2012 State of the Nation

Canada's Science, Technology and Innovation System:

Aspiring to Global Leadership

Science, Technology and Innovation Council

Advisory Council to the Government of Canada

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State of the Nation 2012
Canada's Science, Technology and Innovation System: Aspiring to Global Leadership

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Science, Technology and Innovation Council
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The Science, Technology and Innovation Council (STIC) was created in 2007 to serve as the Government of Canada's external advisory body in the domain of science, technology and innovation (STI). The Council has a dual mandate: to provide the government with confidential advice on STI policy issues critical to Canada's economic development and societal well-being; and to produce biennial public reports—*State of the Nation*—measuring Canada's STI performance against international standards of excellence.

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Executive Summary

The Science, Technology and Innovation Council (STIC) has been mandated by the Government of Canada to produce a biennial report tracking, assessing and internationally benchmarking this country's science, technology and innovation (STI) performance. In this third report, *State of the Nation 2012—Canada's Science, Technology and Innovation System: Aspiring to Global Leadership*, we track where Canada is making progress and identify areas where Canada must devote greater attention to enhancing performance. Understanding this picture contributes to advancing the national STI dialogue, building consensus around avenues for urgent action, and generating the will to work strategically and cohesively towards common goals.

Science, technology and innovation underpin and animate virtually every aspect of modern life, driving economic growth and prosperity and fuelling advances that enhance health, environmental and social well-being. Canadians understand that, if we want to create jobs and opportunity in a competitive world and address the key societal challenges that confront us in the 21st century, STI must be an integral part of the national agenda. Canada's relatively sound economic position provides us with an opportunity to build on and take better advantage of those STI areas where we are strong and enhance our performance in those areas where we are weak—to reach for global STI leadership and thereby reap the resulting economic and societal benefits.

As in the 2008 and 2010 reports, *State of the Nation 2012* examines Canada's funding for research and development (R&D) in an international context and Canada's performance on key indicators related to business innovation, knowledge development and transfer, and talent development and deployment. The findings in *State of the Nation 2012* reinforce much of what was learned in the previous reports: Canada has much to celebrate with respect to the high quality of our talent and our strength in generating new knowledge. However, there are vitally important areas where our performance is lagging, where we must improve—in some cases significantly. We cannot be satisfied with the status quo or with incremental progress—concerted action is needed to reach for global leadership.

State of the Nation 2012 shows that Canada's gross domestic expenditures on R&D (GERD) declined from their peak in 2008 and, when measured in relation to gross domestic product (GDP), since 2001. In contrast, the GERD and GERD intensity of most other countries have been increasing. Canada's declining GERD intensity has pushed its rank down from 16th position in 2006 to 17th in 2008 and to 23rd in 2011 (among 41 economies). While there have been shifts in funding among sectors in Canada over time, the more recent declines in the country's total R&D funding efforts are attributable predominantly to private sector funding of R&D.

Business Innovation

Business innovation is an engine of productivity growth, increased international competitiveness and higher living standards. It is underpinned by investments in R&D, machinery and equipment (especially information and communications technologies (ICT)) and intangible assets. While we recognize that innovative activity is occurring that is not captured in official data, it is nonetheless clear in *State of the Nation 2012* that Canadian firms are not sufficiently harnessing innovation to make competitive gains. In international rankings related to business innovation, Canada continues to place in the middle of the pack on most measures and, on some indicators, Canada's rank has declined.

Canada's performance is particularly poor on measures of business enterprise expenditures on research and development (BERD)—that is, the R&D performed by firms. Although preliminary data suggest that BERD in Canada increased very slightly in both 2011 and 2012, BERD intensity (i.e., BERD as a percentage of GDP) has been in almost continuous decline for the past decade. Canada's rank among comparator countries on BERD-to-GDP fell to 25th in 2011 (of 41 economies). Where Canadian business has performed better is in its funding of R&D in the higher education sector. On this measure, Canada ranked seventh among comparator economies, with significantly better performance than the U.S. and Japan.

Although Canadian business investment in ICT is growing, on the international measure of ICT investment intensity (i.e., ICT as a percentage of non-residential gross fixed capital formation), Canada still ranks in the middle among countries of the Organisation for Economic Co-operation and Development (OECD). Of particular concern, Canada's ICT investment gap with the United States (U.S.) is increasing—ICT investment intensity in the business sector in Canada averaged only 42 percent of U.S. levels over the period from 2000 to 2010. Canada also performs poorly on venture capital investment as a share of GDP, ranking 15th out of 27 comparator countries. As the Government of Canada considers recommendations to modernize its framework policies in support of increased competitiveness, Canadian firms have to become more innovative in order to maximize their success in the global economy.

Knowledge Development and Transfer

The development of knowledge is the root of a country's STI ecosystem. Higher education expenditures on R&D (HERD) in Canada have increased significantly since the late 1990s, to reach $11.5 billion in 2012. Canada's substantial investment in the higher education sector has reaped significant rewards, as the production and refinement of scientific knowledge in Canada continues to be characterized by vitality and high quality. With a share of only 0.5 percent of global population, Canada accounted for 4.4 percent of the world's natural sciences and engineering publications in 2010. This positions Canada eighth after countries with significantly larger populations: the U.S., China, Germany, the United Kingdom, Japan, France and Italy.

But Canada continues to face chronic challenges in knowledge transfer—in effectively moving knowledge developed in higher education institutions to companies that have the ability to absorb it and translate it into commercially viable products and/or solutions to health, environmental and social problems. The most important form of knowledge transfer is "on two feet," via the movement and interplay of people through, for example, students' internships in companies, graduates' employment in the workforce or industry-academia R&D collaboration. We know that there is a great deal of activity in Canada in these areas that is not reflected in available data, especially internationally comparable data. However, on the traditional indicators of knowledge transfer related to licensing activities and spinoff companies, where some limited international comparisons are possible, Canada continues to show disappointing results.

The most recent data available show stagnation in Canadian licensing activities and suggest that U.S. institutions are generally more successful than Canadian ones at creating licences, keeping them active and earning income from them. Similarly, while there was an increase in spinoff companies from higher education institutions in 2011—a promising sign—there was a general downward trend in spinoff creation between 2000 and 2010. Improvement in Canada's knowledge transfer performance will be vital to ensuring that discoveries are translated into practical economic and societal benefits for Canadians.

It is important to note, too, that while HERD in Canada has been growing in dollar terms, the HERD-to-GDP ratio has fluctuated, declining to 0.66 percent in 2011 from its peak of 0.71 percent in 2009. In 2011 (the latest year for which international comparisons are available), while Canada continued to rank first in the G7 in HERD-to-GDP, its relative position deteriorated against the broader comparator group of economies. That year Canada ranked ninth out of 41 economies in HERD intensity (i.e., HERD-to-GDP), down from fourth in 2008 and third in 2006. With their significant investments in research and higher education, other countries are catching up and overtaking Canada.

Talent Development and Deployment

Science, technology and innovation are fundamentally human activities, making talent the key competitive differentiator in the global knowledge-based economy. On the talent front, Canada's highly-educated population continues to be an asset, with 51 percent of the adult population having attained a university or college education, one of the highest levels in the world.

A country's ability to produce doctoral graduates is an indicator of its potential to engage in cutting-edge research and to train the next generation of talent. Canada continues to produce fewer doctoral graduates (per 100,000 population) than many comparator countries, ranking 21st in the OECD on this indicator in 2010. However, Canada's performance that same year was better with respect to science and engineering doctoral graduates (per 100,000 population), on which it ranked 15th among OECD countries. Between 2006 and 2010, Canada experienced 48.7 percent growth in the number of science doctoral graduates and 38.6 percent growth in the number of engineering doctoral graduates, growth rates notably surpassing those of many comparator countries.

But Canada cannot afford to be complacent. With other countries making significant investments in their research and education systems, Canada risks erosion of its competitive talent advantage. Canada could also do more to ensure that its talent is prepared to contribute fully to an innovative, productive and competitive economy, by nurturing talent that better understands the links between STI and business. Expanding the number of programs providing post-secondary students with work-integrated learning opportunities in companies and applied research projects, through internships for example, would contribute to this objective.

Canada also needs to do much better at deploying its STI talent—that is, effectively absorbing this talent into the labour force and utilizing its knowledge and skills to full advantage. On this front, Canada's performance—reflected in the measure of employing human resources in science and technology (HRST) in the labour force—continues to disappoint. Canada's HRST share of the services labour force is 39 percent, positioning Canada in the middle ranks among OECD countries on this measure. On manufacturing, the picture is dismal—the HRST share of the manufacturing labour force in Canada, at 11.5 percent, is among the lowest in the OECD.

Conclusion

To a significant extent, Canada's success in the 21st century will be determined by our ability to harness science, technology and innovation to drive economic prosperity and societal well-being. STIC believes that Canada must strive not only for excellence in STI but also for global leadership. Realizing our full STI potential in this way will help us build strong institutions, companies, industries and communities, and position us among the world's most prosperous, healthy and secure countries.

To reflect this ambition, in *State of the Nation 2012* we have gone beyond examining OECD and other comparator countries (as we did in previous reports) to identify, on key internationally comparable STI indicators, the threshold that Canada would have to attain in order to break into the ranks of the world's top five performing countries. We have gone still further to highlight five particularly important STI indicators on which Canada should aspire to join the ranks of the world's top five performing countries:

- BERD as a share of GDP;
- business investment in ICT;
- HERD as a share of GDP;
- science and engineering doctoral degrees granted per 100,000 population; and
- share of human resources in science and technology.

Attaining the highest standards of international excellence in these five "aspirational" indicators will help secure Canada's future as a global STI leader, allowing us to reap greater economic and societal benefits for Canadians and contribute meaningfully to addressing key challenges faced by the global community. To realize this goal, all participants in our STI ecosystem must assume responsibility. We must work together not only to invest more in STI, but to invest more strategically and coherently, learn from the experience of global STI leaders, and be more agile seizing opportunities. That is how Canada will truly be able to "run with the best."

1 Introduction
Canada's Performance in Perspective

Success in the 21st century is driven by excellence in science, technology and innovation (STI)—by pushing the boundaries of knowledge and by applying discoveries to produce new or improved products and processes. Science, technology and innovation underpin and animate virtually every aspect of modern life. The most competitive economies are built on the recognition that STI drives growth, prosperity and high quality of life.

Canadians understand that, if we want to create jobs and opportunity in a competitive world and address the key challenges that confront us in the 21st century, STI must be an integral part of the national agenda. Success requires a private sector that embraces innovation as a competitiveness strategy; education and research institutions that attract and nurture world-class talent; researchers who expand the frontiers of knowledge; and governments that provide the environment and the support to enable discovery and commercialization to thrive.

Science, technology and innovation drive growth, prosperity and high quality of life.

Despite some persistent challenges, such as increasing household debt and sluggish employment growth, Canada has weathered the economic storm better than most. In the face of a challenging global environment, Canada has managed to maintain its modest economic growth, its relatively healthy fiscal position, and a financial system that is a model for the world. In its June 2012 *Economic Survey of Canada*, the Organisation for Economic Co-operation and Development (OECD) highlighted that "Canada has weathered the global economic crisis well, mainly reflecting sustained growth in domestic spending, and the economy is continuing to grow despite the persistence of international turbulence."[1] As well, the World Economic Forum (WEF) noted in its *Global Competitiveness Report 2012-2013* that Canada features "among the most competitive economies worldwide," pointing to strengths such as Canada's highly efficient goods, labour and financial markets (especially the soundness of Canada's banks), high-quality human capital, excellent infrastructure, and strong, well-functioning and transparent institutions.[2]

Canada's relatively strong economic position provides us with an opportunity that we must seize—the opportunity to get out ahead of our competitors by building on and taking better advantage of those STI areas where we are strong and enhancing our performance in those areas where we are weak. In realizing our full STI potential, we will reap greater economic and societal benefits for Canadians and contribute meaningfully to addressing key challenges shared by the global community. To realize our full STI potential, Canada must not only invest more, but invest more strategically and coherently, building on our current strengths, and capitalizing on emerging opportunities.

1 Economic and Development Review Committee of the OECD, *OECD Economic Surveys: Canada*, Paris (June 2012), p. 2.

2 World Economic Forum, The *Global Competitiveness Report 2012–2013*, Geneva (2012).

Role of the Report

The Science, Technology and Innovation Council (STIC) has been mandated by the Government of Canada to produce a biennial report assessing this country's STI performance, highlighting, where data availability allows, comparisons to other advanced and emerging economies. This enables us to benchmark our STI strengths and weaknesses against international standards of excellence.

Our inaugural report, *State of the Nation 2008*, provided the baseline from which Canada's STI performance could be measured. *State of the Nation 2010* built on that foundation by tracking Canada's performance over the intervening two-year period. Now, another two years later, *State of the Nation 2012* distinguishes trends to track where Canada is making progress, and to identify areas where Canada must devote greater effort towards enhancing performance. Understanding this picture contributes to advancing the national dialogue on science, technology and innovation, identifying avenues for action, and generating the will to work together towards common goals.

Recognizing the critical importance of world-class science, technology and innovation to Canada's success, STIC believes that Canada must strive not only for excellence but for global leadership. Thus, in *State of the Nation 2012*, for each indicator where we report internationally comparable data we identify those countries that are the top five global performers. At the same time, we identify the threshold that Canada would have to attain to break into their ranks and thus achieve global leadership in each of those areas.

What We Measure

As in previous *State of the Nation* (SON) reports, 2012 takes an in-depth look at Canada's performance in three key pillars underpinning the STI ecosystem: business innovation, knowledge development and transfer, and talent development and deployment.

Chapter 4 reviews Canada's performance on the inputs to business innovation, including investment in: research and development (R&D); machinery and equipment, especially productivity-enhancing information and communications technologies (ICT); and intangible assets. This chapter also considers recent firm performance in attracting risk capital, and the diffusion of new ideas and technologies through global linkages. Wherever data availability allows, we continue the effort initiated in SON 2010 to refine the analysis by examining performance by industrial sector.

Chapter 5 looks at knowledge development and transfer, using bibliometric indicators and global university ranking systems to reflect Canada's performance in producing and refining scientific knowledge. We then turn to indicators related to collaboration, contract research, licensing, and spinoffs to assess Canada's performance in translating knowledge into practical applications.

Chapter 6 provides information on talent development and deployment. It begins by looking at Canada's performance in secondary, college, and university (including doctoral) education, as the foundation for developing the skills necessary for scientific discovery and innovation. In addition, we examine the education system's performance in preparing young talent to contribute fully to an innovative, productive and competitive economy, through work-integrated learning and business education. Given the greater internationalization of the STI enterprise, and the increasing mobility of talent, we also investigate Canada's experience in attracting international students and highly qualified immigrants. We then turn our attention to Canada's performance in deploying our talent to use it to full advantage. On this front, we look in particular at the country's performance in absorbing human resources in science and technology, particularly researchers, into the labour force.

Methodology

The indicators utilized in this report are based on the most readily and publicly available statistics of science, technology and innovation activities. They draw from a number of official statistical sources, notably Statistics Canada and the OECD. Where data from these official sources were not available, private and non-profit sector sources were used. As there is typically a two-year time lag in data from official sources, much of the data reported throughout this report are for 2009 and 2010.

The methodologies underpinning the collection of official statistics are based on internationally accepted statistical conventions as described by Statistics Canada, which are based upon the latest (2002) *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development* and the 3rd edition of the *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data.*

Consistent with statistical conventions, data reported in the 2008 and 2010 editions of *State of the Nation* have been updated in cases where final data have been released to replace original estimates.

A number of indicators used in this report (e.g., business enterprise expenditures on research and development, or BERD) are expressed as a percentage of the size of each country's economy—that is, gross domestic product (GDP). This approach is a commonly used and accepted international convention, and allows the comparison of STI indicators across countries of different economic sizes. As with many measures, such ratios are to be interpreted with some care, as they could be influenced by changes either in the indicator under examination (e.g., BERD) or in the relative size of each economy (i.e., GDP) in the comparator group. Nevertheless, all other things being equal, such considerations do not materially affect Canada's international rankings on the indicators cited herein.

In international comparisons, when statistics were not available for a particular country for the most recent year(s) used in the figure depicted, the most recent data available for that country were used instead, rather than omitting the country from the comparison.

All data are in current dollars, unless otherwise noted. All data are in Canadian dollars, unless otherwise noted.

As a preface to this in-depth examination of Canada's performance in the three key pillars, Chapter 2 considers: the importance of science, technology and innovation to Canada's economic and societal well-being; the key players in Canada's STI ecosystem; and the key trends that characterize STI in the modern world. This serves as the foundation for the ensuing discussion of Canada's performance. Chapter 3 examines Canadian funding for R&D in an international context. Particular attention is devoted to government support—not only federal support but, new to *State of the Nation 2012*, provincial support, too. The addition of provincial data helps provide a more integrated, whole-of-Canada picture of resources for R&D.

The Performance Story

Looking at the three key pillars, the findings in *State of the Nation 2012* reinforce much of what was learned in *State of the Nation 2010*. The findings demonstrate that, while Canada has much to celebrate in terms of our knowledge and talent base, we still have much work to do before we can truly "run with the best" and realize Canada's full STI potential.

Canada continues to benefit from a strong foundation built on dual advantages of knowledge and talent. Canada's substantial investments in research in the higher education sector have reaped significant rewards, as the production and refinement of scientific knowledge (reflected in key bibliometric indicators) continues to be characterized by vitality and high-quality. In 2010, as in 2008, Canada (with a 0.5 percent share of global population) accounted for an impressive 4.4 percent of the world's natural sciences and engineering publications.

On the talent front, as reported in *State of the Nation 2010*, half of Canada's adult population has a university or college education, one of the highest levels worldwide. From 2006 to 2010, there was an impressive 31.8 percent increase in the number of undergraduate science and engineering degrees granted and a 7.3 percent increase in the number of engineering degrees granted. At the doctoral level, Canada continues to produce fewer advanced research graduates than many OECD comparator countries; however, the growth rate in the number of science and engineering doctoral graduates is encouraging, surpassing many comparator countries.

Canada cannot afford to be complacent even in these areas of relative strength. Other countries, especially emerging economies, are making significant investments in their education and research systems, some of which are beginning to bear fruit in improving performance, especially with respect to the *quantity* of research outputs. This improving performance in other jurisdictions is affecting Canada's relative position on a number of knowledge and talent development indicators, and Canada risks erosion of its competitive advantage in these areas. Maintaining and expanding our competitive advantage in knowledge and talent development is vital to ensuring a strong foundation for science, technology and innovation.

Canada also continues to face challenges related to knowledge transfer—in effectively moving knowledge developed in higher education institutions to companies that have the ability to absorb it and translate it into commercially viable products and/or solutions to health, environmental and social problems. Anecdotally, we know that a great deal of knowledge transfer is occurring "on two feet"—in other words, through the movement and interplay of people. However, on the traditional measures of licensing and creation of spinoff companies from universities, Canada's performance is typically disappointing, especially compared to that of the United States (U.S.).

Similarly, Canada continues to face challenges in deploying our talent to full advantage to drive discovery and commercialization. On this front, Canada's performance continues to be disappointing on two of the most telling indicators of a country's ability to deploy its innovation talent to best advantage: the share of human resources in science and technology, and the proportion of researchers employed in the private and public sectors.

As concluded in *State of the Nation 2010*, the greatest cause for concern continues to lie in Canada's business innovation performance. Although we recognize that innovative activity is occurring that is not captured in official data, it is nonetheless clear that Canadian businesses are not sufficiently harnessing innovation to make competitive gains. In international rankings related to business innovation, Canada continues to place in the middle of the pack on most measures and, in some cases, Canada's rank has declined. Canada's relatively low business R&D intensity and limited availability of venture capital are areas of particular concern, as is the large gap with the U.S. in private sector investment in productivity-enhancing ICT.

Underlying this mixed performance story is the funding story. The dollar value of Canada's total R&D funding has declined from its peak in 2008, while total funding as a percentage of GDP has declined continuously since 2001. This stands in stark contrast to most other countries, whose gross domestic expenditures on research and development (GERD) and GERD-to-GDP ratios have been increasing. The more recent declines in total Canadian R&D funding efforts are attributable predominantly to lower funding from the private sector.

These findings, and more, are explored in greater depth in the succeeding chapters. The key elements of the performance story are highlighted in the following table, which provides summary comparisons of Canada's performance across the 20 core indicators since the baseline of the *State of the Nation 2008* report. These 20 core indicators were identified by STIC in *State of the Nation 2010*, to use on an ongoing basis to better enable benchmarking, especially against comparator countries, on key measures of science, technology and innovation.

Canada has strong foundations on which to build, but we must do better. All participants in our STI ecosystem have a role to play in driving enhanced performance to elevate Canada to the ranks of the world's leading innovative economies, so that we might enjoy the economic and societal benefits associated with realizing our full STI potential. All players in Canada's STI ecosystem must embrace this responsibility—focusing our resources and efforts, looking to the lessons to be learned from global leaders, improving agility to take advantage of opportunities, and working in concert to allow Canada to "run with the best."

Indicators	State of the Nation 2008	State of the Nation 2010	State of the Nation 2012	Change 2010–12	Change 2008–12
Resources for Research and Development (R&D) and Innovation					
Gross domestic expenditure on R&D (GERD) as a share of Gross Domestic Product (GDP)	***2.00% (2006)***	***1.92% (2008)***	***1.74% (2011)***	▼	▼
Rank	16th out of 41 available economies (2006)	17th out of 41 available economies (2008)	23rd out of 41 available economies (2011)	▼	▼
GERD by funder (CAD millions)	***2006***	***2009***	***2012***		
• Business	14,874	14,148	14,067	▼	▼
• Higher Education	4,574	4,824	5,404	▲	▲
• Federal Government	5,226	5,959	5,838	▼	▲
• Provincial Governments	1,467	1,661	1,681	▲	▲
• Foreign Sector	2,252	2,120	1,960	▼	▼
• Private Non-Profit	827	944	1,077	▲	▲
GERD by performing sector (CAD millions)	***2006***	***2009***	***2012***		
• Business	16,474	15,569	15,493	▼	▼
• Higher Education	9,625	10,818	11,528	▲	▲
• Federal Government	2,496	2,762	2,475	▼	▼
• Provincial Governments	310	352	348	▼	▲
R&D financed by business, by sector (CAD millions)	***2006***	***2009***	***2012***		
• Business	13,947	13,113	13,107	▼	▼
• Higher Education	808	896	863	▼	▲
R&D financed by federal government, by sector (CAD millions)	***2006***	***2009***	***2012***		
• Business	260	313	406	▲	▲
• Federal Government	2,434	2,684	2,400	▼	▼
• Higher Education	2,488	2,932	3,002	▲	▲
Direct federal government support to business R&D as a share of GDP	***0.02% (2005)***	***0.02% (2008)***	***0.03% (2010)***	▲	▲
Indirect federal government support to business R&D as a share of GDP	***0.21% (2005)***	***0.22% (2008)***	***0.21% (2010)***	▼	—
Intramural government R&D: share of GDP	***0.19% (2006)***	***0.19% (2008)***	***0.18% (2011)***	▼	▼
Business R&D and Innovation					
Business expenditure on R&D (BERD) as a share of GDP	***1.14% (2006)***	***1.04% (2008)***	***0.89% (2011)***	▼	▼
Rank	18th out of 41 available economies (2006)	21st out of 41 available economies (2008)	25th out of 41 available economies (2011)	▼	▼
Business expenditure on machinery and equipment (M&E) as a share of GDP	***6.6% (2004)***	***6.6% (2007)***	***5.7% (2011)***	▼	▼
Business information and communications technology (ICT) investment intensity (ICT investment as a share of non-residential gross-fixed capital formation)	***N/A***	***N/A***	***17% (2009)***	***N/A***	***N/A***
Rank	N/A	N/A	9th out of 20 available economies (2009)	N/A	N/A
Information technology (IT) services intensity (in select industries)	***N/A***	***2.3% for mining and quarrying; 7.9% for finance and insurance (Year of data: mid-2000s)***	***N/A***	***N/A***	***N/A***
Rank	N/A	3rd out of 27 for mining and quarrying; 7th out of 27 for finance and insurance (Year of data: mid-2000s)	N/A	N/A	N/A
Venture capital (VC) investment as a share of GDP	***0.13% (2007)***	***0.09% (2008)***	***0.09% (2011)***	—	▼

For rankings, the Science, Technology and Innovation Council used all economies for which data were available.
For most OECD statistics, this refers to OECD member countries and other key economies measured by the OECD.
Performing sector refers to the sector of the economy that carries out R&D activities, while funding sector refers to the sector that pays for the R&D.
For example, the business sector funds a significant amount of activities within the higher education sector.

Indicators	State of the Nation 2008	State of the Nation 2010	State of the Nation 2012	Change 2010–12	Change 2008–12
Trade in technology-intensive services – Receipts as a share of total commercial services receipts 🍁	***N/A***	***42.1% (2009)***	***38.8% (2011)***	▼	***N/A***
Trade in technology-intensive services – Payments as a share of total commercial services payments 🍁	***N/A***	***39.4% (2009)***	***39.1% (2011)***	▼	***N/A***
Number of cross-border trademarks	***N/A***	***28.6 (Average 2005–07)***	***N/A***	***N/A***	***N/A***
Rank	N/A	19th out of 38 available economies (Average 2005–07)	N/A	N/A	N/A
Direct resident trademark applications	***17,719 (2004)***	***21,101 (2007)***	***20,449 (2010)***	▼	▲
Rank	20th out of 212 available economies (2004)	17th out of 212 available economies (2007)	17th out of 212 available economies (2010)	—	▲
Knowledge Development and Transfer					
Higher education expenditure on R&D (HERD) as a share of GDP	***0.66% (2006)***	***0.68% (2008)***	***0.66% (2011)***	▼	—
Rank	3rd out of 41 available economies (2006)	4th out of 41 available economies (2008)	9th out of 41 available economies (2011)	▼	▼
University-industry collaboration in R&D Rank	***14th out of 134 economies (2008)***	***7th out of 139 economies (2010)***	***15th out of 144 economies (2012)***	▼	▼
Total new licences for universities and affiliated teaching hospitals 🍁	***N/A***	***524 new licences (2008)***	***537 new licences (2009)***	▲	***N/A***
Talent Development and Deployment					
Programme for International Student Assessment (PISA) science, mathematics and reading (Score and Rank)	***2006***	***2009***			
• Science	534, 3rd out of 57 available economies	529, 8th out of 74 available economies	N/A	N/A	N/A
• Math	527, 7th out of 57 available economies	527, 10th out of 74 available economies	N/A	N/A	N/A
• Reading	527, 4th out of 57 available economies	524, 6th out of 74 available economies	N/A	N/A	N/A
Percentage of 25–64 year old population with tertiary education	***47% (2006)***	***49% (2008)***	***51% (2010)***	▲	▲
Rank	1st (out of OECD member economies)	1st (out of OECD member economies)	1st (out of OECD member economies)	—	—
Growth in total number of degrees granted in tertiary science, engineering and all fields of study		***2005–08***	***2006–10***		
• Science	N/A	28.00%	31.80%	N/A	N/A
• Engineering	N/A	9.10%	7.30%	N/A	N/A
• All Fields of Study	N/A	13%	5.40%	N/A	N/A
Total number of degrees granted in doctoral programs		***2008***	***2010***		
• Science	N/A	1,704	1,928	▲	N/A
• Engineering	N/A	891	1,036	▲	N/A
• All Fields of Study	N/A	4,827	5,416	▲	N/A
Researchers per 1,000 employment		***2005***	***2008***		
• All sectors	N/A	8.2	8.5	▲	N/A
Rank	N/A	13th out of 35 available economies (2007)	12th out of 37 available economies (2009)	▲	N/A
• Business sector	N/A	5	5.2	▲	N/A
Rank	N/A	8th out of 35 available economies (2007)	9th out of 37 available economies (2009)	▼	N/A
• Government, higher education and non-profit sectors	N/A	3.2	3.3	▲	N/A
Rank	N/A	19th out of 35 available economies (2007)	18th out of 37 available economies (2009)	▲	N/A

Figures and rankings in the State of the Nation 2008 and 2010 columns may not always appear as originally reported.
If data have been revised since the publication of those reports, the revised data have been used.
N/A stands for Not Available.

🍁 Refers to data only available for Canada; all other data are international.

2 Understanding Science, Technology and Innovation

Before looking at Canada's science, technology and innovation (STI) performance story, it is important to understand the context in which this story unfolds. It is useful to first define "science and technology (S&T)," "research and development (R&D)," and "innovation," and to explain their importance to the economic and societal well-being of Canadians. In addition, we describe the key players in the Canadian STI ecosystem and the distinguishing characteristics of the modern STI enterprise.

Defining the Concepts

Consistent with international practice, scientific and technological activities are taken to include the generation, dissemination and application of new scientific and technological knowledge. For statistical purposes, these activities are broken down into research and experimental development (i.e., R&D)—the central activity—and related scientific activities (RSA). RSA, performed predominantly by governments and their agents, include activities such as education support, technical surveys, statistical surveys, information services, special services and studies, and museum services.

The Science, Technology and Innovation Council's (STIC's) 2008 and 2010 *State of the Nation* reports presented the definitions used in the *Frascati Manual* (OECD 2002) for R&D and the *Oslo Manual* (OECD/Eurostat 2005) for innovation.

The OECD's *Frascati Manual* (2002) defines R&D to encompass three activities: "'Basic research' is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. 'Applied research' is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. 'Experimental development' is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed."[3]

Whereas S&T activities, and more specifically R&D, involve the creation of new knowledge or technology, innovation requires the introduction of that knowledge or technology into the marketplace, where value is created, or into an organization, where efficiencies are generated. The *Oslo Manual* (2005) defines 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."[4] The main types of innovation are further elaborated as follows:

- *Product innovation* involves a good or service that is new or significantly improved. This includes substantial improvements in technical specifications, components and materials, incorporated software, user-friendliness or other functional characteristics.

3 OECD *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, Paris (2002), p. 30.

4 OECD/Eurostat, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd edition*, Paris (2005), p. 46.

- *Process innovation* involves a new or significantly improved production or delivery method. This includes noteworthy changes in techniques, equipment and/or software.
- *Marketing innovation* involves a new marketing method with significant changes in product design or packaging, product placement, product promotion or pricing.
- *Organizational innovation* involves a new organizational method in the firm's business practices, workplace organization or external relations.

The definitions of STI activities in the *Frascati* and *Oslo Manuals* are critical to this report because they form the foundation for allowing data comparisons across countries. Building on the *Oslo Manual* definition, STIC defines innovation as the process by which individuals, companies, and organizations develop, master and use new products, designs, processes and business methods. These can be new to them, if not their sector, their country or the world. Innovation activities include R&D, invention, capital investment, and training and development.

Innovation may involve gradual changes to existing products, processes or organizations, or it may entail radically new technologies or ways of doing things. While the latter are easier to identify and count, the former can have as great or greater impact over time on individual firms and the overall economy. The essential ingredient is that something new or improved is being introduced to an organization or directly to the marketplace.

Despite the importance of innovation as a driver of economic growth, it is often difficult to determine how much innovation is taking place in an economy. While traditional measures, such as R&D investments, machinery and equipment investments, and venture capital funding capture many of the innovative activities taking place, they miss some important innovative practices. For example, the significant investments that Canada's natural resource industries make in exploration and evaluation activities and in field testing facilities, while not R&D, nonetheless rely heavily on innovative processes and STI. STIC's *State of the Nation 2010* report recognized the importance of this type of innovation that is not captured through traditional indicators. Furthermore, the high degree to which some Canadian industries are integrated into multinational companies and global supply chains means that Canadian companies can benefit from R&D performed elsewhere and often protect their innovations by patenting elsewhere. These types of knowledge flows and other investments are difficult to track. Anecdotal information, however, helps us understand where and how this type of innovation takes place.

The Importance of Science, Technology and Innovation

STI provides the foundation for a strong economy by increasing productivity growth, creating high-value jobs, and creating and growing firms. Investments in R&D also help address pressing challenges by providing the knowledge, technologies and processes needed to avoid or mitigate the harmful effects of health, environmental and social problems.

Productivity Growth

Productivity growth is a major source of improvement in economic well-being in the long run and is essential for rising wages and increased profitability for investors.[5,6] International analysis also finds that the most productive firms create the most jobs.[7] Innovation is widely considered to be a major driver of productivity. At the firm level, analysis shows that firms that invest more in innovation per employee have higher productivity levels.[8]

Productivity measures the total amount of goods and services produced in a country for each input to production, such as labour, capital or land. Productivity is usually expressed in terms of growth rates or levels. The most common measure of productivity is labour productivity, which measures the amount of goods and services produced by one hour of labour. However,

5 Bank of Canada, "Productivity," *Backgrounders* (2010), p. 1. (http://www.bankofcanada.ca/wp-content/uploads/2010/11/productivity.pdf)

6 The Conference Board of Canada, *Canada's Lagging Productivity: The Case of a Well-Educated Workforce Lacking the Much-Needed Physical Capital* (2010), p. 1.

7 OECD, *Entrepreneurship at a Glance 2012*, Paris (2012). (http://www.oecd.org/industry/entrepreneurshipataglance2012.htm)

8 OECD, *Innovation in Firms: A Microeconomic Perspective*, Paris (2009), p. 13.

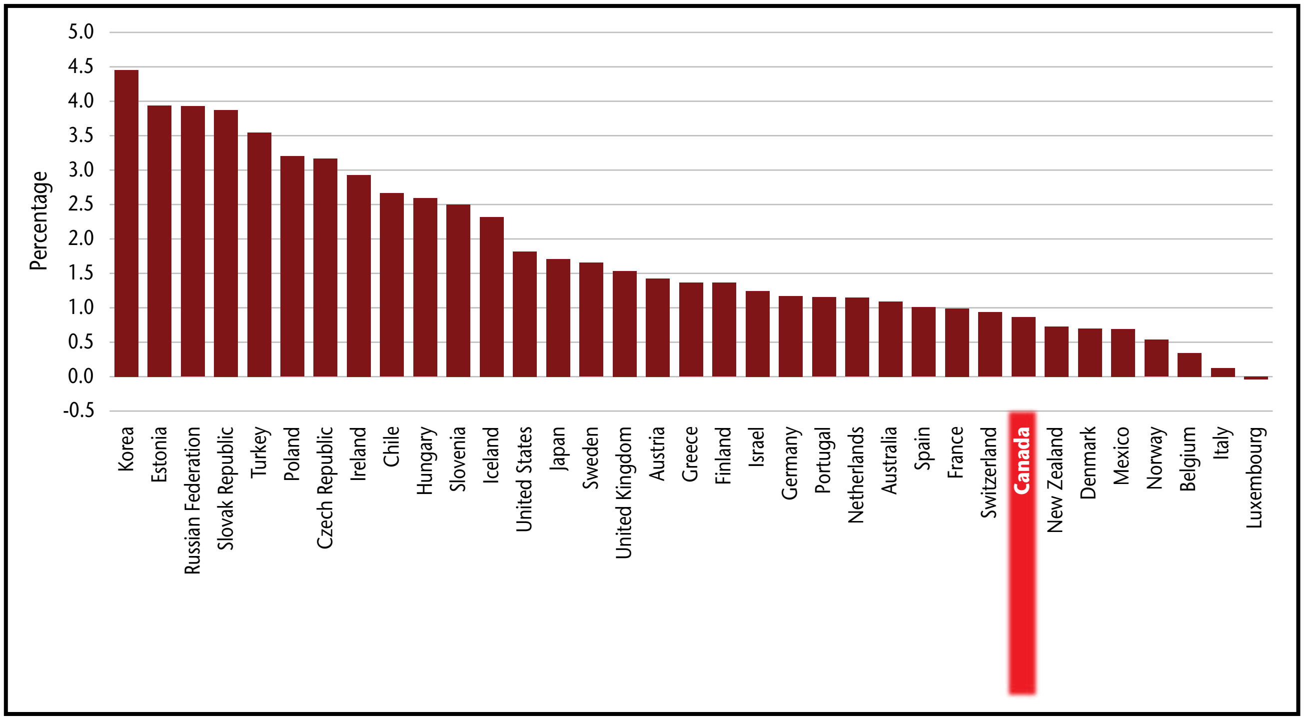
labour productivity (output per hour worked) does not explicitly account for the effects of capital or changes in its composition on output growth.[9] Multifactor productivity (MFP) measures the efficiency with which the combined inputs of capital and labour are used in the production process. MFP captures such factors as improvements in technology, economies of scale, capacity utilization and managerial skills. While this indicator provides a more complete picture of the drivers of productivity, it is also more difficult to measure than labour productivity.

In a number of leading economies (including Austria, Finland, Sweden, the United Kingdom (U.K.), and the United States (U.S.)), it is estimated that between two-thirds and three-quarters of labour productivity growth between 1995 and 2006 was attributable to MFP and investment in intangible assets such as software, databases, skills, exploration and efficient organization design.[10] In many OECD countries, firms now invest as much in innovation-related assets as they do in physical capital, such as machinery, equipment or buildings.

In assessing productivity performance, it is more meaningful to examine growth over long periods rather than in specific years. Figure 2-1 provides an international comparison of average annual labour productivity growth rates of OECD economies over the 2001–2011 period. It shows that Canada's labour productivity growth has been generally weak relative to other advanced economies, with Canada ranking 28th among 35 comparator countries.

Of particular concern is the significant gap between Canada and the U.S. in the *level* of productivity, which is highlighted in Figures 2-2 and 2-3. These figures show that there was a widening of the gap between Canada and the U.S. in terms of both labour productivity and

Figure 2-1: Average Annual Labour Productivity Growth in OECD Economies, 2001–2011



Source: OECD, *Labour Productivity Dataset*, March 2013.

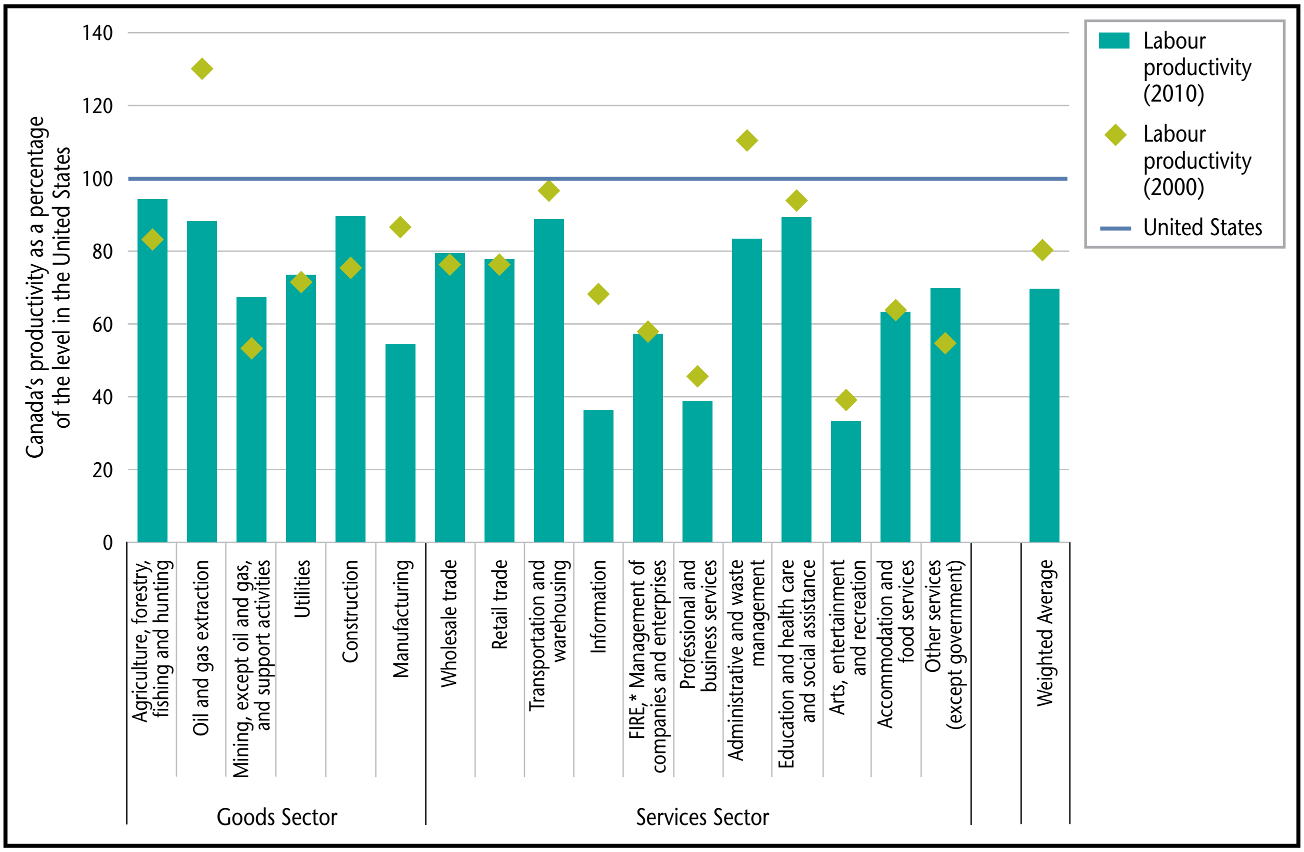
9 Baldwin, R. John, Wulong Gu and Beiling Yan, *The Productivity Review: User Guide for Statistics Canada Annual Multifactor Productivity Program* (Statistics Canada Catalogue 15-206XIE, no. 14), 2007.

10 OECD, "Key Findings," *Ministerial Report on the OECD Innovation Strategy* (2010), p. 4. (http://www.oecd.org/sti/45326349.pdf)

MFP from 2000 to 2010. With respect to labour productivity in the business sector (i.e., the weighted average of all industries included in Figure 2-2), Canadian levels over this time period fell from 80 percent to 70 percent of U.S. levels. Several industries, including oil and gas extraction, manufacturing, transportation and warehousing, information, and professional and business services, saw declines in labour productivity levels relative to the U.S. from 2000 to 2010. On the other hand, other industries, including agriculture, forestry, fishing and hunting; mining, excluding oil and gas, and support activities; utilities; construction; wholesale trade; retail trade; and, other services saw their gap with the U.S. decrease over this period.

With respect to business sector MFP, Figure 2-3 shows that the Canadian level over this time period also fell, from 79 percent to 70 percent of the U.S. level, widening the gap with the U.S. This is attributable to the fact that many Canadian industries saw a relative decline against the U.S. MFP level. Those industries that did not experience a decline include: agriculture, forestry, fishing and hunting; mining, excluding oil and gas, and support activities; utilities; construction; retail trade; and other services. Estimating MFP is complex, and using different approaches can influence the results. *State of the Nation 2012*, like its predecessors, uses the same methodology in estimating MFP for both Canada and the U.S.[11]

Figure 2-2: **Canada–United States Labour Productivity Comparison, 2000 and 2010 (United States = 100)**

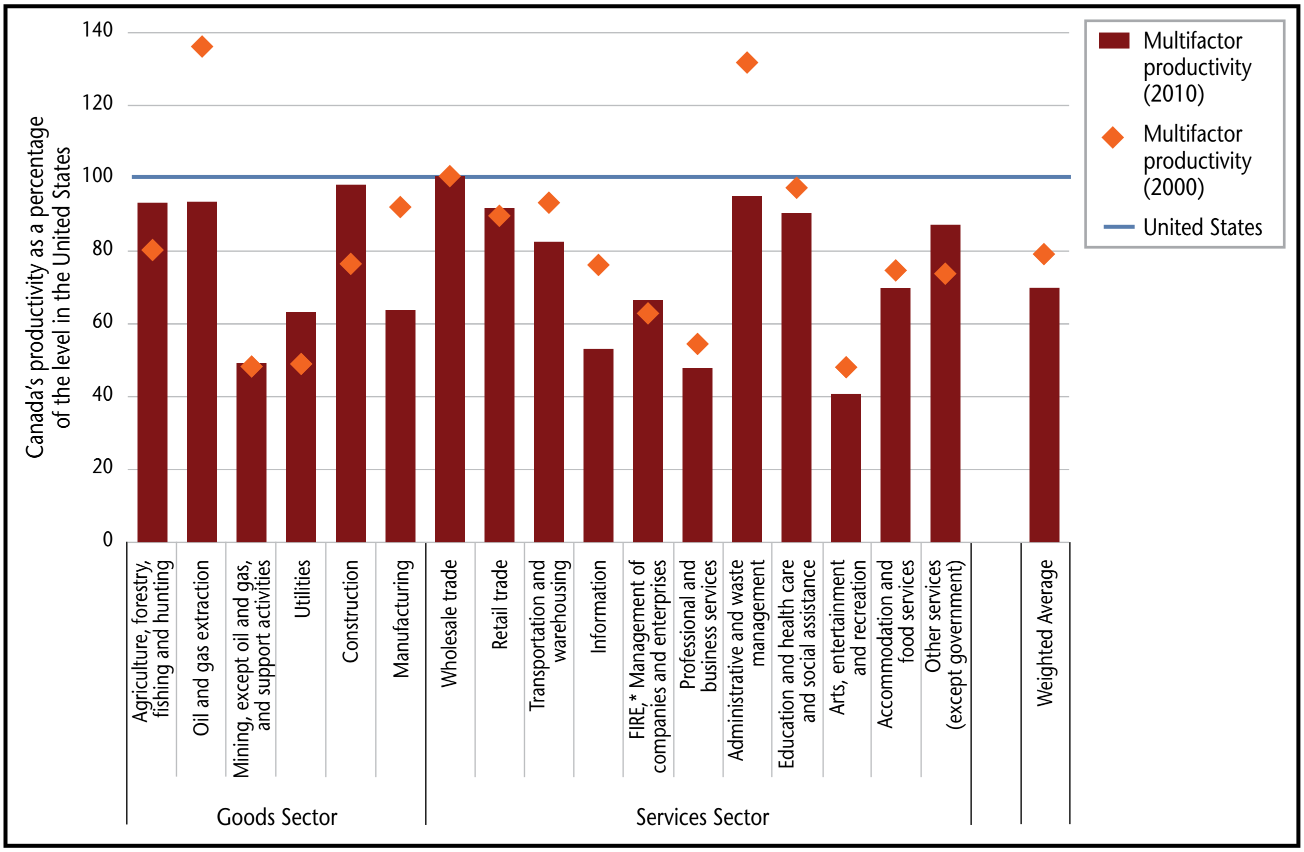


* FIRE is finance, insurance and real estate.

Source: Industry Canada updates of Tang, Rao and Li (2010) for STIC, based on data from Statistics Canada, the U.S. Bureau of Economic Analysis and the U.S. Bureau of Labor Statistics, December 2012.

11 A recent study by Diewert and Yu (published in the Centre for the Study of Living Standards' *International Productivity Monitor*, Fall 2012, pp. 27–45), while using Statistics Canada raw data, comes to a different conclusion. It estimates average MFP growth at 1.03 percent per year over the 1961–2011 period. This compares to the official Statistics Canada estimate of 0.28 percent over the same period. The main reason for the difference seems to lie in the estimates of capital services growth used by the two different approaches.

Figure 2-3: **Canada–United States Multifactor Productivity Comparison, 2000 and 2010 (United States = 100)**



* FIRE is finance, insurance and real estate.

Source: Industry Canada updates of Tang, Rao and Li (2010) for STIC, based on data from Statistics Canada, the U.S. Bureau of Economic Analysis and the U.S. Bureau of Labor Statistics, December 2012.

In general, labour productivity levels and their growth in Canada vary significantly among industries. Figure 2-4 shows that the 2010 labour productivity level in the oil and gas extraction industry was about eight times higher than that of the overall business sector, and the utilities industry was more than three times higher than that of the overall business sector. The mining and oil and gas extraction industry, however, showed a negative annual average growth of -5.4 percent while the utilities industry showed zero growth over the 2000 to 2010 period. A number of industries experienced above average growth, with the agriculture, forestry, fishing and hunting, and wholesale trade industries leading the way.

