.

Process Innovation	Productivity in manufacturing plants is largely driven by the iterative process of incremental innovation. This takes place primarily at the plant level, and the best process innovations are then dispersed throughout the manufacturing base of a multinational enterprise.
New Product Design and Development	The development of commercial products, including new generations of vehicles and parts, is proprietary to individual firms, but may be conducted in collaboration with parts suppliers as required. This research is more centralized than process improvements, but will be located based on the best engineering centre for the project. The parts suppliers will often locate their engineering staff close to the design team of the lead automotive manufacturer (see Box 4 in Chapter 2).
Advanced Technologies & Pre-competitive Research	Basic research on new technologies and projects of a pre-competitive nature are often conducted in conjunction with other automotive firms, universities or dedicated research labs, such as Canada's Auto 21 consortium.

81 The two Oshawa GM plants ranked second and third, the CAMI plant in Ingersoll ranked fifth and the Chrysler Brampton plant ranked ninth (Harbour Consulting, 2008).

The Canadian segment of the industry has focused on process innovations with a tradition of innovation in work processes and organization. For example, Chrysler and the Canadian Autoworkers (CAW) were the first to move to three shifts in a North American assembly plant. The CAW also recently established a unique labour-management relationship with Magna.[82] CAMI (a joint venture of General Motors and Suzuki) was designed to apply Japanese management processes in a union environment in a Canadian assembly plant. This kind of innovation is not captured in the R&D statistics, but has evidently benefited the productivity of Canadian automotive plants and, by doing so, encouraged additional investment in Canada.

Canada's performance in automotive product development has been mixed. While Magna and Linamar are among a small number of leading-edge, globally based parts suppliers, many of the smaller suppliers are focused on efficiency and cost reduction. (This is an example of the implications for firm strategy of being "upstream" in the value chain as discussed in Chapter 5.) Despite pockets of product innovation strength, Canada has primarily been an adapter, rather than a creator.

Although R&D spending is becoming more globally distributed, it continues to be focused primarily in the home country.[83] While GM and Chrysler have engineering centres in Canada at Oshawa and Windsor respectively, other assemblers present in Canada (Ford, Toyota and Honda) continue to source virtually all of their R&D and engineering activity from outside this country. Canada has some areas of strength in basic research – including lightweight materials, fuel cells and biofuel technologies – but better integration of this research with industry-sponsored initiatives would be desirable. Where there are automotive design centres in Canada, these facilities attract both talent and the R&D efforts of their suppliers. To the extent that such centres remain in the United States, or are established elsewhere, they can serve to pull R&D activity, even for Canadian firms, out of Canada.

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82 The "Framework for Fairness" agreement between the CAW and Magna is designed to create a more co-operative relationship between the union and the employer, and includes both improvements to traditional grievance procedures and a commitment by the union to resolve issues without work stoppages.

83 From 1982 to 2003, the percentage of R&D spending offshore by U.S. firms in all sectors more than doubled – from 7% to 16% – but still more than 80% remained in the United States. Meanwhile, Canada's share of that international spending declined from 15% to 11% (McFetridge, 2005); or put differently, Canada's share of R&D conducted by U.S. multinationals actually increased from about 1% to 1.8%.

Innovation Challenges Facing the Automotive Industry in Canada

Dependence on the Big Three

GM, Ford and Chrysler represent more than two-thirds of Canadian vehicle production (Industry Canada, 2006; Sturgeon & Gereffi, 2007), and purchase an even larger share of Canadian-made auto parts. There has been an increase in Canadian R&D and innovation activity by these companies in recent years (especially by GM and Chrysler), partly leveraged through targeted government support for new investment in Canada. But the declining North American market share of the firms – which reflects a long-standing innovation problem, including a failure to react quickly to a shift in consumer taste toward more energy-efficient vehicles – puts further pressure on the Canadian industry. While the pressure can be expected to stimulate a great deal of cost-saving innovation at the plant level, it cannot begin to solve the current problem for the North American auto industry as a whole.

Design of the SR&ED Tax Credit

The SR&ED tax credit (see Box 17) has been viewed as a mixed blessing for automotive innovation. Industry associations have claimed that the program defines R&D too narrowly since it fails to include some important aspects of commercialization and product development. The tax credit has also been criticized as perverse because, as noted in Chapter 8, it does not provide a timely benefit for large firms whose taxable income may be insufficient to use the credit to generate cashflow during a downturn.

U.S. Government Subsidy to Achieve Fuel Efficiency

A new competitive challenge facing automotive R&D activity in Canada is the prospect of U.S. government support (including US$25 billion in approved federal government-guaranteed loans for both research and retooling) to assist the industry in meeting new fuel efficiency standards. The U.S. Department of Energy has ample funding to support both R&D and plant retooling. Without comparable support in Canada, manufacturing capacity could follow the funding, taking engineering work and suppliers with it.[84]

Increasing Globalization

To remain competitive, Canadian assembly plants and parts manufacturers will need to step up their innovation performance in an increasingly global market. Multinational firms, including parts suppliers (e.g., Canadian-based giants such as

84 To provide a comparable level of support for investments and retooling in Canadian facilities, proportional to the size of automotive manufacturing in Canada, would require $4 billion to $5 billion in loan guarantees.

Magna and Linamar) and original equipment manufacturers, allocate their innovation activities across multiple jurisdictions (recall Box 4). Location decisions for R&D, engineering and product development now take into account the global availability of talent and relative costs, rather than being tied to the home country of the firm. Canadian engineers and scientists are relatively cost efficient, but the appeal of Canada as a location for globally sourced R&D programs has been undermined by the appreciation of the Canadian dollar in recent years.

Some Lessons for Business Innovation Strategy

The innovation strategies adopted by firms and establishments in the Canadian auto sector have been influenced heavily by structural characteristics – specifically the integration of the North American market and the role of foreign-controlled assemblers. The global success of parts makers such as Magna and Linamar shows, nevertheless, that ambitious Canadian firms can expand from their base in a Canada-U.S. supply chain to serve the world market.

The experience of Canada's auto industry shows that it is possible to build a successful, competitive industry without a strong base of domestic R&D. The structure of this sector in Canada has instead driven innovation strategies that focus on process efficiency and workplace practices. This raises the question as to whether public policies could be designed to foster more such gains in productivity. And how might the lessons from the auto sector be applied to resource industries where process efficiency is also of primary importance and R&D-driven innovation is less prevalent? While such questions of policy design are beyond the mandate of the panel, they suggest that innovation policies in Canada should not be too heavily focused on the more typical measures of innovation, such as R&D spending. These do not adequately take into account the Canadian context with its unusually high reliance on sectors that are components of global supply chains and do not necessarily require significant R&D spending to achieve greater productivity.

The recent decline of the automotive sector in the face of an extraordinary convergence of adverse factors – some demand-related and some exchange-rate-related – shows that Canada's automotive policy will need to become more flexible and proactive. Fostering Canadian-based innovation by both vehicle assemblers and parts makers, and by Canadian-based and global firms, should be a goal of a new Canadian auto strategy that emerges from the industry's crisis.

LIFE SCIENCES: GREAT PROMISE BUT MIXED RESULTS

Life sciences comprise the most R&D-intensive sector of the economy and generally exhibit a strong strategic commitment to innovation. The scientific dynamism generated by the genomics revolution and its applications promise to make life sciences a defining industry of the 21st century. While the broad definition of life sciences encompasses biological science and technology in relation to health, agriculture and the environment, the focus in what follows is on health-related biotechnology and pharmaceuticals. Companies in health-related life sciences are of three main types, each of which faces different issues (Clark, 2008):

- Large, brand name pharmaceutical companies are foreign owned and dominate the industry with more than 80% of total sales, most of which are patented medicines. In this sector, corporate success globally is dependent on finding new drugs, and in Canada on selling them at competitive prices in an environment where market access and pricing are largely determined by government policies.
- Small R&D-oriented companies – biotech and medical devices – account for relatively insignificant sales, but are important generators of innovation and future growth. These companies, many of which are startups, rely on VC financing, and therefore are sold (perhaps outside Canada) or wound down when VC support ceases.
- Generic pharmaceutical manufacturers represent more than 15% of industry sales and 40% of volume, but do relatively little R&D. (This R&D is aimed primarily at copying established medicines whose patents are about to expire.) Canadian generic firms are nevertheless quite competitive and export a significant proportion of their sales.

Canada's Performance

Canada's role in the global pharmaceutical industry roughly mirrors the country's overall size. With approximately 2.5% of global sales (and also 2% of global business R&D spending), Canada is a small player in the sector overall (Table 10). However, even those small amounts are sufficient to place Canada in the global top 10 by most measures. Within biotechnology, Canada ranks even higher and is typically in the top five. In generics, Canada is also well ahead of its population rank, with strong global competitors in Toronto and Montréal.

Table 10
Share of Global Business Expenditure on Pharmaceutical R&D

	% OF GLOBAL EXPENDITURE			
COUNTRY	1990	1995	2000	2004
U.S.	37.3	41.5	38.3	36.5
Japan	16.2	14.9	14.3	14.8
U.K.	12.1	11.8	13.3	11.1
France	6.4	8.5	7.8	7.6
Germany	8.1	5.0	6.7	7.5
Sweden	2.1	2.7	3.7	3.6
CANADA	**1.2**	**1.5**	**1.7**	**2.0**
Rest of World	16.6	14.1	14.2	16.9
Total Global Expenditure (%)	100.0	100.0	100.0	100.0
Total Global Expenditure ($US billion)	16.9	24.6	33.8	46.2

Data Sources: Macher et al.*, 2008, p. 209; for Canada, calculations derived from OECD data (2008i)*

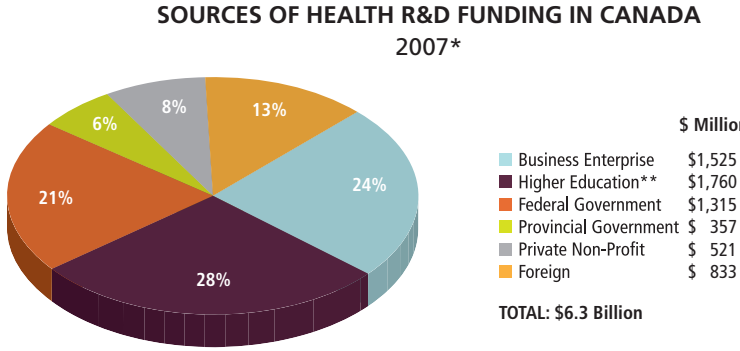
National currencies converted to $US at purchasing power parity (PPP) exchange rates as published by the OECD.

In total, Canada spends a little more than $6 billion annually on R&D in the health-related life sciences sector (Figure 10.2), but that overall figure masks a complex reality:

- Global pharmaceutical firms fund clinical research in health care facilities, which accounts for a large share of total spending. Some of their Canadian affiliates also maintain pre-clinical research facilities, which contribute only a small percentage of their R&D efforts.
- Generic firms spend about $70 million in development R&D.
- Governments and private non-profit organizations fund significant basic and pre-commercialization research in universities and teaching hospitals, which accounts for more than half of the total spending.
- Finally, biotech and medical devices firms spend in total a few hundred million dollars per year, which is funded by VC firms, large pharmas under co-operative arrangements, and refundable SR&ED tax credits.

Anecdotal evidence suggests that the total life sciences research effort is generating significant discoveries, although reliable and up-to-date data are difficult to obtain.[85]

85 One study that looked at drugs approved by the U.S. Food and Drug Administration between 1998 and 2003 found that 2% had Canadian origins, based on the locations of the patent holders (Kneller, 2005). This would be comparable to Canada's current share of global business R&D spending, but greater than Canada's share when the discoveries would likely have been made. In 1990, for example, Canada's share of global business expenditures on R&D was only 1.2%.



*Statistics Canada estimates used for 2007.
**Higher Education includes teaching hospitals and comprises expenditures by the institutions from their own revenues (some of which are provided via general support from governments).

Data Source: Statistics Canada, 2008f

Figure 10.2

Sources of Health R&D Funding in Canada

Public sources (governments, universities and teaching hospitals) contributed about 55% of the funding to support health R&D in Canada, or about $3.4 billion in 2007. The actual performance of the R&D would be more heavily concentrated in universities and hospitals.

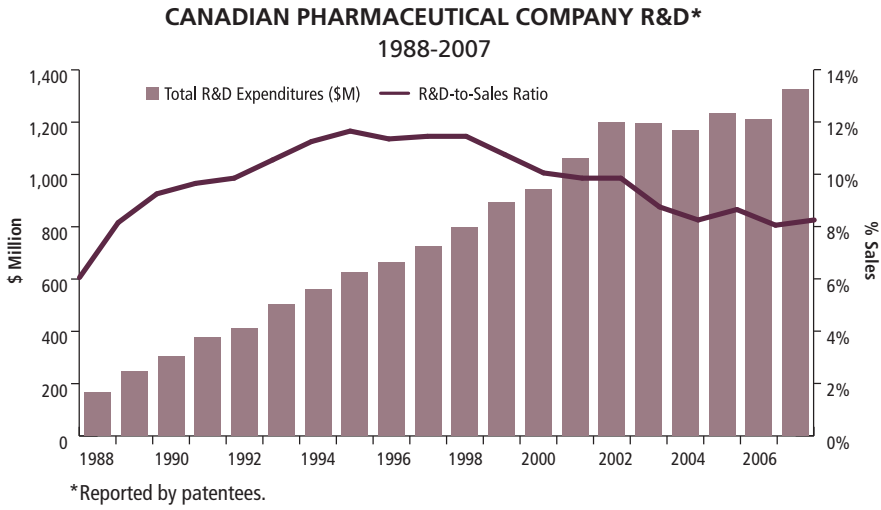
The Role of Public Policies

The life sciences sector has been of significant interest to policy makers and investors for more than 20 years. Beginning in the 1980s, Canadian governments adopted a variety of policies intended to promote the development of the sector, and specifically to encourage growth in R&D. These policies included patent law changes and additional government funding for research. The multinational pharmaceutical companies committed to spend 10% of their sales on R&D in return for favourable patent legislation (colloquially referred to as bills C-22 and C-91).