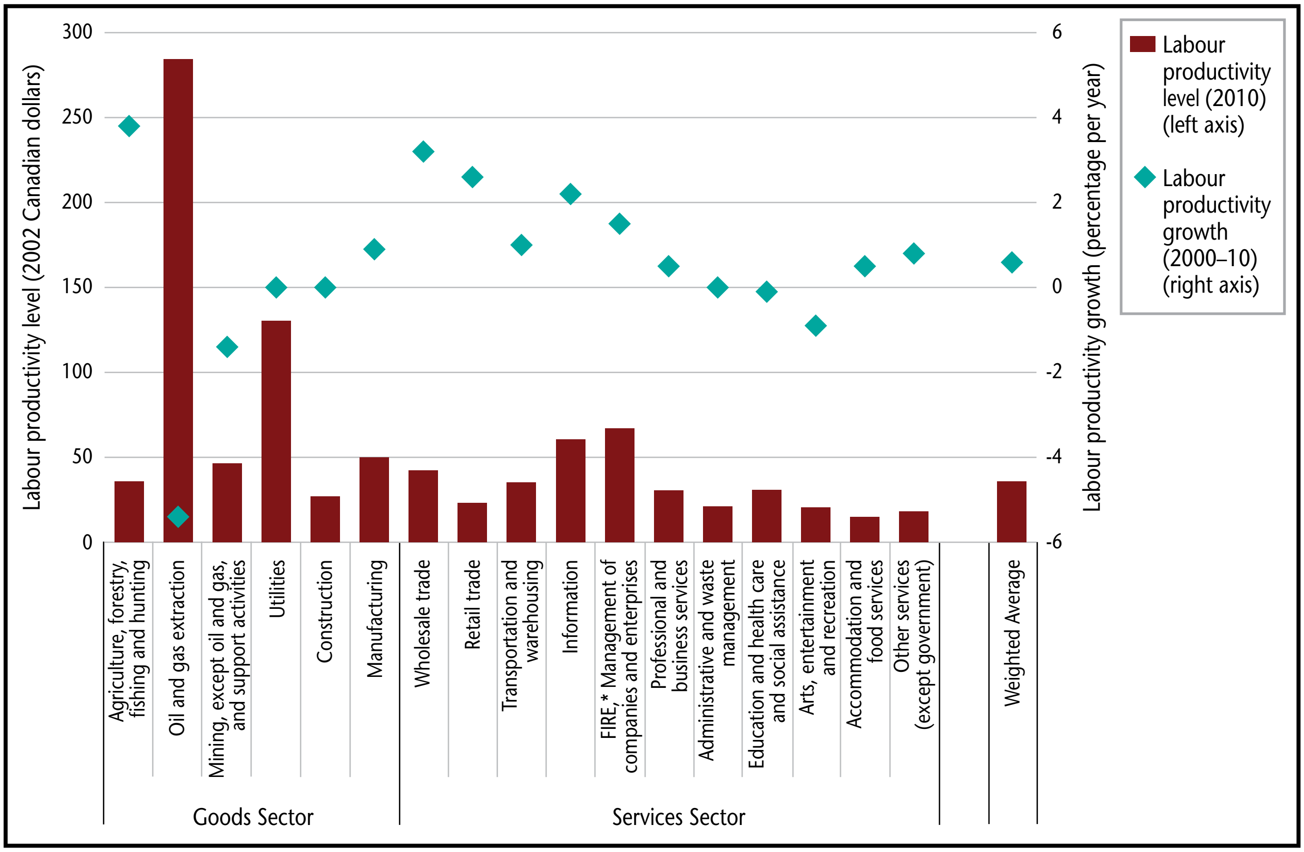
Increased business investment in STI-related assets, such as information and communications technologies and advanced machinery and equipment, are crucial for improving productivity. These issues are addressed in more depth in Chapter 4: Business Innovation.

Employment Growth and Firm Creation

Evidence suggests that investment in STI can create new jobs and expand overall employment, although it may lead to substantial job shifts across industries. By helping firms to become more competitive and thereby access new markets, STI is a key driver of firm expansion and employment growth. STI also encourages the creation of new firms as an avenue for commercializing new products and processes. New firms are a particularly important source of new jobs. In 2007, for example, firms less than five years old accounted for over two-thirds of net new jobs in the U.S.[12]

12 J. Haltiwanger, R. Jarmin and J. Miranda, "Business Dynamics Statistics Briefing: Jobs Created from Business Start-ups in the United States," *Ewing Marion Kauffman Foundation* (2009). Cited in OECD, *OECD Innovation Strategy: Getting a Head Start on Tomorrow*, Paris (2010), p. 24. (http://www.oecd.org/site/innovationstrategy/theoecdinnovationstrategy.htm)

Figure 2-4: **Labour Productivity (2010) and Labour Productivity Growth (2000–10) by Industry**



* FIRE is finance, insurance and real estate.

Source: Industry Canada updates of Tang, Rao and Li (2010) for STIC, based on data from Statistics Canada, the U.S. Bureau of Economic Analysis and the U.S. Bureau of Labor Statistics, December 2012.

In some cases, inventions, such as those emerging over the past century related to communications, computing, biotechnology, transportation and nanotechnology, can create entirely new industries that grow to employ large numbers of people. Of course, new technologies can also make the goods or services of some firms obsolete or less competitive, and thereby lead to firm closures. The gains and losses should be considered at an overall societal level, over the short-, medium- and long-term, with appropriate policies to address the disruption and displacement that may result.

Health, Environmental and Social Challenges

World-class scientific research can lead to breakthrough discoveries and technologies whose applications can address pressing health, environmental and social challenges. On the health front, aging population, the growing impact of diseases such as diabetes, HIV/AIDS, and emerging infectious diseases remain major challenges for the coming decades. In addition to providing new diagnostic techniques, therapies and medicines, STI can help meet these challenges by improving performance of health systems and making them more efficient and effective.

The need to address environmental challenges, such as climate change, air and water pollution, chemical contaminants and hazardous waste disposal, is high on the priority list of many governments around the world and has motivated considerable investments in prevention and mitigation technologies. For example, technological advances that allow for more efficient combustion, the capture of emissions or substitution of fossil fuels by renewable energy sources aim to reduce atmospheric emissions, while advances in bioremediation and other techniques have enhanced our ability to remove contaminants from soil and water.

Concerns over social challenges around food security have driven research and innovation in Canada since the early 20th century, when government scientists developed hardy new crop varieties that could flourish in the Canadian climate. Current work on genetically modified crops aims to improve crop yields, while reducing the amount of fertilizer, pesticides and herbicides used.

The Science, Technology and Innovation Ecosystem and its Key Players

Canada's STI ecosystem involves numerous players, including governments, businesses, universities and colleges, nongovernmental organizations (NGOs), communities and individuals. The links among these players are complex, multi-dimensional, dynamic and continuously evolving. These links facilitate the exchange and creative deployment of the knowledge, capital, talent and other resources required for innovation. For example, the higher education sector may provide new knowledge and talent; suppliers and customers may provide crucial information about market demand and technical improvements; community associations and NGOs may link to financial, business and legal services; and various levels of government may provide a wide variety of financial, knowledge and networking support. While all of these players have important roles in Canada's STI ecosystem, the most active sectors are government, higher education (universities and colleges) and business.

Government Sector

Federal and provincial governments in Canada play significant roles in supporting STI by developing policies that create the environment in which STI can thrive and delivering programs that fund R&D and innovation activities.

In Canada, federal and provincial governments are jointly responsible for the framework conditions that support the production of many of the inputs required for STI. Federal and provincial strategies to strengthen STI include policies related to fiscal and tax systems, intellectual property rights and labour mobility; regulations concerning health, safety and the environment; and policies shaping competition, foreign investment and trade.

Stable and predictable government policies are particularly important to firms to enable them to better calculate the potential returns on investments in research, product development and process improvements. Regulatory regimes influence the size, dynamism and funding of firms, the degree of competition they face, their ability to appropriate the returns on their intellectual property, and whether new products and services can be released into the marketplace. Rigidities in labour markets can also make it difficult for firms to adapt to changing market conditions and may hinder the retention and redeployment of skilled personnel.

Framework conditions also impact R&D carried out in the higher education sector and government laboratories, primarily by providing the economic resources needed to support this work, but also by encouraging STI partnerships with the private sector. Intellectual property regimes also provide some incentive for researchers to pursue potential commercial applications of their discoveries and inventions.

The expansion of markets has been one of the main drivers behind STI, as reductions in tariff and non-tariff barriers and the liberalization of capital markets have opened up new opportunities for trade and international investment. This has expanded markets for innovators and consumers, while facilitating the spread of knowledge, technologies and innovative business practices.

Federal Programs Supporting Science, Technology and Innovation

The federal government provides a wide variety of programs to support STI in both higher education and business. The federal government's three granting councils each provide individual and team research grants, fellowships and scholarships, and help fund collaborative projects with industry, government and not-for-profit organizations. In 2011–12, the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Canadian Institutes of Health Research (CIHR) each provided approximately $1 billion to Canadian researchers and students, while the Social Sciences and Humanities Research Council of Canada (SSHRC) provided approximately $340 million.

The granting councils also manage a number of joint initiatives, including some of the government's largest direct support programs. These include programs directed at building research networks (including networks led by industry), through the Networks of Centres of Excellence (NCE) suite of programs. Tri-council initiatives are also aimed at attracting and retaining top research talent to Canadian universities—notably through the prestigious Canada Excellence Research Chairs program, the Vanier Canada Graduate Scholarships and the Banting Postdoctoral Fellowships.

Through the Canada Foundation for Innovation (CFI), the federal government also funds the infrastructure necessary to enable Canadian research and technology development. CFI funding includes support for equipment, laboratories, databases, specimens, scientific collections, computer hardware and software, communications linkages and buildings. As of March 2012, CFI had invested almost $5.7 billion in infrastructure at research institutions across Canada.

The Government of Canada also provides support to business innovation through the provision of financial capital and assistance for product development and commercialization. In addition to the Scientific Research and Experimental Development (SR&ED) tax credit, which is the single largest source of federal government support for business innovation, the government contributes to the overall financial resources available to help firms innovate through programs such as Business Development Bank of Canada Venture Capital and the Venture Capital Action Plan. A key program that supports product development and commercialization in small and medium-sized enterprises (SMEs) is the National Research Council Canada Industrial Research Assistance Program (IRAP), which is the government's largest direct support program for industry. IRAP also delivers the Digital Technology Adoption Pilot Program, which is aimed at speeding up the rate at which SMEs adopt digital technologies and build digital skills. As well, the federal government supports commercialization by procuring and testing pre-commercial innovations through the Canadian Innovation Commercialization Program. The Government of Canada also supports industry-relevant research, through programs such as the Strategic Aerospace and Defence Initiative, which targets the aerospace, defence, security and space industries.

The federal and provincial governments make significant investments in research performed by higher education institutions and by industry, as detailed in Chapter 3: Canada's Funding for Research and Development in an International Context. The Government of Canada provides substantial funding for universities and, to a lesser extent, colleges, to support research projects, associated infrastructure, development of talent, and creation of collaborative R&D networks. This funding is distributed largely through the three federal granting councils—CIHR, NSERC and SSHRC—and through the CFI. Provincial governments are responsible for funding the operating costs of Canada's public universities and colleges, and thereby contribute considerably to the overhead costs associated with the research funded by the federal government. They also support the direct costs of research and talent, through various funding programs.

The federal and provincial governments' support for private sector R&D (also detailed more in Chapter 3) is delivered both through *direct* funding to firms and through the *indirect* mechanism of tax credits. The federal program mix is heavily weighted towards indirect support, through the SR&ED tax credit program, considered one of the most generous in the world. Most provinces and the Yukon offer similar R&D tax credits to supplement the federal program.

Provincial Programs Supporting Science, Technology and Innovation

Canada's provincial governments support science, technology and innovation through a variety of programs aimed at stimulating business innovation, knowledge development and transfer, and talent development and deployment. These programs vary from one province to another. A sample of these programs includes:

Alberta

The Alberta Innovates Connector Service, launched in 2010, is a free, personalized service that helps entrepreneurs, inventors and companies with innovative ideas connect to Alberta's research and innovation system. Supported by Alberta Enterprise and Advanced Education, the Connector Service assesses business needs, facilitates introductions and directs individuals to programs and service providers, including the Alberta Innovates corporations that offer technical expertise, business services and funding. The Connector Service focuses on the client—determining needs and priorities, and making connections to the information, people, facilities or organizations required to move innovative ideas into the marketplace. The Connector Service has been handling approximately 800 inquiries per year.

British Columbia

The British Columbia Innovation Council (BCIC), a provincial Crown agency, launched a province-wide Mentor Program in January 2011 to improve the success of technology entrepreneurs through access to expert guidance and know-how. Modelled after the MIT Venture Mentoring Service, the program trains and accredits volunteer mentors who are matched with entrepreneurs in the BCIC Venture Acceleration Program (VAP), a structured program designed to accelerate the growth of early-stage technology companies. VAP delivery partners include Accelerate Okanagan, VIATeC/Accelerate Tectoria, Wavefront, the Innovation Island Technology Association and Kamloops Innovation Centre. BCIC is working with additional delivery partners to make these programs available throughout the province. BCIC reports that, as of 2012, more than 170 ventures have received mentoring from the program's 115 active mentors.

Newfoundland and Labrador

The Research and Development Corporation's Petroleum Research and Development (R&D) Accelerator Program aims to stimulate R&D in the petroleum industry by funding, on a non-repayable basis, up to 25 percent of eligible R&D costs, to a maximum of $5 million per project for up to five years. The program targets industry-led projects and leverages 75 percent or more of eligible R&D costs from the applicant (the offshore supplier/technology provider), offshore petroleum producers (collaborators/end-users), R&D partners, and/or other sources.

Ontario

The Ontario Research Fund—Research Infrastructure (ORF-RI) program provides funding for infrastructure in Ontario's publicly funded research institutes to support research and technology development. The Large Infrastructure Fund component of the ORF-RI program assists institutions in developing their research strengths by investing in facilities and bringing together researchers from a range of disciplines, as well as technology experts and industry partners.

Quebec

The Fonds de recherche du Québec provides support to basic research through provision of funding for collaborative and inter-sectoral initiatives. For example, the Fonds de recherche du Québec–Nature et technologies Strategic Clusters Program supports collaborative academic research in areas such as forestry, oceanic and Arctic studies, biology, health, climate change, and information and communications technologies (ICT). Approximately 30 strategic clusters have been created so far, involving researchers from, on average, six Quebec universities, as well as companies and government agencies in the province. Currently, more than 1,300 researchers from universities, colleges, industry, and government are associated with the clusters and contribute to the training of about 3,000 graduate students and 350 post-doctoral fellows.

A number of federal and provincial programs supporting research performed by higher education institutions and industry complement one another. Examples include: the tax credits that the federal government and a number of provincial governments provide for eligible R&D expenses; joint funding of the operating and capital costs of some research programs; and support for large-scale research infrastructure such as TRIUMF (the subatomic physics laboratory located in Vancouver).

Finally, the federal government, through its science-based departments and agencies and their laboratories, engages both in R&D and in the related scientific activities that support its regulatory responsibilities. With few exceptions, provincial governments have not invested heavily in intramural government R&D.

To guide its STI investments, the Government of Canada outlined four broad priority areas in its 2007 science and technology strategy, *Mobilizing Science and Technology to Canada's Advantage*. The four priority areas are: environmental science and technologies; natural resources and energy; health and related life sciences and technologies; and ICT. To provide further focus, in September 2008, the Minister of Industry announced 13 sub-priority areas, identified in the table below, as recommended by STIC. In order to build critical mass in Canada—at a global scale—it is vital that the federal government focus greater resources on these STI sub-priority areas, while at the same time supporting the best ideas regardless of research area. The sub-priorities identified by STIC represent areas where the government can leverage investments to stimulate leading-edge solutions to health, environmental and social challenges and, at the same time, develop practical applications that sustain and deepen the competitive advantage of Canadian business in these domains.

STI Sub-Priorities

(Recommended by STIC and Endorsed by the Government of Canada in 2008)

Priority Areas	Sub-priority Themes
Environment	Water: • health • energy • security
	Cleaner methods of extracting, processing and utilizing hydrocarbon fuels, including reduced consumption of these fuels
Natural Resources and Energy	Energy production in the oil sands
	Arctic: • resource production • climate change adaptation • monitoring
	Biofuels, fuel cells and nuclear energy
Health and Life Sciences	Regenerative medicine
	Neuroscience
	Health in an aging population
	Biomedical engineering and medical technologies
Information and Communications Technologies	New Media, animation and games
	Wireless networks and services
	Broadband networks
	Telecom equipment

Sub-priorities listed above are not ranked within or across categories.

It is estimated that the three federal granting councils collectively funded approximately $516 million in research focused on the sub-priority areas in fiscal year 2011–12, or just under 22 percent of their combined $2.3 billion in extramural R&D expenditures that year. Specifically, NSERC devoted approximately $255 million to the sub-priority areas ($666 million to the four broader priority areas); CIHR about $255 million; and SSHRC about $6 million ($63 million to the four broader priority areas). The specific amounts devoted to each sub-priority area are detailed in appendix A.

This funding reflects both responsiveness to researchers' proposals and proactive targeting of sub-priority areas in research funding competitions. For example, the NCE program targeted the 13 sub-priority areas in its last two competitions in 2009 and 2012. As a result, six new networks were announced, with an NCE investment of $141.6 million. These six networks covered the following sub-priority areas: water; cleaner methods of extracting, processing and utilizing hydrocarbon fuels; biofuels; neuroscience; health in an aging population; and new media, animation and games.

The Canada Excellence Research Chairs (CERC) program is another example where granting council funding has been targeted. Budget 2008 announced the creation of the prestigious program, to award up to $10 million for 20 chairs over seven years to support universities in attracting and retaining world-leading researchers in the four priority areas of the S&T Strategy. Canada's inaugural 19 CERCs were announced by the federal government in April 2010. While the competition did not explicitly target the sub-priority areas, the extent to which proposals addressed these areas was considered when evaluating them for funding. Budget 2011 announced further federal investment to appoint additional CERCs, with new awards available under a second competition that will be finalized by early 2014. Again, one of the criteria by which proposals will be evaluated is the extent to which they fit in one or more of the priority and sub-priority areas.

Higher Education Sector

The higher education sector (universities and colleges) plays a number of important roles in the STI ecosystem, described by the OECD to include "education, training, skills development, problem solving, creation and diffusion of knowledge, development of new instrumentation, and storage and transmission of knowledge."[13] Universities and colleges can anchor clusters of innovative activity in their local communities and act as bridges between businesses, governments and other countries.

At the heart of the innovation process are the people who "generate the ideas and knowledge that power innovation, and then apply this knowledge and the resulting technologies, products and services in the workplace and as consumers."[14]

Universities and colleges play a critical role in developing young talent, providing them with the specific skills, knowledge and trades to help them become productive contributors to Canada's economy, and exposing them to the exciting potential of research and innovation. Universities and colleges also provide education for future entrepreneurs and business leaders who are integral to enhancing Canada's competitive advantage and improving productivity. Perhaps most importantly, these institutions impart critical thinking and problem-solving skills to young talent, as well as the adaptability and flexibility necessary for success in the global knowledge economy.

Canada's universities and colleges also play a critical role in developing and advancing knowledge and its application. Much of the knowledge underlying today's innovation resulted from research conducted in the higher education sector. While the link between research and innovation is complex and the task of commercializing new knowledge is extremely difficult and uncertain, advances in knowledge are necessary to most innovation processes. In high-technology areas such as ICT, biotechnology and nanotechnology, the basic research conducted by universities has been essential. The uncertainties and long-term horizon of this type of research and the impossibility of capturing all of its benefits make it very difficult, if not impossible, for private firms to carry

13 OECD, *Performance-based Funding for Public Research in Tertiary Education Institutions: Workshop Proceedings* (2010), p. 9.

14 OECD, "Key Findings," *Ministerial Report on the OECD Innovation Strategy* (2010), p. 9. (http://www.oecd.org/sti/45326349.pdf)

it out. These firms are, however, increasingly recognizing the innovative opportunities that arise from working closely with universities and colleges.

Through their research activities, Canadian universities also play a critical role in linking Canada to the global pool of knowledge, technology and talent. Through research collaboration with foreign counterparts and through attraction of world-class researchers and scholars to their institutions, universities advance Canada's knowledge and talent advantages.

Business Sector

Firms constitute a fundamental part of the STI ecosystem, as they translate new knowledge and technologies into jobs and wealth and practical solutions to health, environmental and social challenges. They carry out significant R&D of their own, patent and license new knowledge and technologies and, most importantly, take that knowledge into the local and global marketplace. Firms also enhance Canada's talent advantage by providing training to employees and working collaboratively with universities and colleges to offer internships and co-operative programs. Firms also fund some of the R&D carried out in universities and colleges.

Large, established firms are able to finance significant in-house R&D and are able to perform the difficult and very expensive task of translating potentially useful new knowledge into goods and services that people buy. New and young firms are also important, as they often exploit technological or commercial opportunities that have been neglected by more established companies.

As noted above, firms also work closely with others in higher education and government on a wide array of STI activities. These partnerships include jointly funding research and research infrastructure with the public sector, collaborating with universities and colleges to develop and commercialize discoveries and address technical challenges, and providing opportunities for highly skilled personnel to unleash their potential.

Characteristics of the Modern STI Enterprise

The global economy has become more integrated, and increased competitiveness and challenging economic conditions have forced governments and firms to reduce expenditures and look for more efficient ways to create and commercialize knowledge and technology. The modern STI enterprise is characterized by increasing internationalization of activities and a related rise in collaboration, including open innovation, among different players and across national borders. These developments impact Canada's pursuit of STI excellence.

Internationalization

STI is an increasingly global process. Firms are expanding their activities worldwide, not only as a way to enter markets and lower costs, but also as a means to source technological capabilities, tap into local centres and clusters of knowledge, and gain access to highly skilled workers. Multinational firms play a leading role in the globalization of innovation, with close to half of the world's R&D expenditures accounted for by only 700 firms. These firms have been a key factor in the emergence of global innovation networks.

It is not only firms that are engaged in global STI activities. Modern ICT and increasing mobility, coupled with the escalating costs and complexity of research, have driven the increasing internationalization of the research enterprise. Almost one-quarter of research articles in 2010 featured authors from more than one country, up from 10 percent in 1990,[15] while many developed economies are host to many scientists who were born elsewhere.

New global players are also emerging on the STI landscape, with the increased presence of the BRICS countries (Brazil, Russia, India, China and South Africa) in STI activities. China alone accounted for almost a third of the global increase in R&D between 2001 and 2006, as much as the increase in Japan and the European Union combined. It is important to note, however, that while many emerging economies have been investing significantly in R&D, resulting in some improved performance on associated indicators, there is still scope for further improvement in the quality and impact of the research.

15 U.S. National Science Foundation, *Science and Engineering Indicators* (2012), Chapter 5, p. 5-36. (http://www.nsf.gov/statistics/seind12/pdf/c05.pdf)

At the same time that R&D investment has grown, talent in both advanced and emerging economies has become increasingly mobile, willing to follow opportunities around the globe and, in so doing, contributing to the international diffusion of knowledge.

Collaboration

Collaboration and partnerships are important sources of competitive advantage, within sectors and across the economy. As the complexity and costs of engaging in STI have increased, so has collaboration between and among firms and public sector researchers. Through partnerships, firms seek to stay abreast of developments, expand their market reach, gain access to a larger base of ideas and technologies, and get new products to market before their competitors. Data show that firms that collaborate spend more on R&D than those that do not, an indication that collaboration is not simply a means to save on costs but a means to extend the scope of a project or complement firms' competencies. In addition to increasingly sourcing external knowledge, firms also increasingly seek external partners to commercialize innovations that are not used internally. In most countries, collaboration with foreign partners is at least as important as domestic co-operation, a sign of the formation of global networks of innovation.

As a form of collaboration, some firms are increasingly embracing open modes of innovation. In open source innovation, the activities of both creating knowledge and disseminating or commercializing it are open. Open source innovation relies on communities of innovators who freely and reciprocally reveal their innovations to others who subsequently build on these innovations. For companies, using open innovation as a business strategy can provide access to a larger base of ideas and technologies than available within the firm. By pooling with others the development of knowledge, the costs and risks of R&D can be decreased, while the speed of knowledge development and acquisition can be increased. As knowledge becomes more valued as an input to production, and rapid advances in ICT enable greater sharing of knowledge, open modes of innovation may gain greater currency in the global economy.

Collaboration between the private and public sectors increases the possibility that research in the higher education sector will be relevant and applicable for the business and government sectors. Private sector-led clusters are especially effective at fostering research collaboration and partnerships, as they create a web of interconnected companies, universities, colleges and research institutes. The need for increased collaboration among partners of Canada's innovation system was one of the key messages of previous editions of this report. Canada's performance in this area is explored in Chapter 5: Knowledge Development and Transfer.

Conclusion

The three main players described—governments, universities and colleges, and businesses—form the cornerstone of Canada's STI ecosystem. The chapters that follow look at the funding these players devote to STI, their performance in terms of STI inputs and outputs, and Canada's success in developing and deploying the talent that drives it all. The discussion not only gives a snapshot of where Canada is relative to its key competitors but where it has come from. This evidence-based analysis serves to provide a comprehensive assessment of Canada's science, technology and innovation system and benchmark Canada's performance against that of key competitors, providing insights into Canada's relative strengths and weaknesses.

3 Canada's Funding for Research and Development in an International Context

An examination of Canada's science, technology, and innovation (STI) performance begins with an analysis of the investments that the country is making to support and incent research and innovation. While innovation is more than research and development (R&D), there are relatively few indicators of *funding* for innovation available, especially ones that are internationally comparable. Thus, this chapter examines funding for R&D, as an important measure of support for the formal creation of knowledge and the potential commercialization opportunities derived from funded research. Analysis focuses on the total funding of R&D in Canada, as well as breakdowns by the key funding sectors: government (including federal and provincial/territorial); business; higher education; private non-profit; and foreign. This is intended to provide a greater understanding of the funding participants in the STI ecosystem who decide to utilize R&D to advance knowledge, resolve competitiveness and productivity challenges, and/or achieve societal and economic objectives. A more detailed analysis is provided of the two major funding sectors for R&D in Canada: the business sector and the government sector.

Consistent with the intent of *State of the Nation* reports, Canada's performance on funding of R&D is compared to that of Organisation for Economic Co-operation and Development (OECD) members and other countries, to the extent that data are available. International benchmarking of Canada's funding activity is done by reporting total funding of R&D (gross domestic expenditures on research and development, or GERD) as a percentage of gross domestic product (GDP). This measure—otherwise known as GERD intensity or GERD-to-GDP ratio—not only allows comparisons with other countries of different economic sizes, but also provides an indication of the proportion of the country's economy invested in R&D activities.

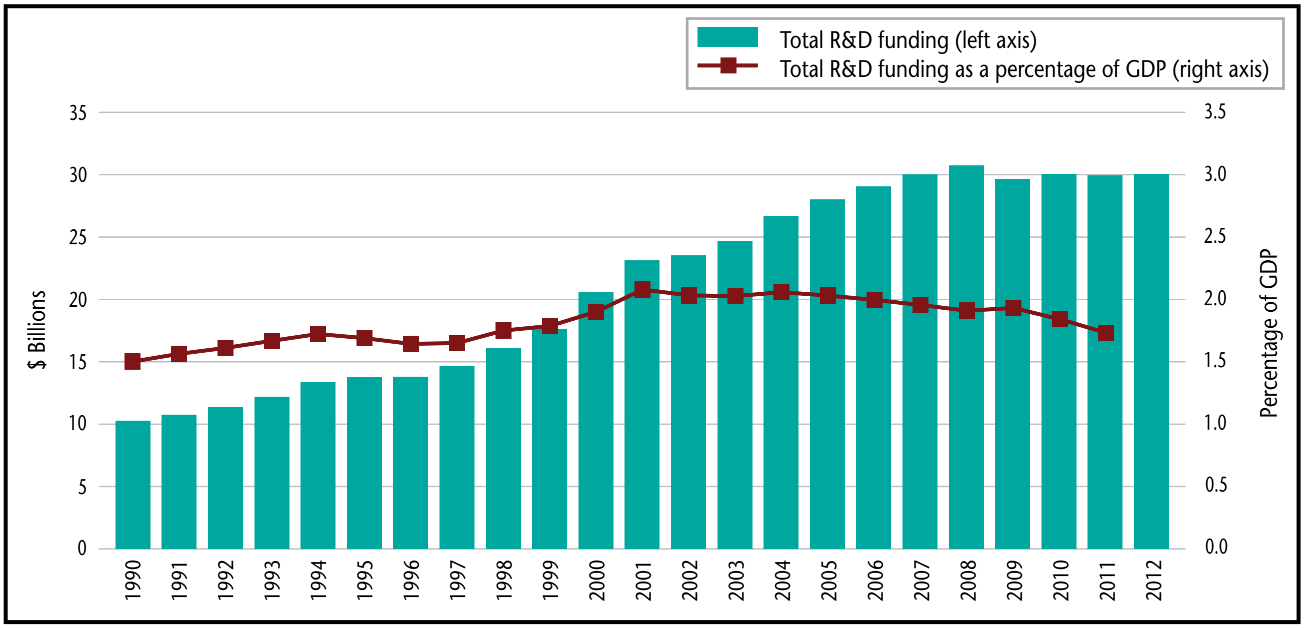
Analysis shows that Canada's total R&D funding has declined from its peak in 2008 and, when measured in relation to the size of the Canadian economy, since 2001. In contrast, the GERD and GERD intensity of most other countries have been increasing. While there have been shifts in funding among sectors in Canada over time, the more recent declines in the country's total R&D funding efforts are attributable predominantly to private sector funding of R&D. It is interesting to note, too, that the federal government's direct funding of business R&D in relation to the size of the economy has essentially flatlined since 1990, and that total (federal and provincial) government direct funding efforts in Canada are below those of most of our international peers.

Since 2001, Canada's GERD intensity has been declining.

Canadian Research and Development in a Global Context

As highlighted in Figure 3-1, the total funding of R&D activities in Canada (GERD) increased considerably between 1990 and 2008, when it peaked at $30.8 billion, before dropping slightly to $29.7 billion in 2009 (likely

Figure 3-1: Total R&D Funding in Canada (GERD), 1990–2012



Source: Statistics Canada, CANSIM Table 358-0001 and Table 380-0017, December 2012.

due to the impact of the recession) and then remaining relatively stable (at around $30 billion) through to 2012. Canada's GERD as a percentage of GDP peaked in 2001, when it reached 2.1 percent. Since 2001, however, despite the growth in R&D funding in Canada, GERD intensity has been declining, to the point where it reached a low of 1.7 percent in 2011.

By comparison, most other advanced and emerging economies have increased their total funding of R&D over the 2006 to 2011 period, with a corresponding rise in their GERD-to-GDP ratio (Figure 3-2). Canada's declining GERD intensity has, as a result, pushed its rank among 41 OECD and leading developing economies down from 16th position in 2006 to 17th in 2008 and then to 23rd in 2011. At that point, Canada's GERD-to-GDP ratio stood at 1.7 percent, more than 1.5 percentage points below the 3.3 percent threshold of the world's top five performers on GERD intensity.

Among these top five performers, GERD intensity exceeded an impressive 3.0 percent in 2011, with Israel leading the pack at 4.4 percent, followed by Finland (3.8 percent), Korea (3.7 percent), Sweden (3.4 percent), and Japan (3.3 percent). Denmark, in sixth position, also surpassed 3.0 percent (coming in at 3.1 percent). Some countries and regions have explicitly identified ambitious goals for increasing their GERD-to-GDP ratios. For example, in 2000, the European Union committed to bring its overall ratio to 3.0 percent by 2010 (the time frame was later reset to 2020). Similarly, during his first term, President Obama declared that the United States (U.S.) should aim for a ratio exceeding 3.0 percent.

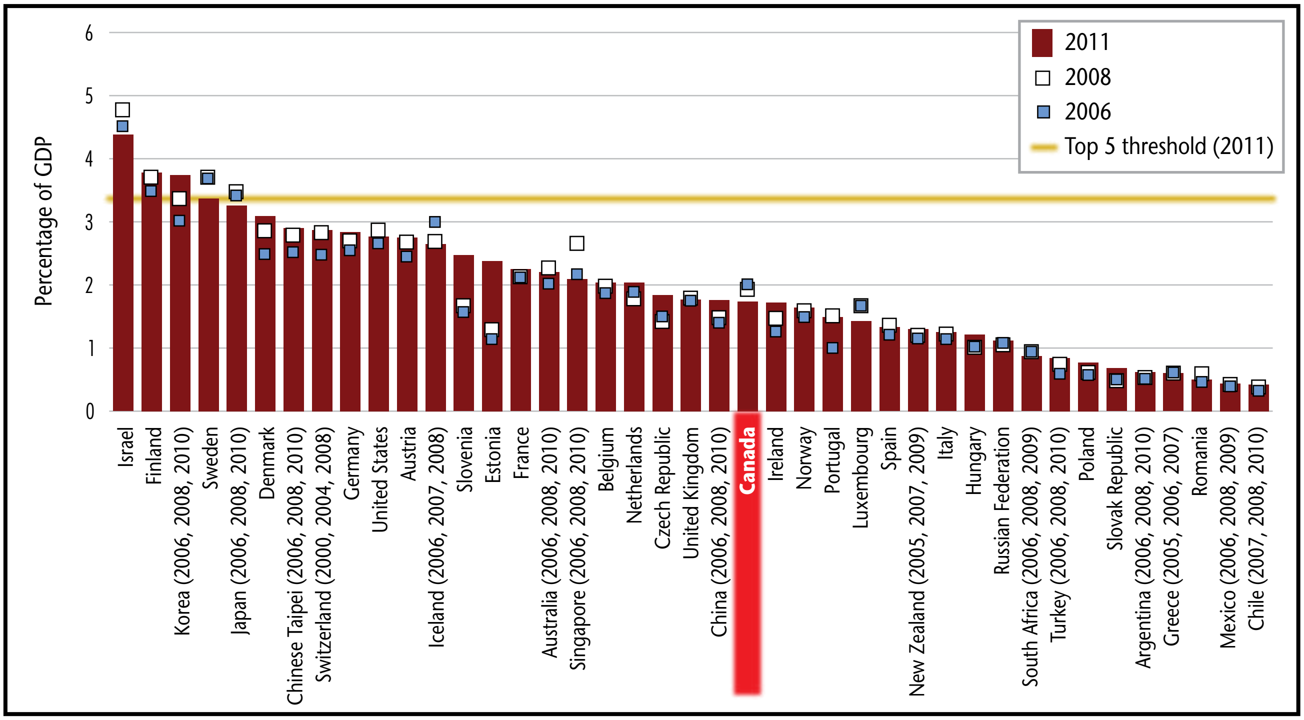
Funders of Research and Development in Canada

Behind Canada's declining GERD intensity is an interesting story about how the different funding sectors have contributed to Canada's overall funding levels over the past two decades.

The most notable change in R&D funding over the past two decades has been the rapid growth of business R&D funding, which first surpassed federal government R&D funding in the mid-1980s and then continued to grow rapidly through to 2008, after which it experienced a sharp decline in 2009 as a result of the recession. This is reflected in Figure 3-3. Federal and provincial government funding[16] of R&D witnessed low or declining

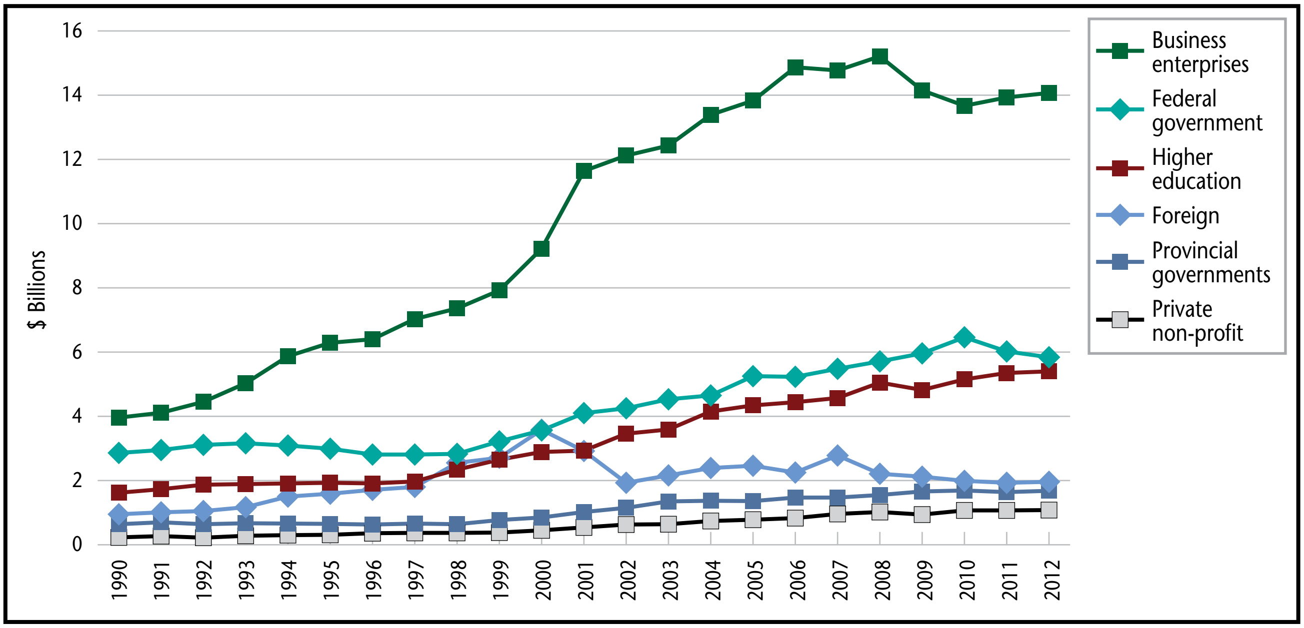
16 In calculating the sources of funding, Statistics Canada combines all components of general university funds, such as R&D contracts and earmarked grants received from governments, to the higher education sector. Conversely, the OECD convention is to report the latter funds as government funding of R&D. As a result, Canadian funding statistics from the higher education sector, as reported by Statistics Canada, are higher than the OECD's depiction of funding from the higher education sector.

Figure 3-2: GERD as a Percentage of GDP, 2006, 2008 and 2011



Source: OECD, *Main Science and Technology Indicators*, January 2013.

Figure 3-3: Sources of R&D Funding in Canada, 1990–2012



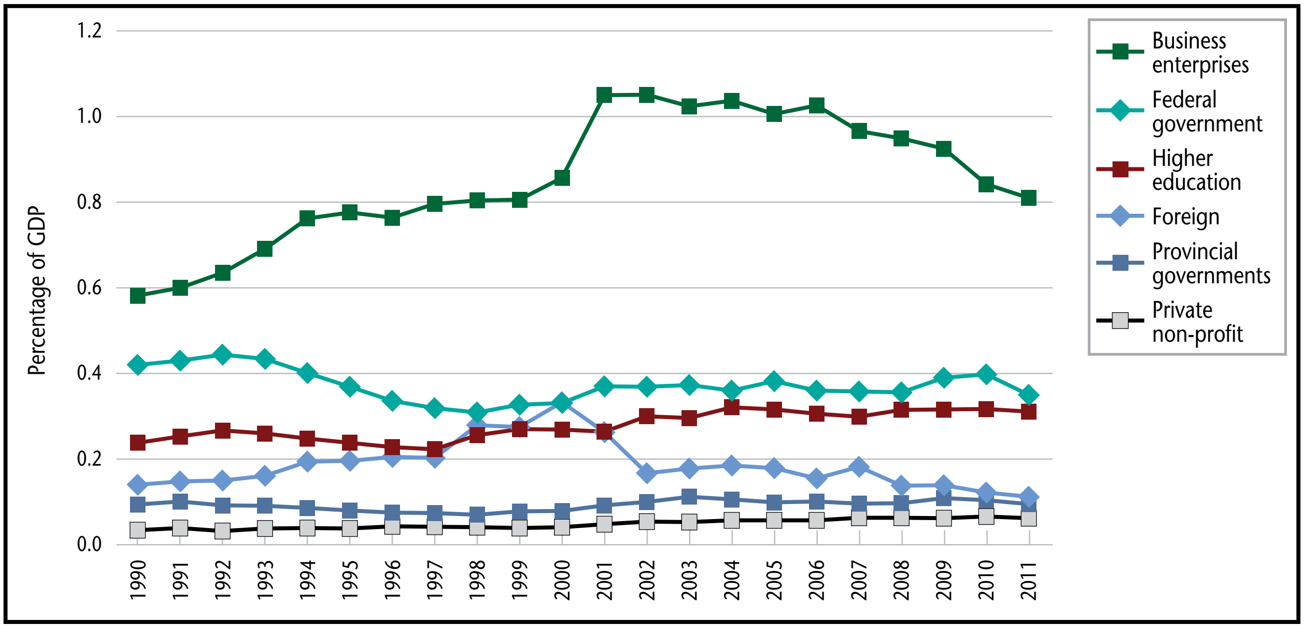
Source: Statistics Canada, CANSIM Table 358-0001, December 2012.

growth in the early to mid-1990s, but both have steadily increased in dollar value from the late 1990s to 2010, with federal funding growing by approximately 128 percent during this period and combined provincial funding growing by 135 percent. The higher education sector[17] in Canada has also increased its funding of R&D over this period, largely at the same rate as the federal government. Also of note is the growth between 1990 and 2000 of foreign sources of R&D funding. After marginally surpassing federal government R&D funding in 2000, peaking at $3.6 billion, foreign R&D funding declined by approximately 47 percent over the next two years, to $1.9 billion in 2002. Much of this decline was attributable to decreases in foreign funding of R&D in the information and communications technologies sector. Foreign funding of R&D in Canada has remained relatively flat since 2002.

By 2011, the business sector was the largest funder of R&D in Canada, at $13.9 billion. This represented 0.81 percent of GDP in 2011, after a steady decline from a peak of 1.1 percent in 2001 and 2002 (Figure 3-4). The federal government was the second largest funder of R&D in Canada in 2011, at $6.0 billion, accounting for 0.35 percent of GDP, followed by the higher education sector at $5.4 billion, accounting for 0.31 percent of GDP. R&D funded by foreign sources declined over the course of the decade—at $1.9 billion accounting for 0.11 percent of GDP in 2011, down from a peak of 0.33 percent in 2000. The provincial government sector accounted for $1.6 billion in R&D funding, and the private non-profit sector accounted for $1.1 billion, respectively 0.095 and 0.062 percent of GDP.

Turning briefly to *performers* of R&D in Canada, the amount of R&D performed by the business sector has risen considerably since the early 1990s, coming in at $15.5 billion in 2012 (Figure 3-5). However, it has yet to climb back to its pre-recession peak of $16.8 billion, reached in 2007. Over the same period, R&D performed by the higher education sector has also increased significantly, from $3.0 billion in 1990 to $11.5 billion in 2012. In comparison, the amount of R&D performed by the federal government has seen very little growth over the past two decades, reaching only $2.5 billion in 2012, up from $1.7 billion in 1990. R&D performance by the business and higher education sectors will be explored in more depth in chapters four and five, respectively.

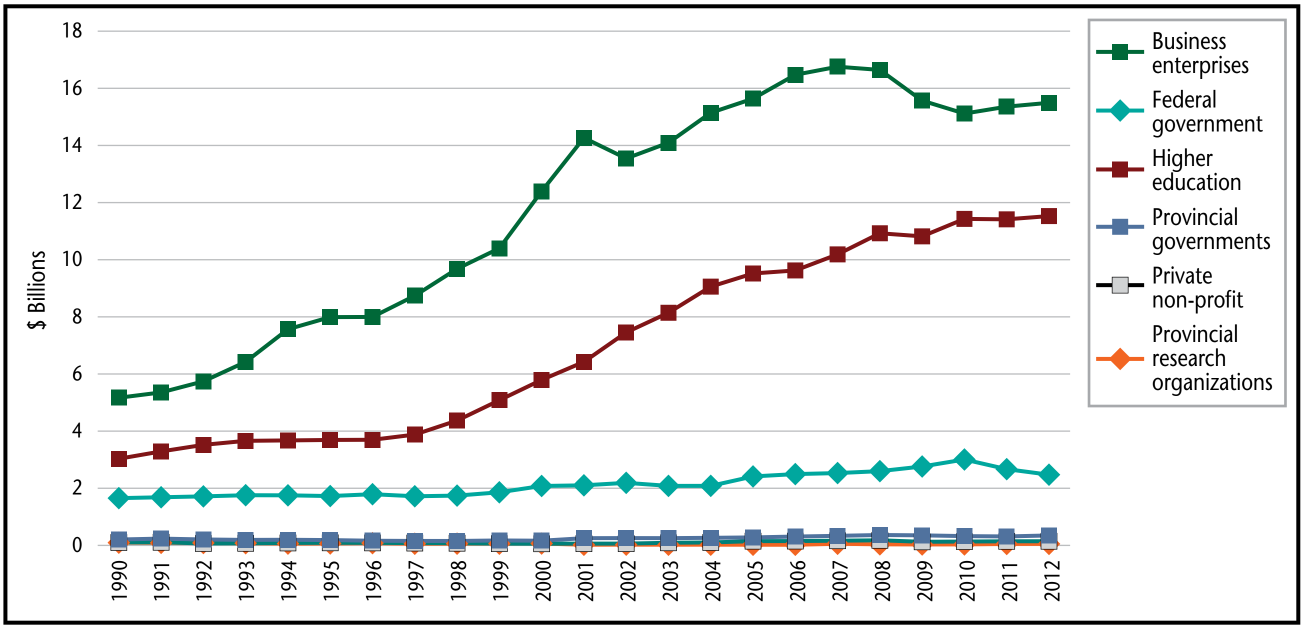
Figure 3-4: Sources of R&D Funding in Canada, as a Percentage of GDP, 1990–2011



Source: Statistics Canada, CANSIM Table 358-0001 and Table 380-0017, December 2012.

17 Much of the higher education sector's contribution is calculated on the basis of its indirect contributions that support R&D, such as a percentage of faculty time and overhead costs. As direct government funding for R&D to the higher education sector increases, so do the indirect costs associated with that funding.

Figure 3-5: **R&D Performed in Canada, 1990–2012**



Source: Statistics Canada, CANSIM Table 358-0001, December 2012.

Government Funding for Research and Development

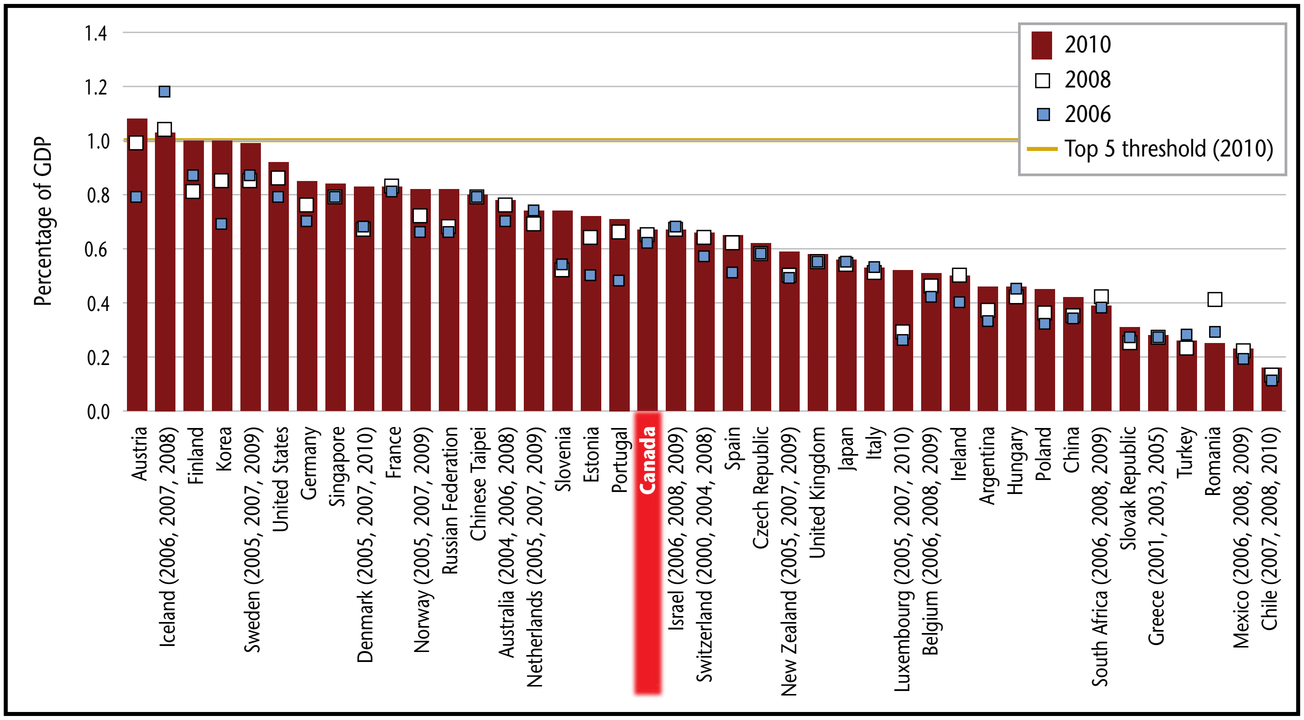
Government support for R&D in Canada includes funding from the federal government and the sum of funding from Canada's provincial and territorial governments. R&D funding from both these levels of government has grown significantly over the past decade, largely keeping pace with GDP growth.