These policies were successful in generating additional R&D in Canada (Figure 10.3). Business spending on pharmaceutical R&D grew from less than $200 million in 1988 to more than $1.2 billion in 2003. Private-sector spending has been complemented by significant public-sector investments, with both the federal and provincial governments increasing their support for health-related R&D more than threefold over this period. No other sector has received this level of direct public R&D support. The public investment nevertheless failed to produce the economic results desired or expected.

Although private R&D funding – mostly by the Canadian affiliates of global pharma – has increased sixfold, the share of the pharmaceutical industry in Canada's business GDP has fluctuated around 0.5%. Meanwhile, the U.S. share has almost doubled, growing from about 0.6% of business GDP in 1987 to 1% in 2002 (Figure 10.4(a) and (b)). While Canada's pharmaceutical exports have grown significantly from $1.5 billion in 1998 to $6.8 billion in 2007, the industry still represents less than 2% of Canada's total exports (Industry Canada, 2008). In sum, although Canada has had a policy to promote pharmaceutical R&D spending in Canada, and has had success doing so, the domestic economic impact has been limited.

Even in areas where Canadian research has been successful, the commercial exploitation of that knowledge has tended to take place elsewhere. This has been the case for not just the R&D undertaken by the large pharma companies, but also by the growing biotech industry – e.g., Biochem Pharma and QLT. While there has been some modest success growing mid-sized firms in Canada, most have been absorbed by larger global enterprises. The one area where Canada has had increased commercial success is in generics, which benefited from the government's previous policy of compulsory licensing.

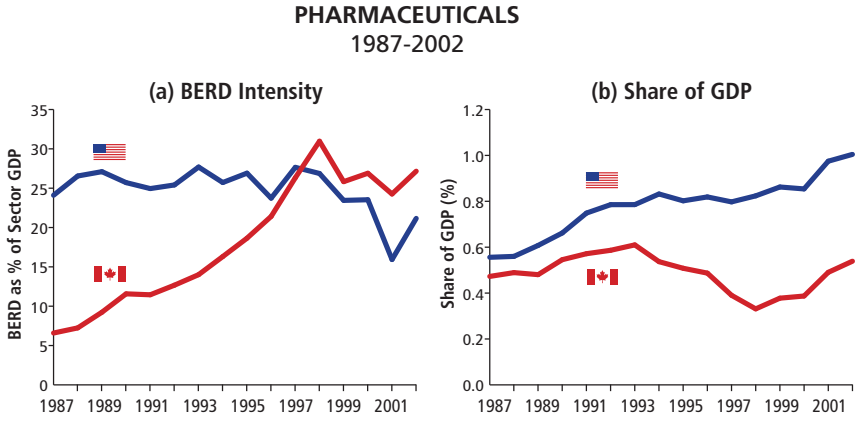


Data Source: Patented Medicine Prices Review Board, 2007

Figure 10.3

Canadian Pharmaceutical Company R&D

The pharmaceuticals industry boosted its R&D spending in Canada very significantly following a commitment to raise R&D to 10% of sales in the context of stronger patent protection (Bills C-22 and C-91).



Data Source: OECD, 2008i

Figure 10.4

Pharmaceuticals

The R&D intensity of the pharma industry in Canada actually exceeded that of the U.S. after the late 1990s – the result of industry undertakings in the context of Canadian patent laws tightening. But the size of the sector in Canada did not grow and in 2002 was much smaller relative to the U.S. than it had been in 1987. (The R&D ratios in Figure 10.4(a) are relative to value added and are thus larger than the ratio in Figure 10.3, which is relative to sales.)

Innovation Challenges Facing Life Sciences in Canada[86]

Segmenting the Product Development Value Chain

Fifteen years ago, Canadian biotech companies in the health sector and the local subsidiaries of large pharmaceutical companies rarely communicated. Biotechs were concentrating on funding their research, which was far from being marketable, and large pharmas had enough promising "molecules" in their pipeline to fulfil their needs. The past decade has seen a significant shift in the R&D spending of large pharmaceutical companies. During the 1990s while their worldwide R&D expenditures tripled, the number of new drugs approved is estimated to have fallen by about half. This has forced the major companies worldwide to look beyond their own doors for new opportunities. The shift in strategy has fit with the need for smaller biotech firms to seek out partners to take promising compounds through high-cost later-stage trials and to market. The product development value chain has thus become segmented: more basic research is taking place in university labs, early development and testing is conducted by biotech firms, and large pharmas step in to complete the regulatory process and apply their global scale to marketing and distribution.

For small Canadian biotech companies, the most appropriate ties to large pharmas are typically not through their Canadian subsidiaries, but directly with R&D or product development groups abroad. Since the symbiosis between biotech and pharma is increasingly important, the countries that will become leaders in the health-related life sciences are those that create conditions where the mutual interdependence can flourish.

Competition for R&D Mandates

The multinational pharmaceutical companies have been tightening their R&D budgets worldwide in response to the sharp decline, noted above, in the innovation productivity of in-house R&D. The competition for local R&D mandates has therefore intensified and Canada is increasingly competing against low-cost locations like China and India. Although the research environment in Canada is strong, the country is seen by the global industry as increasingly uncompetitive in terms of market access to provincial formularies, drug pricing and patent rules, which, in combination, undermine new business opportunities.

Ireland is frequently cited as a jurisdiction that made a concerted effort to develop a domestic life sciences sector by attracting foreign investment and research. While

86 This section should be read in the broader context of Chapter 7, *The Climate for New Ventures*. Most of the analysis and discussion in Chapter 7 applies with particular relevance to new ventures in the life sciences.

the Irish education and tax advantages are well known, these served, in effect, only as headlines to get the attention of global firms. In reality, it is an approach that "hugs" prospective investors, by developing specific policies and incentives to support them, that is more effective in securing and retaining foreign investment.

Challenges for Small Startups

A review of biotechnology innovation worldwide by the U.S. National Academies (Hermans *et al.*, 2008) emphasized the small and immature nature of the biotech industry – less than 500,000 employees worldwide, but with more than one-third focused on R&D. In Canada, some 490 biotech firms collectively employ fewer than 12,000 people; however, more than half of their employees are in R&D, and their combined R&D spending (US$1.2 billion in 2003) is comparable to that of the large pharmaceutical companies in Canada.

Globally, the biotech-based sector consists primarily of small firms, with limited sales (if any), seeking to develop new products. Two big exceptions are Amgen and Genentech, U.S. firms with 2007 sales of US$14.3 billion and US$8.5 billion respectively.[87] Few small firms will carry a product through to commercialization. Instead, once a viable candidate has been identified, it will either partner or merge with a larger player to obtain the funds necessary to complete development and enable distribution on a large scale.

Small biotech companies, typically startups, are dependent on external financing to fund research and product development and thus face the same issues that confront other innovative new ventures, as outlined in Chapter 7. They are particularly dependent on technology transfer, venture financing and local innovation clusters. Moreover, the exceptionally long development cycles in health biotech present a significant challenge that other technology-based sectors do not face to the same extent. (The process of bringing a new pharmaceutical product to market often takes 10 to 15 years, from initial discovery to final regulatory approval, and can cost more than $1 billion.) For a biotech startup focused on a single potential product, there will usually be little or no opportunity to generate revenue throughout this lengthy process. To get a startup to market therefore requires risk capital that is both large and patient.[88] The long product cycle of the life sciences affects the development of the industry because it delays the big rewards from blockbuster successes as well as the industry's movement up the learning curve.

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87 In early 2009 Genentech agreed to a takeover bid by Roche, a global pharma.

88 Startups in the ICT sector can often generate meaningful returns based on products in three to five years, using significantly less capital than biotech firms usually requires. Software firms can be even faster and less capital intensive.

Legacy of Poor Results

The 1990s saw a significant increase in funding for new biotech ventures in Canada. Sharply increased funding of university research and availability of venture capital produced a surge in life sciences investments and new ventures. Unfortunately, the number of invention disclosures did not increase in proportion to the volume of funds injected. Instead, too many spinout companies were created with neither experienced management nor a viable business case. Inexperienced venture capitalists compounded these problems by failing to bring the due diligence and operational expertise that is always needed to weed out unlikely prospects and install better management. Too many companies were founded on the promise of a single compound and therefore had no alternative strategy when that compound proved to be unpromising. With insufficient discipline from the investors at the time, many ideas continued to be funded, albeit at a cripplingly low level, after there was little realistic hope of success.[89]

The poor results of the venture investments in the 1990s have produced a predictable pullback, with the entire sector now finding it difficult to obtain additional funding. This kind of searing experience can ultimately teach a valuable lesson to an entire industry. Even failed startups produce more experienced management, and poor returns help weed out weak players in the VC industry. The challenge created for life sciences is that the learning process can take a decade or longer. Thus survivors from the mid-1990s are only recently likely to be in a position to produce a marketable product. But once there is a critical mass of commercial winners, the industry can become self-sustaining as successful entrepreneurs establish new companies themselves or become the angel investors and savvy mentors of the next generation of startups.

Some Lessons for Business Innovation Strategy

The innovation strategies of life sciences companies are strongly science based and thus are heavily influenced by public policies that support R&D as well as research and training in universities. Public policies in respect of health procurement and regulation are also of great importance, particularly for national subsidiaries of multinational pharmaceutical firms facing strong and increasing competition for innovation in support of world product mandates. The strategies of the smaller, biotechnology-based companies are very heavily influenced by (i) the overall climate for new ventures in Canada, and particularly by the availability of patient early-stage finance and mentorship; and (ii) their ability to strike collaborative arrangements with global pharmas.

89 The ability to weed out losers quickly is key for R&D efficiency. Large firms with multiple compounds in development have this ability whereas the owners of a single-product enterprise are naturally reluctant to cancel further development of that one product – even as realistic hope fades – since this would leave the firm with nothing.

The experience of life sciences demonstrates what can and cannot be accomplished through a targeted government policy. The federal government set out to generate increased R&D spending in the life sciences in Canada. It worked, thanks to the combination of a commitment by large pharma (based on patent law changes), and direct government funding and support. However, this only succeeded in achieving the immediate goal – increased R&D spending – but it has not yet produced the expected follow-on benefits, neither of a rapidly growing research-based pharmaceutical sector nor a vibrant, sustainable biotech industry.

Additional IP protection could strengthen Canada's position as an R&D location and help domestic affiliates in winning global mandates, but new IP policies are not likely to be sufficient. More important is the fact that, with the exception of Québec, governments do not view life sciences as a genuinely high economic priority. Their failure to take a holistic approach to the sector means that government procurement practices are not harmonized with industry development objectives. Despite significant effort to create a favourable investment/innovation climate for life sciences — e.g., patent legislation, R&D tax credits, support for venture capital and direct government funding of research – the economic development potential of life sciences has been implicitly regarded as less important than constraining health care costs through access and pricing controls on drugs.[90]

Given Canada's single-payer health care system, governments here have the opportunity to support innovation that goes beyond the decision of whether to approve a new compound at Health Canada or the provincial formularies. Canadian governments could seek to establish a leading role in using health innovation to improve the productivity and quality of the health care system. An exceptionally promising initiative in this regard is the partnership among the federal and provincial/territorial governments through Canada Health Infoway (a federally funded, not-for-profit organization) to accelerate development of an electronic health record for all Canadians. In the context of an aging population and the increasing importance of health care, innovation opportunities are certain to increase in the future.

The following general conclusions can be drawn from Canada's experience in seeking to encourage innovation in the health-related life sciences:

90 Even when economic development and health policies do not conflict, policies adopted in different jurisdictions can act at cross-purposes. For example, in 2006, just as Québec was removing a price freeze on patented pharmaceuticals, which would have improved the attractiveness of the Canadian market, Ontario adopted Bill 102, which had the opposite effect by imposing new pricing constraints. Canada's reputation in the global industry was not enhanced.

- Research and government funding are not sufficient conditions. While R&D spending may be necessary for innovation success in life sciences, it is the ultimate commercialization success that counts economically for Canada.
- Creating a vibrant life sciences industry requires a coherent set of government policies. These go beyond IP rules and funding for R&D to cover all aspects of government policy making, especially the role of departments of health in controlling the publicly insured market access for new compounds.
- New ventures are difficult. While this is true of all startup companies, it is particularly true in the life sciences sector where the time lag between discovery and taking a product to market can be 10 to 15 years. This requires particularly patient sources of venture financing, and investors and VC fund managers who have not only deep pockets but also deep industry knowledge.
- Public policies should seek to increase links among industry participants: global pharmas with sophisticated product management and marketing competencies; biotech and medical devices companies with creative new products, but facing significant regulatory and marketing challenges; and universities and research centres with great ideas, but few links to the marketplace.

BANKING SERVICES: TRADE-OFF BETWEEN STABILITY AND RADICAL INNOVATION

Financial services contribute almost 7% of Canada's GDP, but play an even more important economic role as the facilitators of investment and of transactions for virtually all goods and services. The degree of financial sector development is thus of paramount importance for productivity growth (Levine *et al.*, 2000). The feedback between finance and innovation underlines the distinction between the innovations enabled by the sector, on the one hand, and innovations within the sector, on the other. This case study addresses the latter in the context of the banking subsector, which comprises about 60% of the overall financial services industry in Canada.

Canada's Performance

The Canadian banking sector has a long history of innovation and technology adoption including some of the earliest deployments of automated teller machine networks, multi-branch banking, the Interac point of sale debit system and electronic bill payments. Canada's relative strength in innovation appears to have been due traditionally to the difference between the banking industry structures in Canada and the United States. The areas where Canada has been an innovation leader have depended on attaining a critical mass of customer and merchant adoption in order to generate benefits. The small number of large, fully national banks in Canada provided the necessary co-ordination and scale of adoption of these technology-based innovations, an advantage that the highly fragmented, state-centred banking

system in the United States lacked. Banking is, in fact, one of the very few industries where scale has traditionally played to Canada's advantage.

Some cross-country measures of bank productivity are described in Box 21. Canadian banks do very well on certain metrics but the absence of "apples to apples" comparisons of banks in different countries, or with different business mixes, make it difficult to draw firm conclusions as to the comparative efficiency of, for example, the Canadian and U.S. banking sectors.

Innovation during the last 20 years in the U.S. market followed a different pattern from that in Canada. The consolidation of the U.S. industry – as multi-state banking restrictions were progressively relaxed during the 1980s and finally eliminated nationwide in 1994 – created giant institutions capable of competing through scope and scale, and which have required technology and process innovations to operate nationally or globally. Smaller financial institutions – unable to compete in terms of scope of services – were forced to specialize, and this required innovative ideas to generate the differentiation needed to survive. At the same time, the largest banks were acquiring or outsourcing specific services from smaller innovative specialists. In the United States, price competition by the specialized firms resulted in rapid, incremental innovation aimed at leap-frogging competitors. For example, the development of direct marketing for credit cards was driven by two small regional banks, MBNA and Capital One, which used ICT and targeted marketing to grow into large, but specialized, credit card providers.[91]

Box 21 – Measures of Bank Productivity

A metric often used to evaluate the productivity of banks is the *expense ratio*, defined as "non-interest expense divided by net revenue". Thus lower ratios indicate greater cost efficiency in revenue generation. A comparison of expense ratios by the IBM Institute for Business Value (2008) showed that, in 2007, the average Canadian expense ratio (0.66) had improved to match the level of larger European and Australian financial institutions, but still remained above a set of large U.S. banks (0.62). Care is needed in interpreting the expense ratio because it can hide important differences among subsectors of the industry. The expense ratios of Canadian retail bank operations are generally close to those of their U.S. counterparts. At the same time,

91 Most of the more novel recent innovations in U.S. banking rely on applications of ICT and include, for example, smart cards; mobile and biometric payments; personalized, bundled and automated mortgages (an innovation that evidently has a major downside if not rigorously managed and regulated); personal product integration and loyalty programs; and microfinance.

Canadian banks are less concentrated in wholesale banking than their U.S. "money centre" counterparts. Since expense ratios are inherently lower in wholesale banking, the greater wholesale weighting in the largest U.S. banks translates to a "structural" tendency for these banks to have lower expense ratios overall than the large Canadian banks. The superior U.S. expense ratios are thus due to a scale effect rather than to superior cost-saving innovation.

Other metrics indicate that the Canadian banking industry may actually be more efficient than the U.S. industry. For example, Allen *et al.* (2006) compared "assets per employee" in the major Canadian and U.S banks and, by this measure, Canadian banks lead. They also estimated the empirical relationship between costs and financial services provided by banks. They found that Canadian banks are more cost efficient and tend to be closer to "best practice" bank efficiency than their U.S. counterparts.

Yet another approach has examined cross-country variations in the price of a standard customer bundle of essential banking services. Since price, in a reasonably competitive market, should reflect the internal cost to the firm of providing services, such a measure could approximate firm efficiency.[92] According to this study (Capgemini *et al.*, 2005), the cost of core banking services in Canada – an average of €93 – was lower than both the global average of €108, and especially the U.S. average of €126. Moreover, this work found that Canada had the least price discrepancy among institutions in terms of core banking. While such price convergence might be interpreted as evidence of an oligopolistic market structure and muted competition, it could equally be evidence of competitive convergence to a margin-based price that earns Canadian banks a standard market return on capital.

Given the many unresolved measurement issues, conflicting results and limited data, it is impossible to come to firm conclusions as to the precise comparison of productivity between Canadian and U.S. banks. More rigorous studies, underway by the Bank of Canada and others, should eventually allow stronger conclusions to be drawn.

92 This measure of efficiency may be skewed by individual country preferences and cultural practices. The Netherlands, for example, has a bundle price of €34, which is more a reflection of payment-in-cash norms than banking efficiency. By the same token, U.S. consumers are prone to using paper cheques, which inflates the estimated price of the consumer bundle. These details illustrate the difficulty of developing reliable "apples to apples" indicators.

The Structure of Competition and Innovation in Canadian Banking

The Canadian banking system is dominated by five major banks of national scope – Royal Bank Financial Group, TD Bank Financial Group, Scotiabank, Canadian Imperial Bank of Commerce and Bank of Montreal – which hold more than 85% of total assets. Standard formal measures of competition, such as the Herfindahl-Hirschman Index, indicate a high level of concentration and this is often taken as evidence of a lack of competition in the industry. However, simple concentration measures may obscure the degree of competition between incumbent firms and the degree of market "contestability".[93] Allen and Liu (2007) find a high degree of contestability in Canadian banking and thus conclude that Canadian banks do not exercise collusive oligopoly power.

The major players in the Canadian banking industry compete primarily through mild product differentiation aimed at creating brand recognition. Rather than competing aggressively on price or in specialized services, they seek to maintain their market share through brand loyalty and thus offer a full range of services to all customers.[94] The particular structure of the Canadian banking industry reduces the incentive for "visible" innovation (in product, service and marketing) since such innovation can be quickly copied by the other competing banks, thus nullifying the benefits sought by the first innovator. Instead, innovation in the Canadian setting typically takes the form of *internal* process and organizational innovation, which is less visible and therefore less readily copied. (This is supported by heavy investment in ICT physical capital and software, which embody a great deal of innovation indirectly.) Innovations from elsewhere eventually diffuse across the Canadian banking industry, usually not in the early phases of adoption, but rather after an innovation proves successful in other markets, and the costs and risks have become well understood. This "early follower" strategy has kept the industry in Canada from slipping behind.

The view among several industry executives consulted by the panel, and who have worked in banking in both Canada and the United States, is that Canadian banks

93 A market is considered to be contestable if barriers to entry are not prohibitive and if firms can exit the market without enduring punitive damages. A contestable market may be characterized by a small number of firms; however, these firms may be motivated to remain highly innovative and efficient by the prospect of new entrants – e.g., as illustrated in the lower right quadrant of Figure 6.1.

94 The national scope and range of services offered by major Canadian banks has steadily expanded since the 1980 Bank Act revision (Allen & Liu, 2007). This allowed the major Canadian banks to expand in trust and securities and thus enhanced the number of financial products that each bank could offer. An important feature of Canadian banking was the absorption by the large commercial banks of the major independent investment banks/dealers in the late 1980s, thus bringing this segment of the financial services industry under the umbrella of the rigorous national regulatory oversight that is applied to commercial banking in Canada.

lack the winner-take-all competitive ferocity found in the United States, although this may be changing given the recent surge of international expansion of Canadian banks. Recently, four major Canadian banks – Royal Bank Financial Group, TD Bank Financial Group, Scotiabank and Bank of Montreal – have made significant retail and commercial banking investments beyond Canadian borders into the broader North American market. (TD Bank, for example, now has more branches in the United States than in Canada.) The forays, together with the recent severe distress in the U.S. financial industry, have propelled these Canadian banks to be among the largest in North America when ranked by assets, deposits, market capitalization or number of branches (BMO Capital Markets, 2009).

Finding the Balance between Innovation and Stability

More than in virtually any other sector, innovation in financial services is a double-edged sword. Both the benefits of getting it right and the costs of getting it wrong are enormous and not easily managed. In particular, banking is an industry that requires exceptionally vigilant regulatory oversight in order to ensure that risk is kept within appropriate bounds, that the bank's obligations are transparently disclosed and that a high level of funder/depositor confidence is maintained.

The events that have recently rocked the world's financial system are proof that innovation and specialization do not always create beneficial results for the institutions themselves, nor for society. The banking crisis is a case where several financial innovations combined in unforeseen ways to generate a drastically negative outcome. First, subprime mortgages were marketed in the United States to the under-banked who were lured by easy access to credit and lower initial interest rates ("teasers"), and by the prospect of continuously rising house values. Second, financial assets, including mortgages, were packaged into securities (often sold to foreign investors) and were frequently used as collateral by their buyers when raising loans, thus amplifying the fragility represented by the high-risk mortgages. The two innovations essentially separated the ultimate investors from those who originated the loans, and greatly complicated the path of recourse in the event of default. This reduced the incentives to carefully evaluate the risk potential of borrowers in the first place. Moreover, the sheer complexity of the financial engineering compromised risk evaluation and oversight. At the same time, regulators in the United States and several other countries looked aside as financial institutions dramatically increased the ratio of assets to capital ("leverage") so as to boost return on equity. When the steady upward march of house prices finally reversed, the fragility of this new financial intermediation process became apparent to everyone.

The forced deleveraging of the financial system has had catastrophic consequences for many banks in the United States, United Kingdom and elsewhere, but not

nearly to the same extent in Canada. High standards of bank supervision in this country and more cautious business strategies (e.g., relatively few "subprime" mortgages were created) have insulated Canada's banks from the worst of the global financial sector turmoil.

Some Lessons for Business Innovation Strategy

The innovation strategies of the major Canadian-owned banks strongly reflect the market structure of the sector – i.e., a small number of domestically dominant players of national scale – and the corresponding nature of competition. The state of domestic competition has militated against a strong focus on product innovation leadership (being content with early adoption) and led instead to strategies to secure customer loyalty and to stay at the cutting edge of service delivery efficiency through heavy ICT investment and training.

The generally more conservative banking and regulatory practices prevailing in Canada – relative particularly to those in the United States and Europe – have kept Canadian banks off the "bleeding edge" of innovation in the design and distribution of the most sophisticated financial instruments. Experience has proven this to be a sound strategy. IMF analysts consider that the performance and stability of Canada's major banks are among the best in the world (IMF, 2008), and a recent WEF survey rated Canada's financial system to be the world's soundest (WEF, 2008).

The success of Canadian banks over many years may have dulled their business ambition. With limited exceptions, most Canadian banks were, until fairly recently, content to focus on the domestic market and to restrict their international activity primarily to commodity-type wholesale banking as parties to international lending consortia. Now Canadian banks have become more aggressively and creatively outward-looking with many examples of large investments to establish a substantive presence abroad.[95]

The recent turmoil in the banking industry globally has created a window of opportunity for Toronto to become one of the major North American, if not worldwide, innovation centres for the financial services industry. (The Global Financial Centres Index, published by the City of London, U.K. (Zen/Y 2008), ranked Toronto 12th worldwide, and fourth in North America behind New York, Chicago and Boston.) Although the headquarters of major Canadian banks are already in Toronto, given the global context of the industry, these banks have

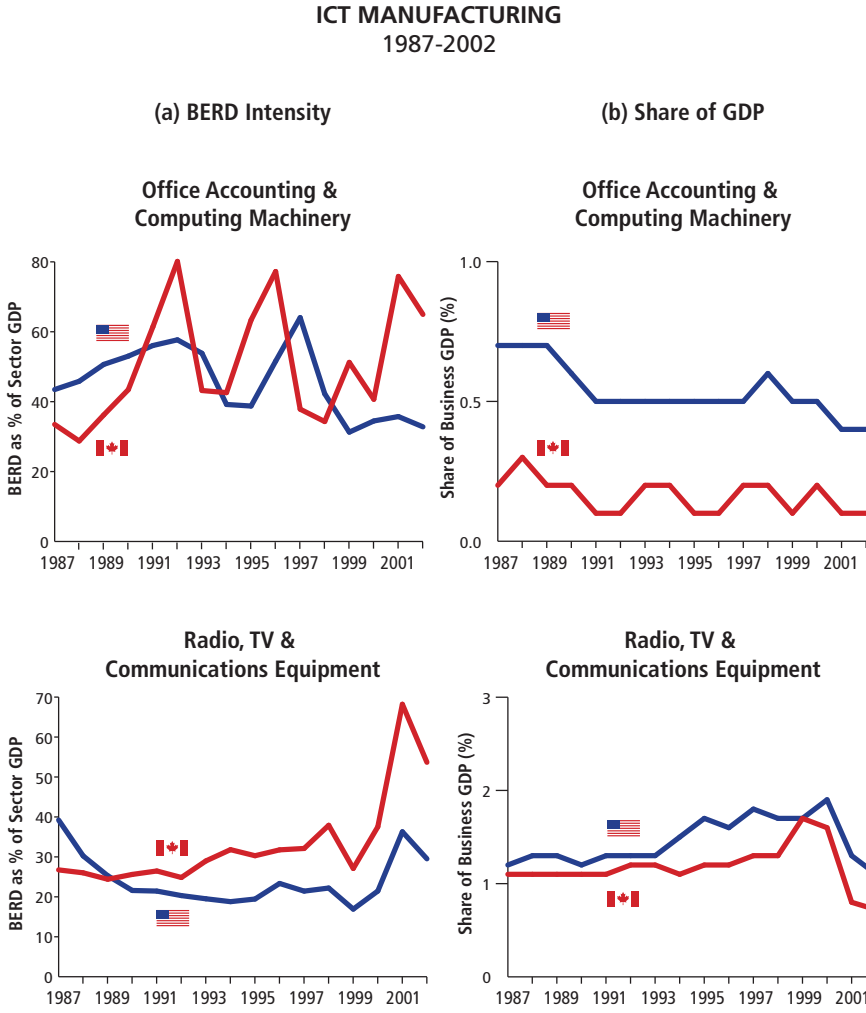
95 This is not an entirely new phenomenon. Several Canadian banks were operating in the Caribbean, even in the late 19th century. Scotiabank has had a branch-based presence in several countries for many decades and the Bank of Montreal acquired Chicago-based Harris Bank in 1984.

economic and strategic decisions to make as to where to locate their product and service development, software programming, data centres and other innovative activities going forward. With the right business climate, Toronto has the potential to emerge as a centre not only for these activities, but also to attract specialists from around the world to create financial industry products and services.