Total government-financed R&D in Canada (i.e., all governments) was 0.67 percent of GDP in 2010, compared to the 0.99 percent threshold of the top five countries, which included Austria, Iceland, Finland, Korea and Sweden (Figure 3-6). This ratio of government-financed R&D in Canada has increased since 2000, when it was 0.56 percent of GDP. It should be noted that, for all countries, these figures include only *direct* funding of R&D and do not capture *indirect* funding such as Canada's Scientific Research and Experimental Development (SR&ED) investment tax credit and similar provincial tax credits. Similar to total funding of R&D for all sectors of the economy, total Canadian government direct funding efforts are below those of most of our international peers. For example, U.S. combined federal and state government direct funding of R&D ranked sixth highest, with a ratio of 0.92 percent of GDP in 2010, whereas Canada ranked 19th on this measure.

Federal Funding of Research and Development

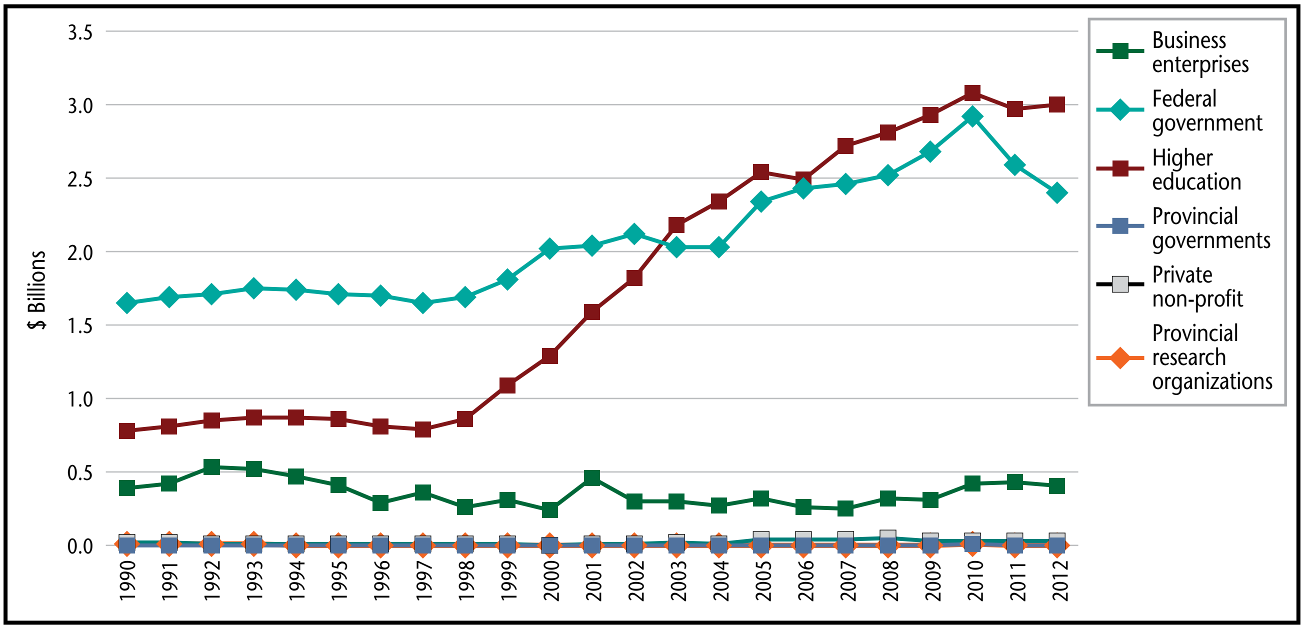
Looking at the Canadian federal government specifically (Figure 3-7), its *direct* funding of R&D stood at $5.8 billion in 2012. The higher education sector has emerged as the largest recipient of federal government direct R&D funding over the past decade, receiving $3.0 billion, or 51.4 percent of total federal direct funding, in 2012. The next largest recipient sector was the federal government itself, which accounted for $2.4 billion, or 41.1 percent of the total. This was down from its peak of $2.9 billion in 2010. The next largest sector for federal government direct funding was the business enterprise sector, at $406 million. Federal *direct* funding to business has barely changed since 1990, when it stood at $390 million, and has declined from its peak of $533 million in 1992. The private non-profit sector, the provincial government sector, and provincial research organizations each accounted for less than one percent of federal government direct funding of R&D in 2012.

Figure 3-6: Government Funded R&D, as a Percentage of GDP, 2006, 2008 and 2010



Source: OECD, *Main Science and Technology Indicators*, January 2013.

Figure 3-7: Federal Government Funding of R&D, to Performing Sectors, 1990–2012



Source: Statistics Canada, CANSIM Table 358-0001, December 2012.

Innovative Procurement by Governments

Governments support innovation through both supply-side and demand-side policies. Supply-side policies' main objective is to boost knowledge development in order to accelerate its diffusion throughout society by: supporting investments in researchers and laboratories; setting framework policies such as effective intellectual property rights; ensuring high levels of competition in the marketplace; and providing tax credits to encourage firms to invest in innovation. In contrast, demand-side policies aim to boost the marketplace opportunity for innovative products by increasing demand for them. Examples of such policies include the development of innovation-specific regulations; provision of consumer tax credits and rebates for new technologies; and, government procurement of innovative products—both goods and services.

By tapping into the large purchasing power of governments, public-sector procurement has the potential to positively increase the market demand for innovative goods and services and reduce the risks associated with commercializing them. It also signals to the marketplace that government is prepared to be a first customer and it provides demonstration opportunities for fledgling firms with innovative products and services. Many governments either utilize, or are considering adopting, government procurement as a means of supporting business innovation.

The Canadian Innovation Commercialization Program (CICP) (originally a $40 million pilot program launched in 2010), connects small and medium-sized enterprises with federal departments and agencies that have a need for innovative goods and services. The CICP was made permanent in 2012 as part of Canada's Economic Action Plan, which committed an additional $95 million over three years and $40 million per year thereafter.

In the United States, the Small Business Innovation and Research Program (SBIR) requires U.S. federal agencies that contract out more than $100 million per year in R&D to set aside 2.5 percent for small business. The U.S. Small Business Technology Transfer (STTR) program requires 0.3 percent set-aside by agencies with over $1 billion in extramural R&D budgets for small business R&D partnerships with academic institutions. While these programs are not strictly innovation procurement programs *per se*, they can lead to some agencies, such as the Departments of Energy and Defense, being the first customer when the research is successful.

Currently, within the European Union, 22 percent of member states' contracting authorities indicate that they include innovation within their procurement strategies and procedures. For example, since 2009, Tekes, the Finnish research and innovation agency, has provided financial incentives to Finnish public procurers undertaking procurement of innovative products. Similarly, since 2010–11, VINNOVA, the Swedish research and innovation agency, has provided financial incentives to Swedish public procurers undertaking public innovation procurements. In the United Kingdom, the National Health Service applies an integrated approach to procurement of innovation that combines the use of pre-commercial procurement, for getting solutions developed for mid- to long-term innovation procurement needs.

China intends to modify the evaluation method in government procurement to include an innovation element. China is currently implementing regulations to encourage and protect indigenous innovation, whereby the government practises a first-buyer policy for major domestically made high-tech equipment and products; provides policy support to enterprises in procuring domestic high-tech equipment; and develops relevant technology standards through government procurement.

Use of government procurement to stimulate business innovation is growing in popularity, since it provides support closer to the end-state of the innovation chain (i.e., commercialization) and is therefore better able to address the commercialization gap faced by many countries.

Indirect versus Direct Government Support for Business Research and Development

At 0.24 percent of GDP (or $3.9 billion), the Government of Canada ranked sixth highest among OECD countries in 2010 for its combined direct and indirect support for business R&D. However, as noted in the preceding chapter, the balance between direct and indirect federal support for business R&D is very different in Canada than in other countries, with substantially more support delivered through indirect mechanisms than direct. In Canada, federal government indirect support for business R&D as a percentage of GDP was the second highest (after France) among available countries in 2010, at 0.21 percent (or $3.4 billion), significantly surpassing the top five threshold of 0.14 percent of GDP (Figure 3-8). Other countries among the top five on this measure included Korea, Portugal and Ireland.

Conversely, federal government direct support for business R&D as a percentage of GDP was substantially smaller than that of almost all countries, at 0.03 percent in 2010 (or $487 million), and significantly lower than the top five threshold of 0.15 percent of GDP (Figure 3-9). Those five countries with the highest proportion of direct support for business R&D (as a percentage of GDP) were the U.S., Slovenia, Austria, Korea and Sweden. While there are advantages and disadvantages to both direct and indirect government support for business R&D, direct funding allows government to focus support on actors, priorities and sub-priorities, or activities considered more likely to achieve high social returns or to advance specific policy goals. In STIC's view, the low level of direct support in Canada handicaps the competitiveness of Canadian business R&D on a global basis.

Provincial Funding of Research and Development

R&D funding is also provided by provincial governments. Similar to federal government funding of R&D since the late 1990s, aggregated provincial government R&D funding has kept pace with growing GDP, increasing from approximately $1 billion to just over $1.7 billion between 2001 and 2012.

Direct versus Indirect Funding for Business Research and Development

The OECD defines direct funding for business R&D to include mechanisms such as loans and guarantees, repayable advances, competitive grants, technology consulting services, and innovation vouchers. Indirect funding refers to tax incentives, such as Canada's SR&ED tax credit.

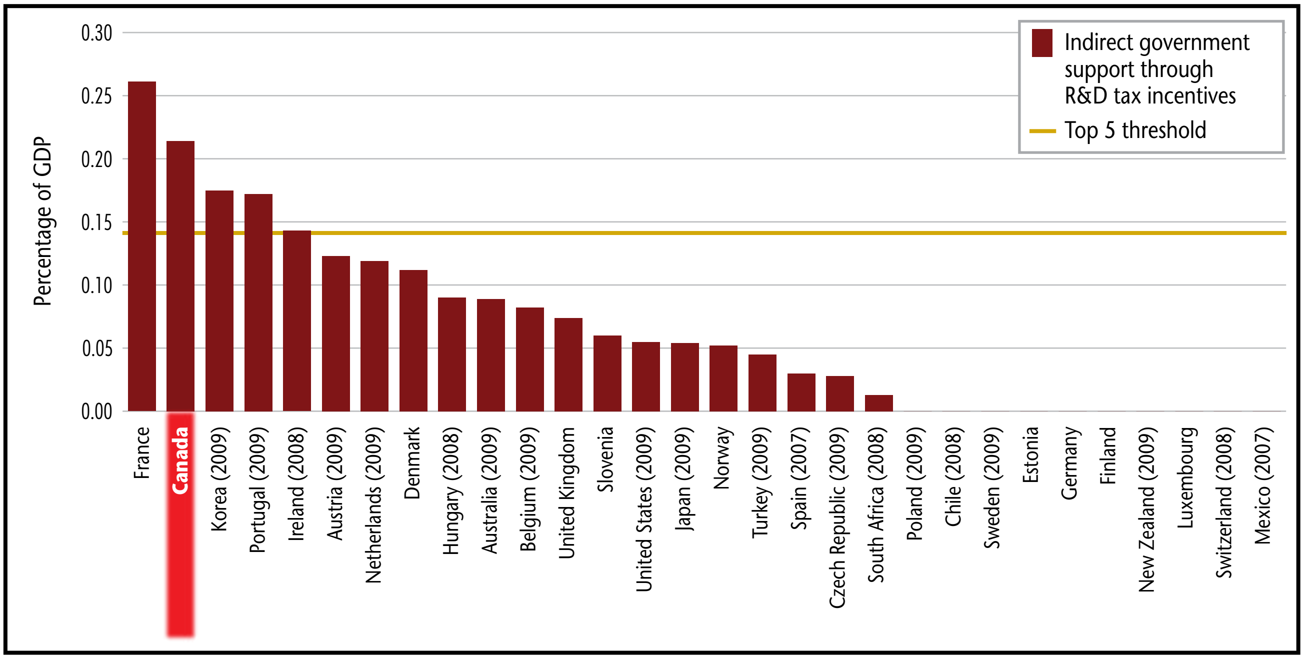
The OECD notes several advantages and disadvantages to both forms of funding. Direct support is considered advantageous insofar as governments are able to focus R&D support on specific areas, projects, industries, and/or regions, to respond to policy priorities. Direct funding programs, however, can result in higher administration costs due to their selection and evaluation processes and the compliance costs of recipients. Indirect measures are available to all interested firms and are thus considered non-discriminatory—responsive to the market rather than based on governments "picking winners."[1] These funding mechanisms are also often easier to use and administer than direct support mechanisms. With indirect funding, however, governments cannot focus R&D support in targeted areas deemed to be priorities.

According to the OECD, the recent general trend among member countries has been to increase their use of indirect funding mechanisms to support business R&D. Notwithstanding this trend, Canada's ratio of indirect funding (compared to direct) is still significantly higher than that of other countries. Among the world's top ten innovative countries (as measured by business enterprise expenditures on research and development (BERD)-to-GDP and GERD-to-GDP), direct support in 2010 consisted of an average of approximately 70 percent of total government support for business R&D, while in Canada it consisted of only approximately 12 percent[2] (the average excludes Israel and Chinese Taipei due to missing data). Canada's direct funding of business R&D stood at 0.03 percent of GDP, compared to the top ten average of 0.11 percent of GDP. In contrast, Canada's indirect funding through tax incentives accounted for 0.21 percent of GDP, whereas the average of the top ten countries was only 0.05 percent of GDP.

1 OECD, *OECD Economic Surveys: Canada* (June 2012), p. 21. (http://www.oecd.org/eco/50543310.pdf)

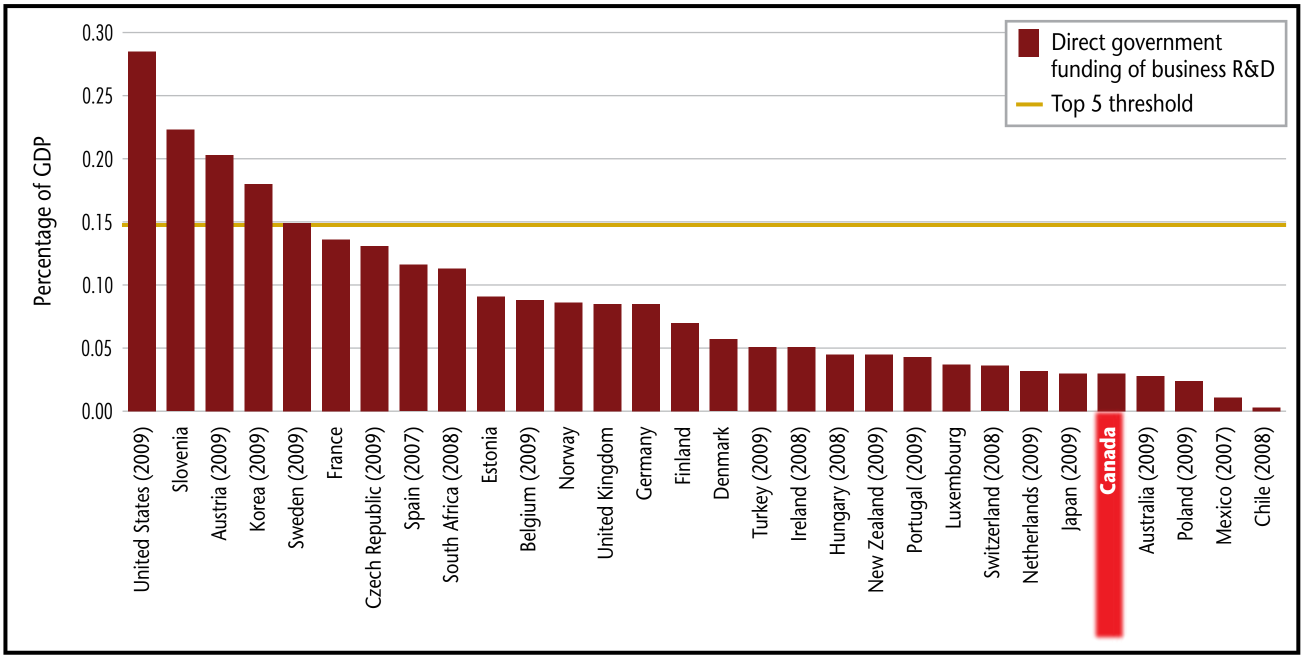
2 OECD, *Science, Technology and Industry Outlook 2012* (September 2012), Figure 6.2. (http://dx.doi.org/10.1787/888932696020)

Figure 3-8: Indirect Government Support of Business R&D, as a Percentage of GDP, 2010



Source: OECD, *Science, Technology and Industry Outlook*, 2012.

Figure 3-9: Direct Government Support of Business R&D, as a Percentage of GDP, 2010



Source: OECD, *Science, Technology and Industry Outlook*, 2012.

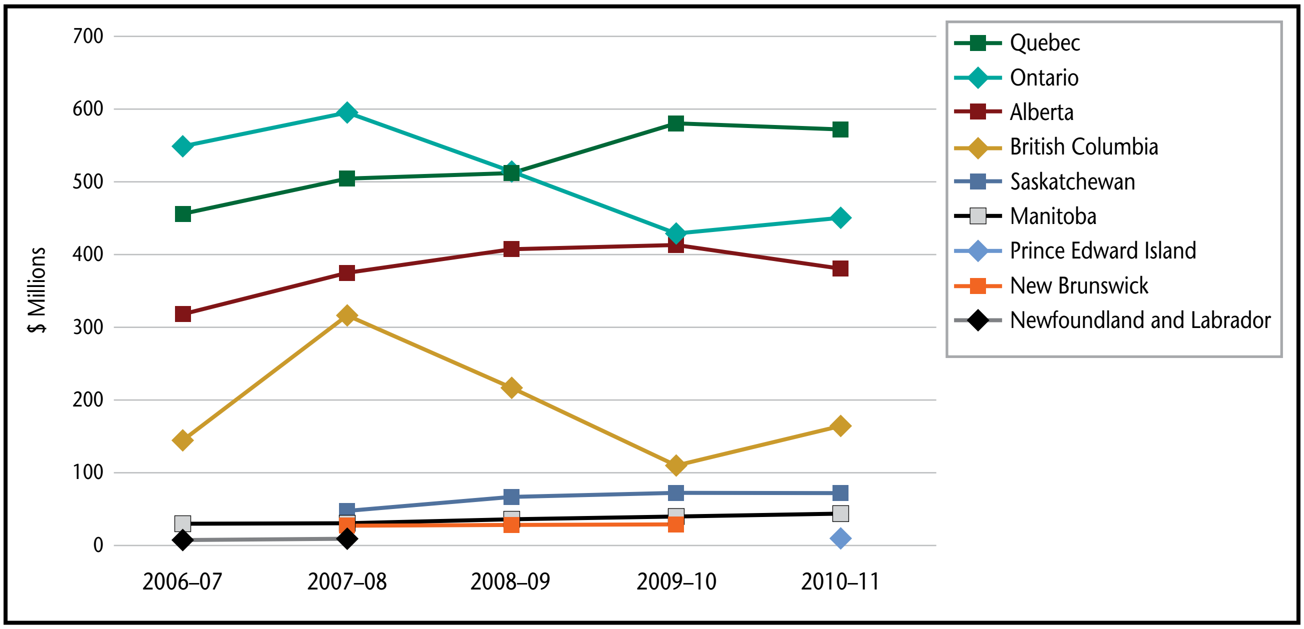
Unfortunately, comparable statistics on individual provincial governments' spending on R&D are not available for every province, as not all provincial governments participate in the Statistics Canada survey that compiles such data. For those reporting provinces, Figure 3-10 shows that R&D funding by the Ontario and British Columbia governments has been particularly volatile, with significant increases and decreases between 2006–07 and 2010–11. R&D funding by the Alberta and Manitoba governments was much more stable over this period. Funding by the government of Quebec grew considerably, making it the largest provincial funder of R&D amongst Canadian provinces since 2009–10.

The socio-economic objectives pursued through the R&D investments of the federal and provincial governments are diverse. They include such areas as natural resources, infrastructure, the environment, human health, industry-related research, basic research, and defence. The areas with the highest amounts of funding for all reporting provinces combined were the protection and improvement of human health (28 percent of total provincial funding); basic research (27 percent); agriculture production and technology (10 percent); and, industrial production and technology (8.4 percent). It should be noted, however, that the funding areas vary significantly across provinces, suggesting that the research and development priorities are quite different among them. Federal government funding, on the other hand, is more evenly distributed across multiple socio-economic objectives, as demonstrated in Figure 3-11.

Business Funding of Research and Development

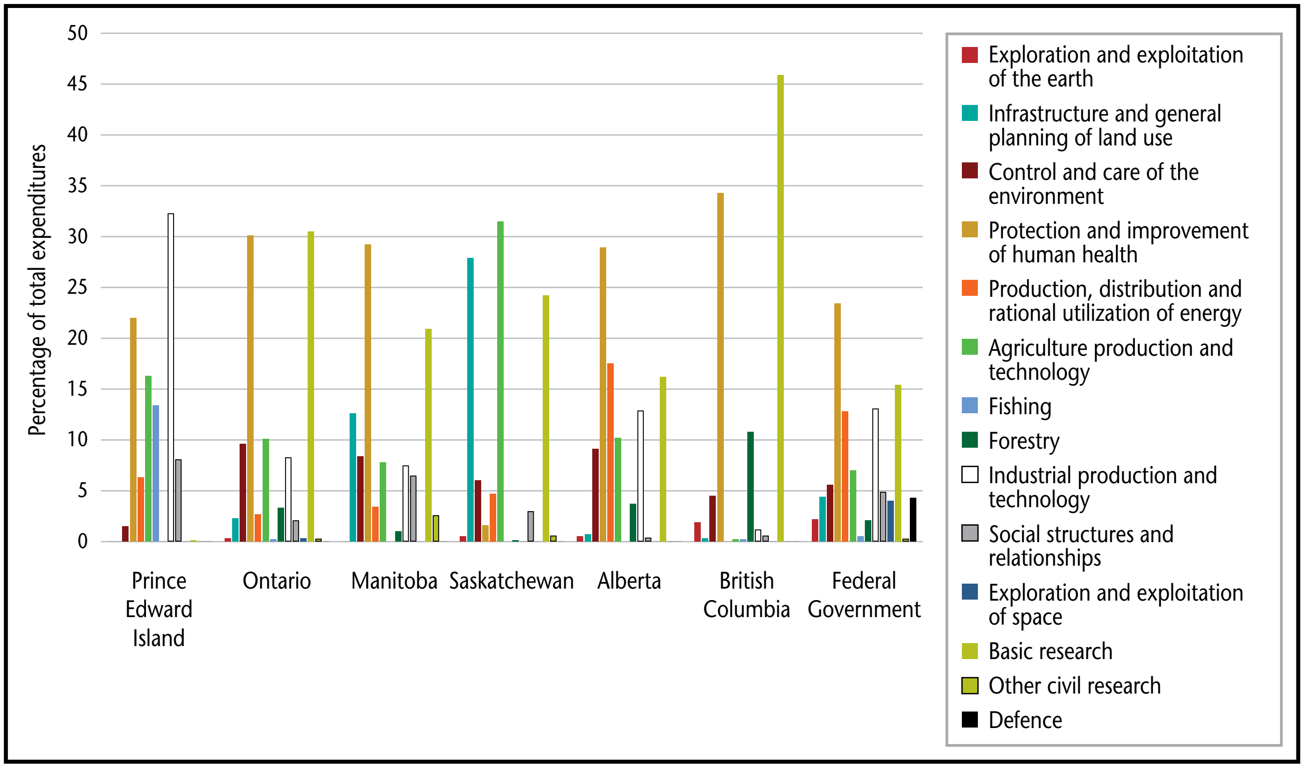
Business enterprise funding of R&D relative to the size of the economy (i.e., as a percentage of GDP) provides an internationally comparative measure of the degree to which different countries' business sectors choose to invest in R&D.

Figure 3-10: **Total Expenditures of Select Provincial Governments on R&D, 2006–07 to 2010–11**



Source: Statistics Canada, *Science Statistics: Scientific and Technological Activities of Provincial Governments and Provincial Research Organizations*, 2006/2007 to 2010/2011, Catalogue No. 88-001, Ottawa, 2012.

Figure 3-11: **Percentage of Total Expenditures of Select Provincial Governments and the Federal Government on R&D, by Objective, 2010–11**



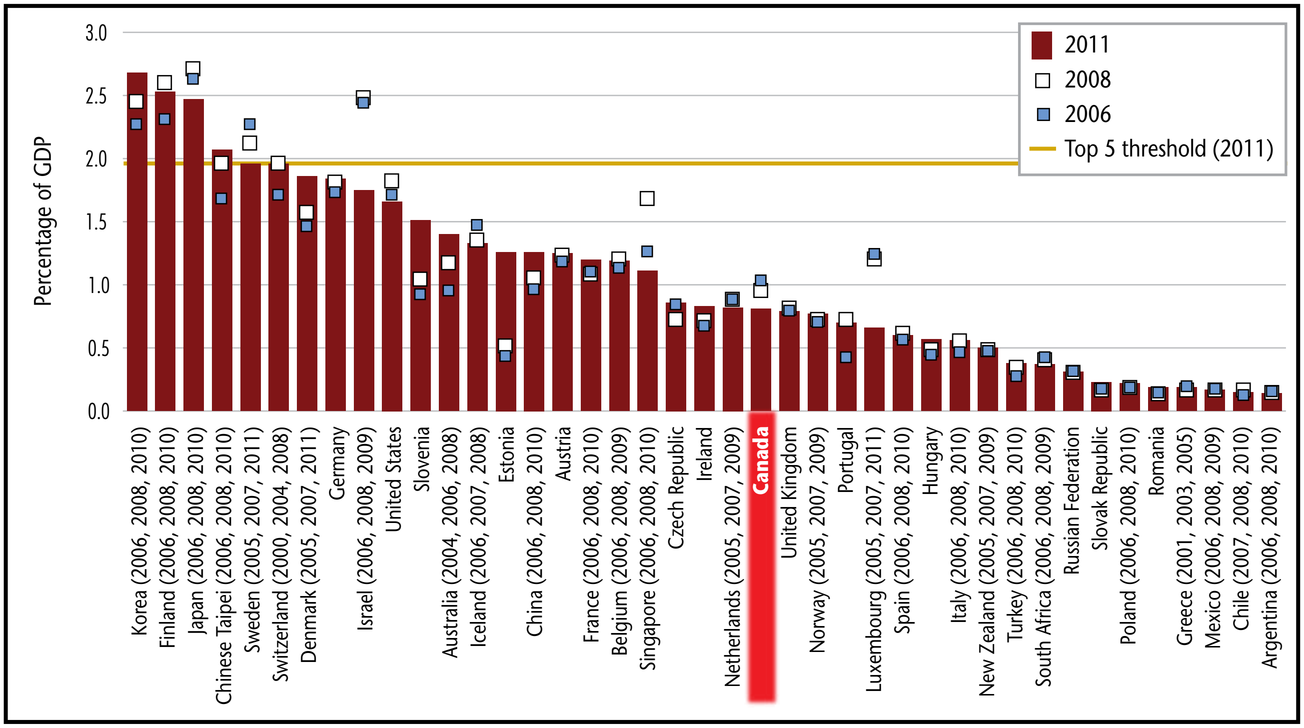
Sources: Statistics Canada, *Science Statistics: Scientific and Technological Activities of Provincial Governments and Provincial Research Organizations*, 2006/2007 to 2010/2011, Catalogue No. 88-001; Statistics Canada, *Federal Scientific Activities*, Catalogue No. 88-204, Ottawa, 2012.

While most countries increased their business R&D funding intensity[18] from 2006 through 2008 to 2011, Canadian business R&D funding intensity declined. Figure 3-12 shows that there is wide variation among economies in terms of the R&D funding intensity of their respective private sectors. Korean business funding of R&D was the equivalent of 2.7 percent of its economy's GDP, making it the leader, followed by Finland (2.5 percent), Japan (2.5 percent), Chinese Taipei (2.1 percent), and Sweden (2.0 percent), while the U.S. took tenth position (1.7 percent). Despite the growth in the dollar value of Canadian business R&D funding noted earlier, Canada ranked 23rd among 41 economies in this comparison of business R&D funding intensity, with a ratio of 0.8 percent in 2011. This is less than one-half the 2.0 percent threshold of the top five economies.

Looking more closely at the decline in Canadian business R&D funding intensity, it is clear that it is part of a long-term downward trend since 2002 (Figure 3-13). At the beginning of this century, Canadian business R&D funding stood at 1.05 percent of GDP, and it has fallen fairly steadily to 0.81 percent in 2011. Industry's share of total funding of R&D in Canada, also reflected in Figure 3-13, has been more volatile, largely due to the economic cycle and to the steady increases in funding from other sectors, notably governments and the higher education sector.

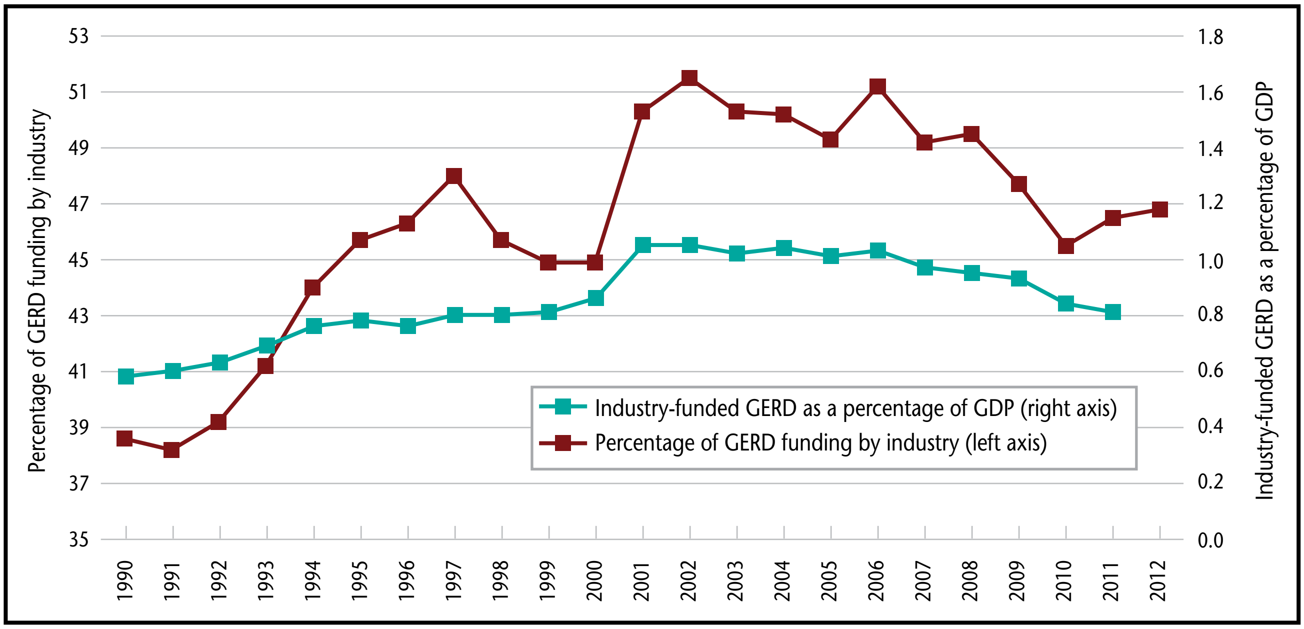
18 Business enterprise R&D *funding* intensity comprises the total business sector funding of R&D, as a percentage of total economy GDP, whether the R&D is performed within industry, the higher education sector, government or other sectors of the economy. This is distinct from BERD intensity discussed in Chapter 4, which covers R&D activities *performed* by firms, either with their own money or money from other sources.

Figure 3-12: Business Enterprise-Financed R&D, as a Percentage of GDP, 2006, 2008 and 2011



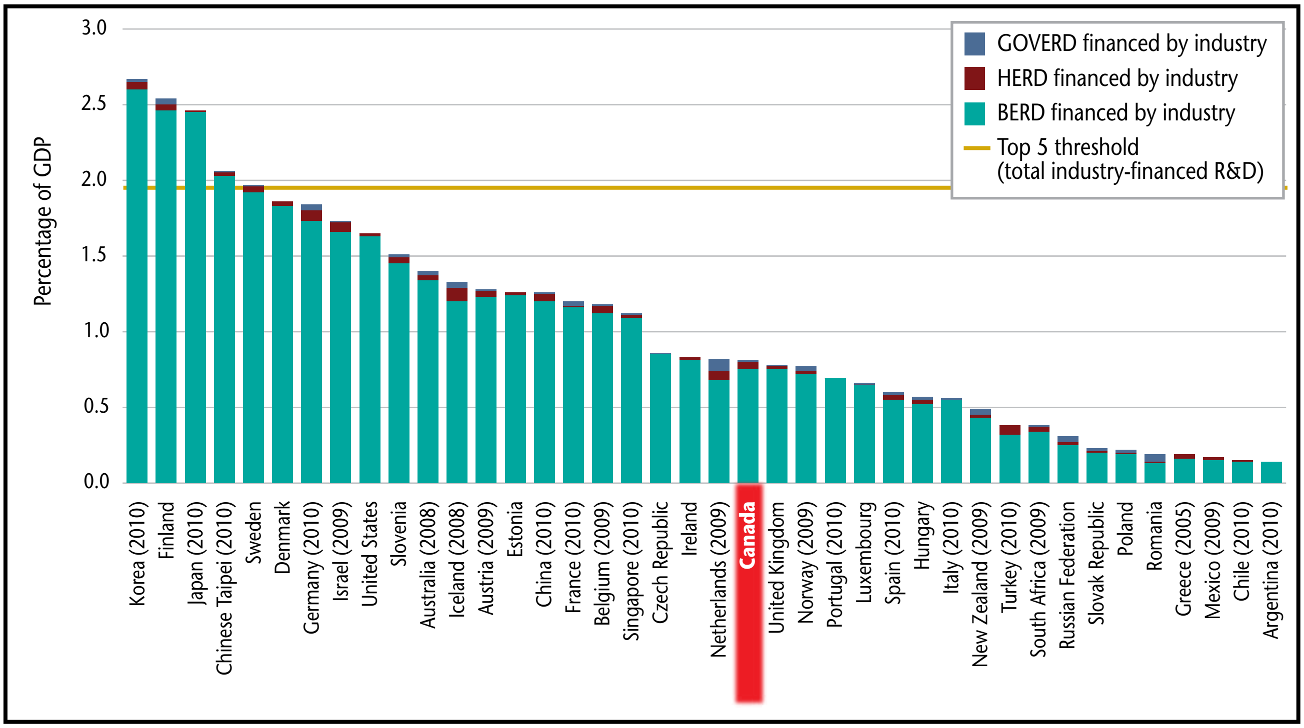
Source: OECD, *Main Science and Technology Indicators*, January 2013.

Figure 3-13: GERD Funding by Business Enterprises in Canada, 1990–2012



Source: Statistics Canada, CANSIM Table 358-0001 and Table 380-0017, December 2012.

Figure 3-14: BERD, HERD, GOVERD Financed by Industry, as a Percentage of GDP, 2011



Source: OECD, *Main Science and Technology Indicators*, January 2013.

Of the $13.7 billion that the Canadian business sector spent on R&D in 2010, $12.7 billion (or 0.75 percent of GDP) was spent within (i.e., performed in) the sector itself (Figure 3-14). The higher education sector was the second largest recipient of business R&D funding, accounting for $833 million (or 0.050 percent of GDP) in 2010. This positioned Canada seventh among 40 comparator economies with respect to business funding of higher education R&D, with a ratio twice that of the U.S. (at 0.021 percent of GDP). Canada's ratio was also significantly higher than Japan's (0.011 percent of GDP) and slightly ahead of the other top five business R&D funding countries of Korea (0.046 percent of GDP), Finland (0.045 percent), Israel (0.047 percent) and Sweden (0.041 percent).

The higher education sector was the second largest recipient of business R&D funding.

4 Business Innovation

Business innovation is an engine of productivity growth, increased international competitiveness and higher living standards. International competitiveness is particularly important for Canada because our economic growth relies, to a significant extent, on international trade and foreign capital and we compete directly with the United States (U.S.), which remains one of the world's largest economies (despite its sluggish growth during the global economic recession).[19] Canada is also facing new competitive pressures (and opportunities) due to the rise of many emerging economies.

While some industries are inherently more innovation-intensive than others, innovation occurs in—and drives the competitiveness of—all industries. Business innovation is underpinned by investments in: research and development (R&D); machinery and equipment (M&E), especially information and communications technologies (ICT); and intangible assets. Business innovation is also supported by access to, and attraction of, risk capital; and, access to new ideas and technologies through strong global connections.

State of the Nation 2010 reported that, on many of these activities, Canada performed poorly in comparison to our international peers. Two years later, the story is unchanged. Despite Canada's relatively strong macroeconomic fundamentals, Canadian firms are not harnessing innovation to make competitive gains. In international rankings related to business innovation, Canada continues to place in the middle of the pack on most measures and, in some cases, Canada's rank has declined.

Canada's performance is particularly poor on measures of business enterprise expenditures on research and development (BERD). Although BERD in Canada increased slightly in both 2011 and 2012, it has not reached its pre-recession value, and BERD as a percentage of gross domestic product (GDP) has been in almost continuous decline for the past decade. As a result, Canada has fallen in the Organisation for Economic Co-operation and Development (OECD) rankings on this important measure. We also perform poorly on venture capital (VC) investment as a share of GDP, and despite strong growth in total VC investment in 2011, it is still considerably lower than the 2007 level. An additional area of weakness is our large ICT investment gap with the U.S.

Given that all OECD countries have policies in place to strengthen their innovation performance,[20] the private and public sectors in Canada must acknowledge a shared responsibility to take urgent action, or Canada risks falling behind in international competitiveness and living standards. As the Government of Canada considers recommendations[21] to modernize its framework policies in support of increased competitiveness, Canadian firms will need to become more innovative in order to maximize their success in the global economy.

19 Someshwar Rao et al., "The Importance of Innovation for Productivity," *International Productivity Monitor (Centre for the Study of Living Standards)*, Vol. 2 (Spring 2001), pp. 11–18.

20 OECD, *Business Innovation Policies: Selected Country Comparisons*, Paris (2011), p. 14. (http://dx.doi.org/10.1787/9789264115668-en)

21 For example, see: OECD, *OECD Economic Surveys: Canada*, Paris (2012); and, Alexandra Bibbee, "Unleashing Business Innovation in Canada," *OECD Economics Department Working Papers*, No. 997 (October 2012).

Improving Plant Health through Innovative Micronutrients

Wolf Trax produces leading-edge, research-proven micronutrients and plant nutrition products. The company, which is based in Winnipeg, has developed DDP® technology to address micronutrient deficiencies in agricultural soil while minimizing negative environmental impacts.

Research and innovation drive Wolf Trax. Hostile soils, such as those that are too cold, too alkaline or too low in organic matter, can make it difficult to free up micronutrients and make them available to the plant. Wolf Trax's unique formulation helps to make the nutrients available to the plant, while its innovative fertilizer coating technology allows precise nutrient placement in the field in the right quantities for the plant, even under the harshest conditions typified by a Canadian spring. The improved formulation and more precise placement result in much lower application rates than required with traditional micronutrient products, increasing farmers' productivity and efficiency, while reducing the environmental load. While products undergo extensive testing under a variety of conditions on a wide spectrum of crops around the world, much of the preliminary testing for Wolf Trax's micronutrient fertilizers took place in Manitoba, because of the challenging weather conditions for micronutrient uptake.

In 2012, Wolf Trax's founders were recognized with a Manning Innovation Award for significantly improving the world of agriculture fertilizers with DDP® technology. Its DDP® nutrients are now sold in 75 regulatory jurisdictions around the world.

Innovation through Research and Development

BERD covers R&D activities performed by firms either with their own money or money from other sources (e.g., governments).[22,23] While other players in the science, technology and innovation (STI) ecosystem carry out R&D, it is BERD that is most closely linked to product and process innovation[24] and thus to productivity growth. As productivity growth positively impacts living standards, lower levels of BERD could adversely affect Canadians' prosperity vis-à-vis that of citizens of other countries.

Business Performance of Research and Development

BERD intensity, which is a key indicator of innovative activity, is the ratio of BERD to a measure of output (e.g., GDP or value-added in industry[25]). Canada's BERD intensity continues to lag that of key competitors, which is reflected in our continued poor performance in international rankings of BERD as a percentage of GDP (Figure 4-1). Canada also lags key competitors in terms of BERD as a percentage of value-added in industry. BERD as a percentage of value-added in industry is a measure of the degree to which a business' resources are dedicated to R&D.

Canada's BERD intensity continues to lag that of key competitors.

22 OECD, *Science, Technology and Industry Scoreboard*, Paris (2011), p. 80.

23 This differs from business enterprise *funding* of R&D and business enterprise R&D *funding* intensity (discussed in Chapter 3), both of which cover business investment in R&D performed in all sectors (i.e., industry, higher education, government, etc.).

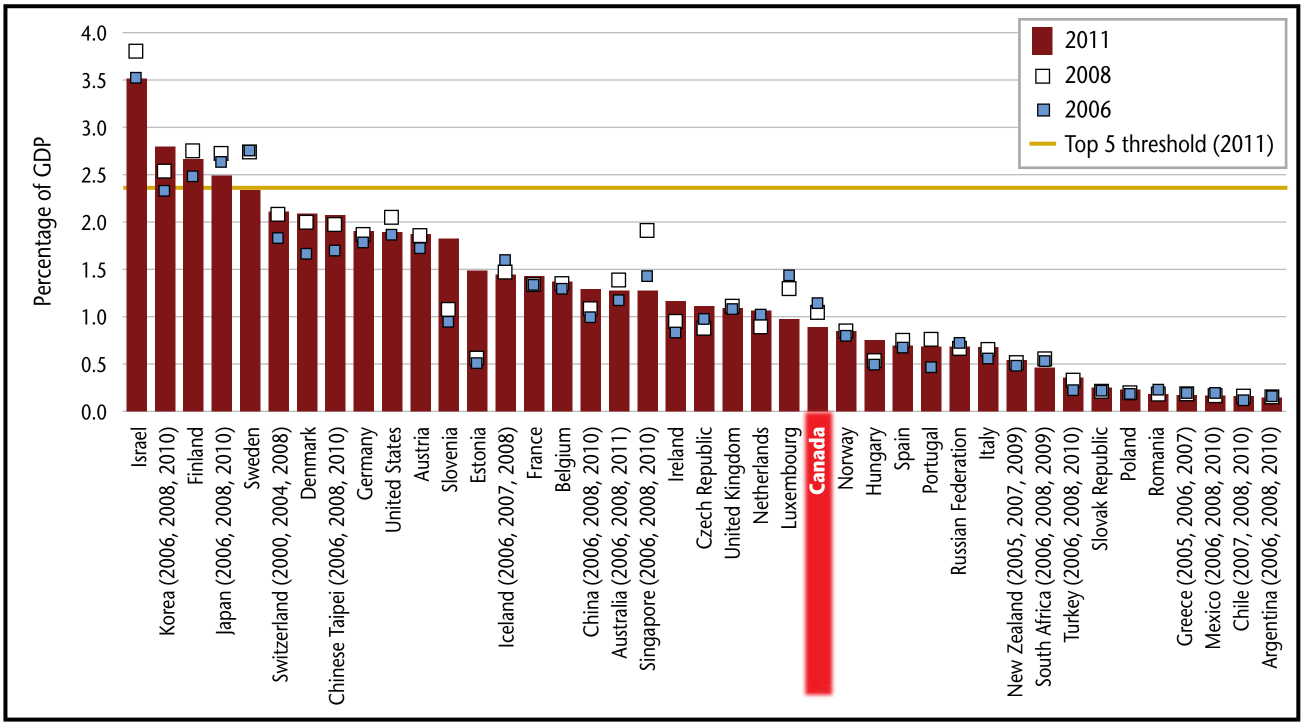
24 OECD, *Science, Technology and Industry Scoreboard*, Paris (2011), p. 80.

25 Value-added in industry, which is composed mainly of profits and wages, is essentially the business contribution to GDP.

According to data from the OECD, BERD as a percentage of GDP in Canada was 0.89 percent in 2011, compared to 1.04 percent in 2008. This is considerably below the level in the U.S. (at 1.89 percent), and it is less than 40 percent of the threshold of the top five performing economies—Israel, Korea, Finland, Japan and Sweden (Figure 4-1). Canada's rank also declined from 2008 to 2011, falling from 21st to 25th out of 41 economies.[26] Significant improvement in Canada's performance in this area will be particularly important to enhancing business innovation and ultimately helping to secure Canada's position as a global STI leader. Over the same period, Canada's rank in terms of BERD as a percentage of value-added in industry declined as well, falling to 26th out of 41 economies (from 20th out of 41).[27]

Looking at Canada specifically, for which more recent data are available, the decline in BERD intensity continued in 2011 and 2012. The picture is even worse when looking at the data over the past decade, which show a downward trend in BERD as a percentage of GDP since 2005 (Figure 4-2). As well, despite very marginal growth in total BERD in 2011 and 2012 (BERD reached approximately $15.5 billion in 2012 compared to approximately $15.1 billion in 2010), it has not yet reached its peak value attained in 2007 (approximately $16.8 billion).[28,29]

Figure 4-1: **BERD as a Percentage of GDP, 2006, 2008 and 2011**



Source: OECD, *Main Science and Technology Indicators*, January 2013.

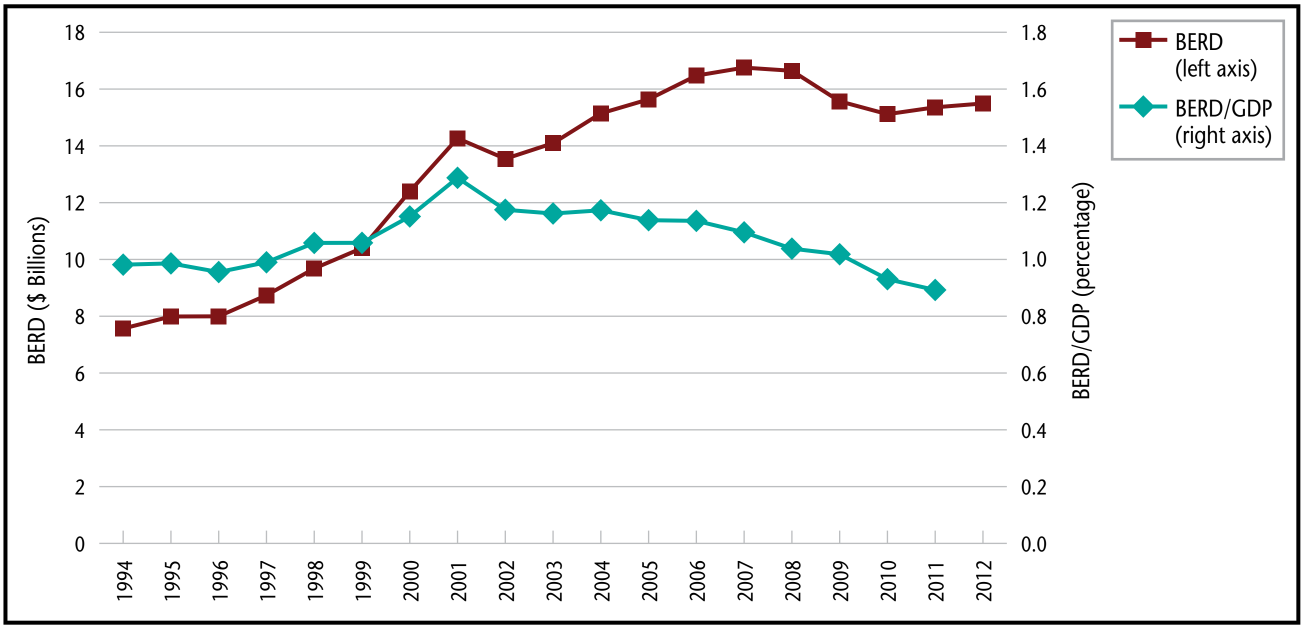
26 Where data for 2006, 2008 and/or 2011 were not available, data for the next closest year were used to calculate the ranking. See years used in Figure 4-1.

27 Based on data from OECD, *Main Science and Technology Indicators* (January 2013). Where data for 2006, 2008 and/or 2011 were not available, data for the next closest year were used to calculate the ranking. See years used in Figure 4-1.

28 Statistics Canada, CANSIM Table 358-0024 *Business enterprise research and development (BERD) characteristics* (October 2012).

29 The increase is in terms of current dollars. In terms of constant dollars, BERD decreased for five consecutive years (2007–11). BERD in constant prices is calculated by using the GDP deflator. The constant dollar value for 2012, as of October 2012, is not yet available. See: Statistics Canada, *Industrial Research and Development: Intentions 2012*, Catalogue no. 88-202-X, Ottawa (2012). (http://www.statcan.gc.ca/pub/88-202-x/88-202-x2012000-eng.pdf)

Figure 4-2: **BERD and BERD as a Percentage of GDP in Canada, 1994–2012**



Source: Statistics Canada, CANSIM Table 358-0024 (Business enterprise research and development (BERD) characteristics) and Table 380-0017 (Gross domestic product (GDP)), November 2012.

Innovating for Competitiveness in Manufacturing

ArcelorMittal Dofasco is a steel company focused on the development of innovative products and processes to enhance its competitiveness and its environmental sustainability.

The auto industry is one of the company's main customers, and providing innovative solutions to auto industry challenges, such as reducing emissions, is a key to the company's competitiveness. New products and processes developed at its Hamilton research lab, in collaboration with ArcelorMittal's global research team, have resulted in a suite of product and process innovations utilizing advanced high strength steels, called S-in motion. These steels maintain crash resistance while saving up to a fifth of a typical vehicle's 'body in white' weight (the stage when a car body's sheet metal components have been welded together, but before moving parts have been added). This results in up to a 14 percent reduction in a vehicle's total life cycle $C0_2$ emissions. Although S-in motion uses more high-specification grades of steel, the volume of steel used is significantly less, so there is no increase in the overall cost to automakers.

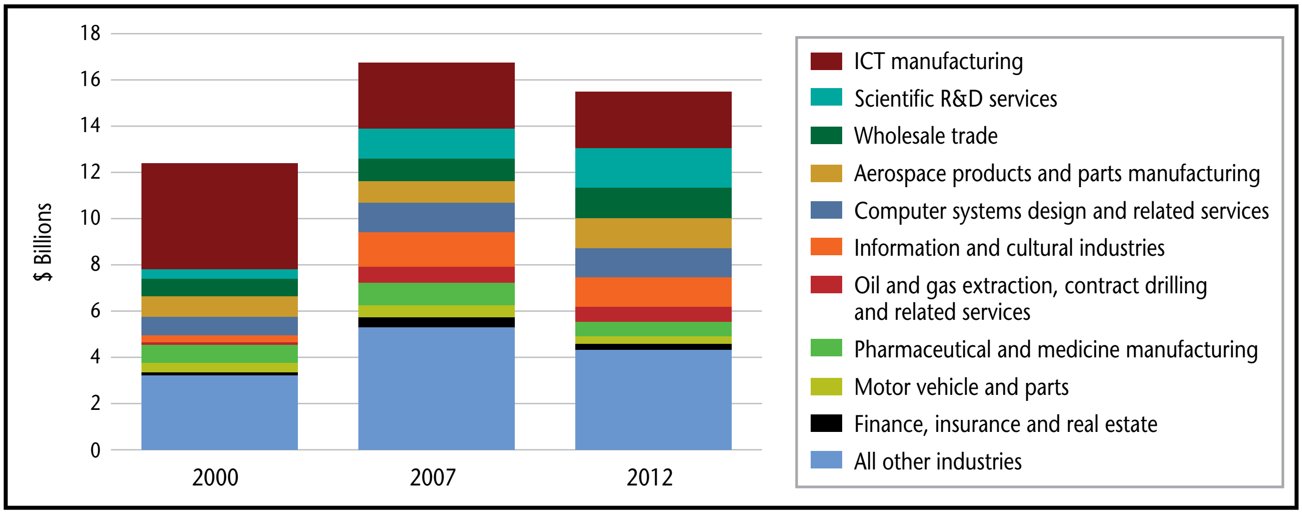
As Ontario's largest user of electricity, ArcelorMittal Dofasco is also working on innovative processes to reduce its energy consumption. Since 2009, the company has undertaken more than 80 internal energy conservation projects. In 2012, the company generated power on-site for the first time using a turbo generator to convert blast furnace and coke oven gas to power. This project, which was completed in collaboration with the Ontario Power Authority's Industrial Accelerator program, resulted in a 2 percent reduction in total power consumption.

Changes in Research and Development Performed by Industries in Canada

In 2012, BERD in Canada was performed primarily by the following industries (Figure 4-3): ICT manufacturing industries[30] (16 percent); scientific R&D services (11 percent); and, wholesale trade,[31] aerospace products and parts manufacturing, computer systems design and related services, and information and cultural industries[32] (all at approximately 8 percent each). These six industries accounted for approximately 60 percent of total BERD.[33]

State of the Nation 2010 highlighted a significant change in the industries performing R&D in Canada between 2000 and 2007, particularly the decline in ICT manufacturing and the increase in information and cultural industries (including software and telecom services). While additional change has occurred since 2007, it has been much less pronounced. Reflecting the lower overall BERD in 2012 (compared to 2007), R&D in a number of industries is also lower. Only three industries showed improved R&D performance between 2007 and 2012 and a corresponding increase in their respective share of total BERD: aerospace products and parts manufacturing, R&D services, and wholesale trade. Computer systems design and related services also increased its share (albeit only slightly), despite a small decline in its R&D performance. The biggest declines in share occurred in pharmaceutical and medicine manufacturing (down approximately 2 percent over five years); ICT manufacturing; motor vehicle and parts manufacturing;[34] and finance, insurance and real estate (FIRE)[35] (down

Figure 4-3: BERD by Industry, Based on the North American Industry Classification System, 2000, 2007 and 2012



Source: Statistics Canada, CANSIM Table 358-0024 (Business enterprise research and development (BERD) characteristics, by industry group based on the North American Industry Classification System), October 2012.

30 Within ICT manufacturing, the Science, Technology and Innovation Council (STIC) includes computer and peripheral equipment manufacturing (North American Industry Classification System (NAICS) 3341), communications equipment manufacturing (NAICS 3342), semiconductor and other electronic component manufacturing (NAICS 3344), navigational, measuring, medical and control instrument manufacturing (NAICS 3345), and other computer and electronic products (NAICS 3343 and 3346).

31 Because of the nature of Statistics Canada's classification of firms, which is based on the principal source of revenue rather than R&D objective, much of the wholesale trade R&D figure is likely attributable to firms from high R&D-intensive industries (such as the pharmaceutical manufacturing industry).

32 Information and cultural industries include: publishing industries; motion picture and sound recording industries; broadcasting; telecommunications; data processing, hosting and related services; and other information services such as libraries and Internet publishing and broadcasting.

33 Statistics Canada, CANSIM Table 358-0024 *Business enterprise research and development (BERD) characteristics, by industry group based on the North American Industry Classification System (NAICS), annual (dollars unless otherwise noted)* (October 2012).

34 Motor vehicle and manufacturing includes motor vehicle manufacturing (NAICS 3361), motor vehicle body and trailer manufacturing (NAICS 3362) and motor vehicle parts manufacturing (NAICS 3363).

35 Finance, insurance and real estate includes finance and insurance (NAICS 52) and real estate and rental and leasing (NAICS 53).

approximately 1 percent each between 2007 and 2012). A small decline also occurred in oil and gas extraction, contract drilling and related services.[36] Some of these changes may reflect overall changes in the composition of the Canadian economy.[37]

A key trend in most OECD countries is the growth of R&D in the service sector.[38] In much of the OECD, services account for one-third or more of BERD, a share that has increased over the last decade.[39] While the service sector accounts for approximately two-thirds of Canada's GDP, it accounts for less than half of BERD,[40] but its importance is growing. The rise in the service sector's share of total BERD, which peaked in 2008 (at approximately 45 percent), reflects both increases in total services R&D and declines in manufacturing R&D. While the share of BERD performed by the service sector has seen strong growth (the share rose from 28 percent in 2000 to 44 percent in 2012), the share of BERD performed by the manufacturing sector has significantly declined, falling from 68 percent in 2000 to 49 percent in 2012.[41]

International Comparison of Research and Development Intensity by Industry Sector

While data aggregated at the country level show that Canada performs poorly in international rankings of BERD intensity, looking at specific industries tells a mixed story.[42] Consistent with performance at the country level, Figure 4-4 shows that, by international standards, Canada tends to have a lower BERD intensity in a number of industries. These industries include those that are important to Canada's economy, such as construction and food products as well as motor vehicles and aircraft and spacecraft manufacturing (which are both industries that, globally, tend to have a high R&D intensity). In these industries, Canada is below the average of selected OECD countries[43] and considerably below the threshold of the top five performers. R&D is important for the long-term competitiveness of all industries, and therefore the low investment levels in these Canadian industries are cause for concern.

Conversely, Canada's BERD intensity in some industries related to ICT (i.e., radio, television and communication equipment; and office, accounting and computing machinery) is above the threshold of the world's top five performers (at third for the former and first for the latter). As well, Canada outperformed the average of selected countries in pulp and paper products (Canada's BERD intensity in this industry is the highest of the selected countries); electricity, gas and water supply; total services; and pharmaceuticals.

36 Oil and gas extraction, contract drilling and related services includes oil and gas extraction (NAICS 211), oil and gas contract drilling (NAICS 213111) and services to oil and gas extraction (NAICS 213118).

37 For example, see: Statistics Canada, CANSIM Table 379-0023 *Gross domestic product (GDP) at basic price in current dollars, System of National Accounts (SNA) benchmark values, by North American Industry Classification System* (NAICS).

38 Services are the result of a production activity that changes the conditions of the consuming units, or facilitates the exchange of products or financial assets. There are 11 main industry groupings, or sub-sectors, within the service sector: wholesale and retail trade; health care and social assistance; accommodation and food services; professional, scientific and technical services; educational services; finance, insurance, real estate and leasing; transportation and warehousing; information, culture and recreation; public administration and defence; business, building and other support services; and other services.

39 OECD, *Science, Technology and Industry Scoreboard*, Paris (2011), p. 180. (http://dx.doi.org/10.1787/888932487951)

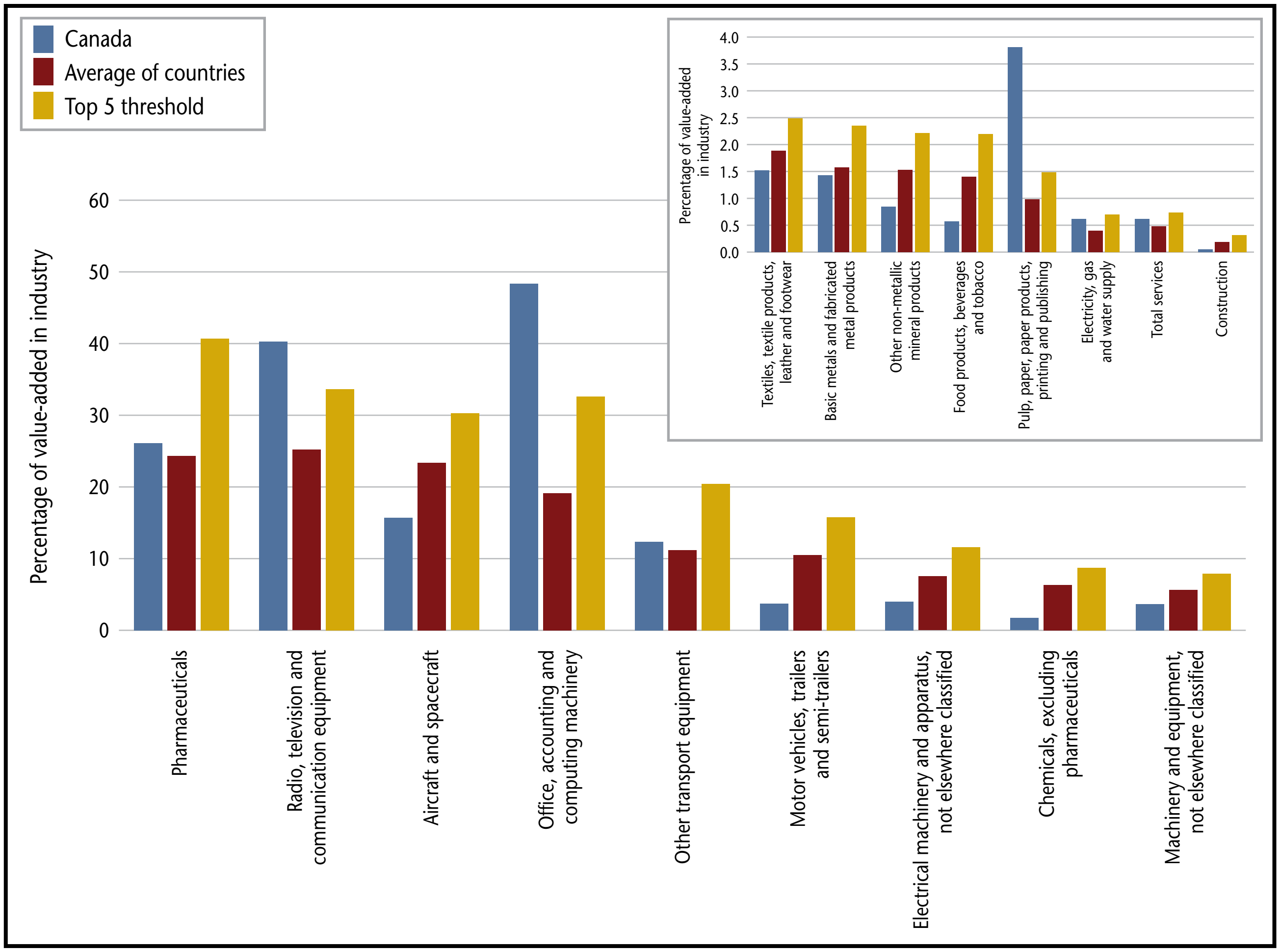
40 Based on Statistics Canada, CANSIM Table 358-0024; and, Industry Canada, *Canadian Industry Statistics* (November 2012). (http://www.ic.gc.ca/eic/site/cis-sic.nsf/eng/home)

41 Statistics Canada, CANSIM Table 358-0024 *Business enterprise research and development (BERD) characteristics, by industry group based on the North American Industry Classification System* (October 2012).

42 As noted in *State of the Nation 2010*, benchmarking R&D expenditures by industry on an international basis poses challenges. Comparable international data are less current and there are differences in the way data are collected. This difference in methodology has the effect of some similar R&D activities being assigned to different industries in different countries.

43 Countries used in the averages include: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Japan, Korea, Netherlands, Norway, Poland, Spain, Sweden, United Kingdom and United States. In general, all data are from 2007, with the exception of data from Australia (2005) and Canada, Denmark, France, Poland and United Kingdom (2006). Exceptions include: average for aircraft and spacecraft does not include Denmark, Greece and Hungary and data for Netherlands and Korea are from 2005; average for chemicals, excluding pharmaceuticals, does not include Norway; average for food products does not include Australia; average for high-technology manufactures does not include Denmark, and data for Netherlands are from 2006 and data for Hungary and Greece are from 2005; average for low-technology manufactures does not include United Kingdom; average for office, accounting and computing machinery does not include Greece; average for pulp and paper does not include United Kingdom; average for radio, television and communications equipment does not include Netherlands; and Australian data for construction and electricity, gas and water are from 2006.

Figure 4-4: **Business R&D as a Percentage of Value-Added in Industry, 2007**



Source: OECD, STAN Indicators, August 2012.

Industry Structure

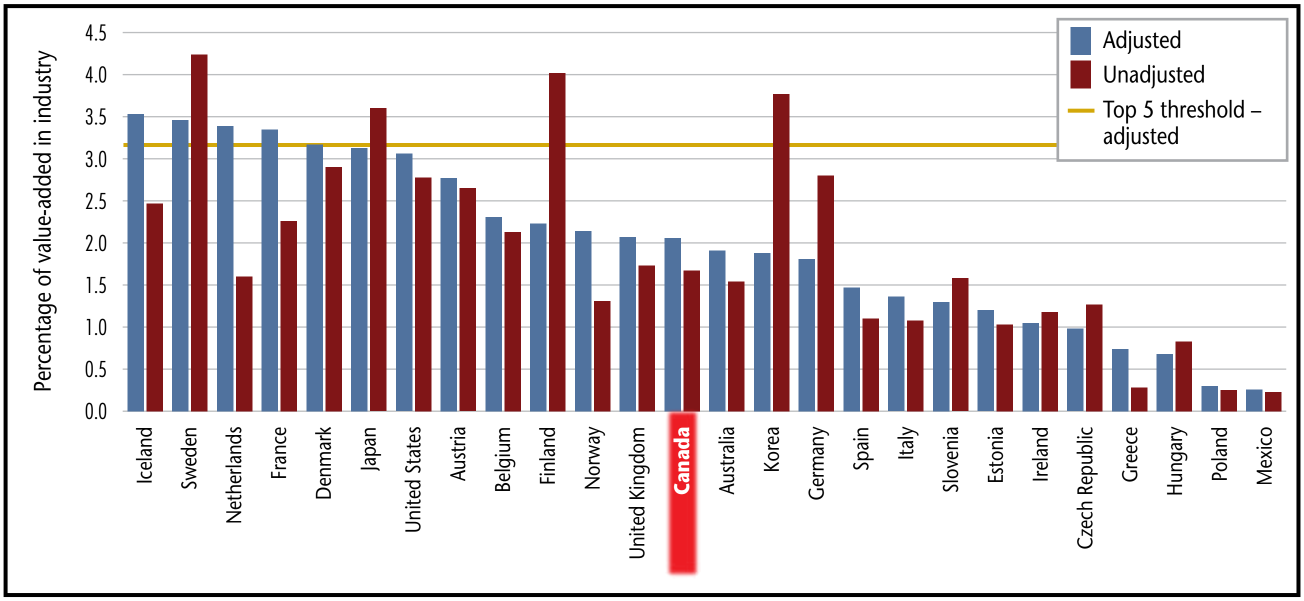
There is ongoing debate about the role that Canada's industry structure plays in our low BERD intensity. While Canada performs well against other countries in terms of BERD intensity in industries related to ICT (i.e., radio, television and communication equipment; and office, accounting and computing machinery) (Figure 4-4), these industries make up a relatively small share of the Canadian economy. In contrast, compared to other developed economies, industries related to mining and oil and gas extraction make up a relatively large share of the Canadian economy.[44] Although anecdotal evidence suggests that these industries are undertaking innovative activities in Canada, they do not engage in significant amounts of R&D. Figure 4-5 estimates Canada's BERD intensity if we had the same industry structure as the average industry structure for OECD countries.[45,46] Although this adjustment results in a slight improvement in Canada's BERD intensity, it makes no difference to Canada's middling position in the international ranking.

44 In 2012, the ICT sector accounted for about 4 percent of GDP while mining, quarrying, and oil and gas accounted for about 8 percent. Calculations are based on Statistics Canada, *CANSIM Table 379-0031 Gross domestic product (GDP) at basic prices, by North American Industry Classification System (NAICS), monthly* (March 2013).

45 OECD, *Science, Technology and Industry Scoreboard*, Paris (2011), p. 180.

46 The industry structure-adjusted indicator of R&D intensity is a weighted average of the R&D intensities of a country's industrial sectors, using the OECD industry structure—sector value-added shares in 2007—as weights instead of a country's actual shares (which are used in the calculation of the unadjusted measure of BERD intensity). BERD data are from 2009 for the Czech Republic, Estonia and Italy; 2007 for Austria, Belgium, Finland, France, Germany, Greece, Mexico, Norway, Sweden, the United Kingdom and the United States; 2006 for Denmark, the Netherlands and Poland; and 2005 for Australia, Canada, Iceland and Ireland.

Figure 4-5: Business R&D as a Percentage of Value-Added in Industry Adjusted for Industry Structure, 2008



Source: OECD, *Science, Technology and Industry Scoreboard*, 2011, Figure 6.8.1, Data link: http://dx.doi.org/10.1787/888932487913.

Achieving Breakthroughs in Vaccine Development and Delivery

Immunovaccine, based in Halifax, is a clinical stage vaccine development company focused on advancing its patented DepoVax™ vaccine adjuvanting platform and product candidates for cancer therapy, infectious disease and animal health. DepoVax™ is a well-developed technology platform which has demonstrated the ability to generate fast, strong and long-lasting immune responses against a range of targets. The technology serves as the foundation for the company's broad vaccine product pipeline, which includes two clinical-stage cancer vaccines and several additional programs in the areas of infectious diseases, addiction medicine and animal health. Patenting of DepoVax™ was supported by funding from the Atlantic Canada Opportunities Agency's Atlantic Innovation Fund.

Immunovaccine grew out of technology developed at Dalhousie University for use in animals, later adapted for humans. In addition to its ongoing internal work on cancer vaccines, the company has established collaborations with important partners, such as the United States' National Institutes of Health (vaccines against bioterrorism agents, including anthrax), Weill Cornell Medical College in New York City (cocaine addiction vaccine) and Zoetis, formerly Pfizer Animal Health (vaccines focused on animal health).

As a result of Immunovaccine's early successes and focus on areas with strong growth potential, the company is well-positioned to develop the next generation of therapeutic cancer vaccines and prophylactic vaccines for infectious diseases, addiction medicine and animal health. In recognition of the company's achievements, it was selected as the "Best Early-Stage Vaccine Biotech" at the 2012 Vaccine Industry Excellence Awards ceremony during the World Vaccine Congress in Washington, DC.

Research and Development by Firm Size

According to data from the OECD, small and medium-sized enterprises (SMEs) account for over 35 percent of total BERD in Canada. This is considerably greater than the share of BERD attributed to SMEs in other key OECD countries.[47] Nonetheless, data from Statistics Canada indicate that the bulk of R&D in Canada's private sector is still performed by larger firms, with the majority of R&D (over 50 percent) performed by firms with over $100 million in revenues. The contribution of small, medium and large firms to R&D varies from industry to industry. It is interesting to note that some industries, including R&D services and computer systems design and related services, appear to have a greater share of smaller firms performing R&D.[48]

A high concentration of R&D in a few large firms is common in many countries, including many with high BERD intensities. While BERD in Canada is fairly concentrated in a small number of leading R&D performing firms, it has become more evenly distributed over the past decade.[49] In 2012, the top 25 R&D performing firms in Canada accounted for approximately 34 percent of total BERD. This share has been fairly stable in the past few years, and although it is up from the low of 28 percent in 2008, it is down considerably from over 45 percent in 2000.[50] The share of the top 100 companies has similarly decreased, from nearly 70 percent in the late 1980s to approximately 51 percent in 2012. The drop-off in concentration in R&D performing firms coincides with the decline of the ICT industries in Canada (including Nortel),[51] and it may be indicative of a lack of "national champions" in Canada that make significant investments in R&D.

There is also evidence to suggest that the propensity of Canadian firms to perform R&D may be increasing although, in reality, less than 3 percent of firms in Canada are performing R&D. Despite some small declines in 2009, there has been consistent growth in the share of firms performing R&D across all industry sectors.[52] The most significant growth has been in manufacturing, which increased from approximately 16 percent in 2005 to approximately 19 percent in 2009.[53] While the number of firms in manufacturing decreased over this period, the number of firms performing R&D has increased. In other industry sectors, growth in the number of firms performing R&D has slightly outpaced growth in the total number of firms. This suggests a growing realization among Canadian firms that they must innovate in order to be competitive.

Innovation through Investments in Machinery and Equipment and Intangible Assets

Investment by firms in M&E (defined as business gross fixed capital formation in M&E) is important for innovation and productivity growth. Firms and countries that acquire M&E can benefit from the technologies embodied therein without having had to assume the risks associated with their development. M&E can also contribute to productivity growth by stimulating process innovation and generating enhanced skills among workers.[54] The appreciation of the Canadian dollar against major currencies (i.e., the U.S. dollar, U.K. pound sterling, and the euro), especially between 2009 and 2012, has presented Canadian firms with the opportunity to increase M&E capital stock by lowering its cost.[55]

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47 Based on data for Australia, Finland, France, Korea, Sweden, United Kingdom and United States (2009 or most recent year) from: OECD, *Business enterprise R-D expenditure by size class and by source of funds* (October 2012).

48 Statistics Canada tabulations for STIC (November 2012), based on Statistics Canada, *Research and Development in Canadian Industry* (2010).

49 Statistics Canada, *Industrial Research and Development: Intentions 2012*, Catalogue no. 88-202-X (Ottawa, 2012), p. 8. (http://www.statcan.gc.ca/pub/88-202-x/88-202-x2012000-eng.pdf)

50 *State of the Nation 2010* reported the 2009 value at 33 percent. Revised data report the 2009 value at 30 percent.

51 Statistics Canada, *Industrial Research and Development: Intentions 2011*, Catalogue no. 88-202-X (Ottawa, 2011), p. 5. (http://www.statcan.gc.ca/pub/88-202-x/88-202-x2011000-eng.pdf)

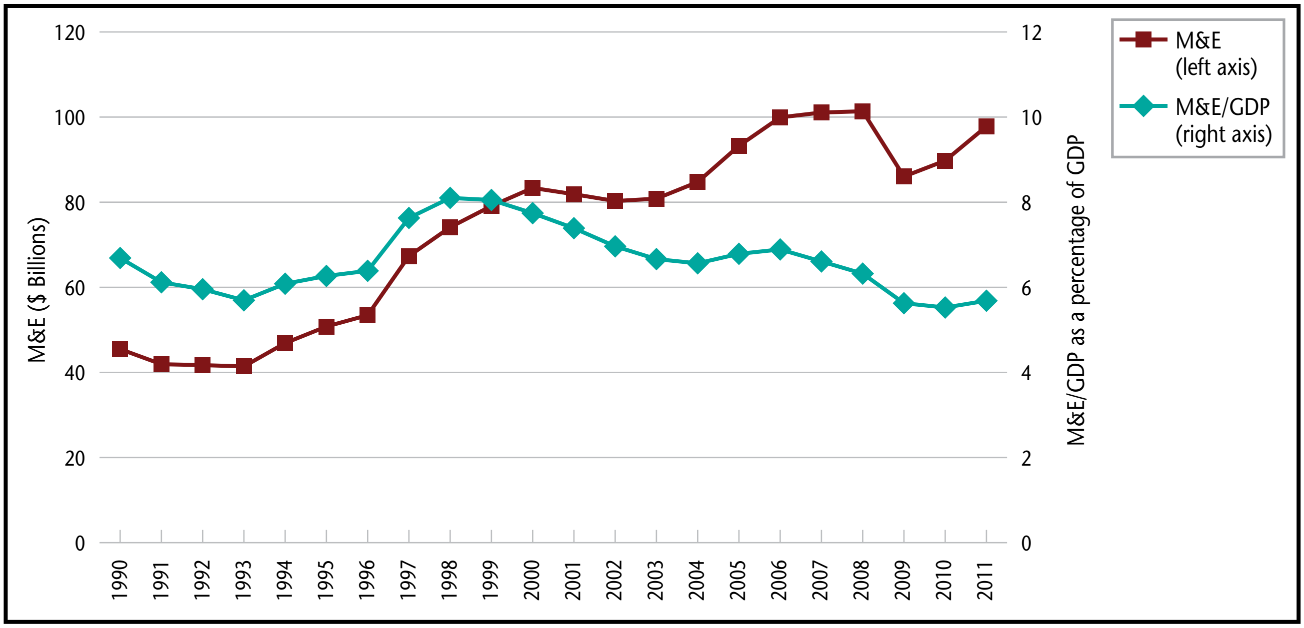
52 Share refers to the number of R&D-performing firms in an industry divided by the total number of firms in that industry. Data are only available up to 2009, so the data may not fully capture the effect of the recession.

53 Statistics Canada, *Industrial Research and Development: Intentions 2012*, Catalogue no. 88-202-X (Ottawa, 2012), p. 43. (http://www.statcan.gc.ca/pub/88-202-x/88-202-x2012000-eng.pdf)

54 Kevin Girdharry, Elena Simonova and Rock Lefebvre, "Investment in Machinery and Equipment is Essential to Canada's Future," *Issue in Focus (Certified General Accountants Association of Canada)* Ottawa (April 2012), p. 7. (http://www.cga-canada.org/en-ca/ResearchReports/ca_rep_2012-04_ict.pdf)

55 Industry Canada, *Business Innovation and Strategy: A Canadian Perspective* Ottawa (2011), p. 1. (http://publications.gc.ca/collections/collection_2011/ic/Iu173-3-2011-eng.pdf)

Figure 4-6: M&E Investment and M&E Investment as a Percentage of GDP in Canada, 1990–2011



Source: Statistics Canada, CANSIM Table 380-0017 (Gross domestic product (GDP), expenditure-based), August 2012.

Investment in M&E in Canada has grown significantly over the past 20 years, as shown in Figure 4-6.[56] Despite a large decline in 2009, investment increased in both 2010 and 2011.[57] M&E investment as a percentage of GDP reached 5.7 percent in 2011, up slightly from 2009 and 2010 but down from the 1994 to 2008 period, when it continuously exceeded 6 percent.[58]

Investments in Information and Communications Technologies

Of all types of M&E, ICT[59] tends to make the greatest contributions to innovation and productivity growth, and a number of studies[60] have suggested that low investment in ICT is a significant contributor to Canada's lagging productivity. Analysis from the OECD shows that ICT enables innovation, and the probability to innovate increases with the intensity of ICT use.[61] As well, over the 2000 to 2009 period, ICT investments provided a significant contribution to labour productivity growth in a number of OECD countries, including Canada, where it accounted for over 50 percent of growth.[62]

In Canada, until 15 to 20 years ago, overall M&E investment was predominantly in non-ICT M&E. Since then, the landscape has changed, as investment in ICT has grown. In 2011, investment in ICT M&E represented 49 percent of total M&E investment.[63] While Canadian

56 Machinery and equipment is in current dollars. GDP at market prices is expenditure-based estimates in current dollars.

57 The value in constant dollars is higher because the cost of M&E has been deflating.

58 M&E and GDP at market prices in current dollars. See: Statistics Canada, CANSIM Table 380-0017 *Gross domestic product (GDP), expenditure-based* (October 2012).

59 According to the OECD, ICT products are those that are primarily "intended to fulfill or enable the function of information processing and communication by electronic means, including transmission and display. OECD, *Guide to Measuring the Information Society*, Paris (2009), p. 90.

60 Previous studies include: Andrew Sharpe, "What Explains the Canada-US ICT Investment Gap?" *International Productivity Monitor (Centre for the Study of Living Standards)*, Vol. 11 (2005); Someshwar Rao, "Cracking Canada's Productivity Conundrum," *Institute for Research on Public Policy*, Study No. 25 (2011); Someshwar Rao et al., "What Explains the Canada-US TFP Gap?" Industry Canada, Working Paper 2006–08 (2006).

61 OECD, *Measuring Innovation: A New Perspective*, Paris (2010), p. 84. (http://www.oecd.org/site/innovationstrategy/45188243.pdf)

62 OECD, *Science, Technology and Industry Scoreboard 2011* (Paris: OECD Publishing, 2011), p. 83. (http://dx.doi.org/10.1787/888932486146)

63 Kevin Girdharry, Elena Simonova and Rock Lefebvre, "Investment in Machinery and Equipment is Essential to Canada's Future," *Issue in Focus (Certified General Accountants Association of Canada)* (2012), p. 6. (http://www.cga-canada.org/en-ca/ResearchReports/ca_rep_2012-04_ict.pdf)

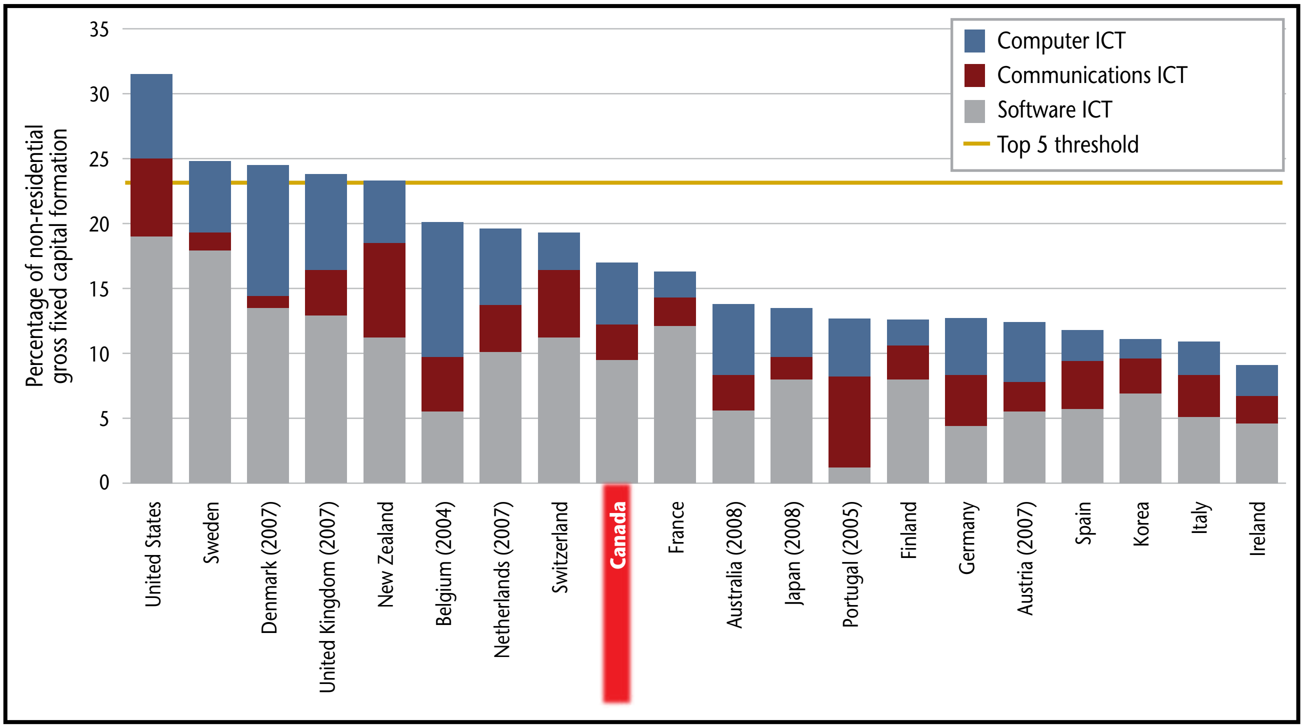
The significant M&E and ICT gap with the U.S. continues to be a cause for concern.

investment in ICT is growing, Canada still ranks near the middle among available OECD countries in terms of ICT investment intensity (i.e., ICT as a percentage of non-residential gross fixed capital formation). Canada performs at approximately 70 percent of the threshold of the top five performers, as reflected in Figure 4-7. Although Canada ranks higher than some key advanced economies, including France, Japan, Finland and Germany, it still trails the top five performers (the U.S., Sweden, Denmark, the United Kingdom and New Zealand). This is another area where improvement in Canada's performance will be particularly important to enhancing business innovation and ultimately helping to secure Canada's position as a global STI leader.

Figure 4-8 compares the relative performance of Canadian industries to their U.S. counterparts. The significant M&E and ICT gap with the U.S. continues to be a cause for concern, as reported in *State of the Nation 2010*. ICT capital intensity in the business sector in Canada (i.e., the weighted average of all industries included in Figure 4-8) averaged only 42 percent of U.S. levels over the period from 2000 to 2010.

While the capital intensity gap exists for most industries, some industries in Canada perform relatively well. Canadian industries such as agriculture, forestry, fishing and hunting; and arts and entertainment exceed the ICT capital intensity levels for the same industries in the U.S. (although these industries have low ICT capital intensities in both countries[64]). The Canadian oil and gas extraction industry, in particular, lags the U.S. in terms of ICT capital intensity, although it is the only industry that does not lag in terms of M&E capital intensity.

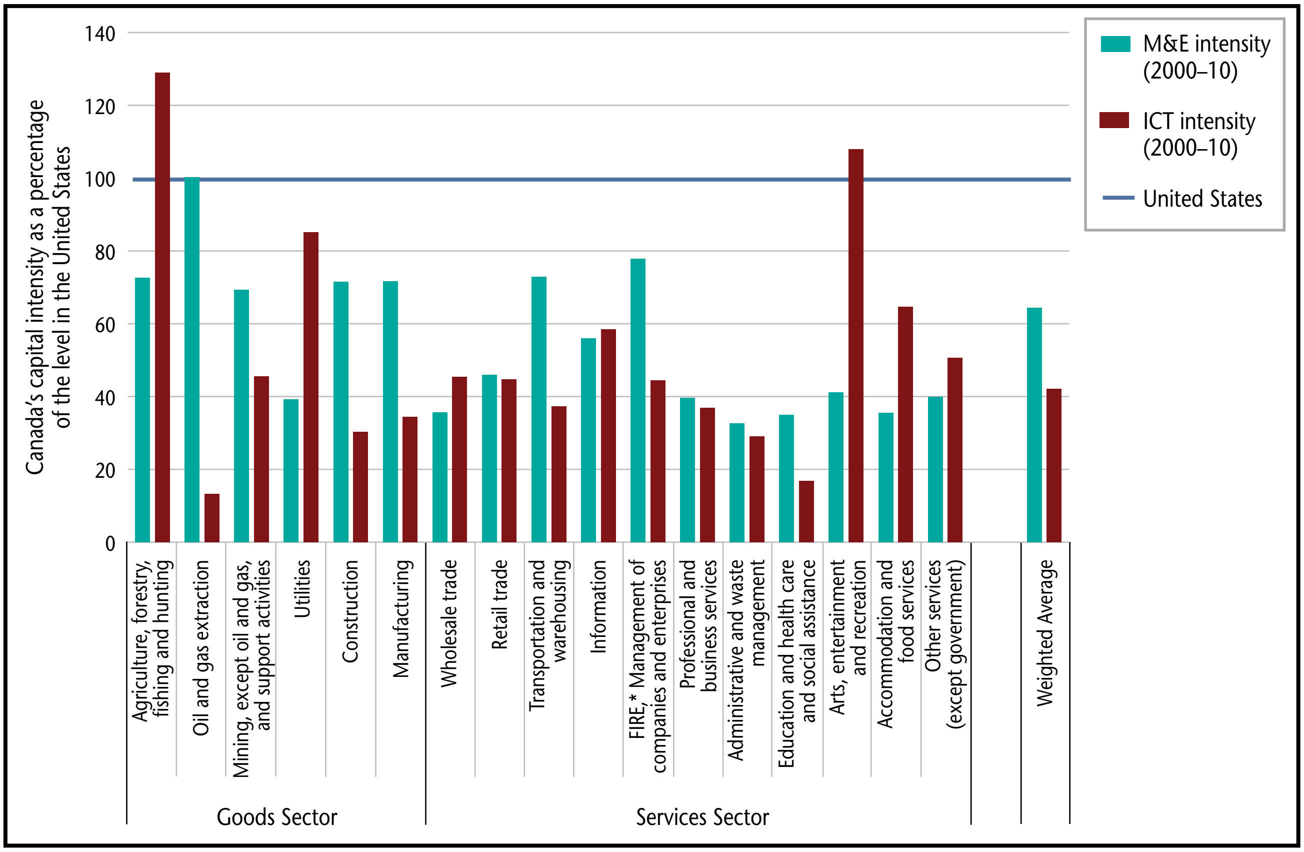
Figure 4-7: ICT Investment Intensity (ICT as a Percentage of Non-Residential Gross Fixed Capital Formation) by Component, 2009



Source: OECD, *Science, Technology and Industry Scoreboard*, 2011 (based on OECD Productivity Database), Figure 2.8.1, Data link: http://dx.doi.org/10.1787/888932486127.

64 Centre for the Study of Living Standards, *Database of Information and Communication Technology (ICT) Investment and Capital Stock Trends: Canada vs. United States* (August 2012). (http://www.csls.ca/data/ict.asp)

Figure 4-8: **Canada–United States Capital Intensity (Capital Stock per Hour Worked) Comparisons, 2000–10 Average (United States = 100)**



* FIRE is finance, insurance and real estate; M&E includes ICT.

Source: Industry Canada updates of Tang, Rao and Li (2010) for STIC, based on data from Statistics Canada and the U.S. Bureau of Economic Analysis, December 2012.

Investments in Intangible Assets

Innovation also requires investments in assets that do not take on physical characteristics, such as design, organizational structure, advertising and marketing, and the development of talent.[65] As discussed in Chapter 2, there is a positive relationship between investment in intangible assets and productivity, which in turn contributes to overall growth and prosperity.[66,67]

Investment in these assets in Canada is growing and stood at approximately 66 percent of tangible asset investment in 2008 (up from 23 percent in 1976).[68] According to 2006 data from the OECD, investment in intangible assets exceeds investment in tangible assets in many highly innovative countries, including Finland, Sweden, and the United States.[69]

65 OECD, *OECD Economic Surveys: Canada 2012*, Paris (2012), p. 55. (http://dx.doi.org/10.1787/eco_surveys-can-2012-en)

66 Conference Board, "Measuring What Counts," *Issues in Intangibles* 1, 1 (Winter 2012), p. 2.

67 Intangible assets have "made a significant contribution to labour productivity growth," accounting for approximately 40 percent of the total impact of capital-deepening between 1976 and 2008 according to: Statistics Canada, "Study: Intangible capital and productivity growth in Canada, 1976 to 2008," *The Daily* (June 1, 2012). (http://www.statcan.gc.ca/daily-quotidien/120601/dq120601b-eng.htm)

68 John R. Baldwin, Wulong Gu, and Ryan Macdonald, "Intangible Capital and Productivity Growth in Canada," *Canadian Productivity Review Research Paper (Statistics Canada)*, Catalogue no. 15-206-X – No. 029 (2012), p. 7. (http://www.statcan.gc.ca/pub/15-206-x/15-206-x2012029-eng.pdf)

69 OECD, *Measuring Innovation: A New Perspective*, Paris (2010), p. 22. (http://www.oecd.org/site/innovationstrategy/45183306.pdf)

Addressing Environmental Challenges through Microbiology

Dr. Monique Haakensen is a scientist who successfully bridges the business and academic worlds to address environmental challenges in the natural resources sector.

With a PhD in microbiology (focused on genomics and bioinformatics), Dr. Haakensen began her career as a university research associate and government scientist, examining the way microbiology could be applied in the natural resources sector. This experience impressed on her the large and growing need within the natural resources sector for applied microbiology research to help companies with bioconversion, a process that uses microbes to remediate contaminated water and soil, such as seepage, effluents and spill sites. This motivated her to start Contango Strategies, which opened its laboratories in Saskatoon in 2011. Specializing in the development, piloting and implementation of lost-cost and sustainable technologies for water treatment and soil remediation, Contango has since won contracts from local and multinational mining companies, oil and gas companies and waste-management firms, and it has expanded its services across Western and Northern Canada.

Dr. Haakensen also serves as an Adjunct Professor and as an advisor to graduate students in a variety of departments at the University of Saskatchewan. In 2011, Dr. Haakensen was named as a winner of *Profit Magazine*'s Future Entrepreneurial Leader's awards, recognizing Canada's top 20 entrepreneurs under the age of 30.

According to analysis from Statistics Canada,[70] the largest component of investment in intangible assets in Canada is economic competencies, which accounted for 58 percent of total intangible investments in 2008 (Figure 4-9). Investments in economic competencies (e.g., advertising and organizational capital, including scientific managerial capabilities) improve the ability of firms to compete or to modify processes in order to improve efficiency. These investments also contribute to the knowledge that firms possess.[71] The second-largest component of investment in intangible assets in Canada is innovative property, which accounted for approximately 31 percent of overall intangible investments in 2008. The smallest component is computerized information, which includes software[72] and databases.

Mineral exploration and evaluation is considered an intangible asset and an innovation activity, which is an important part of the mining and oil and gas extraction industries in Canada. While mineral exploration and evaluation activities are not classified as R&D, they can be considered innovative, as they are constantly adapting to new challenges and making significant use of developments in STI. Expenditures on mineral exploration[73] and evaluation are particularly large in the Canadian economy, standing at approximately $11.8 billion in 2008 (compared to $7.3 billion in 2000), or approximately 8 percent of total investment in intangible assets.[74] While international comparisons are limited, analysis from the OECD shows that expenditures on mineral exploration and evaluation are 1.14 percent

70 John R. Baldwin, Wulong Gu, and Ryan Macdonald, "The New Investment Paradigm?" *Economic Insights Analytical Paper (Statistics Canada)*, Catalogue no. 11-626-X – No. 007 (2012). (http://www.statcan.gc.ca/pub/11-626-x/11-626-x2012007-eng.pdf)

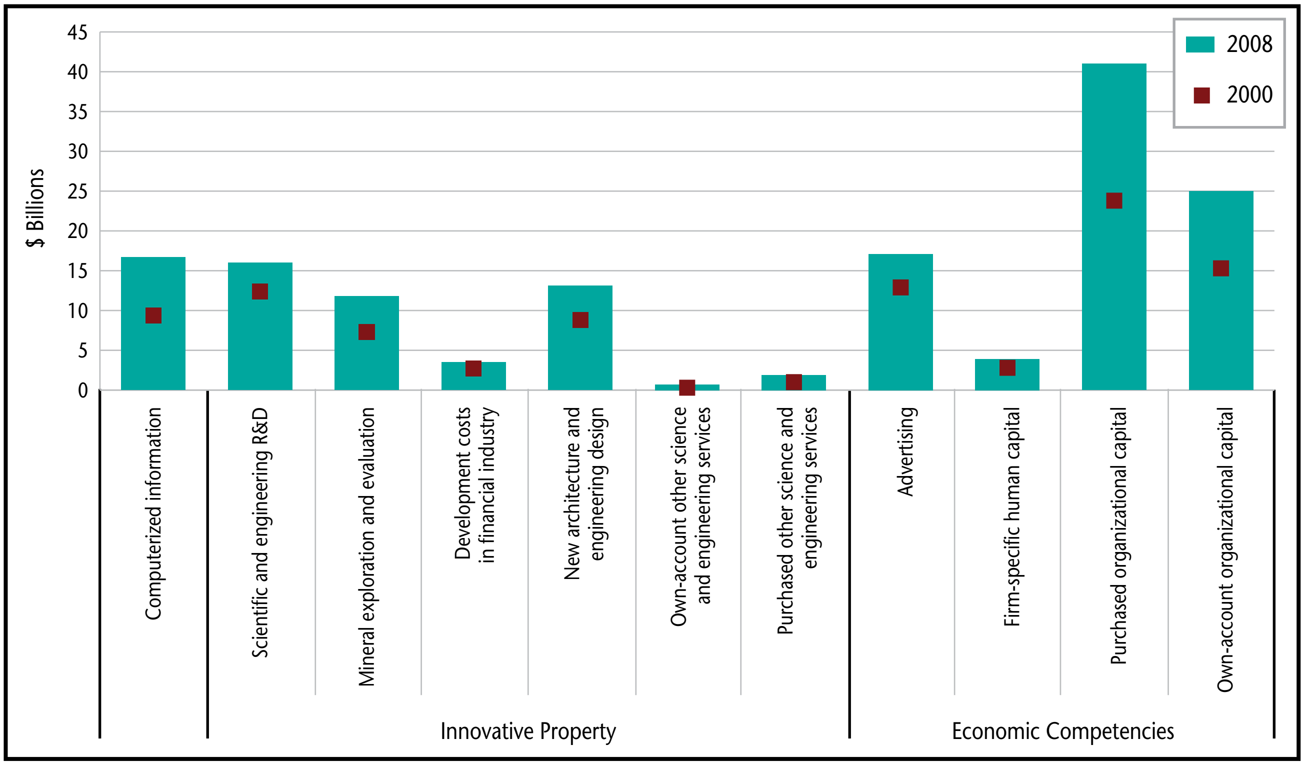
71 John R. Baldwin, Wulong Gu, and Ryan Macdonald, "The New Investment Paradigm?" *Economic Insights Analytical Paper (Statistics Canada)*, Catalogue no. 11-626-X – No. 007 (2012), p. 3. (http://www.statcan.gc.ca/pub/11-626-x/11-626-x2012007-eng.pdf)

72 As noted elsewhere in this section, software is also included in the ICT component of M&E.

73 According to Baldwin et al. (*Investment in Intangible Assets in Canada: R&D, Innovation, Brand, and Mining, Oil and Gas Exploration Expenditures* (2009)), expenditures consist of all exploration, drilling, and geological and geophysical expenditures associated with the predevelopment stage. These data cover most aspects of oil and gas or mineral exploration undertaken in Canada.