ICT: A CATALYTIC ROLE FOR GOVERNMENT

Information and communications technologies are vitally important for innovation because (i) the producers of ICT are themselves key innovation-intensive sectors of the economy; and (ii) the use of ICT in other sectors contributes increasingly to productivity growth in the entire economy, and particularly in service industries. The relatively low rate of ICT adoption in Canada (described in Chapter 3) has not prevented the development of a vibrant industry with successful global competitors. The data in Figure 10.5a (which capture the principal manufacturing components of ICT) show that the Canadian industry matches, or even exceeds, its U.S. counterpart in R&D intensity. On the other hand, Figure 10.5b reveals the principal weakness – i.e., as with other technology-intensive sectors, the Canadian industry is significantly smaller (as a share of GDP) than its U.S. counterpart. While Canada generated an impressive $31 billion of ICT exports in 2006, it had a trade deficit of $18 billion in the sector. For Canada to improve its position in ICT, the challenge is to grow more businesses that can expand the sector's role both in the domestic economy and in exports.

The existing set of ICT businesses in Canada evolved from multiple sources. Multinational firms have established Canadian operations to gain access to the domestic market or to Canadian talent. For example, IBM Canada established a significant presence (both in manufacturing and R&D) to position itself as a Canadian supplier to government. Echoing the principles behind the Auto Pact, IBM received "domestic" treatment in procurement by ensuring that comparable value was produced in Canada. As with the automotive industry, the Canadian operations were specialized to serve a market beyond Canada to ensure that the benefits of economies of scale could be obtained (see Box 24). IBM's presence has been expanded over time through the value of skilled employees and the acquisition of Canadian firms, most recently Cognos. In addition to the multinational presence, Canada has had considerable success growing innovative new ICT businesses, some of which have become major global players (Box 22) while others have attracted foreign investment through acquisition.



Data Source: OECD, 2008i

Figure 10.5

ICT Manufacturing Expenditure on R&D

Canada's R&D intensity in important components of the ICT sector has been comparable to, or even greater than, that of the U.S., despite the large role of foreign companies, especially in the computing machinery segment. (There has been a sharp drop in R&D by the communication equipment sector in both countries since the end of the tech boom in 2001.) The ICT equipment industry, and particularly the computer segment, is much larger in the U.S.

Box 22 – A Tale of Two Innovators: Nortel and RIM

Canada's greatest strength in ICT is in communications equipment. The cluster of firms in Ottawa, built around the presence of Nortel, the National Research Council and the Communications Research Centre, has had considerable success in many areas of communications equipment. There are other pockets of expertise, notably in Waterloo, Québec City, Calgary and Vancouver. Within this group, two companies stand out: Nortel Networks, with a century-long history and a significant record of innovation over the past 40 years; and Research in Motion, a new entrant that has caught the global wave of wireless data services. Both have strong records of innovation, but with very different histories.

Nortel Networks is a traditional telecom equipment supplier that, as described in Box 20, transformed itself from a manufacturer of acquired technology to a developer of world-leading innovations. This strength in innovation allowed Nortel to become one of the largest communications equipment manufacturers in the world at the height of the technology boom at the end of the 1990s. Many of the technology startups in Ottawa (heavily weighted toward communications and networking) can trace at least part of their lineage to the research labs at Bell Northern Research or Nortel itself (Doyletech, 2002).

Since the technology bubble collapsed in 2001, the company has been forced to retrench drastically to the point of seeking bankruptcy protection in early 2009. Part of Nortel's challenge is shared by all the large "legacy" equipment providers (e.g., Alcatel-Lucent): the market they supply has shifted decisively to new Internet-based and wireless technologies that (i) play to the strength of new competitors, such as Cisco, that have developed around the new technology; and (ii) reduce revenue and profit from legacy businesses. The latter challenge has been exacerbated by competition from low-cost Asian suppliers of core legacy products.

RIM was founded in the early 1980s, but only began its significant growth in the last decade with the launch of the now iconic BlackBerry. Unlike Nortel, RIM's entire business is based in an expanding segment of the market (mobile smartphones and services). RIM also reflects a different model of innovation than Nortel – it is a venture-backed company (it did not generate positive net income until 2004) that is centred on a single, core product. Rapid evolution and clever design have kept RIM ahead of its competition, including much larger firms such as Nokia, but the parade of new competitors keeps coming. Unlike Nortel, whose principal strength had been in mature/declining segments of the telecommunications market, RIM is squarely placed in a growth segment (smartphones) within a growth segment (mobile handsets).

Both of these companies are good examples of Canadian innovation success. But, as Nortel and its peers have demonstrated, success is never guaranteed in rapidly evolving technology markets. The ability to sustain a well-financed and commercially productive innovation *process* that can adapt to changing tastes and technologies is key to long-term survival. It is a lesson that all emerging Canadian technology leaders need to keep in mind.

Innovation Challenges Facing the ICT Sector in Canada

Canada lacks the domestic market size to support a full-bore ICT sector. While Canadian exporters have been expanding their market reach beyond the United States to Asia and Europe, the relative weakness of the domestic market has hindered development. A survey of successful venture-backed firms in Canada found the lack of local customers to stimulate performance to be the weakest aspect of Canada's innovation system generally (Martin and Millway, 2005). Venturesome customers benefit innovative businesses by playing a role in the product development process as early or lead adopters.

Slower Adoption of New Technology

The available evidence suggests that Canadian small and medium-sized enterprises are a significant source of Canada's lagging rate of ICT adoption (Sharpe, 2005; Sharpe & Arsenault, 2008). The perception of industry participants is that the slower adoption of new technology among Canadian small businesses (as compared with SMEs in the United States) was a significant source of the growing ICT investment gap during the 1990s. The reasons for this are still debated. Attitudinal issues may explain the technology-follower approach of Canadian firms. Martin and Millway (2007) argue that "management is a significant driver of demand in an effective innovation system. Capable managers *support* the demand for innovation through a keen understanding of the need for product and process innovation in developing company capabilities" (p. 5). From this they conclude that Canada's "lower level of human capital resources means [Canadian businesses] are less able to compete in a technology-based knowledge economy, as well as to serve sophisticated and demanding customers in a global marketplace" (p. 9). While the relative cost of capital and labour has also had an impact on investment in ICT, at least until recently, the perception of many industry participants is that too many Canadian managers of SMEs lack formal training and thus lack the knowledge and confidence to take full advantage of the benefits of ICT.

This adoption gap has an impact on the ICT-producing sectors. In addition to shrinking the effective size of the Canadian market, it leaves Canadian new entrants without local lead customers. As a result, they must either establish operations elsewhere, closer to a base of early adopters, or compete that much harder to overcome the challenges of distance. The weak SME market for ICT investment has the further effect of limiting the development of a surrounding ecosystem of service and support firms that can evolve into growing ventures. This makes ICT adoption by Canadian SMEs that much more difficult.

Globalization of Value Chains

Canadian firms cannot compete internationally on cost – instead, they must rely on superior skill and value creation. Meanwhile, ICT manufacturing has been moving steadily to lower-cost jurisdictions. The rapid shift in personal computer manufacturing to China is one example, but the trend is common throughout the industry. While some high-value production remains in Canada and likely will for some time, retaining mass production is unlikely (Box 23).

Canada has adjusted by developing a growing base of "fabless" semiconductor companies, where the design is conducted in Canada and the manufacturing is outsourced. Canada has also had success in software, but, to maintain and grow capacity, the domestic workforce must remain competitive in the face of the improving skill levels in developing countries. Recent trends are cause for concern. During the 2005-06 academic year, for example, the share of enrolment at Canadian universities in mathematics, computer and information sciences was 3.5% of total enrolment, the lowest since 1992 (Statistics Canada, 2008a).[96]

Traded versus Non-Traded Sectors

ICT hardware and software are almost always traded products; therefore, the firms that choose to participate in these markets must be prepared to compete globally. As a result, the Canadian businesses that have managed to survive and grow in these sectors are innovative and highly competitive. The *services* components of ICT can be very different. Telephone and cable companies are domestically focused, with very limited exports and significant constraints on market entry, reinforced by foreign ownership restrictions. The computer services sector, on the other hand, is more mixed with some components (e.g., maintenance of computer hardware) tied to local markets, while others (e.g., software maintenance and development) are increasingly global.

Communications Services

Canada's communications services sector has had a mixed innovation performance, and the innovation that has occurred has been idiosyncratic and dependent on the actions of individual firms. For example, Rogers Cable was investigating opportunities for two-way (receive and transmit) cable systems as far back as the 1980s, ahead of both its Canadian and U.S. counterparts. The efforts by Canadian cable companies to upgrade their systems and offer new services, particularly high-speed Internet, triggered a competitive response from the incumbent telephone companies that saw Canada lead the United States in both deployment

96 Enrolment in mathematics, computer and information sciences peaked in 2001-02, with 46,000 students, likely influenced by the ICT boom that crested in 2001. The total enrolment in 2005-06, of 36,600 students, represents a 10% decline from the 2004-05 enrolment level (Statistics Canada, 2008a).

Box 23 – The Global Devolution of the Computer Value Chain

The personal computer industry is a good example of how the fragmentation and globalization of the manufacturing value chain have been matched by a similar transformation of the "innovation" value chain (Dedrick & Kraemer, 2008). PC vendors often play a key role in new product development and design – Apple is a leading example – but many, like Dell, are more focused on operational efficiency, marketing and distribution. Most of the R&D in the industry takes place in the component suppliers, such as Microsoft, Intel, and hard drive and display providers. Product management and marketing is increasingly the principal purview of the PC vendors as other elements are dispersed throughout the value chain.

All these roles are fluid. Parts suppliers may attempt to move up the chain by designing larger-scale components – for example, from a single chip to a motherboard. Taiwanese firms began as contract manufacturers, and then moved up into "original design manufacturing" and even manufacturing under their own brand, while simultaneously outsourcing the actual manufacturing to China. Today, China is the world's largest producer of PCs, although most of the production plants are still owned by Taiwanese firms.

The globalization of innovation in the PC industry is only one example of how different industries can evolve. Macher and Mowery (2008) have summarized a series of studies on changes in U.S. competitiveness and innovation in multiple industries, noting that each has developed unique characteristics. The evolution of semiconductors, for example, has produced a separation of manufacturing and design. While actual fabrication of chips has largely migrated to Asia, this has been accompanied by the steady growth of "fabless" firms that design, but do not fabricate. The United States has dominated the fabless design business, with 475 firms (almost 75% of the global total) in 2002. Canada was second, with 30 firms, just ahead of Israel's 29 at the time (Macher *et al*., 2008).

On the other hand, in the case of flat panel displays, particularly those based on liquid crystals, much of the innovation has followed manufacturing production to Taiwan, South Korea and China (Hart, 2008). The main driver appears to be in the key locus of value in a particular product type. For semiconductors, the manufacturing is relatively standard with many competing suppliers, while the products themselves are highly specialized. Most of the innovation (and value) in a semiconductor chip is in its design and its ability to serve a particular function. By contrast, the innovation in flat panel displays is mostly in the manufacturing *process* – both to enable larger and better resolution displays and to improve efficiency. Thus the locus of innovation has migrated with production.

and customer adoption. More recently, however, broadband deployments in Canada appear to be slowing relative to the United States since there has been no competitive spur to stimulate the next major round of investment.[97]

Limited competition in the wireless market – essentially a three-player oligopoly – is believed to be responsible for maintaining high prices in Canada (relative to the United States) and for blunting the incentive to innovate.[98] This is of concern in view of the fact that service innovation is important in the wireless sector because it enables innovation in other industries that rely on communications technologies. Canada's 2008 auction of wireless spectrum to new entrants was designed to increase competition in the sector.

Computer Services

The computer services industry is complex, with a mix of domestic and export-oriented services. Many tasks continue to require a local presence, thus requiring even global players to maintain offices in Canada and regionally. However, the high and low ends of the market are increasingly geography-independent. At the top end, consulting services are based on highly skilled people who can support activities in multiple locations. At the low end, which includes some outsourcing along with servers and hosting, the market is increasingly commoditized and is now a scale-driven business. Where labour is involved in these latter services, the skill requirements are modest, and developing countries, particularly India, have become very competitive. Innovation is important in all aspects of this business, but its nature varies. At the top end, creative problem solving and the development of new methodologies are important to attract and serve customers. At the low end, software that enables automation of processes and improves efficiency is the key to innovation. Canada has had some success in this market through domestic firms like CGI and the Canadian operations of multinationals such as IBM.

Some Lessons for Business Innovation Strategy

The ICT sector is a heterogeneous collection of industries encompassing many different innovation strategies. The following examples illustrate, in the context of several subsectors of ICT, some of the factors identified in earlier chapters, which influence the choice of innovation-based business strategies.

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97 In the United States, Verizon was compelled to build a "fibre-to-the-home" network, as much for cost reasons (i.e., issues with maintaining their legacy copper network) as for customer-benefit reasons. That action is nevertheless now spurring U.S. cable companies to deploy new technology more quickly to keep pace.

98 For reasons discussed in Chapter 6, attempts to create a competitive advantage are discouraged by the expectation that competitors will quickly match any move and thereby nullify the potential benefit, possibly just creating lower margin equilibrium for the entire industry.