74 John R. Baldwin, Wulong Gu, and Ryan Macdonald, "The New Investment Paradigm?" *Economic Insights Analytical Paper (Statistics Canada)*, Catalogue no. 11-626-X – No. 007 (2012), p. 3. (http://www.statcan.gc.ca/pub/11-626-x/11-626-x2012007-eng.pdf)

Figure 4-9: Investment in Intangible Assets in Canada, 2000 and 2008



Sources: John R. Baldwin, Wulong Gu, and Ryan Macdonald, "The New Investment Paradigm?," *Economic Insights Analytical Paper (Statistics Canada)*, Table 2, June 2012 (based on Statistics Canada and authors' calculations) (http://www.statcan.gc.ca/pub/11-626-x/2012007/tbl/tbl02-eng.htm).

of GDP in Canada (2005) compared to 1.01 percent of GDP in the U.S. (2007) and 0.26 percent of GDP in Australia (2005–06).[75]

Trademarking Innovations

Trademarks (as well as other types of intellectual property) can be thought of as a type of intangible asset.[76] The World Bank defines a trademark as a distinctive sign that identifies certain goods or services as those produced or provided by a specific person or enterprise. As well, a trademark provides protection to the owner by ensuring the exclusive right to use it or to authorize another to use it.[77] According to the OECD, because trademarks can be applied to a multiplicity of goods and services, they "may serve as indicators of innovative and marketing activity, and may proxy non-technological innovations and innovation in services."[78]

Canada's performance with respect to direct resident trademarking[79] has changed little since 2007. According to the World Intellectual Property Organization, in 2010, Canada had 20,449 trademark applications and ranked 20th out of 85 economies[80] in the total number of direct resident trademark applications.[81] This compares to 18th out of 105 economies with data available for 2007. By comparison, China and the U.S. ranked first and second, with totals of 973,460 and 236,826 applications,

75 Alexandra Bibbee, "Unleashing Business Innovation in Canada," *OECD Economics Department Working Papers*, No. 997 (October 2012), p. 14.

76 OECD, *New Sources of Growth: Intangible Assets*, Paris (2011). (http://www.oecd.org/science/innovationinsciencetechnologyandindustry/46349020.pdf)

77 World Bank, *Trademark Applications, Direct Resident* (based on data from the World Intellectual Property Organization) (2010). (http://data.worldbank.org/indicator/IP.TMK.RESD)

78 OECD, *Science, Technology and Industry Scoreboard 2011*, Paris (2011), p. 144.

79 According to the World Bank, these are trademark applications filed by domestic applicants directly at a given national IP office.

80 Where 2010 data were missing, 2009 data were used.

81 World Bank, *Trademark Applications, Direct Resident* (based on data from the World Intellectual Property Organization) (2010). (http://data.worldbank.org/indicator/IP.TMK.RESD)

Transforming the Way the World Learns

Software company Desire2Learn, based in Waterloo, is helping to transform the way the world learns by providing a suite of products that offer a more engaging, intuitive and personalized learning experience. Desire2Learn's success is driven by R&D and innovation, which are a core component of the company's business strategy and a key part of its culture. Approximately 40 percent of the Desire2Learn team is focused on R&D, which is essential for remaining at the forefront of the growing eLearning market.

In 2012, Desire2Learn announced it had attracted $80 million in venture financing from New Enterprise Associates and OMERS Ventures. According to Thomson Reuters, this constitutes the largest-ever venture capital investment in a Canadian software company. This investment will allow Desire2Learn to tap into a new network of expertise, and to increase its investment in R&D to address new markets. As well, it will allow Desire2Learn to invest in infrastructure, retain the top talent that is already in the company, and attract new talent to keep the company innovating. Desire2Learn has also received government support, including a $4.25 million grant from the Government of Ontario in 2011.

The company's products are used by over 700 clients and over 8 million learners in higher education, K-12, health care, government and industry (including Fortune 100 companies). Desire2Learn has been recognized as a global leader in the eLearning market, and has received numerous awards, including the Deloitte Technology Fast 50 Leadership Award.

respectively. Two countries smaller than Canada (in terms of population) ranked ahead of Canada: Australia in 13th place (with 39,633 applications) and Chile in 16th place (with 30,133 applications).

Since firms have a tendency to file trademarks first in their home country, direct resident trademarks are not a particularly meaningful indicator. While cross-border trademarks, reported in *State of the Nation 2010*, are a better indicator, updated data are not available. An alternate indicator, which for many economies captures cross-border trademarks, is trademark applications at the Japanese Patent Office (JPO), the European Office for Harmonization in the Internal Market (OHIM) and the United States Patent and Trademark Office (USPTO) as a percentage of GDP. According to this measure, Canada ranked 13th out of 40 economies (based on a 2007–09 average).[82]

Canada performed poorly in terms of VC investment as a percentage of GDP.

Supporting Innovation through Equity Financing

Innovative young firms often depend on access to risk capital to develop and commercialize their ideas, since they are frequently perceived as too high-risk for traditional institutional funding.[83] Research has found that, in Canada, equity financing accounts for over 40 percent of total financing received by innovative SMEs, compared to less than 10 percent for non-innovative SMEs.[84] While 2011 data show significant growth in total investments by both angel investors[85] and venture capitalists

82 OECD, *Science, Technology and Industry Scoreboard 2011*, Paris (2011), p. 144. (http://dx.doi.org/10.1787/888932487172)

83 OECD, *Science, Technology and Industry Scoreboard 2009*, Paris (2009), p. 22.

84 Shunji Wang, "Financing Innovative Small and Medium-Sized Enterprises in Canada Working Paper," *Industry Canada SME Financing Data Initiative* (2009), p. 24. Innovative firms are defined as those that spend more than 20 percent of their total investment expenditures on R&D.

85 National Angel Capital Organization, *Investment Activity by Canadian Angel Groups: 2011 Report*, Toronto (2012), p. 12.

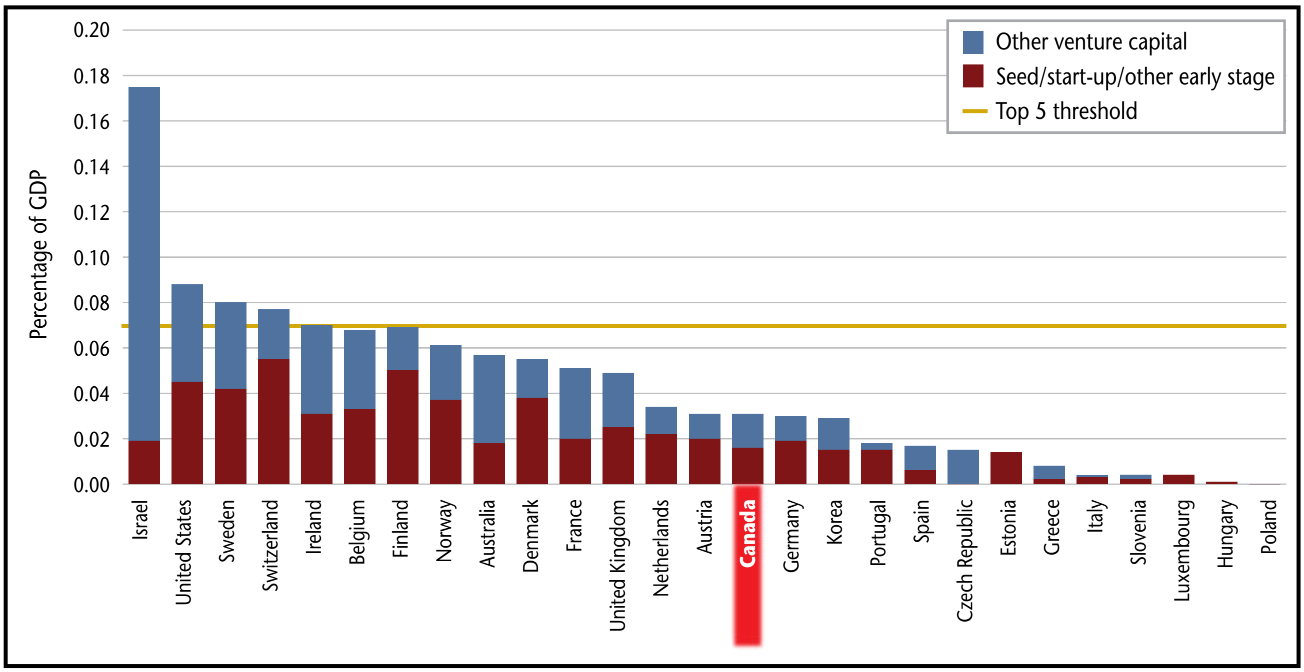
in Canada, investment levels remain considerably lower than those in the U.S., and total VC investment in Canada has yet to return to its pre-recession value.

Canada in International Rankings

As reflected in Figure 4-10, Canada performed poorly in terms of VC investment as a percentage of GDP compared to other countries in the OECD, ranking 15th out of 27 economies and achieving only 44 percent of the threshold of the top five performers.[86] The five leaders, including Israel (the clear trailblazer), the U.S., Sweden, Switzerland and Ireland, all invested at least twice as much VC as a percentage of GDP as Canada did in 2009. The picture improves, however, when looking at VC investment per capita in 2010, where Canada ranked fifth out of 14 economies, and performed better than Switzerland, Finland, Denmark, France, Ireland and the U.K., among others.[87,88]

It is important to note that it is difficult to compare VC investment across countries due to differences in definitions and classification methods. While the OECD has made recent changes to its methodology to better enable comparison across countries, this has made it difficult to compare the results in Figure 4-10 to results in previous years. Applying a consistent methodology to Canada across several years, analysis shows that Canada's VC as a percentage of GDP in 2011 was 0.09 percent.[89] Although this represents an improvement over 2009 and 2010 (when the share was approximately 0.07 percent), it is considerably below the share achieved in 2007 (0.13 percent).

Figure 4-10: **Venture Capital as a Percentage of GDP, 2009**



Source: OECD, *Science, Technology and Industry Scoreboard*, 2011 (based on OECD Entrepreneurship Financing Database), Figure 5.7.2, Data link: http://dx.doi.org/10.1787/888932487362.

86 Venture capital investment as a percentage of GDP measures the sum of seed and start-up capital and early development capital as a percentage of a country's GDP.

87 The Economist, *What next for the start-up nation?* (based on data from National Venture Capital Association, European Private Equity and Venture Capital Association, Israel Venture Capital Research Center, and UN) (January 21, 2012). (http://www.economist.com/node/21543151)

88 Ratio for Canada is estimated by STIC based on CVCA data.

89 Based on VC data reported by the CVCA/Thomson Reuters and GDP data from Statistics Canada, CANSIM Table 380-0017—*GDP at market prices in current dollars, expenditure based* (September 2012).

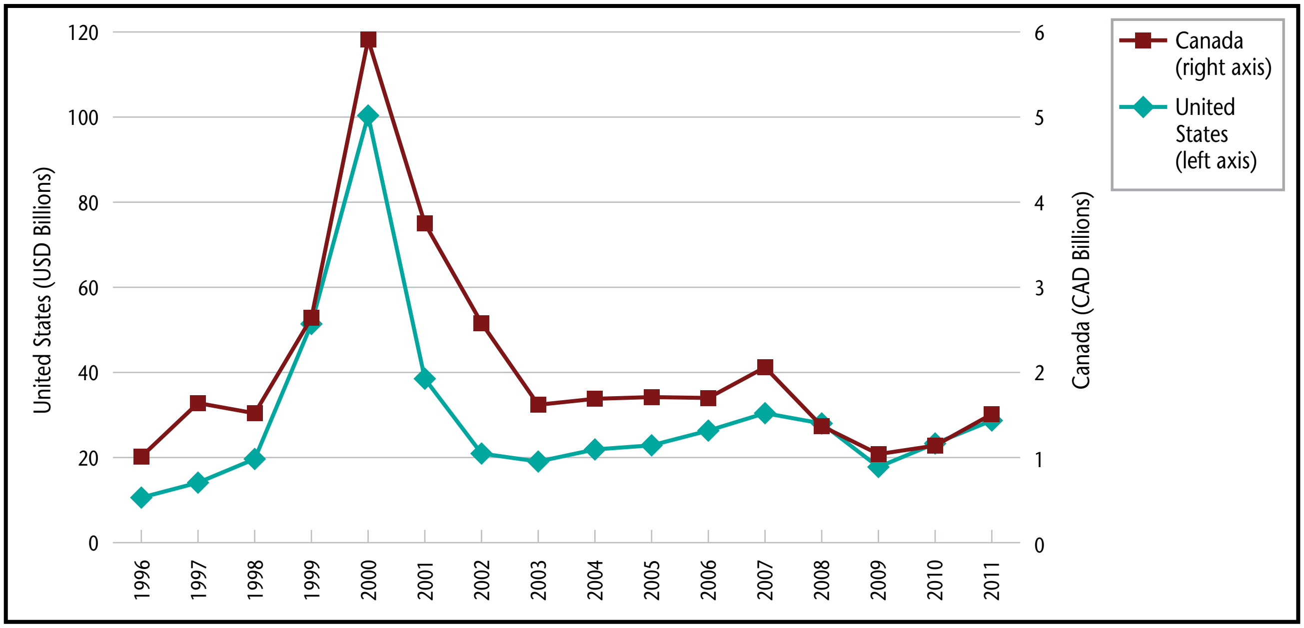
Characteristics of the Canadian VC Landscape

The effect of the economic downturn on the VC industry, which resulted in dramatic declines in investments in 2008 and 2009, was the principal story in the discussion of risk capital in *State of the Nation 2010*. While there was moderate year-over-year growth in 2010, a substantial expansion occurred in 2011 (Figure 4-11). VC investment totalled $1.5 billion at the end of 2011, an increase of 34 percent from the $1.1 billion invested in 2010. Although this was higher than each of the preceding three years, it remained well below the $2.1 billion invested in 2007.[90]

The increased VC activity in 2011 was not accompanied by large gains in deal sizes, which can impact the growth potential of VC-backed firms. Amounts invested per firm averaged $3.4 million in 2011, up slightly from $3.2 million in 2010 and from $3.1 million in 2009 (but still below the $3.6 million averaged in 2008 and the $5.1 million averaged in 2007). As a result, the gap in VC deal sizes between Canada and the U.S. was further eroded in 2011. On average, Canadian firms secured only 37 percent of the dollars going to U.S. firms in 2011, down from 39 percent in 2010.[91]

The availability of venture capital, from the earliest stages of funding for an initial idea or basic research through to the later stages of expansion and ultimately the exit, is important for developing innovative companies. A recent trend in VC investment in Canada has

Figure 4-11: **Trend in Total Venture Capital Investment, United States and Canada, 1996–2011**



Sources: Canada's Venture Capital & Private Equity Association and Thomson Reuters (Canada); PricewaterhouseCoopers, *National Venture Capital Association MoneyTree*™ Report, Data: Thomson Reuters (United States).

90 CVCA, *Canada's Venture Capital Market in 2011* (prepared by Thomson Reuters for the Canadian Venture Capital & Private Equity Association) (2012). (http://www.cvca.ca/files/Resources/2011_VC_Data_Deck.pdf)

91 CVCA, *Canada's Venture Capital Market in 2011* (prepared by Thomson Reuters for the Canadian Venture Capital & Private Equity Association) (2012). (http://www.cvca.ca/files/Resources/2011_VC_Data_Deck.pdf)

been the dramatic increase in later-stage financing, with funding for the expansion component more than doubling from 2009 to 2011. Later-stage[92] financing is important because it can lead to more profitable exits for investors. In 2011, later-stage financing in Canada accounted for 71 percent (or approximately $1.1 billion) of total VC investments, up from 59 percent (or approximately $676 million) in 2010. On the other hand, there has been a small decline in early-stage[93] financing, falling from $458 million in 2010 to $434 million in 2011.[94] In the U.S., 2011 saw strong growth in investments at both the early and later stage.[95]

There are key differences between the sources of VC in Canada and the U.S. (Figure 4-12A and Figure 4-12B). The significance of foreign funds is an important feature of the Canadian VC industry, accounting for approximately 29 percent of total VC investment in 2011. On average, foreign investors invested more than two times the amount of domestic investors. The activity of U.S. and other foreign VC funds in the Canadian market showed growth in 2011, and reflects the highest level of cross-border VC investment in four years.[96] Foreign funds, particularly from the U.S., are often important in later-stage financing in Canada, mostly because Canadian VC funds, being relatively small, are not well-positioned to participate in later-stage financing that requires larger deal sizes. U.S. funds bring not only capital but also expertise and networks, which result in higher exit values.[97] Although foreign partners invest in only approximately 10 percent of Canadian venture capital deals, they account for approximately 30 percent of exits and almost 45 percent of exit proceeds.[98]

While Canadian private independent funds were also essential to the increased total investment in 2011 (investing $377 million, up 42 percent year-over-year), domestic private independent funds make a significantly smaller contribution to overall VC investment in Canada than they do in the U.S. Venture capital in Canada is further distinguished from that in the U.S. by the presence of both government and labour-sponsored funds (although the share of labour-sponsored funds in total VC investment in Canada has declined, from approximately 24 percent in 2009 to approximately 16 percent in 2011). Some economists have attributed the poor performance of the VC market in Canada to "crowding out" by labour-sponsored funds, which have traditionally played a significant role in VC in Canada despite their historically poor returns.[99]

Venture Capital by Industry in Canada

Almost all technology-intensive industries benefited from the increased VC investment in Canada in 2011, with ICT industries continuing to lead with 46 percent of the total (or $692 million, up from $491 million in 2010).

92 According to Canada's Venture Capital & Private Equity Association (CVCA), later stages include:
- Expansion: An established or near-established company that needs capital to expand its productive capacity, marketing and sales.
- Acquisition/Buyout: An established or near-established firm that needs financing to acquire all or a portion of another business entity for growth purposes.
- Turnaround: An established or near-established company that needs capital to address a temporary situation of financial or operational distress.
- Other stage: A Secondary Purchase, or the sale of portfolio assets among investors, and working capital.

93 According to the CVCA, early stages include:
- Seed stage: A developing business entity that has not yet established commercial operations and needs financing for research and product development.
- Start-up: A business in the earliest phase of established operations and needs capital for product development, initial marketing and other goals.
- Other early stage: A firm that has begun initial marketing and related development and needs financing to achieve full commercial production and sales.

94 CVCA, *Canada's Venture Capital Market in 2011* (prepared by Thomson Reuters for Canada's Venture Capital & Private Equity Association) (2012). (http://www.cvca.ca/files/Resources/2011_VC_Data_Deck.pdf)

95 NVCA, *Yearbook 2012* (prepared by Thomson Reuters) (2012).

96 CVCA, *Canada's Venture Capital Market in 2011* (prepared by Thomson Reuters) (2012). (http://www.cvca.ca/files/Resources/2011_VC_Data_Deck.pdf)

97 Review of Federal Support to Research and Development—Expert Panel Report, *Innovation Canada: A Call to Action*, Ottawa (2011), Chapter 7, p. 7-16.

98 BDC, *Venture Capital Industry Review (2011)*. Cited in Review of Federal Support to Research and Development—Expert Panel Report, *Innovation Canada: A Call to Action*, Ottawa (2011), Chapter 7, p. 7-16.

99 Douglas Cumming and Jeffrey MacIntosh, *Crowding Out Private Equity: Canadian Evidence* (2006); and, James Brander et al., *Government Sponsored Venture Capital in Canada: Effects on Value Creation, Competition and Innovation* (2008). Cited in Review of Federal Support to Research and Development—Expert Panel Report, *Innovation Canada: A Call to Action*, Ottawa (2011), Chapter 7, p. 7-13.

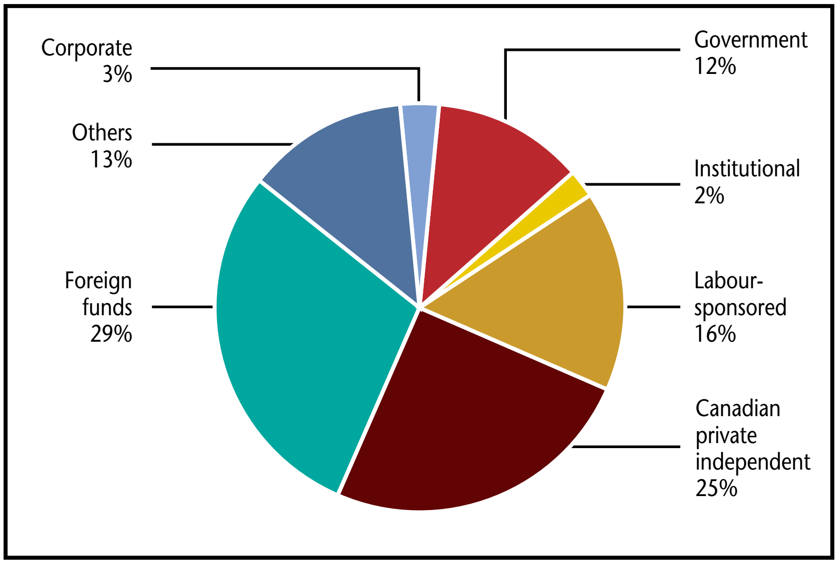
Within ICT, particularly large gains were registered by Internet-focused firms and software firms, which received \$236 million and \$201 million, respectively. Investments in life sciences industries, including biopharmaceuticals and medical devices, also grew in 2011, up 15 percent from 2010 (to total \$343 million or approximately 23 percent of total VC investment). As well, VC investments in energy and environmental technologies industries increased in 2011, up 43 percent from 2010 (to total \$245 million).[100]

While investment in ICT makes up a significant share of total VC investment in Canada, the share is even higher in the U.S. (approximately 57 percent). Investment in life sciences as a percentage of total VC investment is also higher in the U.S. (approximately 27 percent in comparison to Canada's 23 percent).[101] This suggests that a higher share of VC is invested in technology-intensive industries in the U.S. than in Canada.

Venture Capital Exits and Market Capitalization

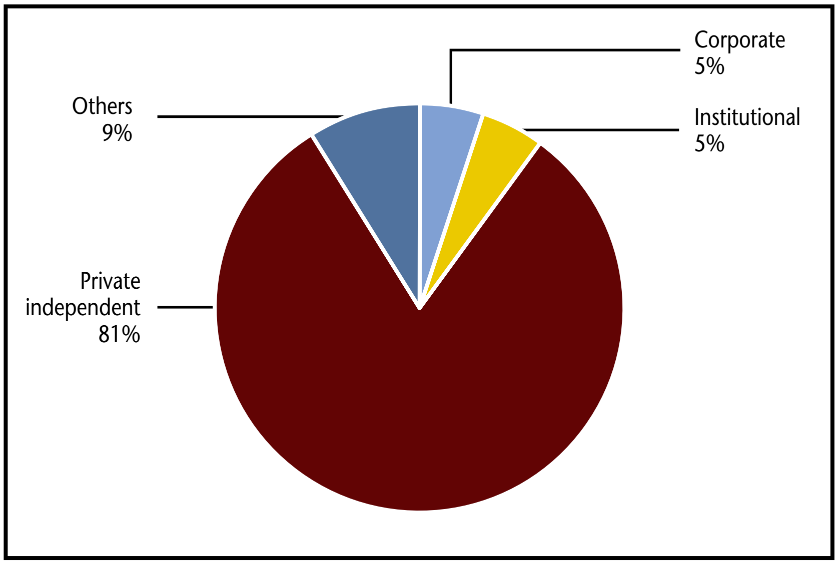
Exit values are important measures of the wealth generated through VC. As well, higher exit values can help VC firms attract funds. An exit value is the price received for the liquidation of a stake in a business, such as through mergers and acquisitions (M&As) or

Figure 4-12A: Venture Capital Funding Sources in Canada, 2011



Source: OECD, *OECD Economic Surveys: Canada 2012* (based on data from Thomson Reuters for the Canadian Venture Capital and Private Equity Association), Figure 1.13, Data link: http://dx.doi.org/10.1787/888932618139.

Figure 4-12B: Venture Capital Funding Sources in the United States, 2011



Source: OECD, *OECD Economic Surveys: Canada 2012* (based on data from Thomson Reuters for the Canadian Venture Capital and Private Equity Association), Figure 1.13, Data link: http://dx.doi.org/10.1787/888932618139.

100 CVCA, *Canada's Venture Capital Market in 2011* (prepared by Thomson Reuters) (2012). (http://www.cvca.ca/files/Resources/2011_VC_Data_Deck.pdf)

101 NVCA and Thomson Reuters, *Yearbook 2012* (prepared by Thomson Reuters) (2012), p. 11 (Figure 5.0).

initial public offerings (IPOs). Reported liquidity events[102] involving domestic and foreign investors in Canadian firms totalled 27 in 2011 (2 IPO exits and 25 M&A exits), down 13 percent on a year-over-year basis, but numbering slightly more than the events reported in both 2008 and 2009.[103] The average M&A transaction size in 2011 was $245 million, considerably higher than the values in 2009 and 2010, and in significant excess of the average M&A deal size for VC-backed firms in the U.S. (which was $150 million in 2011).

Conversely, the average IPO size in 2011 for Canadian VC-backed firms was less than half that in the U.S. ($72 million in Canada[104] compared to $190 million in the U.S.[105]). This may be linked to the relatively low market capitalization[106] of technology firms in Canada compared to the U.S. While the Toronto Stock Exchange (TSX) and TSX Venture Exchange together rank second in North America in terms of exchanges with the most technology companies listed, technology companies make up less than 2 percent of their total market capitalization.[107,108] In comparison, worldwide in 2010, technology firms represented approximately 15 percent of total global market capitalization.[109,110]

There is evidence that technology companies are undervalued in Canada. According to the Business Development Bank of Canada (BDC), the price/earnings ratios of Canadian VC-backed companies listing in Canada consistently underperform those of technology companies listing in the U.S., including Canadian companies.[111] Further evidence that Canadian public markets may be undervaluing technology stocks is that the value of acquisitions of Canadian companies tends to be considerably higher than the companies' market price.[112] This situation can make it difficult to grow large-scale innovative firms in Canada.

Innovation and Global Connectedness

Strong global links are important for the adoption and diffusion of new ideas and technologies that can have a positive impact on innovation performance and international competitiveness. Foreign companies investing in Canada, through foreign direct investment (FDI), provide access to new markets and new technologies for Canadian suppliers, generate knowledge spillovers, and invest a higher share of their revenue in R&D.[113] Meanwhile, Canadian direct investment abroad (CDIA) can stimulate high-value-added head office activities, such as R&D, engineering and design.[114] Through CDIA,

102 Note that there is no requirement to disclose deals.

103 CVCA, *Canada's Venture Capital Market in 2011* (prepared by Thomson Reuters) (2012). (http://www.cvca.ca/files/Resources/2011_VC_Data_Deck.pdf)

104 Data provided by Small Business and Tourism Branch, Industry Canada.

105 National Venture Capital Association and Thomson Reuters, *News Release* (3 January 2011). (http://www.nvca.org/index.php?option=com_docman&task=doc_download&gid=838&Itemid=93)

106 Market capitalization, as defined by the World Bank, is the share price multiplied by the number of shares outstanding.

107 Calculation by STIC based on 2011 TMX data indicating a $34 billion market capitalization of technology companies and an overall market capitalization of approximately $2 trillion: Toronto Stock Exchange, *Leadership in Technology*; and Toronto Stock Exchange, *A Capital Opportunity: A Growth Market for Technology Companies*. (http://www.tmx.com/en/pdf/Technology_Sector_Sheet.pdf and http://www.tmx.com/en/pdf/Technology_Presentation.pdf)

108 At the end of 2011, technology firms represented 4 percent of overall market capitalization on Canadian exchanges; Jos Schmitt, *"Fixing Canada's broken tech scene," Backbone Magazine* (February 27, 2012). (http://www.backbonemag.com/Magazine/2012-02/fixing-canadas-broken-tech-scene.aspx)

109 Tom Tunguz, "Four Trends in the Public Technology Market," *TechCrunch* (based on CapitalIQ research for technology sector data; IMF and U.S. Census for global market capitalization figures) (July 15, 2012). (http://techcrunch.com/2012/07/15/four-trends-in-the-public-technology-market/)

110 The low market capitalization of technology companies in Canada as a percentage of total market capitalization may be an outcome of the relatively high market values of Canadian resource companies and banks. As well, the TSX Venture Exchange is used as an alternative to VC, and as a result, most technology firms listed on the exchange are very small. For more information on the TSXV as a public venture capital market: Cécile Carpentier and Jean-Marc Suret, "The Canadian Public Venture Capital Market," *Centre interuniversitaire de recherche en analyse des organisations* (April 2009). (http://www.cirano.qc.ca/pdf/publication/2009s-08.pdf)

111 Business Development Bank of Canada, *Venture Capital Industry Review*, Ottawa (2011), p. 16. (http://www.bdc.ca/EN/Documents/other/VC_Industry_Review_EN.pdf)

112 Boyd Erman, "We undervalue our tech stocks – and pay the price," *The Globe and Mail* (January 30, 2012). (http://www.theglobeandmail.com/report-on-business/streetwise/we-undervalue-our-tech-stocks---and-pay-the-price/article551345/)

113 OECD, *Science, Technology and Industry Scoreboard 2011*, Paris (2011), p. 174.

114 Walid Hejazi, "Dispelling Canadian Myths about Foreign Direct Investment," *IRPP Study*, No. 1 (January 2010), p. 1. (http://www.irpp.org/pubs/irppstudy/irpp_study_no1.pdf)

Canadian companies can acquire innovations developed abroad and apply them at home. They can also identify and access new talent that enriches their firm.

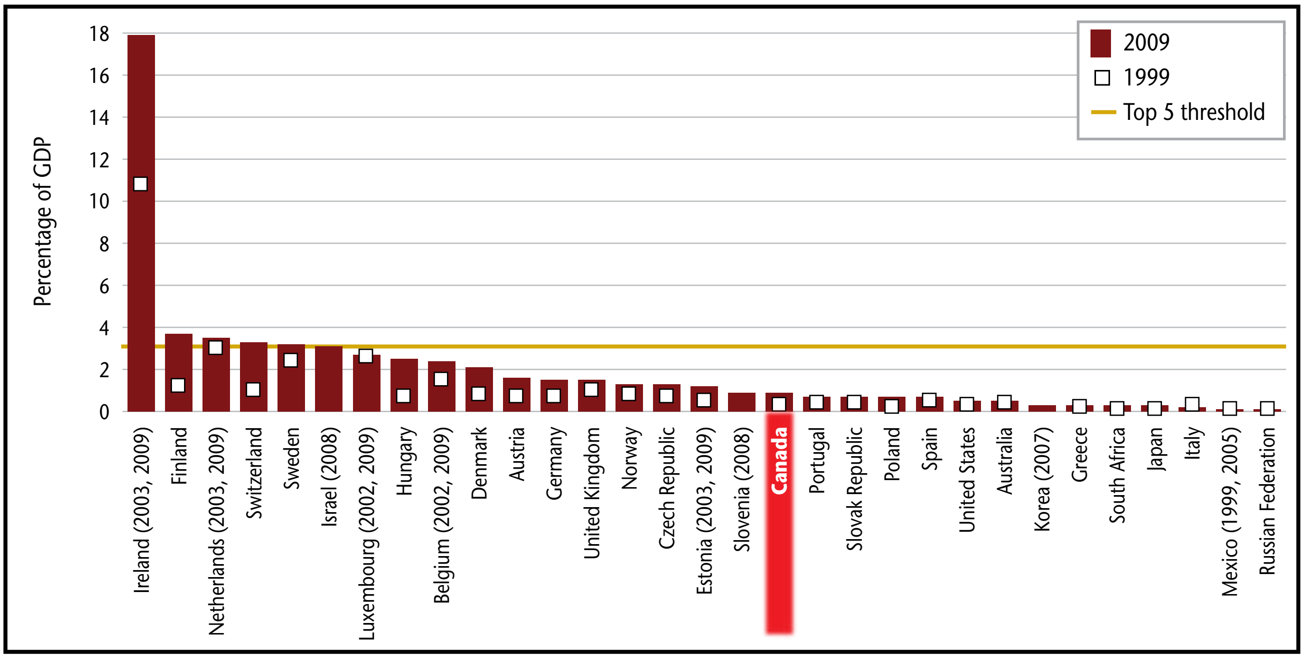
Both FDI in Canada and CDIA have increased considerably since the end of the 1990s, with FDI in Canada reaching approximately $607 billion and CDIA reaching approximately $684 billion in 2011. FDI is highest in manufacturing, followed by mining and oil and gas extraction, and the U.S. is by far the largest source of FDI in Canada. CDIA is highest in the finance and insurance industries, followed by mining and oil and gas extraction, and the U.S. is the primary target for CDIA.[115]

According to data from the OECD, FDI inflows for Canada equalled 2.4 percent of GDP in 2011, while FDI outflows (i.e., CDIA) equalled 2.9 percent of GDP. These values exceed the OECD averages for both FDI inflows and outflows, which are 1.8 percent and 2.8 percent, respectively.[116]

International Technology Flows

International technology flows[117] (Figure 4-13) reflect, to some extent, global linkages established through cross-border trade in R&D outcomes and production-ready technologies.[118] While this includes both inter-firm and intra-firm trade, evidence points to the particular importance of technology flows between parents and affiliates (i.e., intra-firm trade).[119] The importance of intra-firm trade likely holds true for Canada, given that many of our largest companies have operations in the U.S.

Figure 4-13: **International Technology Flows (Average of Receipts and Payments) as a Percentage of GDP, 1999 and 2009**



Source: OECD, *Science, Technology and Industry Scoreboard*, 2011 (based on OECD Technology Balance of Payments Database), Figure 3.10.1, Data link: http://dx.doi.org/10.1787/888932486602.

115 Statistics Canada, CANSIM Table 376-0052—*International investment position, Canadian direct investment abroad and foreign direct investment in Canada, by North American Industry Classification System and region* (October 2012).

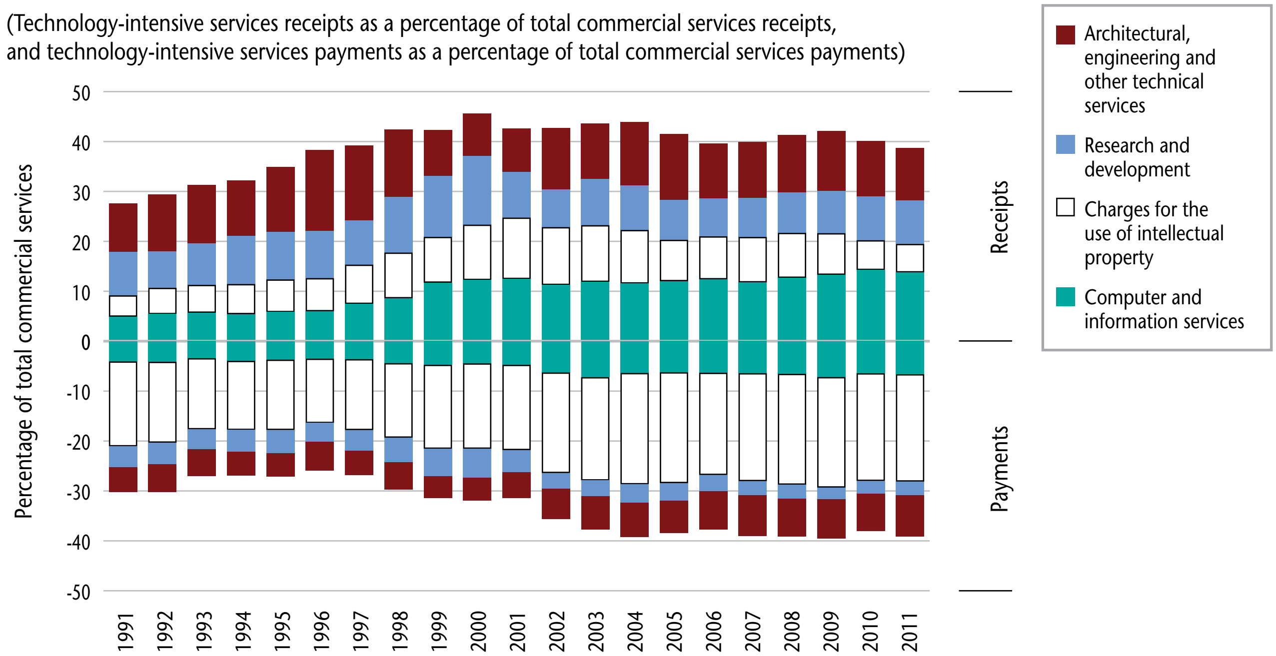
116 OECD, *OECD International Direct Investment Statistics 2012*, Paris (2012). (http://dx.doi.org/10.1787/9789264185708-en)

117 Trade in technology comprises four main categories: transfer of techniques (through patents and licences, disclosure of know-how); transfer (sale, licensing, franchising) of designs, trademarks and patterns; services with a technical content, including technical and engineering studies as well as technical assistance; and industrial R&D.

118 OECD, *Science, Technology and Industry Scoreboard 2011*, Paris (2011), p. 108.

119 For example, according to the OECD (*Science, Technology and Industry Scoreboard 2011*), technology flows to and from Ireland are mainly due to the strong presence of foreign affiliates (particularly U.S. and U.K. firms).

Figure 4-14: **Trade in Technology-Intensive Services, 1991–2011**



Source: Statistics Canada, CANSIM Table 376-0033 (International transactions in services, commercial services by category), November 2012.

Despite Canada's increased participation in international technology flows (from 1999 to 2009), as reflected in Figure 4-13 it still ranks below many key competitors, including the top five performing countries of Ireland, Finland, the Netherlands, Switzerland and Sweden. This suggests that the global linkages of Canadian firms may not be as strong as the global linkages of firms in other countries, and therefore Canada may not be capturing the innovation advantages that they can create.

Figure 4-14 shows Canada's receipts and payments for the most technology-intensive components of commercial services trade.[120] Receipts reflect the ability of Canadian firms to export the outcomes of technology-intensive activities as well as global demand for Canadian ideas and expertise. Payments reflect the desire of Canadian firms to benefit from the technology-intensive activities conducted abroad and awareness of global business opportunities. While many other aspects of services trade may involve R&D activities, the categories used in the figure were chosen because they reflect explicit payments or receipts for technology transfers and the cross-border trade in R&D intensive activities.

Technology-intensive services transactions as a share of total commercial services transactions have grown significantly since 1990, although the share has levelled off in recent years.[121] In 2011, the largest component of technology-intensive service exports was computer and information services (approximately 14 percent) followed by architecture, engineering and other technical services (approximately 11 percent). The largest category of imports of technology-intensive services in 2010 was, by far, charges for the use of intellectual property (approximately 22 percent).

In terms of the total value of receipts and payments for technology-intensive services in Canada, receipts for these services have typically exceeded payments, suggesting that Canada is exporting more than it is importing. In 2011, receipts for technology-intensive services were approximately $19.5 billion, while payments were approximately $18.6 billion. The only component with a historically negative trade balance is charges for the use of intellectual property.[122]

120 Like the OECD data presented above (see Figure 4-13), the data for technology-intensive services trade do not separate out transactions within multinational enterprises, which account for the majority of these payments for services.

121 The total value of both receipts and payments for technology-intensive services has also levelled off in recent years.

122 Statistics Canada, CANSIM Table 376-0033—*International transactions in services, commercial services by category* (November 2012).

5 Knowledge Development and Transfer

The production and refinement of scientific knowledge in Canada continues to be characterized by vitality and high quality.

Over the last 15 years, Canada has invested substantially in research in the higher education sector. This investment reaps significant rewards, as the production and refinement of scientific knowledge in Canada continues to be characterized by vitality and high quality, as reflected in key bibliometric indicators. This, in turn, contributes to building a strong foundation for all sectors of the Canadian science, technology and innovation (STI) ecosystem. Given the increasing internationalization of science, it is worthy of note that Canadian researchers are very active in collaborating with their global counterparts, as evidenced through their participation in international co-publications.

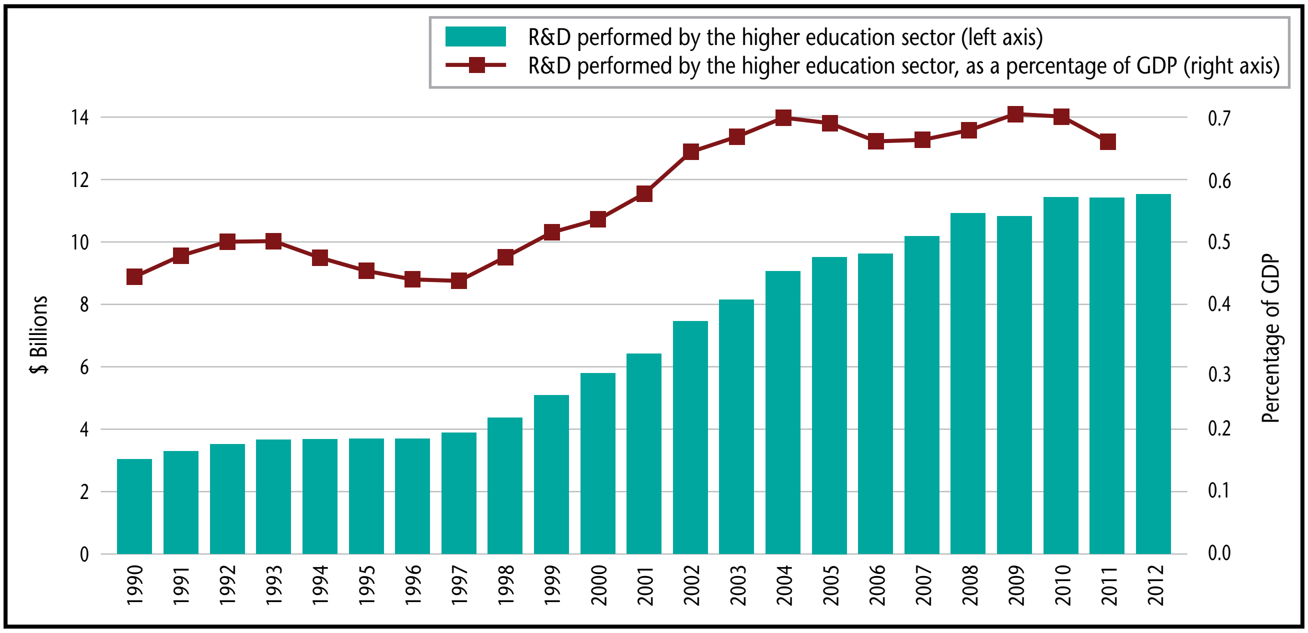
Canada's solid research base, however, does not yield maximum results when it comes to increasing the number of universities ranked among the world's best that could serve as flagships for Canada and attract even more top academics and students to the country. In addition, Canada continues to face chronic challenges in transferring knowledge developed in higher education institutions to the private sector. This is reflected in our typically disappointing results for licensing activities and the creation of spinoff companies from universities. Improvement in this area will be vital to ensuring that discoveries are translated into practical economic and societal benefits for Canadians.

KNOWLEDGE DEVELOPMENT

The development of knowledge is the root of a country's STI ecosystem. Research generates the knowledge that underpins new products, processes, and policies, and it contributes to a more highly skilled workforce that can better meet the demands of the global knowledge economy. Through breakthrough discoveries and the concrete application of those discoveries, knowledge drives our economic and societal well-being.

In Canada, the higher education sector (universities, colleges and affiliated teaching hospitals) continues to be a critically important performer of research and development (R&D). Due largely to increases in government funding, higher education expenditures on R&D (HERD) rose significantly through the late 1990s up to the beginning of the recession in the late 2000s, when growth in spending was very modest. From $3.03 billion in 1990, higher education R&D spending reached $11.53 billion in 2012. Although growing in dollar terms, HERD in relation to the size of the economy (i.e., HERD-to-Gross Domestic Product [GDP]) has fluctuated over the last decade. After peaking in 2009 at 0.71 percent, HERD intensity declined to 0.66 percent in 2011, as reflected in Figure 5-1.

Figure 5-1: **Higher Education Performance of R&D, 1990–2012**



Source: Statistics Canada, CANSIM Table 358-0001 and Table 380-0017, January 2013.

Despite the recent decline in the HERD-to-GDP ratio, in 2011 (the latest year for which international comparisons are available), Canada continued to rank—as in past years—first in the G7. However, as reflected in Figure 5-2, Canada's relative position is deteriorating against the broader comparator group of economies. In terms of HERD as a percentage of GDP, Canada ranked ninth out of 41 economies in 2011, down from fourth in 2008 and third in 2006.[123] This put its HERD-to-GDP performance in 2011 at 87.9 percent of the threshold of the top five performing countries (Denmark, Sweden, Switzerland, Finland and the Netherlands), although significantly higher than that of the United States (U.S.) (at 55.8 percent of the threshold of the top five performers). This is another measure where securing global leadership can help Canada realize its full STI potential, given the critical importance of knowledge development as a foundation for all sectors of the Canadian STI ecosystem.

As in previous *State of the Nation* reports, to look at the results of these investments in higher education R&D, this report uses bibliometric indicators and university rankings to examine Canada's performance. Considering the slow-moving nature of the academic world, results from these two sets of indicators have not changed significantly since the last *State of the Nation* report.

Canada ranked ninth out of 41 economies in HERD-to-GDP performance in 2011.

Measuring Canada's Scientific Outputs

Bibliometric indicators are a set of mathematical and statistical methods used to analyze different characteristics of peer-reviewed scientific articles published in international academic journals. Since peer-reviewed journal articles represent the primary mode of disseminating knowledge in almost all scientific fields, bibliometric indicators are now the most widely used quantitative indicators to evaluate knowledge development, and many countries carry out national bibliometric studies to measure research outputs.

123 Where data for 2006, 2008 and/or 2011 were not available, data for the next closest year were used to calculate the ranking. See years used in Figure 5-2.

There are three types of bibliometric indicators: *quantity indicators*, which measure the productivity of researchers in absolute numbers through number of publications; *impact indicators*, which measure the influence of researchers through counts of citations of publications; and *structural indicators*, which measure, among other things, collaboration among researchers from different countries through international co-publications.

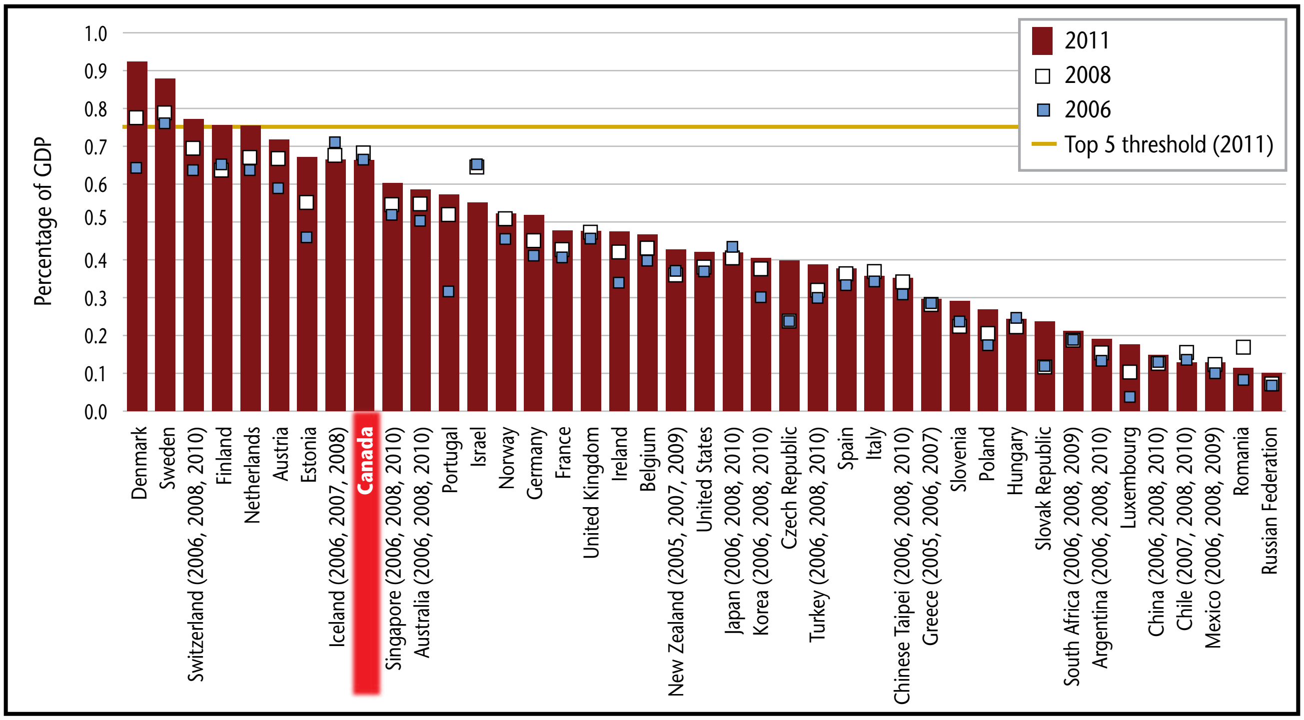
Bibliometric indicators show that Canadian university researchers are prolific publishers, and that their research tends to be of a high quality, particularly in certain fields. The indicators also demonstrate that Canadian researchers are especially well-represented in international co-publications, and they have been very effective at international networking. This is especially important in a global context where the development of knowledge is gradually shifting from individuals to groups and from a national to an international scope.