- The fact that several large players in the computer industry in Canada are foreign controlled has not stunted Canada-based product innovation activity as has been the case, for example, in the automotive and industrial chemicals industries. In the service-oriented IT sector, Canadian affiliates interact with final customers, and therefore their business strategy requires product innovation. On the hardware and software side, the prospect of government procurement contracts for ICT firms that established a substantial presence in Canada provided in some cases (notably IBM) an initial attraction that grew into major activities with global product mandates (Box 24). The impetus has not only come from federal procurement; provincial governments also have considerable purchasing power – for example, IBM Canada built its Bromont facility to address Québec government opportunities. This experience shows that government's role as lead customer can, under the right conditions, provide the impetus to kick-start a new industry. The case of ICT procurement, which catalyzed substantial economic development, stands in contrast to the very different philosophy of procurement that has prevailed for pharmaceutical products as discussed in the case study on life sciences. The federal government's support of Canada Health Infoway is a contemporary example that has the potential to make Canada a leader in the burgeoning field of electronic medical records.
- The evolution of an innovative, world-class telecommunications equipment sector in Canada had quite different origins. Northern Electric (later Nortel) was forced to develop its own technology when cut off from access to AT&T (recall Box 20 in Chapter 9) and was assisted in developing the scale to support leading-edge research by its preferred relationship with Bell Canada and other regional phone companies. The regulated monopoly of these companies – which was a particular manifestation of public policy in an earlier era – allowed the "telcos" to secure the subscriber revenue needed to, in effect, underwrite a great deal of Nortel's early R&D. Building on this domestic base, the company was able to become a global technology provider with the vast majority of revenue coming from outside Canada. Nortel, moreover, became the hub of a cluster of ICT businesses in Canada covering the spectrum from startups to multinationals.
- Canada early on became a leader in satellite and microwave communications technology in order to communicate across a vast geography, a mission that was initially supported by targeted government research and enterprise. For example, Telesat was founded in 1969 as a joint government-private-sector business and in 1972 launched the world's first commercial domestic communication satellite in geostationary orbit. Canada's space-based communications industry has spawned an impressive family of technology leaders including Telesat, MacDonald Dettwiler (now MDA) and the former Spar Aerospace (developer of the "Canadarm"), among others.

- The innovation strategies of the telephone and cable television industries have been heavily influenced by regulation and by the former monopoly, or quasi-monopoly, structure of those sectors. These service companies relied for their innovation primarily on their equipment suppliers – e.g., "smart" services like voicemail and caller ID were embedded in the switches in the network. Their business strategies focused on service reliability and associated heavy capital investment rather than on in-house service innovation. Technology has now largely broken down the monopolies, but the inertia of corporate and customer behaviour, vestigial regulatory restrictions and continuing *de facto* limits on competition have combined to blunt the incentives for major communications services companies to emphasize innovation in their competitive strategy. (The behaviour of the former monopoly providers in most countries has been similar.)
- The climate for new ICT ventures (hardware, software, systems and services) in Canada has been favourable in view of (i) a strong base of research and training in universities and colleges and in major players like Nortel, IBM and RIM; (ii) government supports such as the SR&ED tax credit and various laboratories and programs (e.g., NRC, Communications Research Centre, NSERC, as well as CANARIE, CMC Microsystems, PRECARN and other "fourth pillar" institutions); and (iii) supportive clusters of ICT subsector activity in several centres across Canada. The many successes have produced numerous role models and angel investors, and bred confidence in young ICT entrepreneurs that they could succeed in Canada. Business ambition has not been in short supply although lack of a strong base of leading-edge ICT customers in Canada is a drawback. Moreover, the early-stage financing of ICT startups exhibits many of the weaknesses identified in Chapter 7, though not to the extent seen in biotechnology. Unfortunately, the sharp decline in the telecommunications technology sector since 2001, and now exacerbated by the global recession, has hit Canada particularly hard in view of this country's specialization in several of the most heavily affected market segments. Canada's hard-won advantages are now at risk.

A theme running strongly through the foregoing examples is the key influence of government, at least at the outset. The initiating influence has taken many forms – early procurement, public-private commercial partnership in support of a national mission (e.g., in satellite communication), and research support through targeted university funding and sector-oriented government facilities and programs. The role of government in ICT sectors has typically been catalytic, enabling an innovative line of activity to take root and to build scale to the point where commercial viability has emerged.

With a significant base of businesses and a number of successful clusters,[99] ICT is arguably Canada's leading technology-intensive sector. Greater investment in ICT by Canadian firms will bring business to ICT producers, improving the climate for new ICT ventures and, most important for the economy at large, improving the productivity and service capacity of Canadian businesses in all sectors.

Box 24 – Innovation and Global Product Missions

Multinational companies (e.g., IBM) often assign global product missions/mandates to countries. The mission involves producing a small set of products but at volumes that supply a global market. In this approach, a multinational looks worldwide when determining product requirements, thereby making it more competitive than companies with only a local focus.

The exports associated with the global product mission offset the imports of the multinational's other products that are missioned elsewhere, thus producing a rough balance of trade in the host country. This is perhaps the only way to be competitive in the hardware and software business and, at the same time, to be a good corporate citizen in the countries where the multinational does business. (Services are different since they tend to be locally tailored and delivered.)

The global product mission requires the host government – for example, the Government of Canada – to accept a narrowly mandated, but trade-balanced company as a "Canadian" producer. Unfortunately, the more politically popular course has often been to provide an incentive for companies to do light, final assembly ("snapping tops on bottoms") in Canada, and calling it "made in Canada", to be eligible for preferential government procurement. This approach is ineffective because it only creates a few low-level manufacturing jobs, rather than an organization that can stimulate innovation-based development. The experience with IBM and others shows that it is possible to attract multinational companies to set up globally mandated facilities in Canada with government incentives, but only if rationalized approaches are respected.

99 Waterloo and Ottawa get the most attention, but Toronto has a group of firms surrounding IBM, and Montréal has a strong presence in digital media and Calgary in wireless technology. Vancouver has been growing in software and recently secured a new Microsoft software lab.

Chapter 11 – Conclusions

The panel has approached innovation as an *economic process* rather than as a primarily science and engineering activity. The analysis of business innovation in Canada, as outlined in previous chapters, provides a long-term perspective on the fundamental factors that connect business strategy, innovation activity and productivity growth. The panel's analysis leads to the following two principal conclusions:

The persistently lagging growth of labour productivity in Canada is due primarily to the weak innovation performance of the business sector.

The main quantitative evidence in support of this conclusion is (i) Canada's slow growth of multifactor productivity, which has been documented since the early 1960s; and (ii) more recently, the failure by many Canadian businesses to invest in information and communications technologies to nearly the extent seen in the United States and in several other peer group countries in the OECD. The report shows that the growth of MFP over long periods of time is the appropriate broad measure of business innovation – that is, the combination of human and capital resources in new or more efficient ways to create value.

The weak innovation performance of Canadian business is due to the fact that relatively few Canadian companies adopt innovation-based business strategies.

The central theme of the panel's report is a reframing of the analytical approach to understanding the innovation performance of business. The report shifts the focus from innovation activities like R&D and advanced technology acquisition, which are consequences of an innovation-based business strategy, to the *determinants* of such a strategy in the first place. The panel believes that Canada's business innovation shortcomings can only be understood and addressed by analyzing why companies in Canada decide either to compete on the basis of innovation, or on the basis of some other strategy. The principal factors that influence that decision can be categorized broadly as:

- particular structural characteristics (e.g., related to sector or foreign control);
- competitive intensity;
- climate for new ventures (e.g., availability of early-stage finance);
- public policies that encourage or inhibit innovation; and
- business ambition (e.g., entrepreneurial aggressiveness and growth orientation).

These five factors are themselves influenced by certain deep and long-standing features of Canada's economy, of which the two most significant are the following:

- *Canada is "upstream" in many North American industries.* This positioning, which is related to important structural characteristics such as sector mix and foreign control, is the result of Canada's resource endowment and development history as a commodity supplier and technology adopter. Canada's upstream position in many continentally integrated value chains limits contact with the ultimate end-customer (a strong source of motivation and direction for innovation), and shapes the nature of business ambition in many sectors.
- *Canada's domestic market is relatively small and geographically fragmented.* Small markets are less conducive to innovation than large markets (like the United States) because (i) they offer lower potential reward for undertaking the risk of innovation, and (ii) they tend to attract fewer competitors and thus provide less incentive for a business to innovate in order to survive. (The Canadian domestic market is relatively "cushioned" and pre-tax business profitability, as a percentage of GDP, has exceeded that of the United States in most years since 1961.) The innovation success of countries like Finland and Sweden shows, on the other hand, that the disadvantage of a small domestic market can be offset by a strong orientation toward innovation-intensive exports.

ADDRESSING CANADA'S BUSINESS INNOVATION CHALLENGE

Canada has a serious productivity growth problem. The statistical evidence is unambiguous and of long standing. The panel believes that Canadians should be concerned about the productivity of our export-oriented economy as competition from China and other emerging economies intensifies. Strong productivity growth is the way to remain internationally competitive with a rising standard of living. The panel also believes that Canadians should be concerned about the long-run consequences of continued weak productivity performance in the domestic economy as the population ages and competition intensifies among the mature economies for the best human skills, and particularly for entrepreneurial talent.

Because *Canada's productivity problem is actually a business innovation problem*, the discussion about what is to be done to improve productivity in Canada needs to focus on the factors that encourage, or discourage, the adoption of innovation-based business strategies. This is a complex challenge because the mix of relevant factors varies from sector to sector and requires a much broader conception of innovation than the conventional R&D-centred view, which, while important, is too limiting.

There is no single cause of the innovation problem in Canada, nor is there any one-size-fits-all remedy. The short case studies in this report illustrate the great variety in the circumstances facing individual sectors of the Canadian economy and the very different incentives and constraints that affect the choice of innovation strategy in each. Public policy in respect of innovation therefore needs to be informed by a deep understanding of the factors that influence business decision makers, sector by sector. This clearly requires extensive consultations with business people themselves as well as further development of innovation surveys and other forms of micro-analysis of the innovation process.

Overarching the sector-specific factors that influence innovation strategies are certain issues of pervasive influence identified in the panel's analysis that suggest the need for proactive public policies to:

- encourage investment in advanced M&E in general, and in ICT in particular (such incentives should be designed only in light of a more thorough understanding of the reasons for the relatively slow adoption of ICT in Canada to date);
- sharpen the incentive for innovation-oriented business strategies by increasing exposure to competition and by promoting a stronger export orientation on the part of Canadian firms, particularly in goods and services that are downstream in the value chain and thus close to end-users;
- improve the climate for new ventures so as to better translate opportunities arising from Canada's university research excellence into viable Canadian-based growth businesses, bearing in mind that better early-stage financing and experienced mentorship hold the key; and
- support areas of particular Canadian strength and opportunity through focused, sector-oriented strategies, such as was done in the past in, for example, the automotive, aerospace and ICT industries.

Fortunately, the many successes of Canadian businesses in the hyper-competitive global marketplace show that there is nothing innate or inevitable in the national character that prevents Canada's businesses from being just as innovative and productive as those of other nations.

The panel has completed its analysis of business innovation in the shadow of the most severe global economic downturn in decades. The panel has nevertheless remained focused on the long term because Canada's innovation conundrum is deeply rooted and has little to do with the booms and busts of the economic cycle.

The panel's findings therefore remain relevant notwithstanding the current shock to the global economy. As governments in Canada continue to take measures in the near term to mitigate the downturn, the panel's diagnosis of the nature and underlying causes of Canada's generally weak business innovation performance can help to target those measures so that they also strengthen the nation's economy for the long term.

Annex I – The New (Endogenous) Growth Theory

The first formal theory of the long-term economic growth of nations, as developed by Robert Solow (1956) and Trevor Swan (1956), was based on the accumulation of physical capital and the growth of the labour force. Although technological progress had been recognized to be at the heart of the growth process, it had been treated by economists as a scientific process that, for theoretical and empirical purposes, operated independently from economic forces (Howitt, 2007). In this sense, a large part of labour productivity growth remained unexplained – i.e., it was assumed to flow from a rather mysterious and "non-economic" process of technical progress that was modelled as a progressive outward "shift" of the aggregate production function. (See equation (1) in Annex II where the shift factor, A, is interpreted as multifactor productivity.) By leaving an economic account of technical progress out of its framework, economic theory offered little to policy makers as to how long-term growth could be promoted.

ENDOGENOUS GROWTH THEORY

The "new" growth theory pioneered by Romer (1986) and Lucas (1988) – which built on the ideas of Kaldor (1957), Arrow (1962) and Uzawa (1965) – endeavoured to explain innovation and knowledge evolution as arising from incentives and processes *within* (or "endogenous" to) the economic system itself. Hence endogenous growth theory came to supplant the "exogenous" theories of Solow and other neoclassical theorists. Endogenous growth models incorporate technological progress by capturing the notion of feedback from the economy to technology and vice versa. The central insight is that ideas, unlike physical capital, are non-rival in the sense that one individual's ability to use an idea is not prevented or diminished by others' use of that idea. In this sense, ideas are fundamentally different than physical assets. For example, once Henry Ford created the assembly line, many firms could use (and improve upon) this idea. In other words, ideas can be shared and used concurrently, whereas a piece of physical capital is specific to its owner.

First Generation Models

The first generation of endogenous growth models treated individual knowledge accumulation like other forms of capital accumulation, as subject to diminishing returns at the individual level. The crucial difference was that, unlike the economy-wide stock of physical capital, the economy-wide stock of knowledge conferred benefits – whether from research, experience or education – to the surrounding society. In contrast to the Solow model, endogenous growth theory demonstrated that the rate of saving (and therefore, investment) could affect not just the level but

also the rate of economic growth. This process of knowledge "spillover" explains how economies use the continuous generation of knowledge to escape the otherwise inevitable limits of the diminishing returns to the simple accumulation of any particular kind of physical capital. For example, providing a single carpenter with more and more hand saws adds very little (if any) to output; however, supplying the same carpenter with the innovation of a power saw leads to a remarkable increase in output. The continued invention of more productive carpentry tools and methods can thus allow carpenters to keep ahead of the "law" of diminishing returns.