> *Canada, with a share of only 0.5 percent of global population, accounted for 4.4 percent of the world's natural sciences and engineering publications.*

Bibliometric Quantity Indicators

The distribution of scientific production around the world has changed significantly in the last 25 years, with North American and European countries witnessing a decrease in their relative share of scientific publications and Latin American and Asian countries seeing an increase. International data published by the *Observatoire des sciences et des technologies* in Montréal[124] show that, in 2010, Canada, with a share of only 0.5 percent of global population, accounted for 4.4 percent of the

Figure 5-2: R&D Performed by the Higher Education Sector as a Percentage of GDP, 2006, 2008 and 2011



Source: OECD, *Main Science and Technology Indicators*, January 2013.

124 The bibliometric section of *State of the Nation 2010* drew on international data published by the *Observatoire des sciences et des techniques* in Paris, which differs from the *Observatoire des sciences et des technologies*. These data were not updated on time to be used in this report. Differences in calculation methods account for the differences in the numbers reported in *State of the Nation 2010* and in this 2012 report. In terms of trends over time, however, the results published by the two organizations are strongly correlated, thus making this bibliometric analysis complementary to the one offered in *State of the Nation 2010*.

Optimizing the Value Chain in the Forest Industry

Photo provided by the Natural Sciences and Engineering Research Council of Canada.

Established in 2002 under the leadership of Sophie D'Amours and several of her colleagues at Université Laval, FORAC (De la FORêt Au Client—Forest to Customer) Research Consortium brings together the expertise of researchers from disciplines such as industrial engineering, forestry, computer science and management sciences to optimize the value chain in the forest industry.

Companies and clients use web-based decision-making platforms developed by FORAC to model processes that include forest management, wood supply, mill operations, manufacturing and deliveries to customers. FORAC also develops logistics and manufacturing plans that include measurement of environmental impacts. These tools and methods are instrumental in advancing Canada's leadership in sustainable forest products manufacturing.

FORAC brings under one umbrella eight industrial partners, who contribute roughly one third of the Consortium's annual budget of $1.5 million. The rest of the Consortium's funding comes from the Quebec and federal governments, including the Industrial Research Chairs and Collaborative Research and Development programs of the Natural Sciences and Engineering Research Council of Canada (NSERC).

FORAC's achievements have earned it the 2012 Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering from NSERC.

world's natural sciences and engineering publications—a proportion unchanged from 2008. In absolute terms, this places Canada in eighth position after countries with significantly larger populations: the U.S., China, Germany, the United Kingdom (U.K.), Japan, France, and Italy. With the exception of China, these countries have seen their respective share of world scientific production decrease since 2003. In contrast, Canada's share has actually increased, defying the trend in global distribution of scientific production noted above.[125]

It is useful to not only do a publication count but also look at the number of publications in the most influential 25 percent of the world's scholarly journals in their category (as determined by the *SCImago Journal Rank* indicator on the basis of citation data). According to a count of countries' publications in these top journals, Canada ranks tenth among Organisation for Economic Co-operation and Development (OECD) and Brazil, Russia, India and China (BRIC) countries on a per capita basis, after Switzerland, Sweden, Denmark, Iceland, the Netherlands, Norway, Finland, Australia, and the U.K.[126] This suggests that Canadian researchers, even though prolific publishers, could enhance visibility for their research results by seeking more actively to publish in top quartile journals.[127]

Bibliometric Impact Indicators

Bibliometric impact indicators measure the influence of a country's researchers as reflected by citation counts—the more citations a journal article gets, the more it is assumed to have influenced later scientific research. The *Observatoire des sciences et des technologies* compiles an average relative citations (ARC) index by country, which measures short-term impact for natural sciences and engineering publications.[128] According to this indicator, when a country has an ARC value greater than 1, its

125 Observatoire des sciences et des technologies (Thomson Reuters–Web of Science).

126 OECD, *Science, Technology and Industry Scoreboard 2011*, Paris (2011), p. 94.

127 This conclusion is corroborated by the Shanghai Jiao Tong University Ranking, which measures, for all ranked universities, the number of papers published in the two most prestigious scientific journals, *Nature* and *Science*, between 2006 and 2010, and the number of papers in these two journals per staff. The performance of most of Canada's top-ranked universities on these indicators is generally well below their overall rankings.

128 This indicator is based on the number of citations received by natural sciences and engineering papers from a given country for a three-year period following their publication. These citation counts are then normalized by the average number of citations received by all papers in the same subfield, taking into account that citation practices vary from one subfield to another.

publications get more citations than the world average and therefore have more impact. In 2010, Canada's ARC was 1.32 (up from 1.29 in 2008), which places it well above the world average, but still 24th, behind countries including Switzerland (1.66), Denmark (1.63), the Netherlands (1.59), the U.K. (1.46), and the U.S. (1.38). Canada's ARC has risen continuously since 2001 (when it was at 1.22) but, with the exception of the U.S., Cambodia and Gambia, all the countries that place above Canada in 2010 saw their ARC increase more than Canada's during this period. Canada's relatively lacklustre ARC performance against the top countries is linked to the fact, noted above, that Canadian researchers do not publish as much in top quartile journals, which are, by definition, the journals that receive the most citations.

A breakdown by field of study reveals that Canada's ARC exceeds the international average in all scientific fields. Canada obtains its best ARC scores in physics, with an ARC of 1.47. Other areas of Canadian strength include clinical medicine (1.46) and earth and space (1.42).

For other scientific fields, Canada's scores are as follows: biomedical research (1.31), biology (1.28), chemistry (1.28), mathematics (1.17), and, engineering and technology (1.05).

It is also possible to consider bibliometric impact indicators at the institution level. The OECD undertook work to identify the 50 universities with the highest impact (in terms of citations to publications across all disciplines) in the world. In 2009, 40 of the top 50 universities in this respect were located in the U.S., with the remaining ten located in Europe: five in the U.K., two in France, and one in each of the Netherlands, Switzerland, and Italy.[129] No Canadian university was ranked in the top 50 overall, but Canada fared better on a subject-by-subject basis, with its universities placing among the top 50 in 11 out of 16 areas. There were four universities in earth and planetary sciences, and three in pharmacology, toxicology and pharmaceuticals. There were also two universities in each of computer science, engineering, environmental science, immunology and microbiology, neuroscience and psychology. Finally, there was one university in each of materials science, medicine and social sciences.

Uncovering the True Nature of Fundamental Forces and Particles

Named Scientist of the Year 2012 by Radio-Canada, Canadian physicist Pierre Savard is helping to uncover the true nature of fundamental forces and particles.

Dr. Savard is an Associate Professor of Experimental Particle Physics at the University of Toronto and a scientist at Canada's Vancouver-based TRIUMF, one of the world's leading subatomic physics laboratories. Dr. Savard played a key role in what has been described as one of the most important scientific quests of a generation. As Canadian Physics Coordinator of ATLAS (a particle physics experiment at the Large Hadron Collider in Switzerland, the world's largest and highest energy particle accelerator), Dr. Savard belongs to one of two teams that proved the existence of the Higgs boson—a massive elementary particle that gives all objects mass—in July 2012. Dr. Savard and six other researchers from the University of Toronto (Richard Teuscher, David Bailey, Peter Krieger, Robert Orr, Pekka Sinervo and William Trischuk) built an essential component of the ATLAS detector and sifted through ATLAS data using the SciNet computing resources at the university to identify collisions containing Higgs boson candidates.

Apart from advancing our knowledge on the fundamental laws of physics, this type of research contributes to the training of a highly skilled technology workforce and leads to many technological spinoffs. Dr. Savard's research was funded by the Natural Sciences and Engineering Research Council of Canada, the Canada Foundation for Innovation and the Ontario Research Fund.

129 OECD, *Science, Technology and Industry Scoreboard 2011*, Paris (2011), p. 42.

Structural Indicators

In the global knowledge economy, collaboration among researchers from different countries is an increasingly important feature of scientific research. Evidence suggests that international co-publications receive more citations and have more impact, and that the broader the collaboration, the higher the impact of the research. Data published by the *Observatoire des sciences et des technologies* showed that, in 2010, 48.8 percent of natural sciences and engineering articles published by Canadian researchers were international co-publications. This is a peak reached after a steady upward trend, from 14.3 percent in 1980, 22.7 percent in 1990, 36.3 percent in 2000, and 45.9 percent in 2008. Interestingly, from 1980 to 2007, the difference between Canada's rate of international co-publications and the average rate of G7 countries increased from 8 percent to 16 percent.[130] In 2010, Canadian researchers in natural sciences and engineering collaborated most with researchers in the U.S. (47.6 percent of Canada's co-publications), followed by the U.K. (13.9 percent), Germany (10.8 percent), France (10.6 percent), and China (10.4 percent).

Increasing International Recognition for Canada's Leading Scholars and Scientists

The Governor General of Canada, His Excellency the Right Honourable David Johnston, is leading an initiative to enhance the visibility of Canada's increasing contributions to global research excellence. Recognizing Canadian research achievements serves to promote a culture of excellence and innovation, and to inspire young Canadians to pursue academic studies and careers in research. It also increases Canada's profile internationally as a top location for study, research and citizenship.

Under this initiative, early steps have been taken to support nominations of Canada's leading scholars and scientists for major scientific prizes and awards, including Nobel prizes, which have seldom been won by Canadian researchers. The presidents of Canada's three federal granting councils—NSERC, the Canadian Institutes of Health Research (CIHR), and the Social Sciences and Humanities Research Council of Canada (SSHRC)—have offered their assistance to Canada's research-based stakeholders in supporting the development of compelling dossiers on their top candidates for international awards.

Measuring the Performance of Canada's Universities

Globalization has fuelled competition among universities on a global basis and has increased the attention afforded to world rankings of universities as measures of a country's performance in research. There are currently three major university ranking systems, each of which ranks universities on different criteria: the Graduate School of Education, Shanghai Jiao Tong University (GSE-SJTU) Academic Ranking of World Universities (the "Shanghai ranking"); the Times Higher Education (THE) ranking; and the Quacquarelli Symonds (QS) World University Rankings.

State of the Nation 2008 and *2010* reported Canada's results in all three rankings in detail, while acknowledging the rankings' many limitations and methodological flaws. The latest results from all three ranking systems show that their respective top ten lists continue to be monopolized by institutions from the U.S. and the U.K. Canada is notable insofar as it is one of only three other countries across all three ranking systems that hosts universities ranked between 11th and 20th place. Canada and Switzerland both have two top 20 rankings, while Japan has one.

However, despite Canada's considerable investments in higher education R&D, it has shown no consistent progress in enhancing its standings in the top 100 universities in any of the ranking systems since *State of the Nation 2008*, and it has been unsuccessful in moving any of its leading research universities closer to the top ten. Some evidence even suggests that Canada's performance is falling slightly in the top 100, while some countries' performance is improving. Canada is competing in a global environment where some countries are investing aggressively in higher education and research and are adopting targeted strategies aimed at catapult-

130 Observatoire des sciences et des technologies, "Research in Canada 2007: a Collaborative Affair," *S&T Observation* Note no. 22 (December 2009), p. 4. (http://www.ost.uqam.ca/Portals/0/docs/note/OST_Note22_e.pdf)

Asian Countries' Strategic Investments in Higher Education Research

In recent years, many Asian economies, including China, India, Japan, South Korea, Singapore, Hong Kong, Chinese Taipei, and Malaysia, have developed ambitious plans to strategically build world-class universities in support of their economic and societal development. For example, the Chinese government launched the 985 Project, designed to develop 39 universities to meet world-class standards and establish international reputations. Among these 39 universities, nine were further targeted to be developed into world-class, "Chinese Ivy League" universities. Even among the nine, distinctions were drawn to further concentrate national resources on Peking and Tsinghua Universities, in an effort to propel them into the world's top twenty higher education institutions.[1] Between 1999 and 2007, the central government invested Y32.0 billion (approximately US$4.9 billion) in the 985 Project, with more than half of that going to the top nine universities. Since 1999, these nine universities have significantly increased the number of publications they feature in quality scientific journals, and they have seen their relative positions steadily improve in university ranking tables.[2]

1 Richard Levin, "The Rise of Asia's Universities," *Foreign Affairs* (May/June 2012), p. 4.

2 Qing Hui Wang, Qi Wang, and Nian Cai Liu, "Building World-Class Universities in China: Shanghai Jiao Tong University," in Philip G. Altbach and Jamil Salmi (editors), *The Road to Academic Excellence: The Making of World-Class Research Universities* (Washington: The International Bank for Reconstruction and Development/The World Bank, 2011), pp. 34–36.

ing their universities into the ranks of the world's best. In this environment, the competitive position of Canada's research universities could erode, and it could become increasingly difficult to secure and improve their place in the select group of world-leading institutions. Bold initiatives, including a coherent national strategy, are needed to propel more Canadian universities into the very top ranks of the world's leading institutions.

KNOWLEDGE TRANSFER

Knowledge transfer is the process of transferring scientific knowledge from one organization to another for the purpose of commercialization and/or public benefit. It covers a continuum of activities, involving all sectors and actors of the science, technology and innovation ecosystem, in which knowledge is transferred back and forth between knowledge creators and users who convert knowledge into goods, services or innovation. Knowledge transfer activities are therefore critical to economic and societal well-being.

As industry grows in knowledge intensity, knowledge transfer will play an increasingly important economic role. This is especially true for the transfer of knowledge and intellectual property associated with discoveries made at higher education institutions. More and more countries are currently designing programs to transfer knowledge from higher education institutions in order to enhance economic development. As universities and colleges become important partners in economic development, this will lead to more complex interactions and relationships among actors of the science, technology and innovation ecosystem.

Canada continues to face challenges in transferring knowledge from academic institutions to the private sector.

As the old adage acknowledges, the most important form of knowledge transfer is "on two feet"—in other words, it is through the movement and interplay of people. Knowledge is transferred back and forth between industry and academia when college and university students (at all levels) undertake internships and co-op terms in companies. Internship and co-op programs provide work-integrated learning opportunities for students, by placing them for a particular period of time in firms that foster, and also benefit from, their talents and knowledge. Knowledge is also transferred when graduates find employment that brings their knowledge directly to bear in the job market. Canada's performance related to these forms of knowledge transfer is addressed in Chapter 6: Talent Development and Deployment.

Industry-academia R&D collaboration is another vital form of knowledge transfer "on two feet." Collaboration may take many forms, including: experienced researchers sitting on companies' boards or spending time working in industry; and companies creating university research institutes or funding postgraduate scholarships to better train students to meet industry's needs. The most meaningful industry-academia collaboration occurs on long-term, discovery-oriented research initiatives with the potential to transform industries and on applied research projects closer to the market. Direct and sustained university-industry R&D collaboration can happen through research networks, which can revolve around university-based research centres established in collaboration with industry. Supporting networks in our large but sparsely populated country is a central design feature of programs supporting R&D in Canada.

Although there are many excellent examples of industry-academia collaboration in Canada, the need for increased collaboration among the partners of Canada's science, technology and innovation ecosystem has been a consistent message of *State of the Nation* reports. In the World Economic Forum's *2012–2013 Global Competitiveness Report*, a survey of business leaders ranked Canada 15th out of 144 economies in terms of university-industry R&D collaboration (down from 7th place in 2010–11 and 14th place in 2008–09), behind countries such as Switzerland (first place), the U.K. (second), the U.S. (third), Germany (11th), and Australia (13th).[131] Caution should be exercised when interpreting results because this ranking lacks the methodological rigour of more quantitative data, since it reflects the

Knowledge Transfer at Work in the Oil Sands

Industry and academia are collaborating at the Centre for Oil Sands Innovation (COSI) to find new ways to ensure the environmentally, economically and socially sustainable development of Canada's oil sands resources.

COSI was established at the University of Alberta (U of A) in 2005 through a partnership between Imperial Oil Resources Ltd. and the university's Faculty of Engineering. Since its creation, COSI has developed into a research network that employs more than 100 research personnel through the involvement of provincial government agencies, private companies and four other Canadian universities—the University of Victoria, the University of British Columbia, Queen's University and the University of Ottawa. Research projects carried out at COSI typically engage university and industry researchers in partnership at every stage of the research cycle, from identification of research ideas and assessment of the potential value to the industry, to execution and evaluation of the research results.

Oil sands research at the centre focuses on minimizing water and energy use, lowering greenhouse gas and other emissions, and yielding high quality products at lower cost. For example, a research group led by U of A professor Dr. Natalia Semagina recently developed catalysts for fuel upgrading based on metals that are less expensive than platinum currently used in refineries. The research problem was identified by Imperial Oil, and the U of A research team proposed an efficient methodology to solve it. Frequent meetings between the university research personnel and the industrial scientists allowed efficient knowledge exchange and helped tailor the academic fundamental science to the needs of the company. The newly developed catalysts are intended to improve the quality of fuel, reducing its negligible environmental and health impact, as well as to reduce the energy consumption for fuel upgrading technologies.

Since its inception, COSI has received funding from its industrial partner, Imperial Oil Resources Ltd., as well as from Alberta Innovates and the Natural Sciences and Engineering Research Council of Canada.

131 World Economic Forum, *Global Competitiveness Report 2012–2013*, n.p. (2012), p. 515.

Earlier Detection and Better Treatment of Diseases through Gene Analysis

Sequencing the human genome, along with new ideas about the role of so-called "junk" DNA, are exponential leaps forward in understanding how our bodies truly work—and these advances are setting the stage for one day providing individuals with medical care custom-tailored to fit their unique DNA. The McGill University and Génome Québec Innovation Centre is playing an important part in advancing this work, by decoding the role a person's genetic sequence plays in disorders such as cardiac disease, asthma and Type 2 diabetes. The end goal: earlier detection, more effective treatments and improved quality of life for millions of Canadians.

The Innovation Centre provides complete DNA and RNA analysis services—including novel methodologies for single-molecule sequencing and functional annotation of genomes—to industrial users and academic institutions. The centre has also attracted industrial partners, working with IBM, for example, to identify solutions to deal with the massive amounts of data generated by genomics research.

The work of the Innovation Centre has already proven instrumental in many large-scale genomic investigations. The Finding of Rare Disease Genes in Canada (FORGE) project, for example, uses the Innovation Centre's Next-Generation Sequencing technology to quickly analyse a person's genetic code, allowing researchers to identify genes that cause birth defects, intellectual disability and other problems. Researchers in the Canadian Pediatric Cancer Genome Consortium are using that same technology to learn the hidden weaknesses of six of the most aggressive childhood cancers.

The Innovation Centre is led by Scientific Director Mark Lathrop, who joined McGill in 2011, returning to Canada with a wealth of cutting-edge research experience, including laying the groundwork for the Human Genome Project by co-founding the Centre National de Génotypage in Paris in 1998. Since its inception, the Innovation Centre has received funding from Genome Canada, Génome Québec, the Canadian Institutes of Health Research, the Fonds de la recherche en santé du Québec and the Canada Foundation for Innovation.

perceptions of business leaders *in* Canada *about* Canada relative to the perceptions of business leaders from other countries about their respective countries.

In addressing Canada's performance on knowledge transfer, it is important to consider indicators associated with the "demand-pull" model and the "supply-push" model. The "demand-pull" model is when universities and other research organizations are solicited by industry to find solutions to production and innovation problems (reflected here in contract research data). The "supply-push" model is when institutions transfer academic inventions to existing firms or to new ventures via the licensing or spinoff of intellectual property (IP).

Unfortunately, as in *State of the Nation 2008* and *2010*, the absence of internationally comparable data constrains the ability to compare Canada's "demand-pull" and "supply-push" knowledge transfer performance relative to peer countries. Cumulative evidence, however, suggests that Canada—while showing some positive signs regarding "demand-pull" knowledge transfer—continues to face challenges in transferring knowledge from academic institutions to the private sector. This is disappointing, especially given the Canadian government's explicit focus on commercialization since the mid-2000s. Improved performance in this area will be necessary to ensure that Canada benefits fully from its investments and strengths in knowledge development.

Demand-Pull Knowledge Transfer

Knowledge Transfer through Contract Research

The companies and organizations that contract research to universities and hospitals do so to address a specific problem or need. This makes contract research an especially effective mechanism for transferring knowledge that has practical applications and potential commercial value.

In 2009, Canada's 95 universities and university-affiliated research hospitals undertook research contracts worth $1.65 billion, down from the almost $2 billion in 2008 reported in *State of the Nation 2010*, a decrease that could probably be attributed largely to the economic crisis. Still, the 2009 value represents an increase over 2005, 2006, and 2007, when Canadian universities undertook research contracts worth $1.00 billion, $1.15 billion and $1.27 billion, respectively.[132] This compares very favourably to the U.S. where, in 2009, research contracts accounted for $4 billion of total research expenditures in a sample of roughly 185 U.S. institutions (universities, hospitals and research institutions).[133]

From 2005 to 2008, universities' and research hospitals' contracts with Canadian firms and non-profit organizations accounted for approximately 33 percent of the total value of research contracts, while their contracts with the federal and provincial governments accounted for roughly 20 percent and 25 percent, respectively. Foreign sources (governments, business enterprises or organizations) accounted for the rest (22 percent).

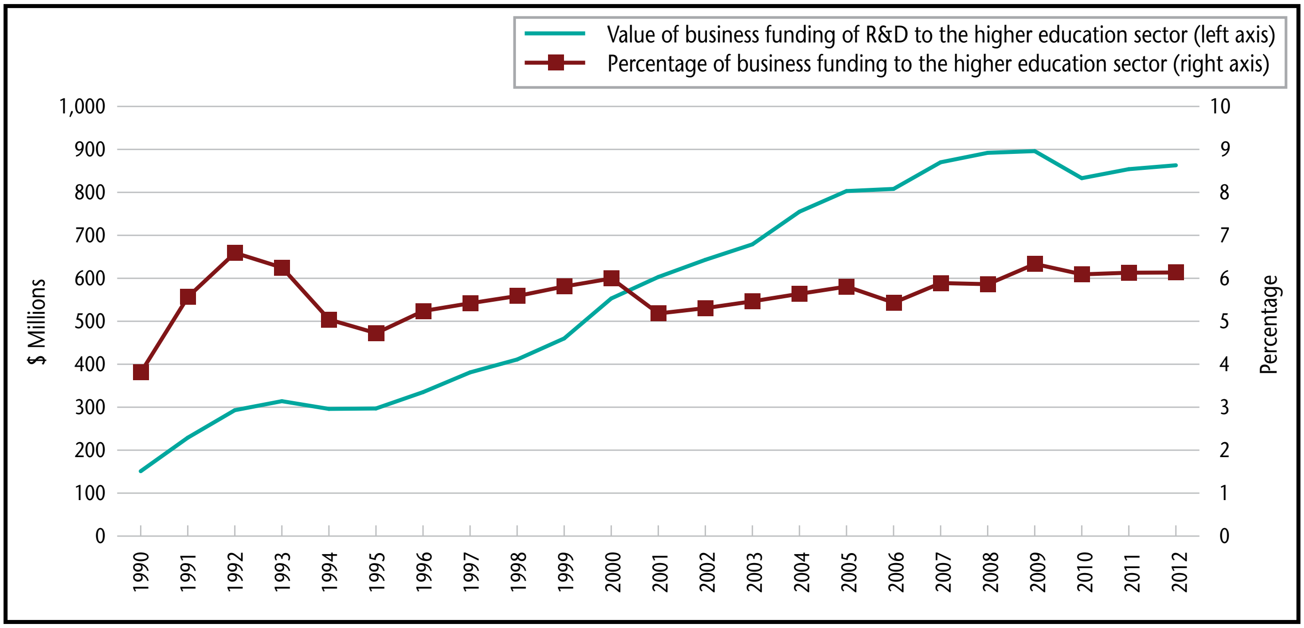
It is interesting to note that the value of Canadian business funding of higher education R&D (much of it through contract research) has increased over time, to reach a high of $896 million in 2009, as reflected in Figure 5-3. After reaching 6.33 percent of total business R&D expenditures in 2009, the higher education sector's share declined to 6.13 percent in 2012, but this remains notably higher than in 2001, when it was 5.18 percent.

Supply-Push Knowledge Transfer

Licensing Technologies

Indicators based on licences measure commercially valuable knowledge transfer to the private sector and indicate leveraging of public investments in the higher education sector. The most recent numbers reported by Statistics Canada show either stagnation or a drop in Canadian licensing activities. According to the *Survey*

Figure 5-3: **Business-Financed R&D Performed by the Higher Education Sector, 1990 to 2012**



Source: Statistics Canada, CANSIM Table 358-0001, January 2013.

132 Statistics Canada, CANSIM Table 358-0025, January 2013. (http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=3580025&paSer=&pattern=&stByVal=1&p1=1&p2=37&tabMode=dataTable&csid=)

133 Association of University Technology Managers, *U.S. Licensing Activity Survey: FY2011*, n.p. (2012), p. 19.

Bridging the Commercialization Gap between Academia and Industry

The Centre for Drug Research and Development (CDRD) (a Centre of Excellence for Commercialization and Research (CECR)) is Canada's fully-integrated national drug development and commercialization centre. Its mandate is to transform discoveries stemming from publicly-funded health research into new medicines to treat human diseases and viable investment opportunities for the private sector.

Based in Vancouver, CDRD combines a not-for-profit drug development platform with a commercialization vehicle, CDRD Ventures Inc. (CVI). Both CDRD and CVI have developed a number of partnerships with leading global pharmaceutical companies, including Pfizer, GlaxoSmithKline, Johnson & Johnson and Roche. Through these partnerships, specific funding has been committed to help advance Canada's most innovative and therapeutically promising health technologies towards commercialization, and to provide valuable commercial expertise into early-stage technology development. Under these partnerships, CDRD and/or CVI drive the development of projects jointly selected in cooperation with each of the industry partners. CDRD/CVI, along with the respective industry partners, collectively determine the most appropriate development paths for the intellectual property associated with the selected projects and assess opportunities for collaboration, funding, management and commercialization of these technologies.

CDRD/CVI has operational facilities located on the campuses of the University of British Columbia, Simon Fraser University and the BC Cancer Agency. In February 2013, it was awarded with $8 million in new funding as a result of the federal government's latest CECR competition.

of Intellectual Property Commercialization in the Higher Education Sector (2009), 76 percent of the 95 responding Canadian universities and university-affiliated research hospitals were engaged in IP management, down from 81 percent in 2008. According to the same survey, those same institutions created 537 *new* licences and options (i.e., the right to negotiate for a licence) in 2009, basically unchanged from 2007 and 2008, and they had a total of 2,662 *active* licences, down from 3,343 in 2008.

The Association of University Technology Managers (AUTM) also publishes data on knowledge transfer activities by Canadian universities. The data in AUTM's 2011 *Canadian Licensing Activity Survey* derive from a considerably smaller sample than that captured by Statistics Canada (covering approximately 40 Canadian universities and affiliated research hospitals). In being less comprehensive, the data should be considered *indicative* of Canadian activity. AUTM data are, however, more recent than Statistics Canada data and allow comparisons with U.S. data, reported in AUTM's 2011 *U.S. Licensing Activity Survey*, which captures about 185 American institutions.

Overall, as reflected in Figure 5-4, the data reported by AUTM show that U.S. institutions are generally more successful than Canadian ones at creating licences, keeping them active, and earning licensing income. The AUTM 2011 Canadian survey confirms the stagnation reported by Statistics Canada in the creation of *new* licences and options between 2007 and 2009[134] and suggests a continuing decline since that time. The AUTM 2011 U.S. survey reveals that the creation of new licences and options also stagnated somewhat in the U.S. between 2007 and 2010, but then increased significantly in 2011. With respect to *active* licences, AUTM reported a marginal improvement for Canadian institutions since 2009, and a more significant improvement

134 Association of University Technology Managers, *Canadian Licensing Activity Survey: FY2011*, n.p. (2012), p. 36.

People-Centred Information Technologies

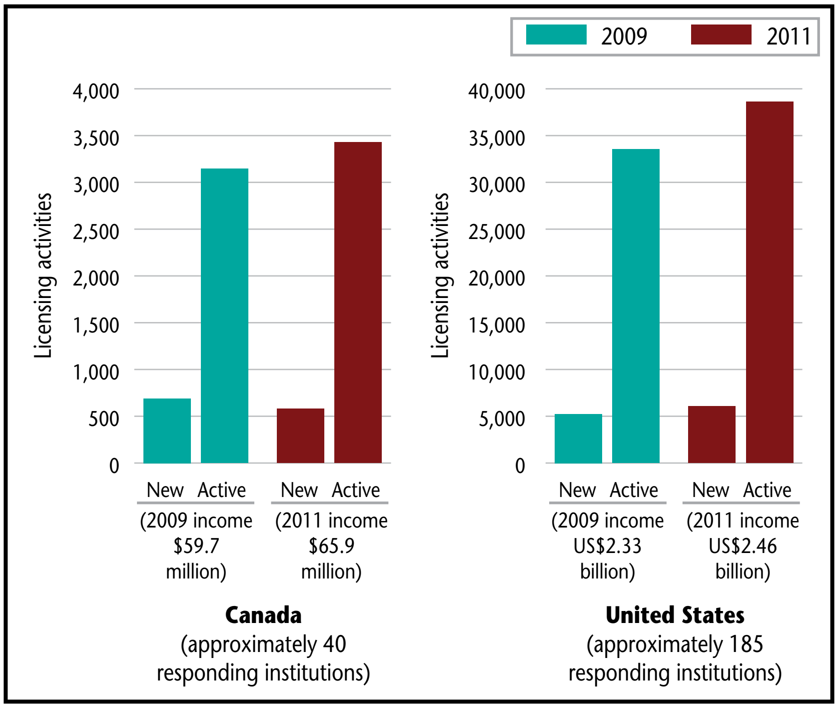
Sheelagh Carpendale is at the forefront of efforts to ensure that information technology devices serve the people who use them in practical, intuitive ways that support the way we live and work. She is the NSERC/AITF/SMART Industrial Research Chair in Interactive Technologies and the Canada Research Chair in Information Visualization at the University of Calgary. There she leads a research team—one of the few in the world—developing interactive tabletop display applications that receive input through natural human actions rather than a mouse, keyboard or special input device.

Dr. Carpendale draws on her broad, interdisciplinary research expertise—including fine arts, psychology, ethnography, information visualization and human computer interaction—to enable the design of innovative, people-centred information technologies. By studying how people interact with information, images, technology and each other, she designs more natural, accessible, interactive and understandable visual representations of data.

Dr. Carpendale's partnership with Calgary-based SMART Technologies has influenced the development of its interactive whiteboards and has prompted the company to include interactive tabletops as part of its multi-touch displays used in classrooms and offices around the world.

Dr. Carpendale's involvement with Canada-wide research collaborations funded by the Natural Sciences and Engineering Research Council of Canada (NSERC)—networks such as NECTAR (human-computer interaction), SurfNet (touch-based interaction) and GRAND (digital media and technology)—has played an important role in the development of her work, which earned her a 2012 E.W.R. Steacie Memorial Fellowship from NSERC.

Figure 5-4: **Canadian and U.S. Licensing Activities, 2009 and 2011**



Source: Association of University Technology Managers, *Canadian Licensing Activity Survey: FY2011* and *U.S. Licensing Activity Survey: FY2011*, 2012.

in the U.S. Finally, according to AUTM numbers, licensing *income* at Canadian institutions increased to $65.9 million in 2011, while remaining somewhat constant in the U.S., at US$2.46 billion. Despite the increase in Canadian licensing income, this nonetheless means that a Canadian institution received, on average, approximately $1.6 million from licensing income, while a U.S. institution received, on average, approximately US$13.3 million.

Making University Intellectual Property More Easily Accessible— The Example of Southern British Columbia Research Universities

The Southern British Columbia Research Universities (The University of British Columbia, The University of Victoria and Simon Fraser University) have recently launched an initiative to reduce the burden associated with negotiating a licence agreement with these institutions and to make their IP more accessible. Through this initiative, they are aiming to harmonize their technology transfer practices and create simple and inexpensive ways for entrepreneurs and industry to access university-generated IP and technology. Funding requested by the three universities from the British Columbia Innovation Council will support the formation of the BC Express Technology Licensing Program, which will provide standardized and simplified licence agreements for commercial partners, and the Open IP Program, which will stream-line industry access to non-patented innovations developed at these universities.

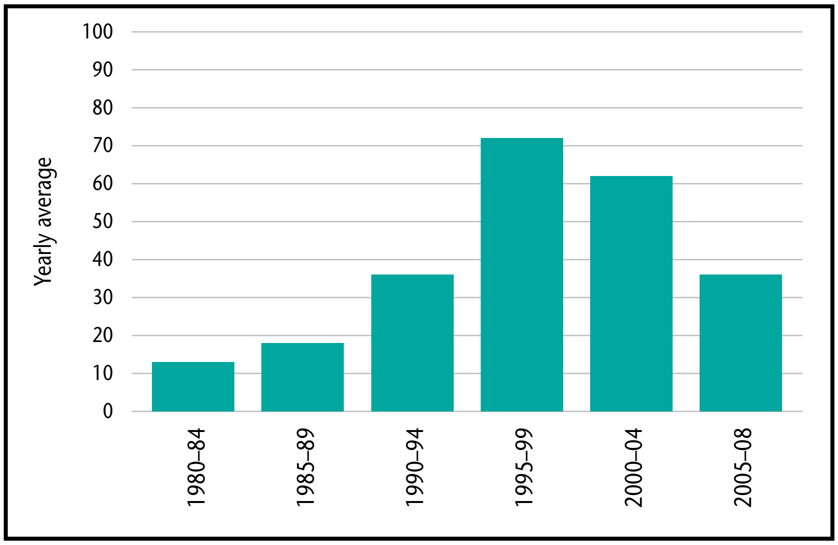
Canada's relatively poor performance in licensing activities could signal that Canadian universities are less focused than American ones on producing the type of knowledge that firms need. Canada's poor performance could also suggest that companies are discouraged by the excessive amount of time and resources typically associated with negotiating a licence agreement in Canada.

Spinoff Companies

The creation of spinoff companies from universities and university-affiliated research hospitals can be viewed as a reflection of these institutions' commitment to commercialization. The number of spinoff companies created on a yearly basis by Canadian institutions is notably lower than that in the U.S.

The most recent edition (2009) of Statistics Canada's *Survey of Intellectual Property Commercialization in the Higher Education Sector* provided no updates on spinoffs, but according to the 2008 edition, Canadian universities and university-affiliated research hospitals incorporated 19 spinoff companies in 2008, down significantly from 50 in 2007. The number of spinoff companies incorporated on a yearly basis since 1980 showed a steady upward trajectory through to 1999, with a strong peak from 1995 to 1999, and a steady decline since then. This downward trend saw Canadian institutions revert back in 2008 to pre-1990 numbers in terms of spinoff creation on a yearly basis, as reflected in Figure 5-5.

Figure 5-5: **Canadian Universities' Yearly Average of New Spinoffs**



Source: Statistics Canada, *Survey of Intellectual Property Commercialization in the Higher Education Sector 2009*, 2012.

Data gathered independently by AUTM in its licensing surveys confirm the general downward trend in spinoff creation in Canada between 2000 and 2010. The surveys also show, however, for a sample of approximately 40 Canadian institutions, an increase from 50 spinoff companies created in 2010 to 68 in 2011, which represents a significant 36 percent increase between the two years.[135] It will be interesting to see if this marks the beginning of a new upward trend in Canada. AUTM's U.S. data—based on a sample of roughly 180 U.S. institutions—show that the number of spinoff companies created annually by universities in the U.S. went up continuously between 2006 and 2011, from 462 to 670. To put this in comparative terms, this translates into about 1.7 spinoff companies per reporting institution in Canada in 2011, in contrast to 3.7 spinoffs per reporting institution in the U.S. These results suggest that U.S institutions are much more active than Canadian ones in generating spinoff companies. Canadian technology, engineering, and natural science students and researchers could benefit from better training—through entrepreneurship courses in developing and commercializing research products with commercial potential.[136]

135 Association of University Technology Managers, *Canadian Licensing Activity Survey: FY2011*, n.p. (2012), p. 43.

136 Association of University Technology Managers, *U.S. Licensing Activity Survey: FY2011*, n.p. (2012), p. 37.

6 Talent Development and Deployment

At their core, science, technology and innovation (STI) are fundamentally human activities. It is people who create knowledge and transform that knowledge into goods and services that Canadians and others in today's world need and want. Talent has become the key competitive differentiator in the global economy, and having the right people in the right place at the right time positions us for success.

Canada's highly-educated population continues to be an asset, as education provides a fundamental foundation for STI, and thus productivity and economic growth. Canada has much to celebrate regarding our education system—a fact acknowledged by the World Economic Forum and the Organisation for Economic Co-operation and Development (OECD), who note that Canada has been successful in nurturing high-quality talent compared with other advanced economies.[137] As reported in *State of the Nation 2008* and *2010*, 15-year-old Canadian students continue to perform well internationally, ranking high in the OECD in terms of reading, math and problem-solving skills, and science. Approximately half of our adult population has attained a university or college education, one of the highest levels worldwide. There is also continuing impressive growth in the number of science and engineering doctoral degrees in Canada (although Canada continues to produce fewer doctoral graduates than many other key countries).

Canada's highly-educated population continues to be an asset.

Even in this area of strength, Canada cannot afford to be complacent. With other economies (especially emerging economies) making significant investments in their education systems, the quantity and quality of talent in other countries is increasing. This improving performance in other jurisdictions is affecting Canada's relative position on a number of talent development indicators, and Canada risks erosion of its competitive advantage in this area. A coordinated strategy to maintain and expand this competitive advantage is vital to Canada's success in the 21st century.

Canada could also do more to ensure that its talent is prepared to contribute fully to an innovative, productive and competitive economy. This means better marrying of STI and business knowledge, as well as developing talent with a wide range of skills and perspectives. Opportunities lie in enhancing work-integrated learning for students, improving the links between business and STI curricula, and encouraging more international learning opportunities that help students expand their experience.

137 World Economic Forum (WEF), *The Global Competitiveness Report 2012–2013* and OECD, *Science, Technology and Industry Outlook 2012*, 2012.

Above all, to be competitive, Canada needs to better deploy its STI talent—to strategically position people to create new knowledge and translate that knowledge into innovative products and processes. On this front, Canada's performance—reflected in the ability to employ human resources in science and technology, particularly researchers, in the labour force—continues to be disappointing.

TALENT DEVELOPMENT

Developing world-class talent is the foundation for Canada's success now and in the future. Nurturing and growing the knowledge and skills of people through all stages of their lives allows them to contribute to society and the economy, and it underpins the country's progress and competitiveness in all areas. Investment in ongoing, high-quality education, training, and mentoring of our talent must be a priority.

Preparing our Young Talent

A secondary education prepares young talent for university or college and is an important step toward success at work.

Secondary Student Enrolment

Canada continues to have relatively high enrolment rates (as a proportion of population) for 15 to 19 year-olds in upper secondary education. Since 1995, the rate has remained constant, hovering around 80 percent. Specifically, in 2009, 81 percent of 15 to 19 year-olds in Canada were enrolled in upper secondary education. At the same time, performance has been improving among other countries. Enrolment rates among 15 to 19 year-olds in OECD countries increased, on average, by 10.4 percentage points between 1995 and 2010, with the average rate reaching 83 percent in 2010.[138]

The percentage of those aged 20 to 24 in Canada who were not attending school and had not graduated from high school (known as persons not in education, employment or training, i.e. "dropouts") has decreased steadily from 1990–91 (when it was 16.6 percent) to 2011–12 (7.8 percent).[139] Furthermore, dropout rates have decreased for both men and women, from 19.2 percent for men and 14.0 percent for women in 1990–91, to 9.7 percent for men and 5.9 percent for women in 2011–12. As in many countries, dropout rates have also been consistently lower for women than for men. Between 1990–91 and 2011–12, the average disparity was 4.2 percentage points.

Secondary Student Performance

As reported in *State of the Nation 2010*, Canadian 15-year-olds continued to perform well according to the OECD's Programme for International Student Assessment (PISA), displaying strong skill sets in reading, mathematics and problem-solving, and science. While Canada's scores remained stable between 2000 and 2009, and the country continued to rank near the top of OECD economies in each of these skill sets,[140] its relative ranking declined in all three areas. In 2009, Canada ranked sixth in reading (down from fourth in 2006), tenth in math (down from seventh in 2006) and eighth in science (down from third in 2006). This decline can likely be attributed to improvements in the performance of other countries as they grow their investments in their educational systems, and to the introduction in PISA ratings of Shanghai (China) and Singapore, both of which demonstrated high performance levels.

In Canada, notable gender differences exist in secondary student performance (as measured by PISA in 2009), with girls outperforming boys in reading and boys outperforming girls in both mathematics and science.[141] In terms of reading, Canadian girls scored an average 34 points higher than boys (or over half a proficiency level and roughly the equivalent of an average school

138 OECD, *Education at a Glance 2012: OECD Indicators* (2012), Chart C1.2, p. 321 and Table C1.2, p. 331. The reference year for data reported by most countries was 2010; however, the reference year for Canadian data was 2009.

139 Data from Statistics Canada, Labour Force Survey 2012 presented on the Indicators of Well-being in Canada website: http://www4.hrsdc.gc.ca/.3ndic.1t.4r@-eng.jsp?iid=32

140 OECD, *PISA 2009 Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science (Volume I)* (2010): Figure I.2.16, Figure I.3.10 and Figure I.3.22.

141 OECD, *PISA 2009 Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science (Volume I)* (2010).

year's progress). As reading proficiency is linked to continuing in education,[142] this could be a factor in explaining why secondary school dropout rates have been consistently lower for girls than for boys. For math, the gender disparity in Canada was the same as the average difference across OECD economies, with boys scoring 12 points higher than girls. This disparity was smaller than that in the United States (U.S.) and the United Kingdom (U.K.), but greater than that in most of the economies where 15-year-old students performed better than Canada in math.[143] For science, the gender disparity is less marked. In most economies, differences in the average score for boys and girls were not statistically significant. For Canada, boys outperformed girls by five points, which again was less than the U.S. and the U.K. but greater than every economy where 15-year-old students performed better than Canada in science.[144] These findings suggest that Canada could improve its overall PISA performance by reducing the educational disparities between boys and girls.

Engaging Secondary Students in Science and Technology

Gender differences also carry over into the career expectations of secondary students. Forty-two percent of 15-year-old students in Canada reported that they expected a science-related career at age 30.[145] This is similar to results for the U.S. (45 percent) and higher than the OECD average of 33 percent. It is interesting to note that, of these 15-year-old students in Canada, only 3.2 percent of girls expected a career in engineering, architecture and computing, compared to 18.8 percent of boys. This is fairly consistent with the OECD results, where 4.6 percent of girls expected a career in engineering, architecture and computing, compared to 18.2 percent of boys. This picture changes, however, when it comes to pursuing a career in health services. In every OECD economy, including Canada, more girls than boys reported that they wanted to pursue a career in health services, a pattern that holds even after nurses and midwives are excluded from the list of health-related careers. In Canada, 30.1 percent of the 15-year-old girls who reported that they expected a science-related career at age 30 identified health services as their expected career (compared to 11.8 percent of boys).

We are living in a digital world, where information technology is an integral part of our daily lives and embedded in many of the products we develop and use at leisure and at work. Access, skills and use are three common indicators used to measure and compare information and communications technologies (ICT) across countries. As access and skills are preconditions to ICT use, it is helpful to consider the use of ICT in education. According to the 2009 index of computer use by students,[146] constructed to summarize the frequency with which students perform different types of ICT activities at school,[147] Canadian students use computers at school at a frequency above the OECD average, but below leading countries such as Denmark, Norway, Australia and Sweden. In terms of teaching digital

142 The relationship between PISA reading literacy scores and subsequent life outcomes in Canada is documented in the OECD report *Pathways to Success: How Knowledge and Skills at Age 15 Shape Future Lives in Canada*. Tracking Canadian students who had taken part in the PISA 2000 reading assessment, the study found that, after adjusting for background variables such as parental, school, demographic and geographic factors, proficiency on the PISA reading literacy scale was associated with a significantly higher likelihood of continuing in education.

143 For Canada, the point difference is 12 points in mathematics (the average for the OECD) compared to 20 points in the United States and the United Kingdom. There were 35 economies, including Canada, with an advantage for boys and 5 with an advantage for girls in math. Of the top 12 performing economies on the average math scale, only 3 had greater score point differences for boys (Liechtenstein, Switzerland and Hong Kong-China).

144 For Canada, the point difference is 5 points in science compared to 14 points in the United States and 9 points in the United Kingdom. There were 22 economies, including Canada, with an advantage for boys and 43 with an advantage for girls in science. In fact, Canada and Hong Kong-China were the only two economies amongst the top 8 performing economies where there was any advantage for boys on the average science scale. The other 6 all had advantages for girls on the average science scale.

145 OECD, *Education at a Glance 2012: OECD Indicators* (2012), Tables A4.2 and A4.3.

146 Canadian Education Statistics Council, *Education Indicators in Canada: Report of the Pan-Canadian Education Indicators Program* (Statistics Canada, May 2012): Table C.5.7.; Sources used were: Statistics Canada, Programme for International Student Assessment (PISA), 2009 database; Organisation for Economic Co-operation and Development (OECD), 2009 PISA database.

147 This PISA 2009 index reflects a composite score based on 15-year-old students' responses when asked how frequently they perform the following nine activities: chat online; use email; browse the Internet for school work; download, upload or browse material from the school website; post work on the school's website; play simulations; practice and do drills (e.g., for mathematics or learning a foreign language); do individual homework; and do group work and communicate with other students.