Later Generation Models

Later generations of endogenous growth models separated innovation from capital accumulation to "portray a free enterprise economy that is constantly being disturbed by technological innovations from which some people gain and others lose: an economy in which competition is a Darwinian struggle whose survivors are those that succeed in creating, adopting, and improving new technologies" (Howitt, 2007). Multifactor productivity growth results from the intentional innovative efforts of profit-maximizing individuals responding to incentives within a dynamic economy. The potential profit accruing from an innovation is thus the catalyst behind the economist's theory of technological progress and accords with Joseph Schumpeter's assertion that "it is not the observed performance [of technological progress] due to that stream of inventions that revolutionized the technique of production. . . [but] the businessman's hunt for profits. The carrying into effect of those technological novelties was the essence of the hunt" (Schumpeter, 1942). Economic growth is thus conceptualized as an economic, political and social process that is affected by policies, institutions and social forces that shape not only the incentive to save, but also the incentives to innovate and adapt to change. The emphasis in the panel's report on the central importance of business strategy, and the factors that influence the choice of strategy, is very much in this spirit.

Although there are slight differences in the presentation of innovation – e.g., Romer (1990) assumes innovation increases the variety of products or processes available while Aghion and Howitt (1992) emphasize the process by which new innovation renders older innovations obsolete – all endogenous growth models share some core principles and general policy prescriptions: (i) labour productivity growth is driven primarily by the rate of technological innovation, (ii) innovation generally results from entrepreneurial investment involving risky learning and experimentation, and (iii) innovation investments respond to the incentives produced by the economic environment.

Growth-Promoting Policies

The insights from endogenous growth theory, although not entirely new to economics, highlight some specific policy and institutional recommendations that can spur labour productivity and economic growth:

- Tertiary education increases the efficiency, size and novelty of new innovations while primary and secondary education enhance the capacity of an economy to accommodate or adapt these innovations (Howitt, 2000).
- Financial development and access to venture capital provide an avenue for innovators to finance their risky innovation investments (Levine, 2005).
- Competition, or the threat of competition, induces incumbent firms to innovate to maintain their market share (Aghion *et al.*, 2005).
- Macroeconomic stability provides a stable and predictable environment for innovators to make long-term investments (Box, 2009).
- Property rights, in the form of patent protection for example, allow innovators to reap the benefits of successful innovation (Gilbert & Newberry, 1982).
- Openness to international trade provides a larger market for the sale of new products or processes, increases competitive intensity and fosters international knowledge spillovers (Helpman, 2004).

Unlike the traditional Solow growth theory, endogenous growth theory sheds considerable light on the nature of knowledge accumulation, innovation, labour productivity and economic growth, while simultaneously providing broad guidance as to growth-promoting policies.

Annex II – Growth Accounting

The growth accounting framework was developed by Robert Solow (1957) to provide a methodology to decompose labour productivity growth into contributions from changes in labour composition, capital deepening and a residual term referred to as multifactor productivity or MFP. Growth accounting is a way to account, after the fact, for a given change in labour productivity by measuring associated changes in the key factors believed to drive productivity growth. Although this framework cannot identify the ultimate causes of changes in the labour and capital inputs or MFP, it has proven to be an extremely useful first step in understanding the sources of aggregate growth.

THE PRODUCTION FUNCTION

The most basic version of growth accounting starts with a simple mathematical representation of output as a function of the economy's stock of capital, labour and "everything else". (The latter is subsumed by the concept of MFP.) The standard (Cobb-Douglas) production function can be expressed as

(1) $Y = AK^{\alpha} (HQ)^{1-\alpha}$

where Y denotes real GDP; K is the capital stock; H is the total number of hours worked in the economy; Q is a measure of labour "quality" that adjusts the number of hours worked to reflect differences in the capabilities of different workers (depending primarily on education and experience); A is multifactor productivity; α is the share of GDP attributable to the capital stock; $(1-\alpha)$ is the share attributable to labour.[100] These variables can be estimated statistically and, in more sophisticated versions of the production function, provide a reasonable basis for productivity analysis (Baldwin & Gu, 2007).

Dividing equation (1) by the total hours worked yields an expression for labour productivity

(2) $Y/H = A(K/H)^{\alpha} Q^{1-\alpha}$

100 The parameter α is typically estimated to be approximately 0.3 (Barro & Sala-i-Martin, 2003).

This expression can be used to derive an equation for labour productivity growth as the weighted sum of the growth rates of MFP, the capital-labour ratio and labour quality

$$(3) \quad \Delta(Y/H) = \Delta A + \alpha\, \Delta(K/H) + (1 - \alpha)\, \Delta Q$$

where Δ denotes the percentage change in each of the variables in a unit of time (typically per year).[101]

LABOUR "QUALITY"

To estimate changes in labour quality (ΔQ), Statistics Canada disaggregates all workers into 112 categories by gender, seven age groups, four education levels (primary, secondary, post-secondary and university) and two employment categories (paid and unpaid (self-employed)), and weights the hours in each of these categories by the category's share of total compensation on the assumption that the relative contribution to productivity of a given hour of work is roughly proportional to its relative compensation. Changes in the difference between the weighted and the unweighted sums of hours in the economy capture structural changes in the "quality" of the workforce as achieved, for example, through increased education or experience levels.

CAPITAL DEEPENING

Statistics Canada estimates the growth of capital services per hour worked ("capital deepening") by calculating the capital stock across 28 asset classes and aggregating each class with weights equal to the user cost of capital (a measure that incorporates the market rate of return, depreciation and taxation). A change in the level of aggregate capital consists of both changes in the quantity of capital of a given type and changes in the composition of various asset types with different marginal products and user costs.[102]

LIMITATIONS OF THE MODEL

The Solow growth model (1956), which serves as the theoretical building block for this framework, has many limitations. First, the model assumes that output adjusts

101 Equation (3) is derived by taking logarithms of equation (2), then differentiating and approximating the logarithmic derivatives by annual percentage changes of the variables in equation (3).

102 For a detailed discussion of the measurement procedures used in estimating aggregate labour and capital, see Griliches (1985, 1998). The basiscs of statistics Canada's approach to growth accounting are described in Baldwin & Gu (2007).

instantly when new investments in capital are made. In reality, the benefits are often not felt until firms adopt a cluster of changes – specific adaptations and organizational modifications – and ultimately learn to use the new capital goods. In fact, the introduction of "general-purpose technologies" (Helpman, 1998; Lipsey *et al.*, 2005), such as the electric motor or the computer, will usually reduce output in the short run during the adaptation phase. Second, instantaneous adjustment ignores the procyclical utilization of capital. For example, during an economic boom (slump) when capital utilization rises above (falls below) the normal level, growth accounting will incorrectly attribute this effect to increasing (decreasing) MFP. Third, since this framework does not include public infrastructure capital, estimates of MFP will partially reflect this capital variety since it is not explicitly included in the measure of (business) capital stock.

The Solow model also assumes perfect competition in capital and labour markets and constant returns to scale in production (i.e., if all inputs are increased by a certain common factor, output is increased by that same factor). If production is in fact characterized by increasing returns to scale ("economies of scale"), this methodology will tend to understate the input contribution of capital. If the total stock of capital within the economy positively influences the productivity of individual firms, then such spillovers should be attributed to capital and not to the MFP residual. Finally, if, as endogenous growth theory (Annex I) posits, there are new varieties, or increased quality, of capital goods, then any failure to include their increased services in the measure of capital also biases the growth accounting procedure toward MFP.[103] It has been argued that unmeasured technical change, embodied in capital, may in fact account for the majority of MFP growth (Jorgenson, 1995). The Canadian and U.S. measures of capital used in the growth accounting analysis summarized in Chapter 2 include estimates of the qualitative improvement in the ICT components of the capital stock and thus remove this significant potential distortion from the estimation of MFP.

Since long-run economy-wide growth and cross-country income differences are largely determined by MFP growth (Hall & Jones, 1999), understanding precisely what constitutes MFP is of great importance. MFP growth is not observed directly, but is estimated via equation (3) as:

$$(3) \quad \Delta A = \Delta(Y/H) - \alpha\Delta(K/H) - (1 - \alpha)\,\Delta Q$$

103 Much innovation activity goes toward new and improved products, which means that quality-adjusted prices fall faster than prices based on quantities only. Real output growth is correspondingly larger if a proper deflator is used and this obviously has an impact on MFP measurement. However, computing such a deflator is difficult and involves assumptions, especially about the treatment of new goods which have, in effect, infinite price before they are introduced.

Errors in ΔA may thus result from error in the measurement of real GDP, capital, labour, factor shares (the parameter "α") or model mis-specification. At a more conceptual level, MFP growth includes a myriad of factors – omitted variables – that influence the efficiency with which capital and labour are used. In fact, since MFP is a residual, it captures *all* factors not included in capital and labour estimations. But, for reasons explained in Chapter 2, the estimation of differences in MFP growth rates between Canada and the United States over long periods of time, and employing substantially identical methodology, mitigates the possible sources of error and provides a strong indicator of differences in business innovation between the two countries.

Annex III – Analysis of R&D Intensity by Sector

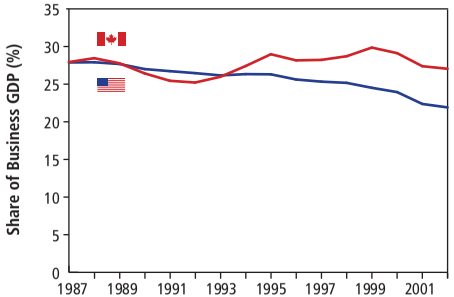
What follows is a set of charts that analyze the gap in BERD intensity (business expenditure on R&D as a percentage of GDP) between Canada and the United States, sector by sector and over a 16-year period: 1987 through 2002. These data provide a more detailed account of the trends underlying Figure 5.2.

There are three panels for each industry or sector: (i) share of business GDP, (ii) BERD intensity, and (iii) contribution to the BERD intensity gap. The contribution of a sector to the gap is the difference between the United States and Canada of the following product: "Sector share of GDP x BERD intensity of sector".

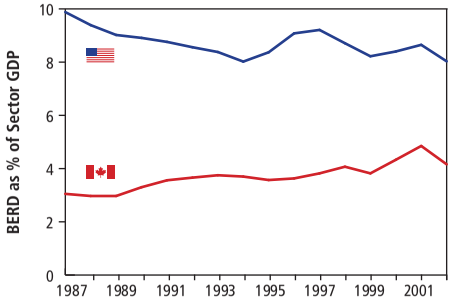
The charts are based on data from the STAN database of the OECD, accessed during summer, 2008. (Incomplete sector by sector coverage for years after 2002 limited the analysis to 1987-2002 at the time the charts were prepared.)

TOTAL MANUFACTURING

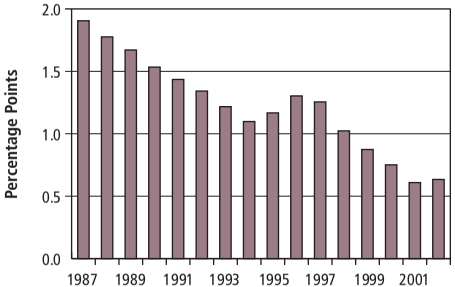
Share of GDP



BERD Intensity (BI)

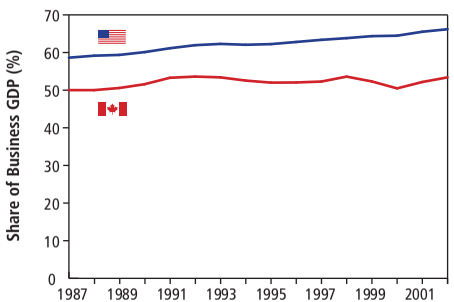


Contribution to BI Gap

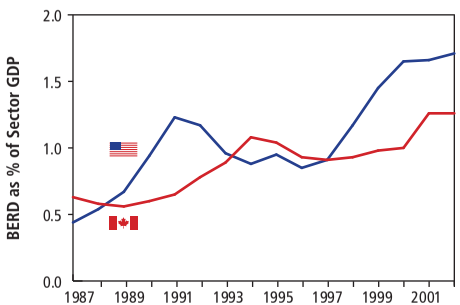


TOTAL BUSINESS SECTOR SERVICES

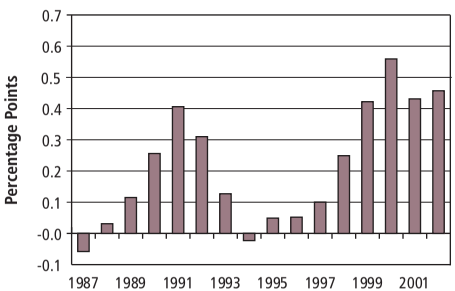
Share of GDP



BERD Intensity (BI)

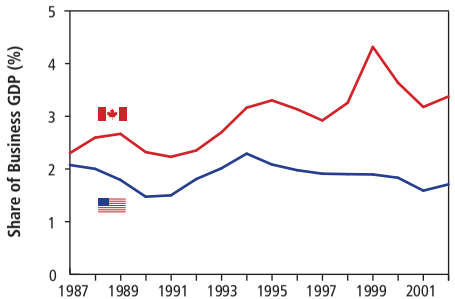


Contribution to BI Gap

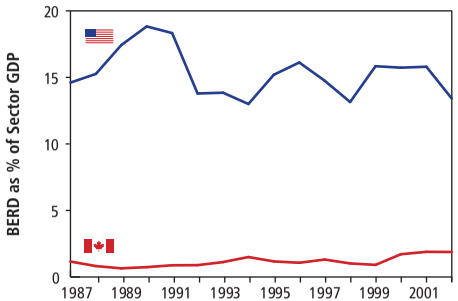


MOTOR VEHICLES & TRAILERS

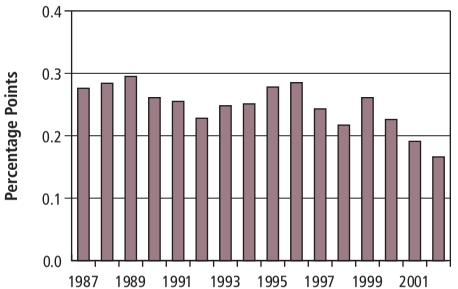
Share of GDP



BERD Intensity (BI)

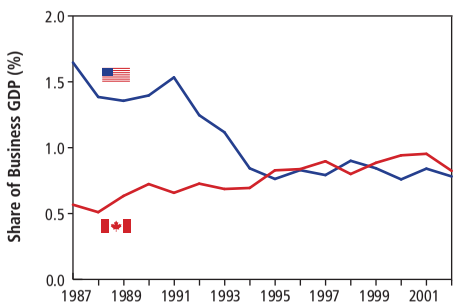


Contribution to BI Gap

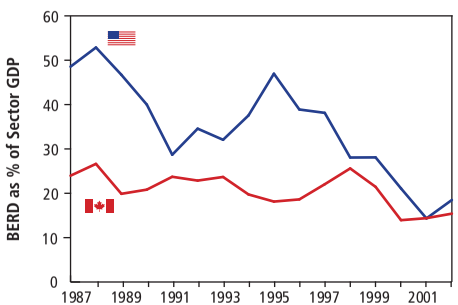


AIRCRAFT & SPACECRAFT

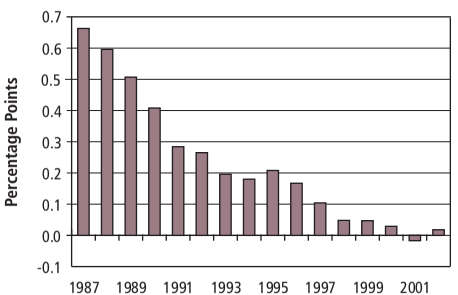
Share of GDP



BERD Intensity (BI)

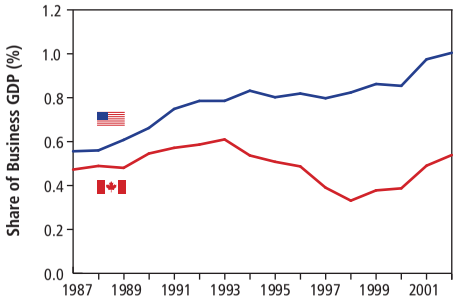


Contribution to BI Gap

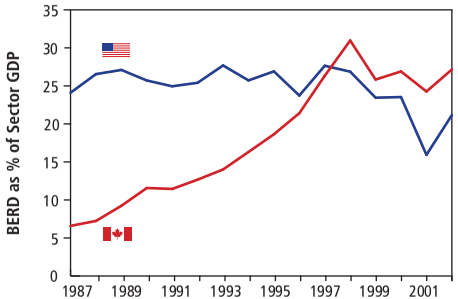


PHARMACEUTICALS

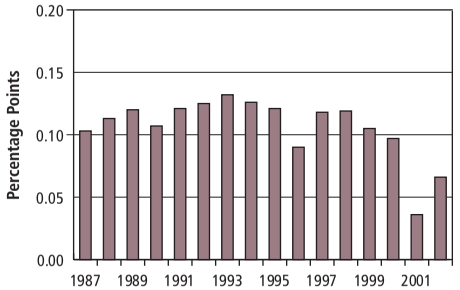
Share of GDP



BERD Intensity (BI)

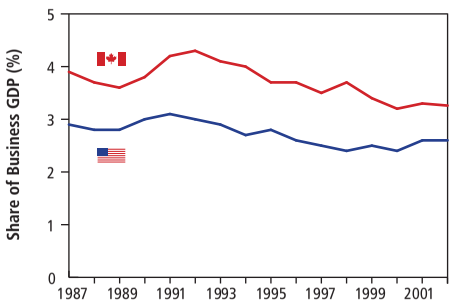


Contribution to BI Gap

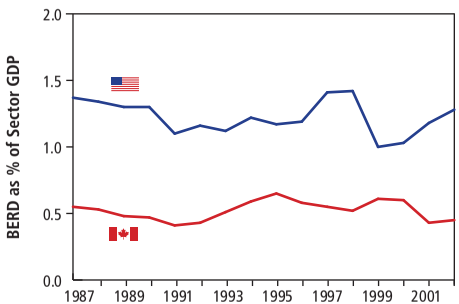


FOOD PRODUCTS, BEVERAGES AND TOBACCO

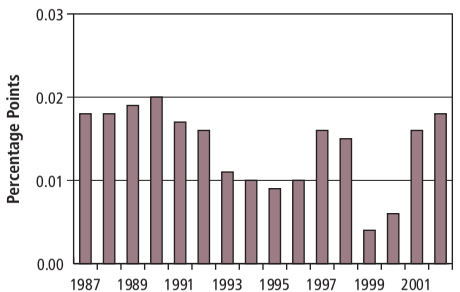
Share of GDP



BERD Intensity (BI)

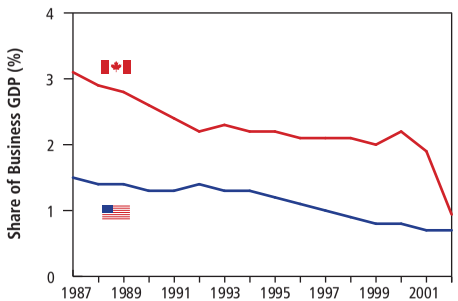


Contribution to BI Gap

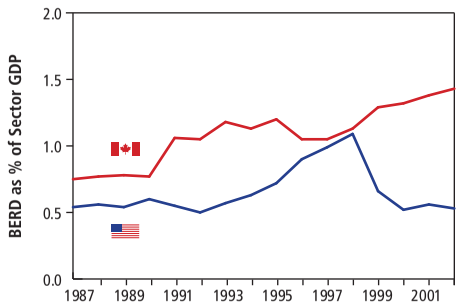


TEXTILES, LEATHER, FOOTWEAR

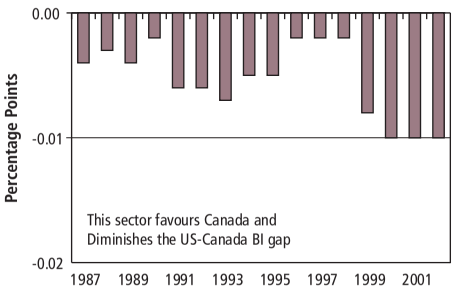
Share of GDP



BERD Intensity (BI)

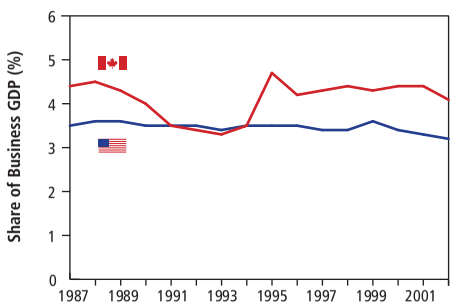


Contribution to BI Gap

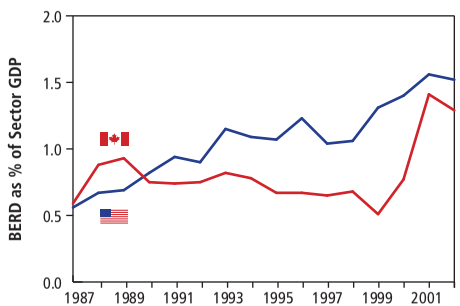


PULP, PAPER PRODUCTS, PRINTING & PUBLISHING

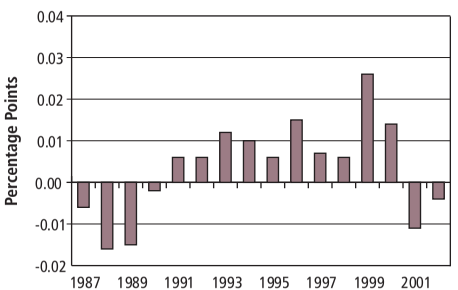
Share of GDP



BERD Intensity (BI)

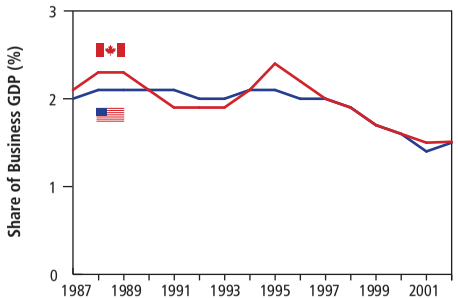


Contribution to BI Gap

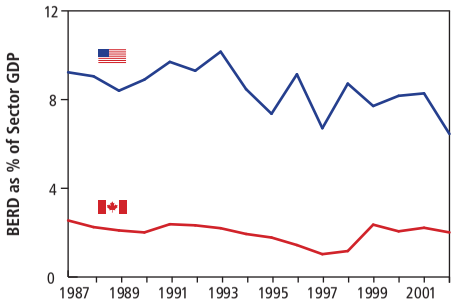


CHEMICALS, EXCLUDING PHARMACEUTICALS

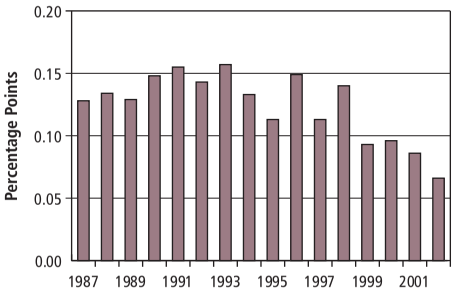
Share of GDP



BERD Intensity (BI)

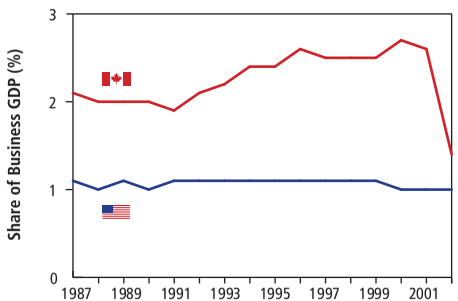


Contribution to BI Gap

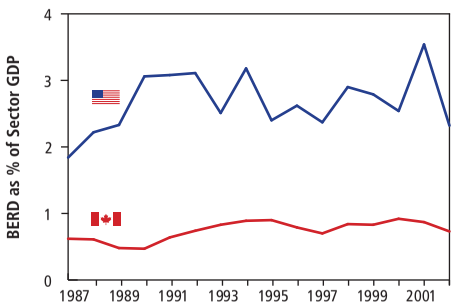


RUBBER AND PLASTICS

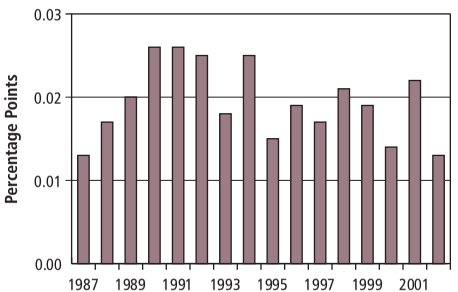
Share of GDP



BERD Intensity (BI)

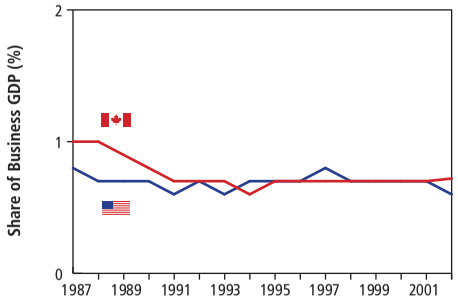


Contribution to BI Gap

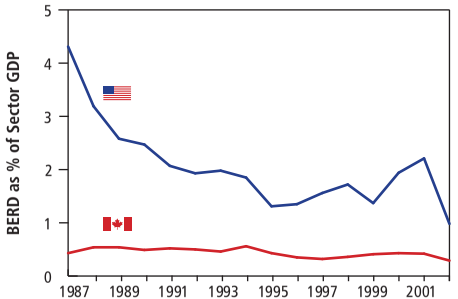


OTHER NON-METALLIC MINERAL PRODUCTS

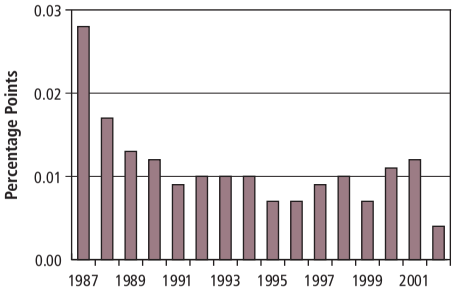
Share of GDP



BERD Intensity (BI)

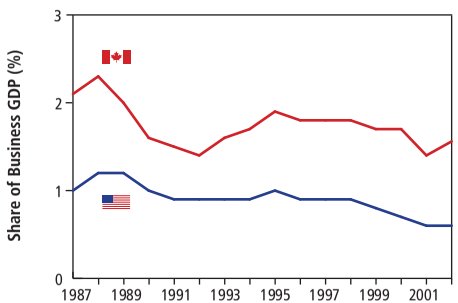


Contribution to BI Gap

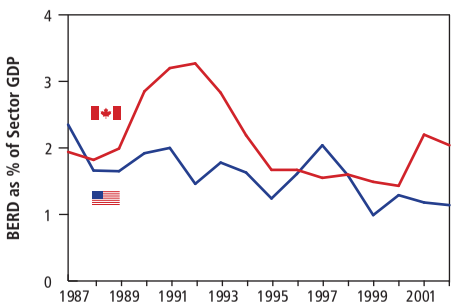


BASIC METALS

Share of GDP



BERD Intensity (BI)



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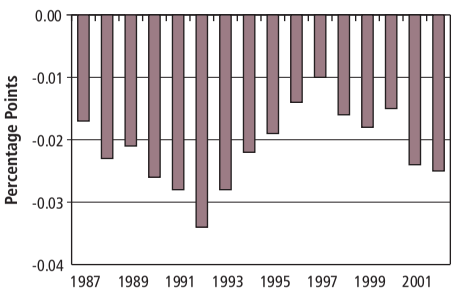
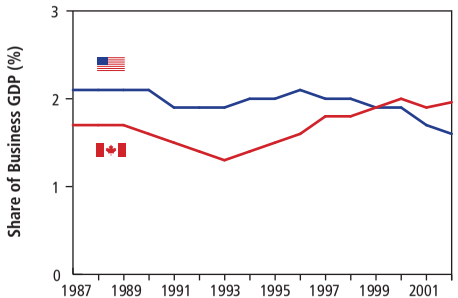
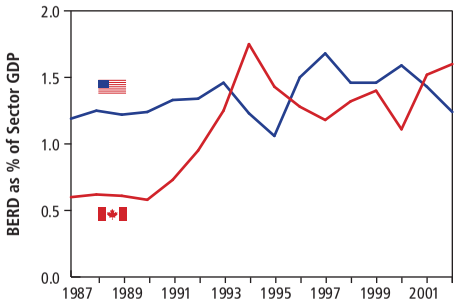