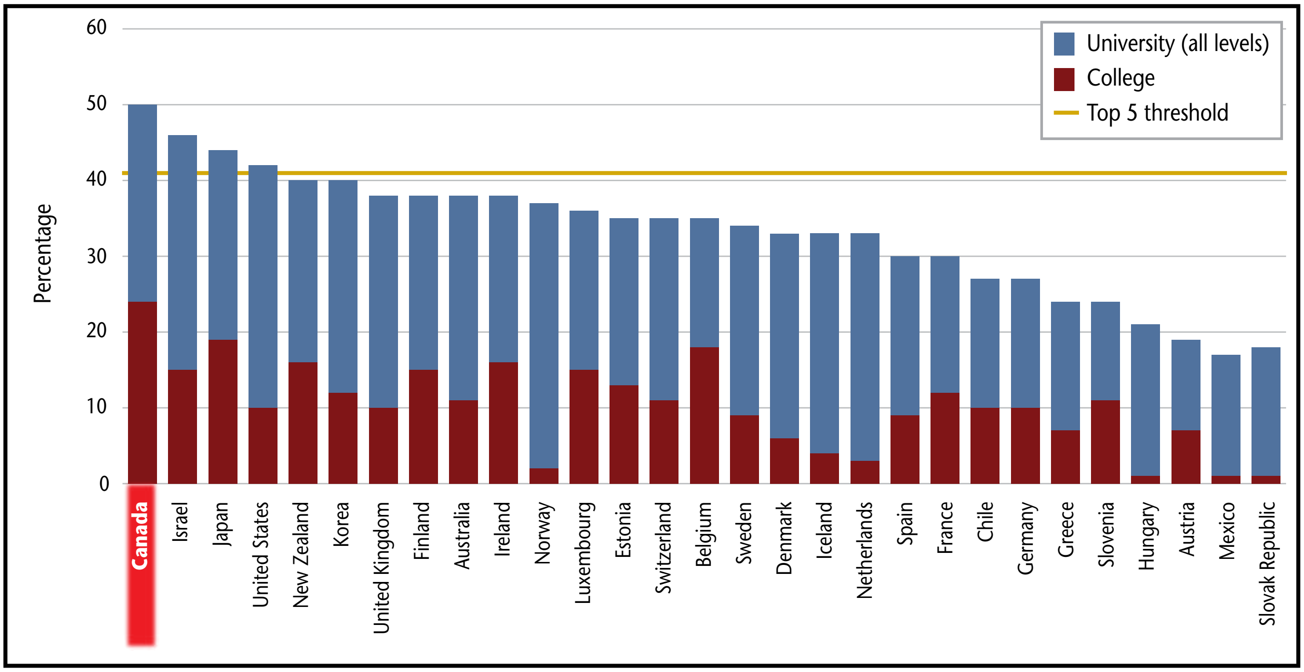
literacy, Canada could learn from other countries, such as Uruguay and South Korea, which are paving the way for the widespread use of digital technologies by systematically introducing them into their education systems.[148] In terms of the broader population, according to the International Telecommunications Union,[149] in 2011 Canada ranked 23rd in ICT access among 155 economies (a drop from 22nd position in 2010), 20th in ICT skills, and 19th in ICT use (both unchanged from 2010). These rankings stand in contrast to the quickly rising rankings of emerging economies such as Brazil, Estonia and Vietnam.

Canada's proportion of the population with a college or university education continues to be the highest in the OECD.

Supply of Advanced Skills: College and University Education

College and/or university educational attainment is an important indicator of a country's supply of advanced skills that contribute to science, technology and innovation. According to 2010 data, Canada's proportion of the population (25 to 64 years old) with a college or university education, at 51 percent, continued to be the highest among available OECD countries, as demonstrated in Figure 6-1. Israel held the second position,

Figure 6-1: **Percentage of 25–64 Year-Old Population with a College or University Education, 2010**



Source: OECD, *Education at a Glance 2012*, Table A1.3a.

148 Uruguay's Plan Ceibal was launched in 2008 with the goal of providing every grade school student and teacher in Uruguay with a laptop connected to the Internet. In 2011, the program was expanded to introduce laptops into nursery schools. This program has been very successful and widely recognized as a world-leading best practice, in part because it is complemented by an educational plan for teachers, students and their families. South Korea will digitize its entire elementary-level educational textbooks and materials by 2014. By 2015, the entire school-age curriculum will be available on computers, smartphones, and tablets. In a 2009 PISA test, Korean students ranked first out of 19 countries on digital literacy (Canada was not among the countries evaluated in this test). A Strategy for American Innovation outlined the Obama Administration's Educate to Innovate campaign that seeks to harness public-private partnerships to improve K-12 education in part through digital technology.

149 International Telecommunications Union, *Measuring the Information Society 2011*, Geneva (2011) Tables 2.7, 2.9 and 2.11.

Paving the Way for a New Generation of Batteries

Linda Nazar's research on lithium batteries has been described as "groundbreaking and transformational" by her peers. Her work, exploring the potential of nanotechnology in lithium-sulfur and lithium-oxygen batteries, is paving the way for a new generation of cost-effective, environmentally friendly batteries.

Dr. Lazar is a faculty member in the University of Waterloo's Department of Chemistry, and is cross appointed to the Department of Electrical Engineering. She is also a member of the Waterloo Institute of Nanotechnology and a Canada Research Chair in Solid State Materials. Looking for safe, low cost, long lasting, and rechargeable means of storing energy is one of the greatest challenges in filling the gap between the growing demand for readily available energy and the development and growth of sustainable and clean energy supplies. The prospect of "better" batteries has, for decades, preoccupied scientists, engineers and the manufacturers of modern day battery-operated products. For instance, electrified vehicles are seen as an excellent way of shifting our economy's reliance on fossil fuels to less costly and more environmentally sustainable energy sources. The challenge is that the batteries on which these vehicles operate do not have the capacity that drivers want and demand. Many of the electrified vehicles currently on the market can only travel very limited ranges on a single charge. Dr. Nazar's work is paving the way for a new generation of batteries that can power a car for several hundred kilometres on a single charge and cost far less than today's lithium batteries.

followed by Japan, the U.S. and New Zealand. This proportion was even higher (56 percent) for the cohort of 25 to 34 year-olds, a performance exceeded only by Japan and Korea. Of the 25 to 64 year-old Canadian population that had attained a college or university education, women had a higher attainment rate at approximately 55 percent compared to an attainment rate for men of 45 percent.

College Education

To a significant degree, Canada's leadership position in educational attainment is attributable to the role of colleges in Canada's education system.[150] In Canada, colleges of applied arts and technology and private career colleges have full-time and part-time diploma (two or three year) and certificate (one year or less) programs, as well as pre-trades and apprenticeship training, language training and skills upgrading. A number of colleges—for example the polytechnics—also offer undergraduate-level degrees in applied areas of study. Colleges tend to focus on applied and/or career-oriented programs.

At 24.2 percent, the proportion of the 25 to 64 year-old population in Canada with a college education is considerably higher than that of any other OECD member country (Figure 6-1).[151] Canada's first-place rank on this measure has not changed in 12 years. Figure 6-2 shows that the field of business, management and public administration witnessed the largest number of graduates from Canadian colleges from 2000–01 through to 2010–11.[152]

University Education (All Levels)

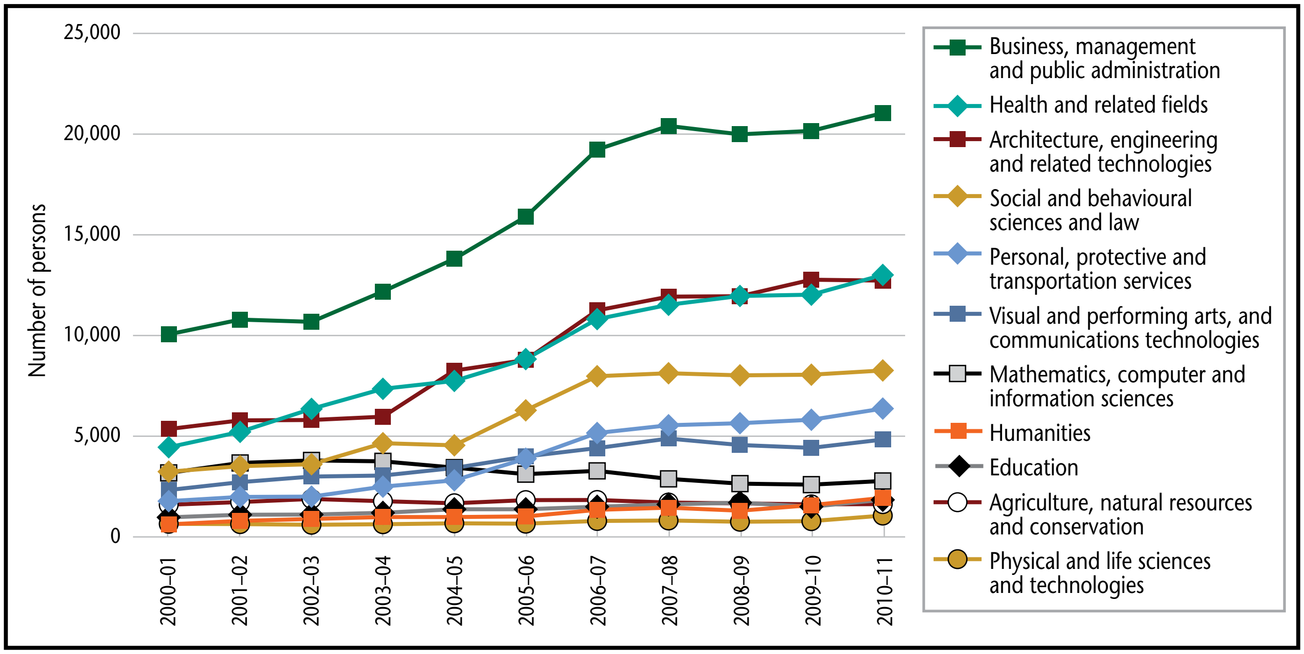
With respect to university education, the proportion of Canada's 25 to 64 year-old population with a university degree (in undergraduate, master's and doctoral programs combined) is 26.4 percent (Figure 6-1). While this represents a notable increase over the last dozen years (from 19.0 percent in 1998), Canada's relative rank on this measure has nonetheless deteriorated, from fourth among available OECD countries in 1998 to tenth in 2010. Clearly other countries are making significant strides in improving their performance in this area.

150 Calista Cheung, et al., "Tertiary Education: Developing Skills for Innovation and Long-Term Growth in Canada," *OECD Economics Department Working Papers, No. 991* (2012), p.7.

151 OECD, *Education at a Glance 2012* (2012): Table A1.3a.

152 It should be noted that there is significant variability year-to-year in the Post-Secondary Student Information System (PSIS) data reported in CANSIM, due to methodological changes. For example, PSIS changed its counts of enrolments and graduations in 2009–10, particularly at the college level. Thus these data should be interpreted with some caution. This applies to all PSIS data used in this report.

Figure 6-2: Annual Number of Persons Graduated from Canadian Colleges, by Field of Study, 2000 to 2011



Source: Statistics Canada, CANSIM Table 477-0020 (Post-Secondary Student Information System), February 2013.

Over the four-year period from 2006 to 2010, there was a 5.4 percent increase in the number of degrees (all levels) granted by universities in Canada, with an impressive 31.8 percent increase in science degrees granted and a 7.3 percent increase in engineering degrees granted.[153] The growth in the number of science degrees granted was driven largely by women, with growth twice that for men (45.8 percent compared to 20.7 percent). For engineering, the opposite was true, with 8.8 percent growth in the number of engineering degrees granted to men from 2006 to 2010, compared to 2.8 percent growth in the number granted to women.

In 2010, the largest shares of graduates (all levels) from Canadian universities were in the fields of business and administration (18 percent), social and behavioural sciences (14.9 percent), humanities and arts (12.4 percent), and education (11 percent) (Figure 6-3). Looking at the international context, relative to the average of comparator countries, Canada produced larger numbers of university graduates (as a proportion of all university graduates that year) in social and behavioural sciences as well as the science, technology, engineering and math disciplines known as the "STEM" disciplines, including life sciences,[154] physical sciences, mathematics and statistics. Conversely, Canada produced fewer graduates in 2010 than the average of comparator countries in health, engineering and engineering trades, computing, and architecture and building.

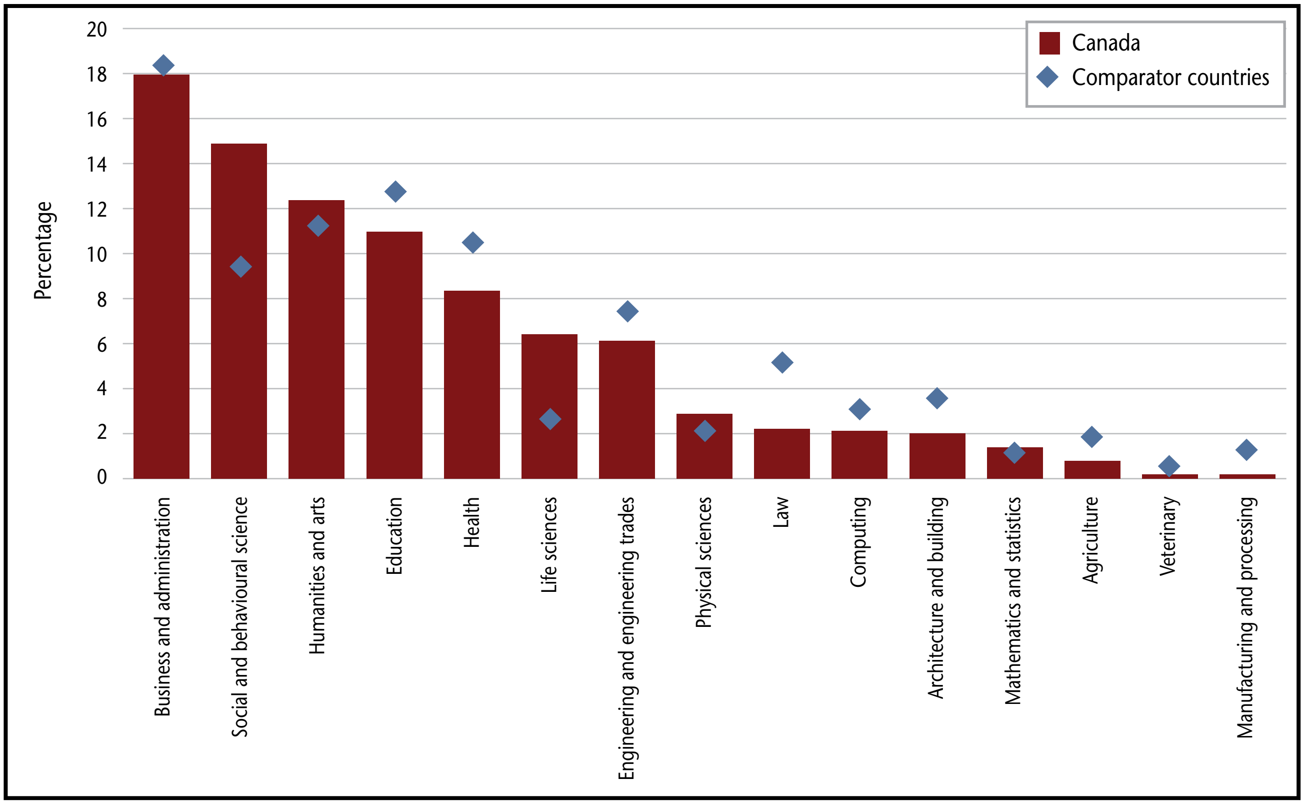
Undergraduate and Master's Level Education

Looking at the undergraduate and master's levels specifically, Figure 6-4 demonstrates that, among the STEM disciplines, the most significant growth in the annual number of graduates from Canadian universities over the last decade has been in the health field. In 2010–11, there were almost one-third more graduates in health than the 2nd-place architecture and engineering, which was followed by physical and life sciences, then math, computer and information sciences, and finally agriculture, natural resources and conservation.

153 STIC tabulation using data extracted from OECD.stat (http://stats.oecd.org) on August 2012; Dataset: Graduates by field of study.

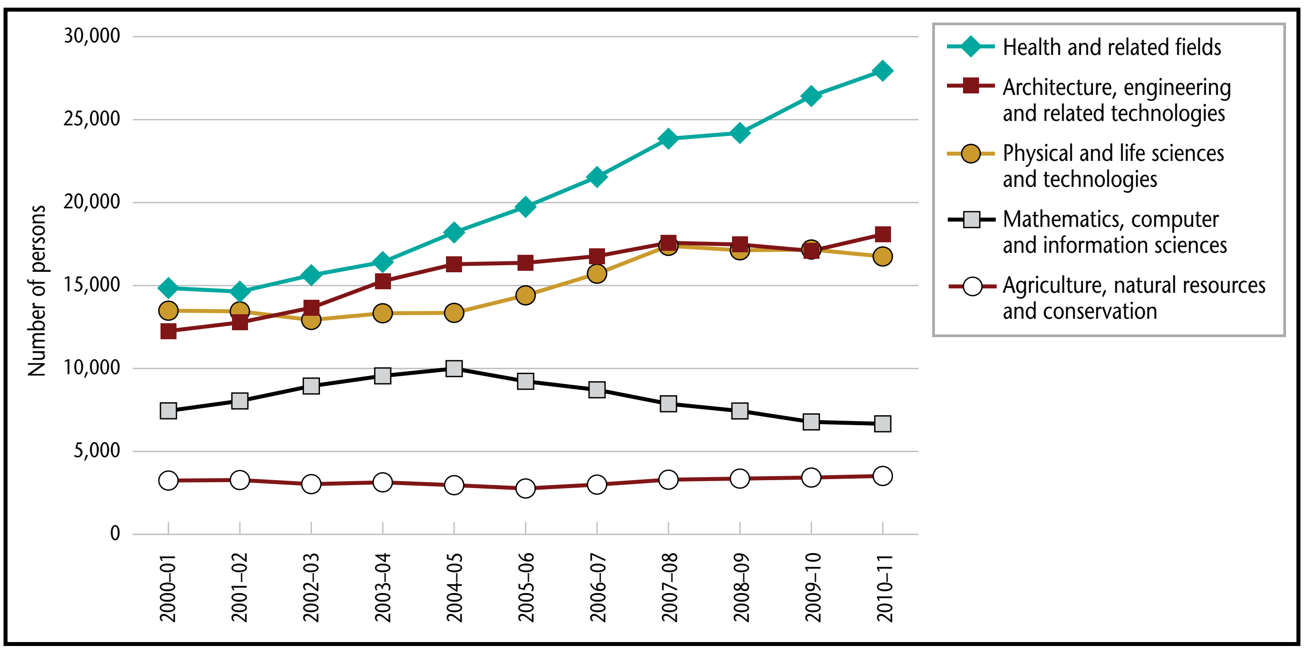
154 Life sciences are largely biological and biomedical sciences, as defined in the Classification of Instructional Programs—Primary Groupings. In contrast, health fields are largely health professions (dentistry, medicine, veterinary medicine) and related clinical sciences.

Figure 6-3: **Percentage of University Graduates (All Levels), by Field of Study, Against Comparator Countries, 2010**



Source: OECD, *Graduates by Field of Study*, December 2012.

Figure 6-4: **Annual Number of Persons Graduated from Canadian University Undergraduate and Master's Science, Engineering, Math, Computer, Information Sciences and Related Programs, 2000–11**



Source: Statistics Canada, CANSIM Table 477-0020 (Post-Secondary Student Information System), February 2013.

Understanding Human Nature

Kiley Hamlin is leading research that is expanding our understanding of human nature. Having obtained her PhD from Yale University in 2010, Dr. Hamlin is now Canada Research Chair in Developmental Psychology and Director of the University of British Columbia's Centre for Infant Cognition. Her research examines whether very young infants make social and moral judgments, and how this ability develops over the first few years of life. Her research is changing the way we think about the origins and development of morality and social behaviour.

There is no doubt that experience plays a large role in moral and social development. However, the work of Dr. Hamlin and her Canadian and American colleagues is showing that some aspects of socially important moral behaviour—such as the judgment of individuals' actions as good or bad, as deserving of reward or punishment, and as morally praiseworthy or blameworthy—may be innate. Observing very young infants who have not fully developed complex cognitive abilities (such as language and inhibitory control), and have little experience with cultural norms and values, Dr. Hamlin says she is "trying to answer questions that have puzzled evolutionary psychologists for decades. Namely, how have we survived as intensely social creatures if our sociability makes us vulnerable to being cheated and exploited? These findings suggest that, from as early as eight months, we are watching for people who might put us in danger and prefer to see anti-social behaviour regulated."

In addition to degrees granted, it is interesting to look at trends in university undergraduate and master's-level enrolments (although it must be understood that these statistics reflect *intentions* to attain a designated education level and not attainment of the level itself). There are many factors that people consider when choosing to enroll in a particular field of study; however, it is known that prospective students choose fields of study, in part, on the basis of earnings they can expect in those fields. The demand for educational programming in particular fields of study therefore, in part, reflects demand for particular talent in the labour market. Mirroring graduation statistics, in 2010–11, the highest enrolments in STEM-based university programs in Canada were in health, followed by architecture and engineering, and physical and life sciences.[155] In addition, given the importance of ICT to innovation, it is particularly encouraging to note that, in 2009–10 and 2010–11, enrolments in math, computer and information sciences have increased in Canada, following years of declining enrolments from 2002–03 through 2008–09. This could signal the gradual recovery of the information technology industry in Canada following the sharp decline ten years earlier.

Canada's Top Talent Supply: Doctoral Education

Doctoral graduates represent top talent in a world where the creation and application of new knowledge is driving much of today's global economic growth. A country's ability to produce doctoral graduates is therefore an indicator of its potential to engage in cutting-edge research and commercialization and to train the next generation of talent.

Relative to other countries, Canada continues to produce fewer doctoral (advanced research[156]) graduates. In 2010, 15.9 persons per 100,000 population graduated

155 Statistics Canada: *Post-Secondary Student Information System*, CANSIM Table 477-0019, www5.statcan.gc.ca/cansim, accessed February 2013.

156 Advanced research refers to Level 6 of the International Standard Classification of Education (ISCED 1997). This level is reserved for tertiary programs, which lead to the award of an advanced research qualification. The programs are therefore devoted to advanced study and original research and are not based on coursework only. Programs at this level typically require the submission of a thesis or dissertation of publishable quality, which is the product of original research and represents a significant contribution to knowledge. They also prepare graduates for faculty posts in institutions offering ISCED 5A programs (undergraduate), as well as research posts in government, industry, etc.

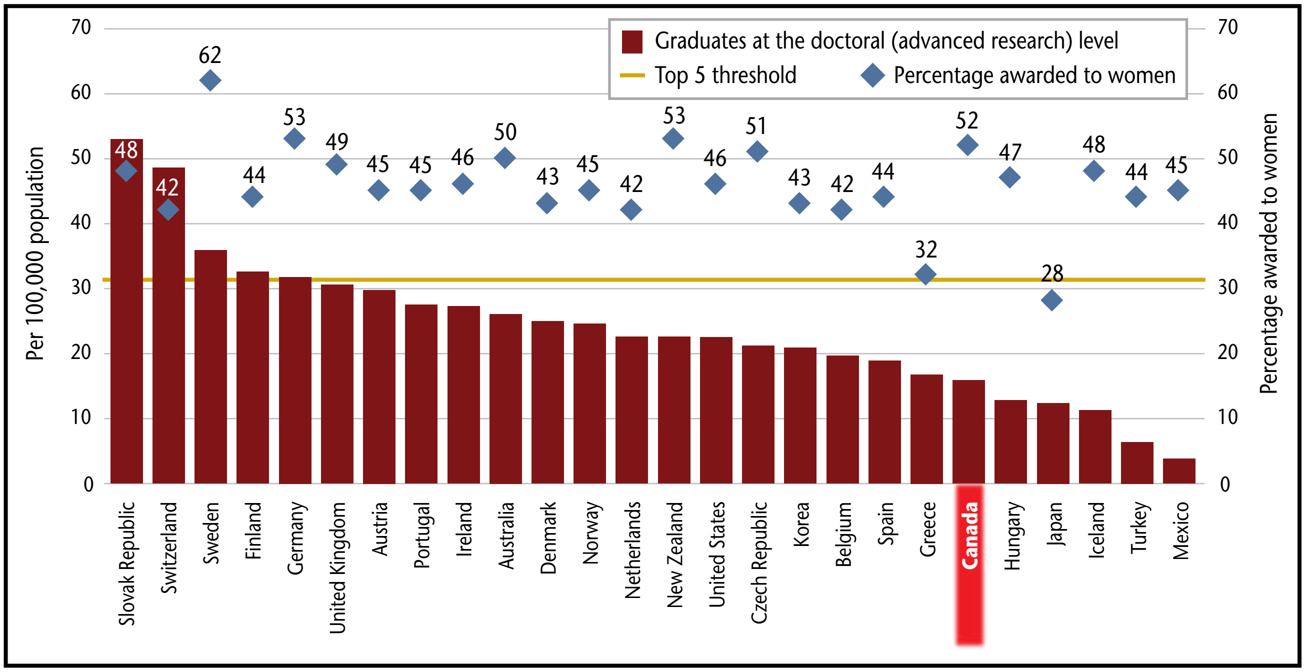
Relative to other countries, Canada continues to produce fewer doctoral graduates.

at the doctoral level from Canadian universities, positioning Canada 21st among available OECD countries on this indicator (Figure 6-5). In interpreting these data, it is important to acknowledge that doctoral education varies quite substantially across countries in terms of its intensity (e.g., duration). Nonetheless, Canada would have to double the number of graduates per 100,000 population to break into the ranks of the top five performing countries (Slovak Republic, Switzerland, Sweden, Finland and Germany) in this area.

Although Canada continues to produce fewer doctoral graduates than many other key countries, its performance improves with respect to STEM disciplines. Relative to other available OECD countries, in 2010 Canada placed 15th in the number of science and engineering doctoral graduates per 100,000 population, performing at approximately 64 percent of the threshold of the top five performers (Slovak Republic, Switzerland, Sweden, Ireland and the U.K.) (Figure 6-6). Given the importance of doctoral talent to the creation and application of new knowledge, this is another indicator where Canada should focus concerted attention on enhancing its performance.

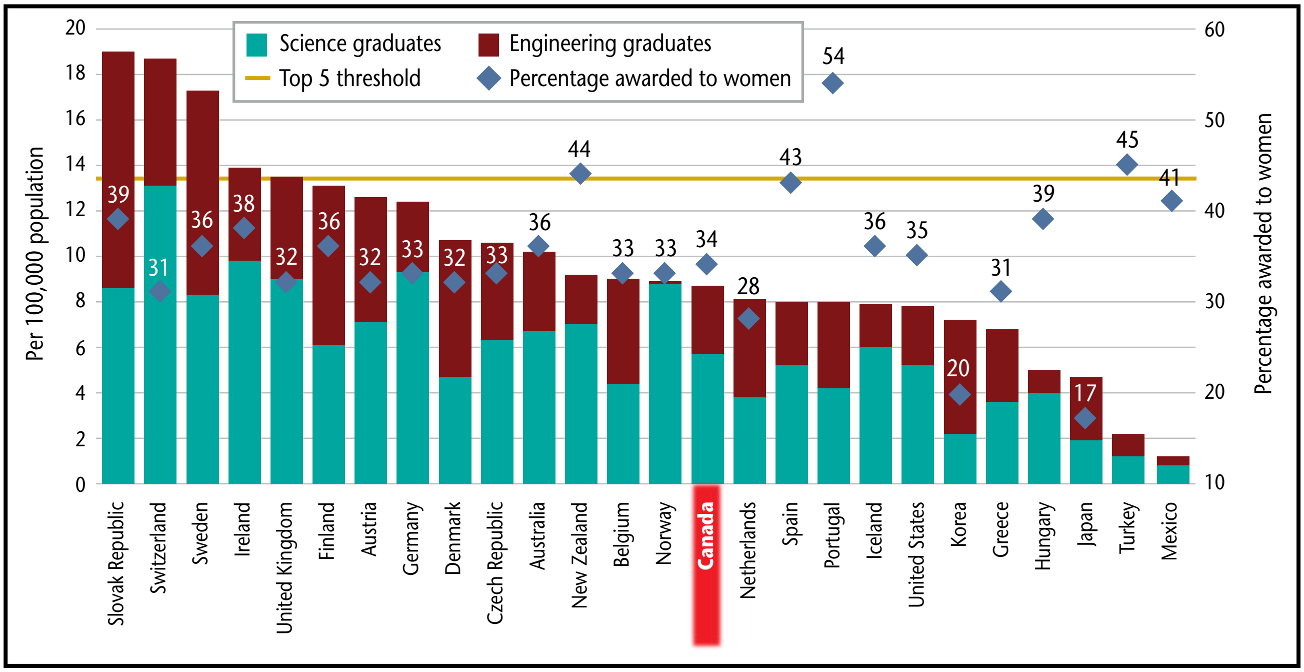
Figure 6-7 shows that Canada experienced 48.7 percent growth in the number of science doctoral graduates and 38.6 percent growth in the number of engineering doctoral graduates over the four-year period from 2006 to 2010, a growth rate notably surpassing many comparator countries. Globally and in Canada, while absolute numbers of science and engineering doctoral graduates have increased significantly since 2000, their relative share of total doctoral graduates (all fields) has been declining in a majority of available OECD countries, suggesting that Canada has been able to sustain its science and engineering research potential.

Figure 6-5: Graduates at the Doctoral (Advanced Research) Level in 2010 (per 100,000 Population)



Source: OECD: *Graduates by Field of Study* and *Population*, December 2012.

Figure 6-6: Science and Engineering Graduates at the Doctoral Level, per 100,000 Population, 2010



Source: OECD: *Graduates by Field of Study* and *Population*, December 2012.

In terms of gender breakdown, in 2010, 52 percent of those graduating from doctoral programs in Canada were women. Among doctoral graduates, 34 percent of science and engineering graduates were women, on par with the U.S. and the U.K. (also at 34 percent). Although this figure reflects an under-representation of women in these fields, it is interesting to note the significant growth from 2006 to 2010 in the number of women graduating from science and engineering doctoral programs—57.4 percent and 54.6 percent, respectively, well ahead of the growth in the number of men graduating from these programs during this period.[157]

The largest proportion of doctoral graduates in STEM-based programs in 2010–11 was, by far, in physical and life sciences and architecture and engineering (Figure 6-8). However, by field of study, the highest growth rate from 2000 to 2011 in STEM-based PhD graduates in Canada was in math and computer and information sciences.

On a final note, turning to enrolments (again, these statistics reflect *intentions* to attain a designated education level and not attainment of the level itself), it is interesting to see positive growth in enrolments in all STEM-based doctoral programs since 2000–01. Enrolments in architecture and engineering doctoral programs saw the highest growth from 2000–01 to 2010–11 of all Canadian STEM-based PhD programs.[158]

Education of Canada's Entrepreneurs and Business Leaders

Canadian firms may lack an appreciation of the role that STI can play in improving their competitive position, and/or they may have weak receptor capacity to take advantage of and exploit science, technology and innovation opportunities. While there are many factors that influence STI investment decisions, focusing on the education of future corporate leaders is critical to enhancing Canada's competitive advantage.

157 STIC tabulations based on data from OECD, *Graduates by field of study* (December 2012).

158 Statistics Canada: *Post-Secondary Student Information System*, CANSIM Table 477-0019, www5.statcan.gc.ca/cansim accessed February 2013.

Figure 6-7: Graduates in Doctoral (Advanced Research) Science, Engineering and All Fields of Study for 2010 (for OECD Countries, by Gender and per 100,000 Population); and Percentage Change from 2006 to 2010

	Science				Engineering				All Fields of Study		
	Science PhD Graduates 2010	Growth from 2006 to 2010	Science PhD Graduates, Number per 100,000 Population 2010	Science PhD Graduates as a Percentage of all PhD Graduates 2010	Engineering PhD Graduates 2010	Growth from 2006 to 2010	Engineering PhD Graduates, Number per 100,000 Population 2010	Engineering PhD Graduates as a Percentage of all PhD Graduates 2010	Total Number of PhD Graduates 2010	Growth from 2006 to 2010	PhD Graduates, Number per 100,000 Population 2010
United States	15,920	18.5	5.2	22.9	7,981	3.9	2.6	11.5	69,570	19.4	22.5
Germany	7,654	17.0	9.3	29.4	2,514	13.0	3.1	9.7	26,039	4.2	31.8
United Kingdom	5,539	7.3	9.0	29.5	2,770	13.5	4.5	14.8	18,756	12.2	30.6
Japan	2,458	-6.4	1.9	15.5	3,569	-3.1	2.8	22.5	15,867	-0.7	12.4
Korea	1,095	9.6	2.2	10.4	2,506	9.5	5.0	23.8	10,542	17.9	20.9
Spain	2,405	8.4	5.2	27.7	1,296	59.0	2.8	14.9	8,696	17.7	18.9
Australia	1,498	13.8	6.7	25.7	779	6.7	3.5	13.4	5,825	9.4	26.1
Canada	1,928	48.7	5.7	35.6	1,036	38.6	3.0	19.1	5,416	22.5	15.9
Turkey	852	53.4	1.2	18.2	693	46.6	1.0	14.8	4,684	44.6	6.4
Mexico	916	42.6	0.8	22.0	407	38.6	0.4	9.8	4,167	32.8	3.8
Switzerland	1,025	-5.7	13.1	27.0	438	14.2	5.6	11.5	3,800	11.0	48.6
Netherlands	626	23.5	3.8	16.8	709	24.5	4.3	19.0	3,736	19.9	22.6
Sweden	779	-9.8	8.3	23.1	843	-35.1	9.0	25.0	3,371	-12.2	35.9
Portugal	449	-219.6	4.2	15.3	399	-80.7	3.8	13.6	2,927	-82.5	27.5
Slovak Republic	469	54.8	8.6	16.3	564	61.0	10.4	19.6	2,878	57.7	53.0
Austria	592	19.6	7.1	23.7	461	6.1	5.5	18.4	2,500	13.7	29.8
Czech Republic	661	26.9	6.3	29.7	449	-15.4	4.3	20.2	2,228	9.2	21.2
Belgium	476	-17.4	4.4	22.4	501	42.9	4.6	23.6	2,126	19.2	19.7
Greece	411	30.2	3.6	21.7	361	35.7	3.2	19.1	1,892	-28.8	16.8
Finland	328	-26.8	6.1	18.7	374	-11.5	7.0	21.4	1,750	-8.5	32.6
Denmark	261	36.4	4.7	18.8	333	30.6	6.0	24.0	1,388	34.4	25.0
Hungary	396	54.3	4.0	31.1	100	48.0	1.0	7.8	1,275	20.6	12.8
Ireland	436	6.0	9.8	35.7	182	14.8	4.1	14.9	1,222	19.9	27.3
Norway	432	44.0	8.8	35.9	6	-1,516.7	0.1	0.5	1,202	26.6	24.6
New Zealand	307	31.9	7.0	31.1	94	45.7	2.2	9.5	987	35.4	22.6
Iceland	19	73.7	6.0	52.8	6	66.7	1.9	16.7	36	58.3	11.3

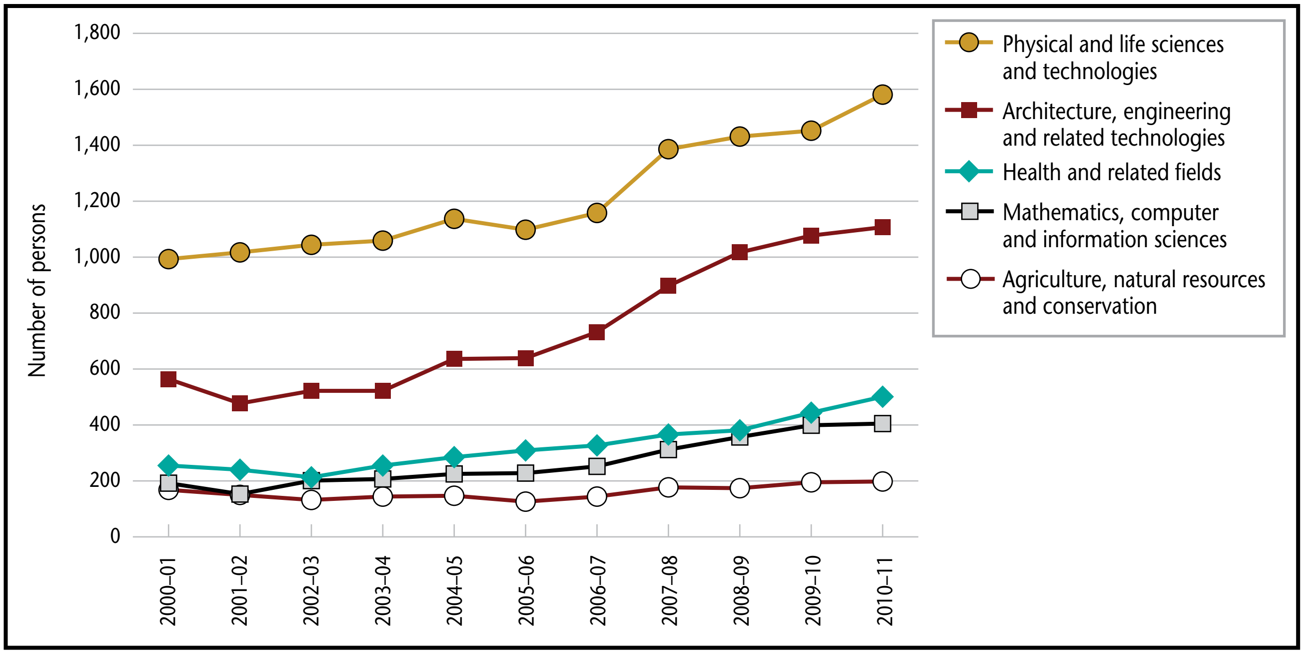
Source: OECD, *Graduates by Field of Study*, December 2012.

Competitive businesses need educated leaders with the management, entrepreneurial and innovation 'savvy' to respond to the increasingly sophisticated marketplace. Figure 6-9 shows that 76.7 percent of Canadian managers[159] have at least some post-secondary education, compared to 79.7 percent of American managers. However, only 12 percent of Canadian managers have graduate and/or doctoral degrees, compared to 19 percent of American managers.

Furthermore, Canada's business schools have shown little progress in improving their rankings in the top 100 of any of the global rankings of business schools since *State of the Nation 2008*. The evidence, in fact, suggests that Canada is falling slightly in the top 100, while the business schools of other countries are improving their respective rankings.

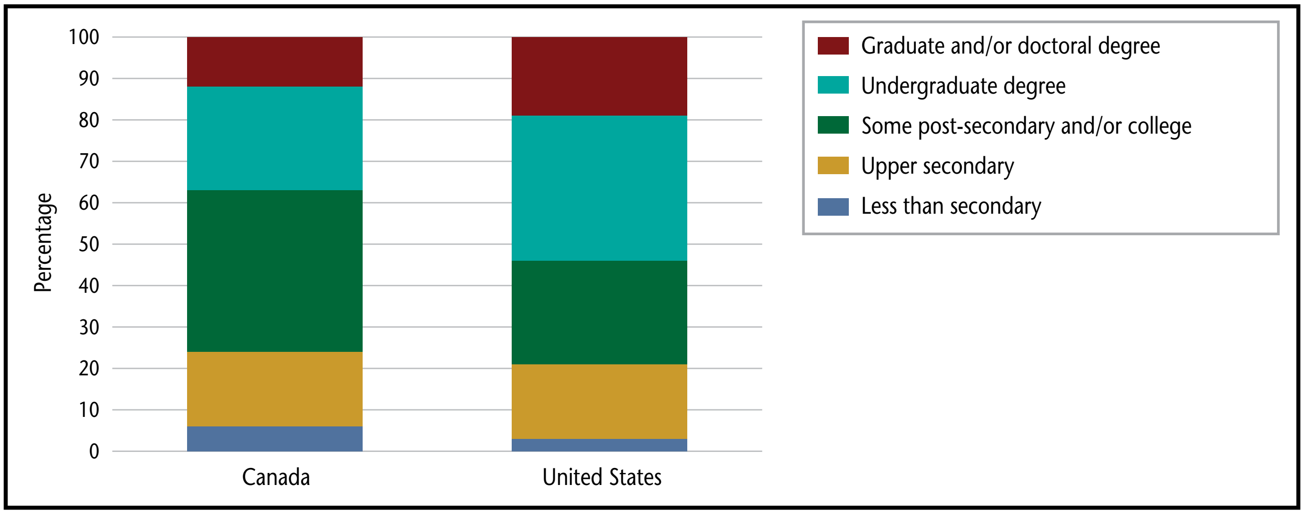
159 As defined by the National Occupational Classification 2006 structure, generally speaking, senior managers develop and establish objectives for an organization and develop or approve policies and programs. They plan, organize, direct, control and evaluate, through middle managers, the operations of their organization in relation to established objectives.

Figure 6-8: Annual Number of Persons Graduated from Canadian University Doctoral Science, Engineering, Math, Computer, Information Sciences and Related Programs, 2000–11



Source: Statistics Canada, CANSIM Table 477-0020 (Post-Secondary Student Information System), February 2013.

Figure 6-9: Educational Attainment of Managers (25 to 64 Years Old), Canada and the United States, 2006 to 2009 Average



Source: Institute for Competitiveness and Prosperity analysis based on data from Labour Force Survey and Current Population Survey.

Connecting a Community of Talent

Virtual Marine Technology Inc. (VMT) graduated from the Genesis Centre in 2009.

Connecting innovative people to the talent and experience around them that will help them become successful entrepreneurs is vital to the success of Canada's science, technology and innovation ecosystem. Business incubators such as the Genesis Centre help entrepreneurs take their ideas from start-up to prosperous enterprise by providing tools, information and, most importantly, advice.

A division of Genesis Group Inc.—the commercialization arm of Memorial University in St. John's, Newfoundland—the Genesis Centre helps technology entrepreneurs bring great ideas to the market by assisting them in the early stages of their companies' development and growth. Awarded the 2011 Canadian Business Incubator of the Year Award, the Centre helps entrepreneurs gain access to the marketing, financial and management expertise of mentors and advisory board members. It also connects its clients to the scientific, technical and business expertise resident at Memorial University. By helping these entrepreneurs develop comprehensive business plans and implement effective advisory boards, the Centre prepares promising ventures for private investment. Entrance to the Genesis Centre is a competitive process administered by a selection board of experienced business people. The result of all these networks is a community that connects the entrepreneurs to the relevant talent and experience around them.

Opened in 1997, the Genesis Centre has assisted 52 companies, 30 of which have "graduated." Some notable graduates of the Centre include Rutter Technologies (now part of Rutter Inc.), Verafin, Virtual Marine Technology and Avalon Microelectronics (now Altera NTC). Clients and graduates of the Centre's programs now employ over 440 people and have raised over $22 million in private equity (63 percent of which came from outside the province).

In the 2012 *Financial Times* (FT) of London rankings,[160] five Canadian business schools placed in the top 100 Master's in Business Administration (MBA) programs,[161] positioning Canada fourth behind the U.S., the U.K., and China in the number of schools ranked in the top 100. Several countries have at least one school that placed ahead of Canada's top-ranked school (Rotman School of Management), including the U.S., the U.K., France, Singapore, Spain, China, India, Switzerland, the Netherlands, Australia, and Italy. Canada fares slightly better in *The Economist* MBA program rankings, with six Canadian business schools ranked in the 2012 top 100, placing Canada 3rd overall (tied with France), behind the U.S. and the U.K. Of the six Canadian schools identified in *The Economist*, three were also among the FT top 100,[162]: Schulich School of Business (York University) (placing 16th in *The Economist*'s ranking), Desautels Faculty of Management (McGill University) (75th), and Sauder School of Business (University of British Columbia) (91st). There were also six Canadian business schools in the top 100 FT Executive MBA (EMBA) ranking for 2012,[163] positioning Canada, once again, fourth (tied with France and Singapore), behind the U.S., the U.K. and China.

160 The *Financial Times* of London annual global survey of business schools takes into account 21 measures across a number of categories, including graduate salary and career progress, international student and faculty counts, and faculty research. For *The Economist*'s MBA rankings, business schools are ranked according to the three-year average of 13 measures falling under four categories, including new career opportunities, personal development/education experience, increased salary and potential to network.

161 These Canadian schools were: Rotman School of Management (University of Toronto) (at 44th); Schulich School of Business (York University) (59th); Desautels Faculty of Management (McGill University) (61st); Richard Ivey School of Business (University of Western Ontario) (68th); and the Sauder School of Business (University of British Columbia) (82nd).

162 The other three Canadian business schools that made *The Economist*'s top 100 list included: John Molson School of Business (Concordia University) (78th); École des Hautes Études Commerciales (HEC) Montréal (93rd); and the Haskayne School of Business (University of Calgary) (95th).

163 These Canadian schools were: Kellogg-Schulich (York University) (at 27th); Rotman School of Management (University of Toronto) (29th); Richard Ivey School of Business (University of Western Ontario) (43rd); a joint EMBA program between the Johnson School of Business and Queen's School of Business (Cornell University/Queen's University) (45th); the Queen's School of Business itself (Queen's University) (92nd); and the Haskayne School of Business (a joint EMBA program between the University of Calgary and University of Alberta) (99th).

For those with a background in science or social science, entrepreneurship training with courses primarily focused on the assessment of business development needs, opportunity recognition, and problem solving can be an important part of developing talent with the right 'package' of skills so that they can commercialize their ideas more easily. A survey conducted by Industry Canada in 2009 on entrepreneurship education in Canadian universities and colleges[164] found, however, that the majority of this type of programming was delivered at the undergraduate level and within the business (95 percent) and engineering (39 percent) subject areas.[165] Entrepreneurship education by colleges and universities in Canada needs to be modernized, to expose students across all disciplines to the skills associated with entrepreneurship.

Work-Integrated Learning

Work-Integrated Learning (WIL) refers to student employment experiences that add practical, employment-based experience to classroom learning or programs of study. The integration of learning and work is garnering a great deal of interest internationally because of its value for both students and employers. Participation in these types of programs is associated with increased rates of school completion,[166] and students have the opportunity to translate their knowledge from theory into practice, while learning valuable workplace skills. At the same time, businesses gain a competitive advantage by accessing research and high-quality talent with the skills they demand.

The impact of work-integrated learning was the focus of a 2011 exploratory study commissioned by the Higher Education Quality Council of Ontario (HEQCO).[167] When asked if they later hired students who had participated in a WIL program in their workplace, almost all the employers and community partners surveyed reported making job offers to WIL students, regardless of the type of WIL in which the students had participated. In making hiring decisions, the majority of employers and community partners reported looking for job applicants with WIL experience rather than job experience more broadly.

The absence of internationally comparable data constrains our ability to compare Canada's performance in work-integrated learning relative to peer countries. However, anecdotal evidence suggests that, while other economies are actively pursuing opportunities to systematically improve the integration of learning and work in order to drive growth, Canada lacks the type of concerted approach to WIL that would capitalize on the potential advantages to students and employers.

Looking at Canada, a 2011 survey of a select sample of Canadian students[168] showed that, in terms of structured WIL opportunities, 16 percent had participated in a co-op program, 18 percent in an internship program and 17 percent in a research assistantship.

In 2006–07, there were approximately 80,000 co-op students enrolled in the programs of the members of the Canadian Association for Co-operative Education, representing approximately 6 percent of full-time students enrolled in universities and colleges across the country that school year.[169] Canadian co-op programs are offered by colleges and universities. They are most common at the undergraduate level and relatively rare at the graduate level, except for those disciplines that mandate work experience prior to graduation as part of the requirements for membership in the profession.[170]

164 Industry Canada, *The Teaching and Practice of Entrepreneurship within Canadian Higher Education Institutions*, Canada (2010), p.10.

165 This is consistent with the *2000 National Graduate Survey* data of Statistics Canada.

166 Canadian Council on Learning, *The Impact of Experiential Learning on Student Success*, Ottawa (2009).

167 P. Sattler, *Work-Integrated Learning in Ontario's Postsecondary Sector*, Toronto: Higher Education Quality Council of Ontario (2011), p. 8.

168 Miriam Kramer and Alex Usher, *Work-Integrated Learning and Career-Ready Students: Examining the Evidence*, Toronto: Higher Education Strategy Associates (2011), p. 7.

169 There were 1,255,761 full-time students enrolled in post-secondary education in Canada in the 2006–07 school year, as reported by Statistics Canada, CANSIM Table 477-0019 (Post-Secondary Student Information System).

170 Patricia Rowe, *Survey of Graduate Programs with Cooperative and Internship Options in Canadian Universities: Initial report of a study of graduate co-operative education in Canada* (University of Waterloo, Centre for the Advancement of Co-operative Education): https://uwaterloo.ca/centre-advancement-co-operative-education/sites/ca.centre-advancement-co-operative-education/files/uploads/files/SurveyofGradProgramsTables.pdf.

Federally Supported Internship Programs

The Government of Canada offers a number of internship programs that provide work-integrated learning opportunities for undergraduate and graduate students and post-doctoral fellows. This suite of programs is aimed at creating opportunities for young talent, increasing the long-term uptake of highly qualified people by firms and strengthening STI capacity within the private sector.

Industrial Research and Development Internships

The Government of Canada established the Industrial R&D Internships (IRDI) program through Budget 2007. The program places graduate students and post-doctoral fellows from any academic discipline in businesses that foster and use their talents. With an annual budget of $7 million to support up to 1,000 internships per year, the program is administered by the Networks of Centres of Excellence and delivered through third-party organizations (currently through the Mitacs-Accelerate program (850 interns) and AUTO21's Connect Canada program (150 interns)).

Mitacs-Accelerate

In addition to funding through the IRDI program, Mitacs receives support for its Accelerate program from a number of federal departments and agencies, including the Atlantic Canada Opportunities Agency, Western Economic Diversification Canada, and the National Research Council–Industrial Research Assistance Program. In Budget 2012, the federal government announced an additional $14 million over two years to significantly increase the number of IRDI offered annually through Mitacs-Accelerate program.