FABRICATED METAL PRODUCTS

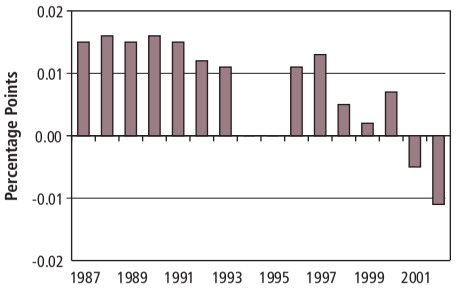
Share of GDP



BERD Intensity (BI)

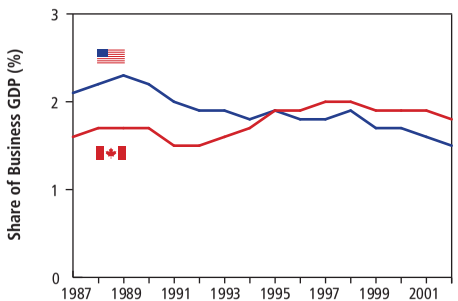


Contribution to BI Gap

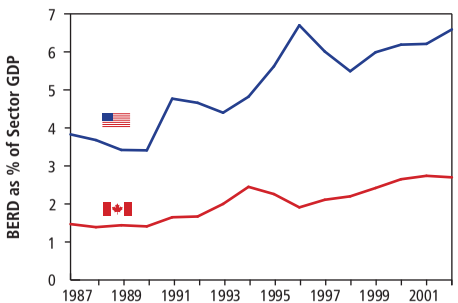


MACHINERY AND EQUIPMENT n.e.c.

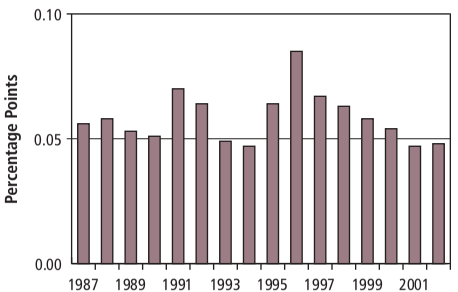
Share of GDP



BERD Intensity (BI)

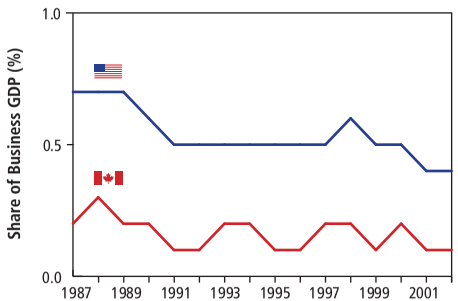


Contribution to BI Gap

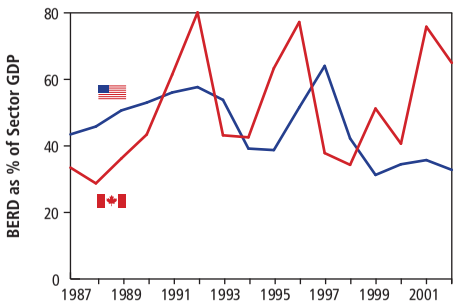


OFFICE ACCOUNTING & COMPUTING MACHINERY

Share of GDP



BERD Intensity (BI)



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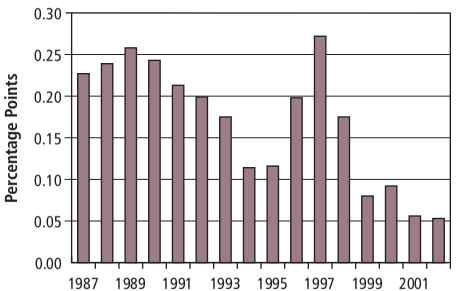
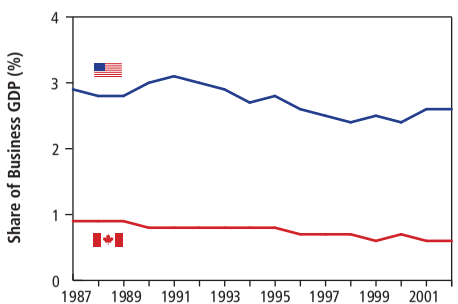
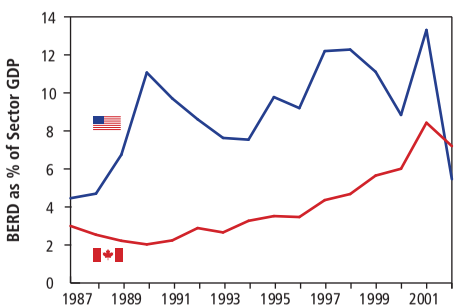


ELECTRICAL MACHINERY AND APPARATUS n.e.c.

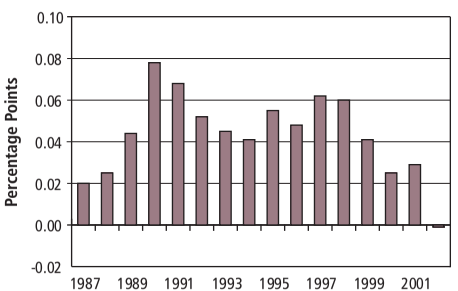
Share of GDP



BERD Intensity (BI)

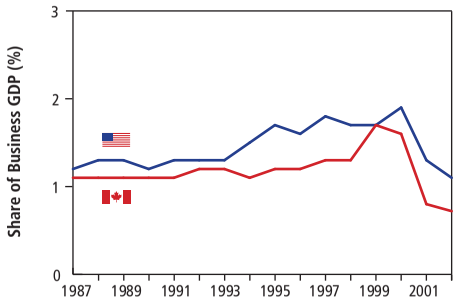


Contribution to BI Gap

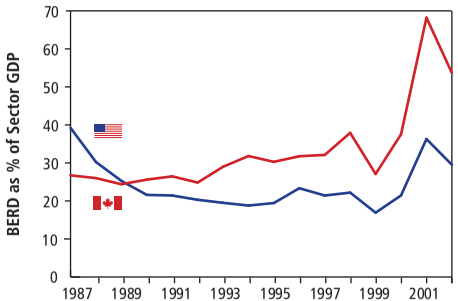


RADIO, TV & COMMUNICATIONS EQUIPMENT

Share of GDP



BERD Intensity (BI)



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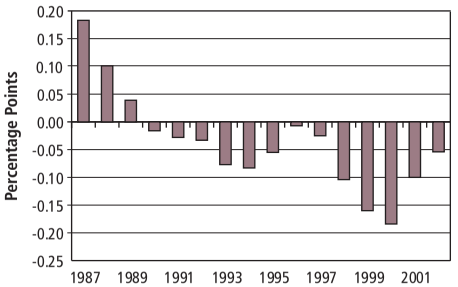
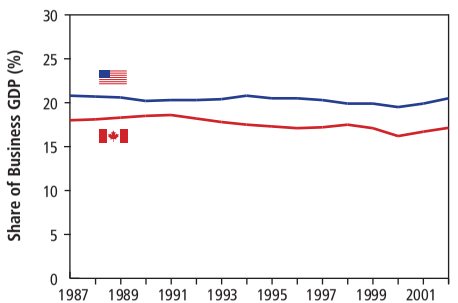
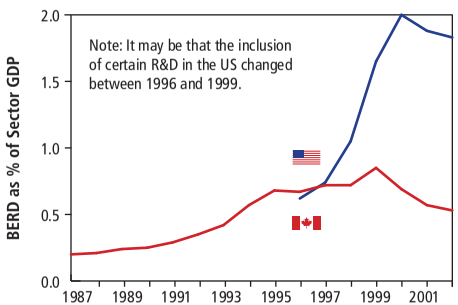


WHOLESALE AND RETAIL TRADE

Share of GDP



BERD Intensity (BI)



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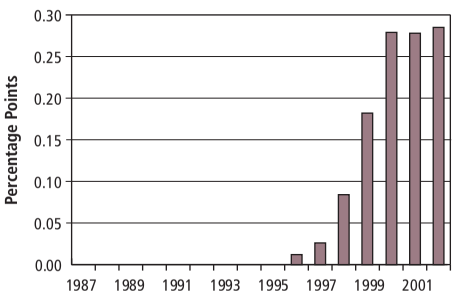
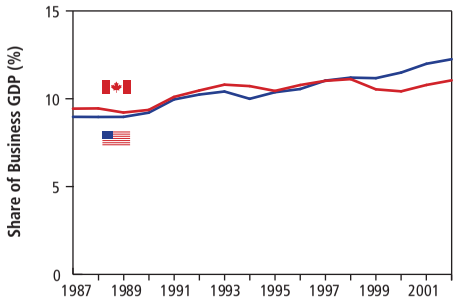
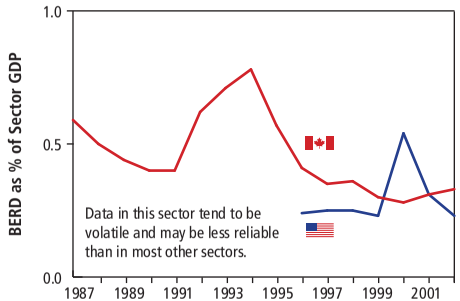


FINANCIAL INTERMEDIATION

Share of GDP



BERD Intensity (BI)



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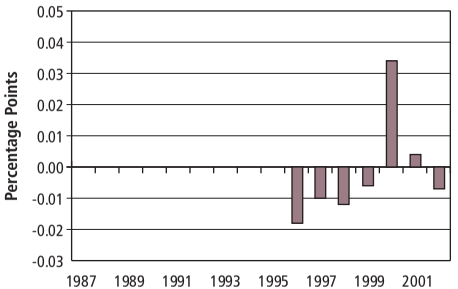
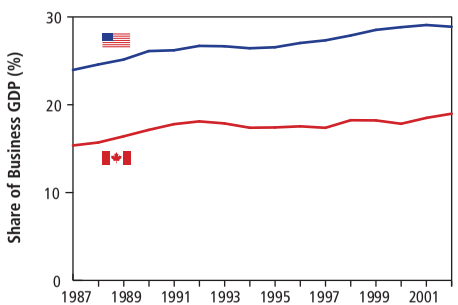
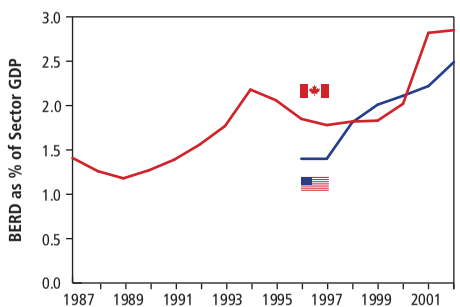


OTHER BUSINESS SERVICES

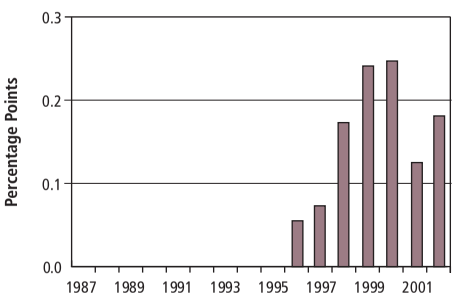
Share of GDP



BERD Intensity (BI)

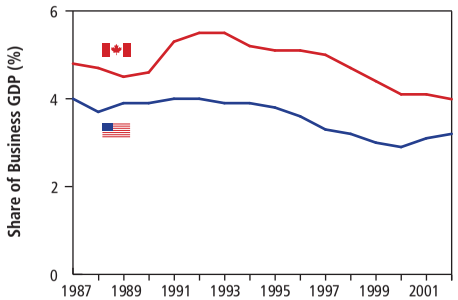


Contribution to BI Gap

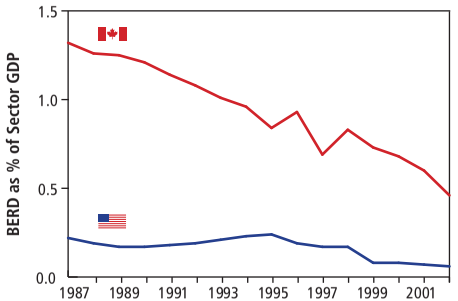


UTILITIES

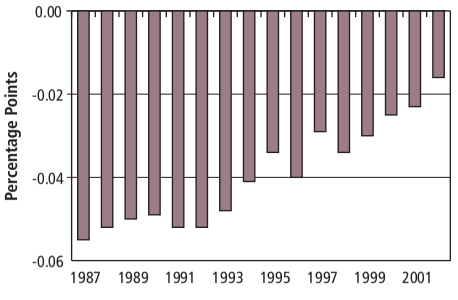
Share of GDP



BERD Intensity (BI)



Contribution to BI Gap



Annex IV – Individuals and Institutions Consulted

During the course of the assessment, the panel met or received written comments from the following individuals and institutions. The panel thanks these parties for their contributions while noting that responsibility for the content of this report rests solely with the panel. The parties listed below have not been asked to endorse the report's findings and conclusions.

Abouchar, Andrew	Partner, TechCapital Partners
Adair, Richard	
Adams, David	President, Association of International Automobile Manufacturers of Canada
Asgarpour, Sohel	Petroleum Technology Alliance Canada
Baldwin, John	Micro Economis Studies, Statistics Canada
Bapty, Brian	Raymond James Ltd., Vancouver
Barber, Doug	Chair, Board of Governors, McMaster University and founder of Gennum Corporation; Professor Emeritus, McMaster University
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