Natural Sciences and Engineering Research Council Internship Programs

The Natural Sciences and Engineering Research Council of Canada (NSERC) offers a variety of internship programs focused on developing talent in the natural sciences and engineering.

The *Industrial R&D Fellowships (IRDF)* program provides financial contributions that support recent doctoral graduates to engage in R&D in the private sector for terms up to two years. In 2011–12, the IRDF program supported 275 fellowships.

The *Industrial Postgraduate Scholarships (IPS)* program provides financial support for graduates, allowing them to gain research experience in industry while undertaking graduate studies (either master's or doctoral) in Canada. The student spends a minimum of 20 percent of their time working at a company, on research related to their thesis. In 2011–12, the IPS program supported 398 awards.

The *Industrial Undergraduate Student Research Awards (I-USRA)* program provides 16-week internships for undergraduate students, who take on research projects in companies. In 2011–12, the I-USRA program supported 878 awards.

The *Collaborative Research and Training Experience Program (CREATE)–Industrial Stream* provides private sector internships for students and post-doctoral fellows that focus on developing skills that will be useful for the transition to the workplace, such as communication, collaboration and professional skills.

Co-op programs are particularly popular among college students, who are twice as likely as university students to participate in them.[171] While co-op programs are increasingly being offered in a wide range of disciplines, including social sciences, health sciences and education, they are more concentrated in fields such as engineering, mathematics and business.[172]

Mobile Talent in a Global Economy

The search for the best talent is a race taking place at the global level. Competitive firms and institutions vie to attract the brightest people in their fields, from wherever they come. This talent is increasingly willing and able to relocate to take advantage of the opportunities and

171 David Walters and David Zarifa, "The earnings and employment outcomes for male and female postsecondary graduates of coop and non-coop programs," *Journal of Vocational Education and Training*, 60 (4): pp. 377–399.

172 David Walters and David Zarifa, "The earnings and employment outcomes for male and female postsecondary graduates of coop and non-coop programs," *Journal of Vocational Education and Training*, 60 (4): pp. 377–399.

benefits an international career can bring. At the same time, governments throughout the world are developing programs to attract highly educated and highly skilled foreign talent.

Contributors to the 'Diplomacy of Knowledge'

A 2009 study conducted by the Canadian Bureau for International Education found that a majority of Canadian students understand the benefits of studying abroad.[173] An international education helps Canadian students acquire a global perspective, thus preparing them to contribute to the "diplomacy of knowledge"[174] and to understand and respond to the increasingly global marketplace. When returning to Canada, these students bring back knowledge, skills and networks that contribute to Canada's economy and society.

Despite increasing mobility, only 3.4 percent of Canadian university and college students were enrolled abroad in 2009.[175] This places Canada near the middle of the pack when compared with other OECD countries. The U.S. was the primary target of Canadian students in 2009, with 29,209 students studying there, followed by the U.K. with 5,350, and Australia with 4,390.[176] According to the Canadian Resident Matching Service (CaRMS), there were also roughly 3,500 Canadians enrolled in foreign medical schools in 2010.[177]

Statistics Canada data from 2005–06 (the most recent year for which such data are available) showed that 21 percent of doctoral graduates in Canada planned to live outside the country upon completion of their degree.[178] Most of these students planned to move to the U.S., many of them in order to complete post-doctoral studies. Of the doctoral graduates from Canadian universities who were living in the U.S. in 2007, the highest proportions were in life sciences[179] and computer, mathematics and physical sciences (all at 17 percent). It is also important to note that the majority (55 percent) of the graduates planning to live outside Canada also indicated that they planned to return to Canada to live and work in the future. Furthermore, two years following graduation, 24 percent of those who had left for the U.S. had subsequently returned to Canada, while the majority still in the U.S. continued to report their intention to return to Canada.

Attracting International Students to Canada

Just as there are benefits to having Canadian students study abroad, there are also advantages to attracting international students to Canada. In addition to the immediate economic benefits, international students, upon graduation, provide an educated talent pool for immigration to Canada, one with established Canadian credentials and work experience. Even if these students return to their home countries, their ties to Canada often mean they act like ambassadors, developing opportunities for enhanced research, trade and investment linkages, and generally raising Canada's profile abroad.

In 2010, 7 percent (or 95,590)[180] of all university and college students in Canada were international students,[181] placing Canada near the OECD average. It is

173 Dr. Sheryl Bond, *World of Learning: Canadian Post-Secondary Students and the Study Abroad Experience*, Canadian Bureau for International Education (2009) (http://www.cbie-bcei.ca/wp-content/uploads/2012/03/20100520_WorldOfLearningReport_e.pdf)

174 The Governor General of Canada, His Excellency the Right Honourable David Johnston, defined the diplomacy of knowledge as "our ability and willingness to work together and share the knowledge we uncover and refine across disciplines and across borders to improve the human condition together" (from the Opening Address to the Conference of the Americas on International Education in Rio de Janeiro, Brazil, April 26, 2012).

175 OECD, *Education at a Glance 2012* (2012), Table C4.5.

176 OECD, *Foreign/International Students Enrolled* (October 2012). Followed by Ireland with 594, Germany with 546, New Zealand with 419, Switzerland with 378, and Sweden with 254 (no data were available for Canadian students in France and non-OECD countries).

177 Canadian Residence Matching Service, *Canadian Students Studying Medicine Abroad* (2010), p. 6. (http://www.carms.ca/pdfs/2010_CSA_Report/CaRMS_2010_CSA_Report.pdf)

178 Darren King, et al., *Doctorate Education in Canada: Findings from the Survey of Earned Doctorates, 2005/2006*, Ottawa, Statistics Canada and Human Resources and Social Development Canada (2008), p. 35.

179 Agricultural sciences, biological sciences and health sciences included.

180 OECD, *Foreign/International Students Enrolled*, October (2012).

181 OECD, *Education at a Glance 2012* (2012), Table C4.1. The OECD differentiates between non-citizen students (foreign students) and non-resident students (international students). Non-resident/international students are generally labelled as such if they "left their country of origin and moved to another country for the purpose of study." Meanwhile, foreign students/non-citizen students are labelled as such "if they are not citizens of the country in which the data are collected." The 'international student' data are considered more useful than 'foreign student' data. For example, in some countries, many second-generation immigrant students are still labelled as foreign students due to the country's naturalization policies.

interesting to note that this is double the proportion in the U.S. (at 3.4 percent); however, it is significantly lower than the proportion in key competitor countries such as Australia (21.2 percent), New Zealand (14.2 percent) and the U.K. (16.0 percent). Australia, with a population roughly 12 million less than that of Canada, hosted 271,231 international students at the college and university level, while New Zealand, with a population more than seven times smaller than that of Canada, hosted 37,878 international students at the college and university level. The U.K., with a population almost double that of Canada, hosted 397,741 international students at the college and university level, just over four times the number of international students hosted by Canada.

Despite Canada's modest performance in this area, it is interesting to note that international students are responsible for a significant part of the growth in science-based PhD enrolments in Canada. From 2000–01 to 2010–11, the growth rate in international students outstripped the growth rate by Canadian registrants in all of the science-based PhD programs (ranging from a 5 percent growth rate in international PhD students in health sciences to a 24 percent growth rate in architecture and engineering).[182] Women accounted for an increasing share of the international students registered in science-based PhD programs in Canada. For example, of the 20,871 international PhD students enrolled in architecture and engineering between 2000–01 and 2010–11, women accounted for 3,792, an increase of 78.9 percent since 2000–01. Although this population is small overall, this trend is noteworthy.

Clearly many of the international students who come to Canada are interested in staying. In 2008, 33 percent of international students in Canada changed their immigration status to stay on in Canada, mostly for work purposes.[183] This positioned Canada first among selected OECD countries on this measure.

Attracting Highly Educated Immigrants to Canada

Because a significant percentage of Canada's workforce growth now comes from immigration, economic drivers have assumed increasing significance in Canada's immigration policy, and the system is oriented towards

Leading-edge Water Research

Director of the Global Institute for Water Security and Canada Excellence Research Chair (CERC) in Water Security, Howard Wheater is one of the world's foremost hydrologists. He was recruited through the federal government's CERC program by the University of Saskatchewan in 2010, after 32 years at Imperial College London, in the United Kingdom.

Likening his role to that of a symphony conductor,[1] Dr. Wheater leads the Institute's water-related research, which engages numerous faculty and government scientists as well as post-doctoral fellows and students from across multiple disciplines. One of Dr. Wheater's challenges is to bring together all of this talent in collaborative work at local, national and international levels and across broad research themes such as land and water management, sustainable resource development, climate change, human health and socio-hydrology.

The Institute—partnering with the Centre for Hydrology, Toxicology Centre, Canadian Light Source (Synchrotron), and several colleges, schools, and departments at the University of Saskatchewan—benefits from $30 million in joint federal-provincial-university funding over seven years. Current research aims to improve understanding of climate and environmental change in the Saskatchewan River Basin (home to important natural resources and 80 percent of Canada's agricultural production). Data collected by Dr. Wheater and his "orchestra" will be used to create improved modeling tools to develop better predictions of climate and land use change, improve land and water management practices and guide policy decisions.

1 Allan Casey, *Water Music*, Green and White (University of Saskatchewan, Winter 2011), http://www.usask.ca/greenandwhite/issues/2011/winter2011/features/cover_story.php

182 STIC calculations based on data extracted from Statistics Canada, CANSIM Table 477-0019 (October 2012).

183 OECD, *International Migration Outlook 2011* (2011), Figure I.8.

attracting highly educated talent. Forty-five percent of the 1.9 million permanent residents (15 years of age or older) that were accepted into Canada from 2001 to 2010 had at least an undergraduate degree.

Figure 6-10 shows that, in 2009–10, as in 2000–01, among available OECD countries, Canada had the highest percentage of college and/or university-educated people in the foreign-born population (all age groups), with over 50 percent of the immigrant population having a college and/or university education. Canada was followed by the U.K. on this indicator, and then Ireland, Luxembourg and Australia.

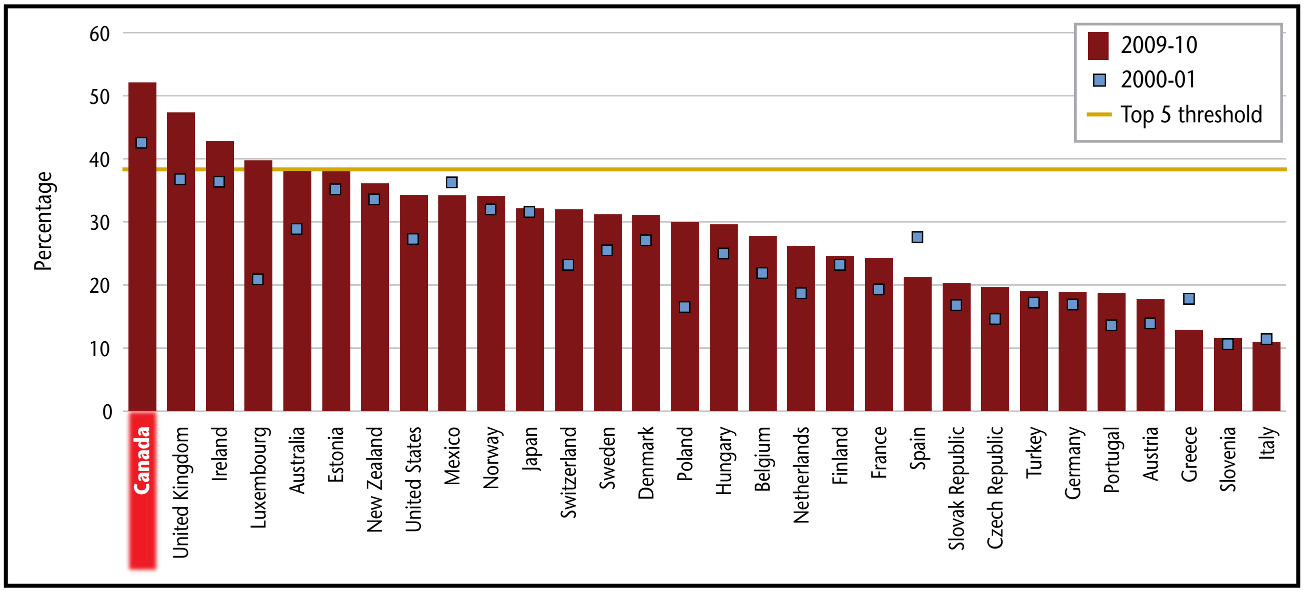
Differences in immigration systems and policies constrain our ability to compare Canada's performance to that of other countries in terms of attracting highly educated talent.

To maximize the contribution of Canada's highly educated immigrant talent, it is important to ensure that these new immigrants are able to integrate into the Canadian labour market in areas where their skills can be used to best advantage. It is here that Canada must improve its performance. Evidence suggests that, while immigrants are able to obtain employment relatively rapidly in Canada, the quality of that employment at entry has deteriorated appreciably over the last few decades.[184]

TALENT DEPLOYMENT: MAKING THE MOST OF OUR TALENT

To be competitive, countries need to take advantage of their talent, to strategically maximize opportunities to create new knowledge and translate that knowledge into innovative products and processes. While there is growing demand for talent with university or college

Figure 6-10: Percentage of University and College-Educated in the Foreign-Born Population, 2000 and 2010



Source: OECD, *International Migration Outlook 2012*, Table I.15 (DIOC, Labour Force Surveys), Data link: http://dx.doi.org/10.1787/888932615251.

184 Garnett Picot and Arthur Sweetman, "Making It in Canada: Immigration Outcomes and Policies," *IRPP Study, No. 29* (April 2012). Male immigrants entering Canada from 1976 to 2005 attained employment parity with Canadian-born men after approximately five years (the picture for women generally tracks that of men). When male immigrants are compared with Canadian-born men with similar characteristics (such as education, age and marital status), the cohort entering during the late 1970s had annual earnings that were roughly 85 percent of those of their Canadian-born counterparts during the first five years in Canada. For the cohort of men entering during the early 1990s, this figure had fallen to 60 percent.

qualifications in Canada's economy, the country faces a number of challenges in fully absorbing and utilizing the knowledge and skills offered by Canada's highly educated talent.

Success in the Labour Market

The demand for, and supply of, labour in Canada's economy, as in other countries, is continually changing, responding to population changes, shifting markets, and the introduction of new technologies or advances in science, technology and innovation. The pace of this change can be rapid, while the development of new skills and knowledge typically has a longer time horizon. Matching the qualification and skills of the available talent pool (the supply) with those required in the labour market (the demand) of the 21st century knowledge economy is a complex and important challenge, particularly as global competition increases and rapid scientific and technological change intensifies. Measuring that match in Canada is important in order to know that the talent development and education investments this country is making are meaningful.

Making the Match: Canada's Absorption of its Well-Educated Workforce

Analysis of the capacity of Canada's economy to absorb and utilize the knowledge and skills of its talent supply points to the growing demand for, and increasing value of, the knowledge and qualifications associated with a college and/or university education.[185] A 2009 report[186] looked at the ability of Canada's university graduates to find employment related to their studies and found that: 64.9 percent of university graduates indicated that their job closely matched their education, while 22.5 percent said it was somewhat related, and 12.6 percent said it was not related at all. According to the same study,[187] Canadian graduates in health sciences and education had the best chance of finding employment related to their studies, followed by graduates in math, computer and information sciences, and then graduates in business and engineering. This is not surprising, as these applied fields prepare students to work in specific occupations in the labour market. Also not surprising is that the majority of doctoral graduates were employed in educational services (mostly in universities).[188] In most fields, this majority was significant, with the exception of engineering, where an almost equal proportion of graduates were employed in professional, scientific and technical services (Figure 6-11).

Qualifications gained through education are an important foundation for science, technology and innovation. Transforming people's ideas and knowledge into goods and services for today's global market requires talent with a wide range of skills and perspectives. That is why, in today's economy, companies are looking for talent not only with the right qualifications but also the right skills, including effective communications, creative problem-solving, and collaborative decision-making skills.

Skill shortages happen when employers are unable to recruit employees with the skills they are looking for at the going rate of pay. Skill shortages can be both cyclical and structural. On the one hand, shortages occur in periods of rapid economic growth, when unemployment is low and the pool of available workers is reduced. On the other hand, some structural changes—such as the adoption of new technology—could require skills that are not immediately available in the labour market, creating shortages while wages adjust and the education system adapts.

Survey data from Manpower Group's 2012 Talent Shortage Survey,[189] based on more than 38,000 employers in 41 countries and territories, showed that 25 percent of employers in Canada continue to have difficulty filling

185 Kevin Stolarick, *The Changing Returns to Education in Canada and its Provinces: 1971–2006*, Martin Prosperity Institute Working Paper, Toronto: Martin Prosperity Institute (January 2012).

186 Brahim Boudarbat and Victor Chernoff, *The Determinants of Education-Job Match among Canadian University Graduates*, Forschungsinstitut zur Zukunft der Arbeit/Institute for the Study of Labor (IZA) Discussion Paper No. 4513 (October 2009), p. 11.

187 Brahim Boudarbat and Victor Chernoff, *The Determinants of Education-Job Match among Canadian University Graduates*, Forschungsinstitut zur Zukunft der Arbeit/Institute for the Study of Labor (IZA) Discussion Paper No. 4513 (October 2009), p. 13.

188 Louise Desjardins and Darren King, *Expectations and Labour Market Outcomes of Doctoral Graduates from Canadian Universities*, Culture, Tourism and the Centre for Education Statistics Research Paper (January 2011), p. 33.

189 Manpower Group, *2012 Talent Shortage Survey Research Results* (2012).

Figure 6-11: Distribution of Doctoral Graduates by Fields of Study and Industry of Employment

	Manufacturing	Professional, Scientific and Technical Services	Educational Services	Health Care and Social Assistance	Public Administration
			Percentage		
All Fields of Study	**4**	**13**	**56**	**13**	**7**
Life sciences	4	14	51	19	8
Engineering	13	31	34	x	9
Computers, mathematics and physical sciences	7	18	56	4	7
Psychology and social sciences	x	5	54	28	9
Humanities	x	4	77	2	3
Education and other fields	x	7	76	6	5

x - suppressed to meet the confidentiality requirements of the *Statistics Act*.
Note: Excludes unpaid workers, respondents still taking education credits and those outside the labour force.

Source: Statistics Canada, National Graduates Survey (Class of 2005) (Figure reproduced from Desjardins, Louise and Darren King, Expectations and Labour Market Outcomes of Doctoral Graduates from Canadian Universities, Culture, Tourism and the Centre for Education Statistics Research Paper, January 2011).

job vacancies (up from 21 percent in 2010 and down from 29 percent in 2011), compared to 34 percent globally and 41 percent in the Americas.[190] Of those Canadian employers reporting difficulty filling vacancies, 41 percent cited "the lack of available applicants" as the most common reason (compared to 33 percent of global respondents). A roughly equal percentage (up from 22 percent in 2011) cited "lack of technical competencies/hard skills"—in particular, the lack of industry-specific qualifications in both professional (for example, engineers, technicians, information technology) and skilled trades categories. Skilled trades topped the list of jobs that employers are having difficulty filling in both the U.S. and Canada. Engineering jobs ranked as the second most difficult positions to fill, in Canada, the U.S., and globally.

Annual Canadian job vacancy data[191] show that, in 2011, the mining, quarrying, and oil and gas extraction industries had the highest national vacancy rates, at 3.1 percent. Coinciding with the high world prices of oil and other commodities produced in Canada, this reflects a significant demand for talent in the skilled trades such as heavy-duty mechanics, welders, electricians, and petroleum technologists. Professional, scientific and technical services, as well as health care—two service industries that traditionally use highly qualified and highly skilled talent—had the next highest national vacancy rates (at 2.2 percent and 2.1 percent, respectively). The lowest national vacancy rates in 2011 were in management of companies (at 1.0 percent) and educational services (at 0.7 percent).

Deploying Canada's Science, Technology and Innovation Talent

Two of the most telling indicators of a country's ability to absorb and use its science, technology and innovation talent to best advantage are the share of human resources in science and technology (HRST) and the proportion of researchers employed in the private and public sectors. Canada's performance on both indicators continues to be disappointing.

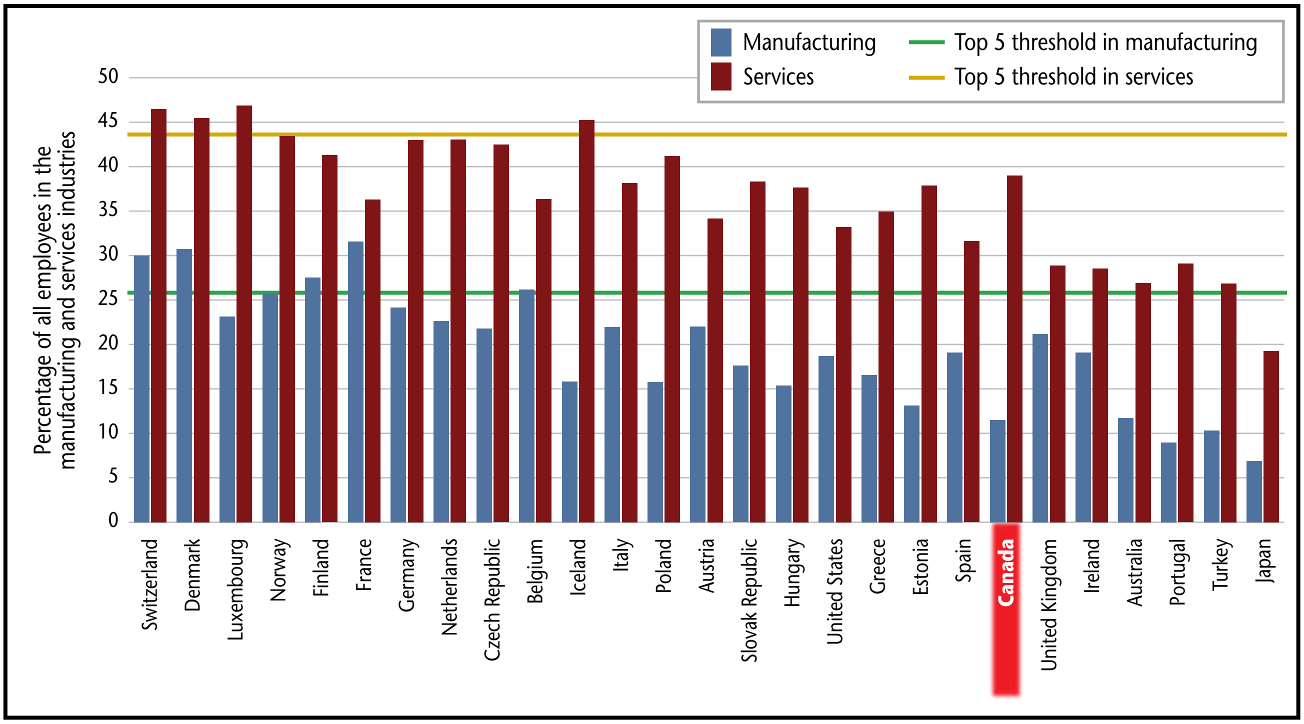
190 Argentina, Brazil, Canada, Colombia, Costa Rica, Guatemala, Mexico, Panama, Peru and the U.S.

191 Statistics Canada, *Job Vacancy Statistics* (2011).

Like most OECD countries, more of Canada's human resources in science and technology[192] continue to be concentrated in the services sector than in the manufacturing sector, as reflected in Figure 6-12. In fact, in Canada, growth in the share of HRST in services was almost four times greater than the growth in the share of HRST in manufacturing between 1998 and 2008. This, in part, reflects the shift in Canada's economy from manufacturing to services. Canada's HRST share of the services labour force, at 39 percent, sits in the middle of the pack among available OECD countries and behind the top five performers of Luxembourg, Switzerland, Denmark, Iceland and Norway. On manufacturing, the picture is far worse—the HRST share of the manufacturing labour force in Canada, at 11.5 percent, is among the lowest in the OECD, significantly behind the top five performers of France, Denmark, Switzerland, Finland and Belgium. This is yet another area where Canada must focus concerted attention to significantly improve performance, if we are to fully realize the potential of our strong talent base.

The HRST share of the manufacturing labour force in Canada is among the lowest in the OECD.

Figure 6-12: **Human Resources in Science and Technology (HRST) Employees by Industry Sector (as a Percentage of all Employees in the Manufacturing and Services Industries), 2008**



Source: OECD, *Science, Technology and Industry Scoreboard*, 2011, Figure 2.3.2, Data link: http://dx.doi.org/10.1787/888932485861.

192 Human resources in science and technology are defined according to the Canberra Manual (OECD and Eurostat, 1995) as persons having graduated at the tertiary level of education in a science and technology field or employed in a science and technology occupation for which a high qualification is normally required and the innovation potential is high. To classify occupations, the OECD uses ISCO Group 2 (Professionals) including physical, mathematical and engineering science professionals; life science and health professionals; teaching professionals; and other professionals as well as ISCO Group 3 (Technicians and associate professionals) including physical and engineering science associate professionals; life science and health associate professionals; teaching associate professionals; other associate professionals.

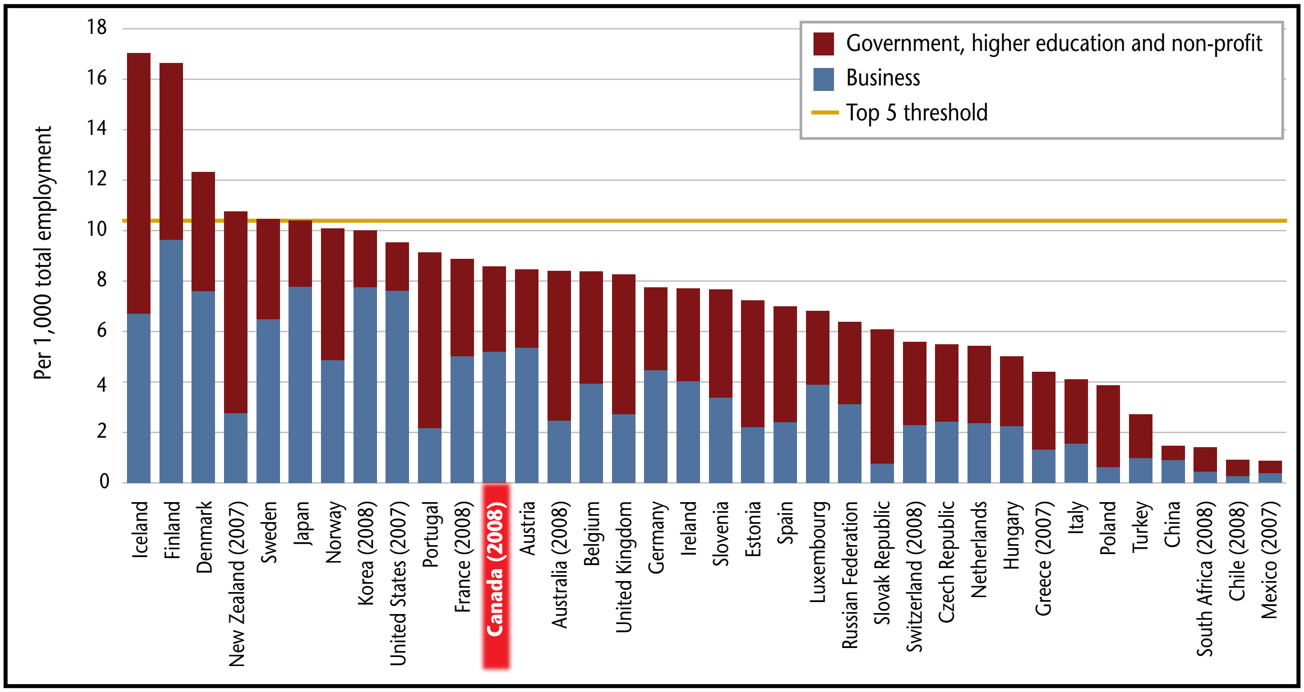
Looking at researchers specifically (defined as professionals engaged in the conception and creation of new knowledge, products, processes, methods and systems, who are directly involved in the management of projects) in 2008, there were 5.2 researchers[193] employed by the business sector in Canada for every 1,000 workers and 3.3 researchers employed by the combined government, university and college, and private non-profit sectors for every 1,000 workers (Figure 6-13). This places Canada slightly above the OECD averages of 4.81 and 2.74, respectively, but almost two researchers (per 1,000 workers) below the top five global leaders, including Iceland, Finland, Denmark, New Zealand and Sweden.

Gender Balance in Science, Technology and Innovation Leadership

Leaders play a critical role in creating an environment where those around them are encouraged to apply science, technology and innovative thinking to solve problems and develop new goods and services. Research has shown that there is a positive link between diversity in corporate leadership and firm performance, particularly in terms of financial performance, the ability to attract and retain talent, and increase STI.

The ethnic diversity of Canada's business sector in relation to other countries is difficult to assess, as few countries collect such data, with the exception of the U.S. and the U.K.[194] However, internationally comparative data are available on gender diversity in the top ranks of Canada's business sector.

Figure 6-13: **Researchers by R&D Performing Sector, 2009**



Source: OECD, *Science, Technology and Industry Scoreboard*, 2011, Figure 2.4.1, Data link: http://dx.doi.org/10.1787/888932485899.

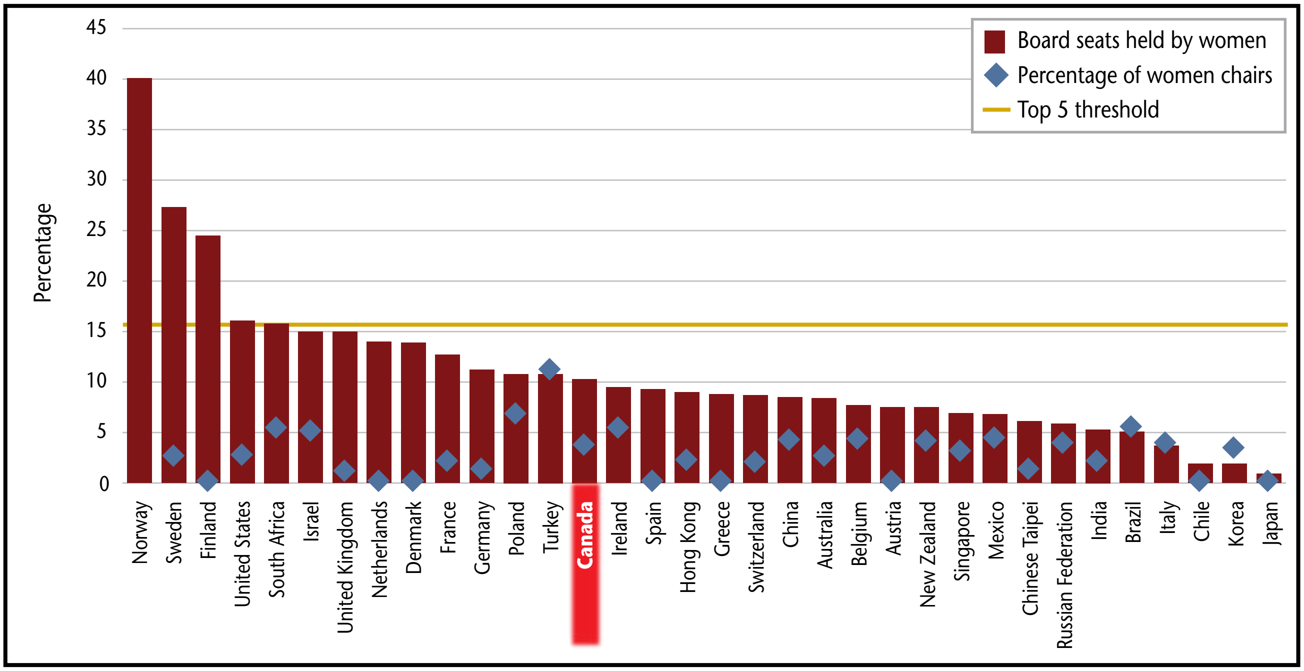
193 The number of researchers is expressed in full-time equivalent (FTE) units. A person working half-time on R&D is counted as 0.5 person year in FTE. FTE refers to staff engaged in R&D during the course of a given year. FTE data are a more accurate measure of the volume of research conducted by a country's researchers. Researchers are shown relative to total employment in the OECD National Accounts. Employment in industry excludes persons engaged in real estate, public administration and defence, education, health and social work and private households.

194 Forbes Insights. *Diversity and Inclusion: Unlocking Potential – Global Diversity Rankings by Country, Sector and Occupation*, Forbes (January 2012), p.18. (http://images.forbes.com/forbesinsights/StudyPDFs/global_diversity_rankings_2012.pdf)

According to Catalyst's 'Women on Boards Around the World' (Figure 6-14),[195] 10.3 percent of board seats in Canada (public companies only) were held by women in 2011, while only 3.6 percent of chair positions (public and private companies listed on the *Financial Post 500*) were held by women. Compared to other available economies, this positions Canada in the middle of the pack on both measures, but significantly lagging key competitors such as the U.S.[196] This finding is consistent with Governance Metrics International (GMI) annual rankings,[197] which also positions Canada in the middle of competitor countries, but significantly lagging the top performers such as Norway, Sweden, Finland, the U.S. and South Africa. GMI looked at 134 prominent Canadian companies in 2011 and determined that 13.1 percent of their board members and 2.2 percent of their chairs were women. Canada needs to improve significantly in this regard.

At the same time, an estimated 36 percent of public and private sector managers in Canada were women in 2012.[198] Looking more closely at the senior management ranks, this proportion falls to 27 percent.[199] In comparison, in the U.S., in 2011, it was estimated that women comprised 39.1 percent of management positions and 24.2 of chief executive positions.[200]

Figure 6-14: Percentage of Board Seats Held by Women and Percentage of Chair Positions Held by Women, 2011



Source: Catalyst, *Women on Boards Around the World*, Data link: http://www.catalyst.org/knowledge/women-boards.

195 Data compiled by STIC using Catalyst, *Women on Boards Around the World*. (http://www.catalyst.org/knowledge/women-boards)

196 Catalyst's figures are based on their own internal research, Governance Metrics International's 2012 *Women on Boards Survey*, and various national studies where deemed appropriate. Catalyst explains that their 'board seats held by women' figure for Canada is derived from public companies only rather than public and private companies listed on the Financial Post 500 as it is more in line with the other figures in their chart. Meanwhile their figure for women chairs was derived from their '2011 Catalyst Census: Financial Post 500 Women Board Directors' study. The following website outlines the methodology for that study. (http://www.catalyst.org/etc/Census_app/11CAN/Appendix_1_2011_FP500_Census.pdf)

197 Kimberly Gladman and Michelle Lamb, *GMI Ratings' 2012: Women on Boards Survey*, Governance Metrics International (GMI) (March 2012). (http://library.constantcontact.com/download/get/file/1102561686275-86/GMIRatings_WOB_032012.pdf) GMI's survey includes data from over 4,300 international companies largely relying on market indices.

198 Statistics Canada, CANSIM Table 282-0010 (Labour force survey estimates (LFS) (February 2013).

199 Statistics Canada, CANSIM Table 282-0010 (Labour force survey estimates (LFS) (February 2013).

200 U.S. Bureau of Labor Statistics, Current Population Survey, Table 11: Employed Persons by Detailed Occupation, Sex, Race, and Hispanic or Latino Ethnicity, Annual Averages 2011(2012).

7 Conclusion and the Way Forward

Canada must strive not only for excellence in STI but also for global leadership.

To a significant extent, Canada's success in the 21st century will be determined by our ability to harness science, technology and innovation (STI) to drive economic prosperity and enhance societal well-being. STI is key to increasing productivity growth, generating high-value jobs, creating and growing firms, and addressing pressing health, environmental and social challenges.

State of the Nation 2012 confirms what we learned in our 2010 and 2008 reports—that Canada has strong STI fundamentals related to the high quality of our talent and our strength in generating new knowledge. But we cannot be satisfied with the status quo, or incremental progress. Other countries are strategically planning and investing to improve their STI ecosystems, and our latest report shows they are starting to reap the rewards.

We believe that Canada must strive not only for excellence in STI but also for global leadership, so that we might reap the resulting economic and societal benefits. In *State of the Nation 2012* we have gone beyond examining Organisation for Economic Co-operation and Development (OECD) and other comparator countries (as we did in previous reports) to identify the threshold that Canada would have to attain in order to break into the ranks of the world's top five performing countries on key indicators.

In concluding this *State of the Nation 2012* report, we want to go still further, by highlighting five of these indicators in particular where Canada should aspire to join the ranks of the world's top five performing countries. Improved performance in these five "aspirational" indicators will help secure Canada's future as a global STI leader and make an enormous contribution to our country's success. Failure to do better in these five areas will significantly constrain our ability to move into an STI leadership position and to harness STI advances for the economic and societal well-being of Canadians. In future reports, we will track progress on these five indicators and continue to promote better performance in these areas. These five "aspirational" indicators span the three key pillars underpinning Canada's STI ecosystem—business, knowledge and talent. While they serve distinct purposes, they also mutually reinforce one another in maximizing Canada's STI potential. They include:

- business enterprise expenditures on research and development (BERD) as a share of gross domestic product (GDP);
- business investment in information and communications technologies (ICT);
- higher education expenditures on R&D (HERD) as a share of GDP;

- science and engineering doctoral degrees granted per 100,000 population; and
- share of human resources in science and technology (HRST).

The first two of these five indicators relate to the extent to which Canadian companies embrace innovation as a competitiveness strategy, as reflected in BERD as a share of GDP and business ICT investment intensity, both described in Chapter 4. We believe concerted efforts must be directed at enhancing BERD and ICT investment as they are both closely linked to product and process innovation and thus to productivity growth. Enhanced productivity will serve to enhance Canada's global competitiveness and drive economic growth.

As reported in Chapter 4, Canada's BERD intensity has almost continuously declined for the past decade, and Canada has fallen to 25th out of 41 economies in the OECD's 2011 rankings. This is less than 40 percent of the threshold of the top five performers. Where Canadian business has performed better is in its funding of R&D in the higher education sector. On this measure, Canada ranked seventh among comparator economies, with significantly better performance than the United States (U.S.) and Japan.

In business ICT investment intensity, while Canadian investment is growing, Canada still ranks in the middle of OECD comparator countries. On this indicator, Canada performs at approximately 70 percent of the threshold of the world's top five performers.

To improve Canada's performance on these indicators, companies must more actively pursue innovation as a competitiveness strategy, including greater investment in research and development (R&D) and productivity-enhancing machinery and equipment (M&E), especially ICT. While evidence shows that firms are investing a smaller share of their profits in R&D and M&E, the current economic climate would suggest that Canadian companies should be putting their money to work.

All levels of government in Canada have a role to play in supporting companies' pursuit of enhanced innovation. At the federal level, we strongly encourage the government to make progress in redressing the imbalance between its direct and indirect support for business R&D. As noted in Chapter 3, the balance of Canada's business R&D support is heavily weighted to indirect funding, in stark contrast to most other countries. Among the world's top 10 innovative countries (as measured by BERD-to-GDP and gross domestic expenditures on research and development (GERD)-to-GDP), direct support in 2010 consisted of an average of approximately 70 percent of total government support for business R&D, while in Canada it consisted of only approximately 12 percent.

While recent changes to the Industrial Research Assistance Program and the launch of the Digital Technology Adoption Pilot Program are encouraging, more direct funding in support of business innovation in Canada is needed. For instance, the federal government could signal through its procurement activities that it is prepared to be a lead user for innovative products. Governments around the world are increasingly using procurement to stimulate business innovation and address the commercialization gap. The Canadian Innovation Commercialization Program, introduced in 2010, was an excellent beginning. Now the program must be expanded to reach businesses of all sizes across Canada.

The lack of venture capital (VC) in Canada remains a key challenge facing the growth of innovative companies, and may hinder improvements in BERD intensity. Data presented in Chapter 4 show that Canada trails many of its international peers in terms of VC as a share of GDP, and there is a significant VC investment gap with the U.S. Recently, the federal government took a positive step towards addressing this deficiency by announcing the deployment of $400 million in new capital through the Venture Capital Action Plan.[201] The government should use this as a springboard to launch other initiatives, which could include a review of government policies to further encourage VC activity and new measures to address other gaps, such as the shortage of serial entrepreneurs.

201 Prime Minister of Canada, "Venture Capital Action Plan," *Backgrounders* (2013). (http://www.pm.gc.ca/eng/media.asp?category=5&featureId=6&pageId=48&id=5237)

The higher education sector in Canada can also play an important role in fostering enhanced business innovation, by adopting further initiatives to support "knowledge transfer on two feet." This means closer collaboration with industry in long-term, discovery-oriented research and in applied research closer to the market. It also means expanding programs that support work-integrated learning for STI students and graduates, and developing curricula to fill the gaps between science and business skills.

The third indicator where Canada should aspire to join the ranks of the world's top five performing countries relates to Canada's commitment to the generation of new knowledge, reflected in HERD as a share of GDP. We singled out this indicator because the development of new knowledge is fundamental to the strength and vitality of the whole STI ecosystem.

As noted in Chapter 5, although growing in dollar terms, HERD funding has fluctuated over the last decade in relation to the size of the economy. Canada's relative position in terms of HERD as a share of GDP is deteriorating against the broad comparator group, with Canada ranking 9th out of 41 economies in 2011, down from 4th place in 2008 and 3rd in 2006. Canada's HERD-to-GDP performance was 87.9 percent of the threshold of the top five performers in 2011, although it came in significantly above that of the U.S., which stood at 55.8 percent of the top five economies.

Research in the higher education sector generates the discoveries that underpin new products, processes and policies and that help address our society's most pressing challenges, whether health in an aging population, sustainable means to extract natural resources, or improving living standards for all Canadians.

Through collaboration with industry and practical application of research findings, the research activities undertaken by our universities and colleges also hold enormous potential for stimulating business innovation. Applied research collaborations with colleges and universities are particularly important to small and medium-sized enterprises, which often lack the resources to invest in innovation projects. Canada's relatively strong international performance in HERD as a share of GDP highlights an important achievement in knowledge development that should be sustained and expanded, particularly in a world where other countries are investing aggressively in higher education and research.

The remaining two "aspirational" indicators relate to our talent advantage. The ability to produce and deploy top research talent is critical in a world where the creation and application of new knowledge drives economic growth and societal advances. Thus we point to the need to improve our performance in producing doctoral graduates, as reflected in science and engineering doctoral degrees granted per 100,000 population. Increasing the number of doctoral graduates in Canada will enhance our capacity to undertake cutting-edge research and to train successive generations of talent.

As reported in Chapter 6, in 2010 Canada placed 15th among OECD countries on science and engineering doctoral degrees granted per 100,000 population, and performed at approximately 64 percent of the threshold of the top five global performers. On a more encouraging note, between 2006 and 2010, Canada experienced about 49 percent *growth* in science doctoral degrees granted and about 39 percent growth in engineering doctoral degrees—growth rates surpassing those of many comparator countries. To continue this growth, we need to foster a greater "science and innovation culture" in Canada to increase interest among young people, as early as elementary school, in pursuing advanced studies and successful careers in STI-related fields.

The ability to deploy our talent to best advantage—to maximize the impact of people's knowledge and skills in our labour force and our society—is equally important. Thus our list of five "aspirational" indicators is rounded out with the share of human resources in S&T in the labour force. On this measure, Canada's performance continues to lag that of key competitor countries. As noted in Chapter 6, in the services sector, Canada's performance is mediocre when compared to other OECD countries. In manufacturing, the picture is dismal—the HRST share of the manufacturing labour force is among the lowest in the OECD. More public and private sector support for work-integrated learning initiatives would help transition STI graduates into productive employment in the labour force and would serve to demonstrate to prospective employers the value that this talent can bring to their organizations.

Canada has strong STI foundations on which to build, but we must do better—in some areas, much better. The five "aspirational" indicators we have identified will be a measure of our success. The responsibility is shared: all participants in our STI ecosystem have a role to play in driving enhanced performance and lifting Canada into the ranks of the world's leading innovative economies. It is not just about investing more, but about investing more strategically and coherently, focusing our resources and efforts, learning from the experience of global STI leaders and improving agility to seize emerging opportunities. That is how Canada will truly be able to "run with the best."

Appendix A

Granting Council Funding for Science, Technology and Innovation Sub-Priority Areas

Estimates of Granting Council Funding of STI Sub-Priorities: Fiscal Year 2011–12

<table>
<tr><th>STI Priorities and Sub-Priorities</th><th>NSERC
($ 000)</th><th>CIHR
($ 000)</th><th>SSHRC
($ 000)</th></tr>
<tr><td>Environment</td><td>161,203.1</td><td>26,288.8</td><td>21,408.2</td></tr>
<tr><td>Water, health[1]</td><td rowspan="2">19,568.5</td><td>26,288.8</td><td>535.8</td></tr>
<tr><td>Water, security</td><td></td><td>162.0</td></tr>
<tr><td>Water, energy</td><td></td><td></td><td></td></tr>
<tr><td>Cleaner methods of extracting, processing and utilizing hydrocarbon fuels, including reduced consumption of these fuels</td><td>10,740.6</td><td></td><td></td></tr>
<tr><td>Other (non-sub-priorities)</td><td>130,894.0</td><td></td><td>20,710.4</td></tr>
<tr><td>Natural Resources and Energy</td><td>162,219.0</td><td>8,021.2</td><td>2,346.7</td></tr>
<tr><td>Energy production in the oil sands</td><td>14,449.2</td><td></td><td>57.0</td></tr>
<tr><td>Arctic, resource production</td><td>2,181.7</td><td></td><td></td></tr>
<tr><td>Arctic, climate change adaptation[2]</td><td rowspan="2">24,589.3</td><td>8,021.2</td><td></td></tr>
<tr><td>Arctic, monitoring</td><td></td><td></td></tr>
<tr><td>Biofuels, fuel cells and nuclear energy</td><td>30,809.5</td><td></td><td>6.0</td></tr>
<tr><td>Other (non-sub-priorities)</td><td>90,189.3</td><td></td><td>2,283.7</td></tr>
<tr><td>Health and Life Sciences</td><td>165,319.1</td><td>221,229.6</td><td>14,304.6</td></tr>
<tr><td>Regenerative medicine</td><td>5,939.8</td><td>73,972.3</td><td>46.4</td></tr>
<tr><td>Neuroscience</td><td>33,392.9</td><td>126,700.7</td><td></td></tr>
<tr><td>Health in an aging population</td><td></td><td>20,556.6</td><td>67.2</td></tr>
<tr><td>Biomedical engineering and medical technologies</td><td>49,339.3</td><td></td><td>884.2</td></tr>
<tr><td>Other (non-sub-priorities)</td><td>76,647.1</td><td></td><td>13,306.8</td></tr>
</table>

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STI Priorities and Sub-Priorities	**NSERC** *($ 000)*	**CIHR** *($ 000)*	**SSHRC** *($ 000)*
Information and Communications Technologies (ICT)	**177,889.7**		**25,118.2**
New media, animation and games	8,255.5		3,809.1
Wireless networks and services[3]	34,674.7		212.3
Broadband networks			
Telecom equipment	21,092.7		
Other (non-sub-priorities)	*113,866.8*		*21,096.8*
Subtotal: Priority Areas	**666,630.9**	**255,539.6**	**63,177.7**
Subtotal: Sub-Priority Areas	255,033.7	255,539.6	5,780.0
Non-Priority Areas	**369,535.1**	**695,190.4**	**276,146.9**
Total Extramural Expenditures	**1,036,166.0**	**950,730.0**	**339,324.6**

1 For NSERC, compilations for Water-Health includes Water-Security.
2 For NSERC, compilations for Arctic-Climate Change Adaptation includes Arctic-Climate Change Monitoring.
3 For NSERC, compilations for Wireless Networks and Services includes Broadband Networks.

Appendix B
Glossary of Terms

ANGEL INVESTOR: A high-net-worth individual active in venture financing, typically participating at an early stage of company growth.

BIBLIOMETRIC IMPACT INDICATORS: A measure of the influence of researchers through counts of citations of publications.

BIBLIOMETRIC INDICATORS: A mathematical and statistical method used to analyze different characteristics of peer-reviewed scientific articles published in international academic journals.

BIBLIOMETRIC QUANTITY INDICATORS: A measure of the productivity of researchers in absolute numbers through number of publications.

BIBLIOMETRIC STRUCTURAL INDICATORS: A measure of collaboration among researchers from different countries through international co-publications.

BUSINESS ENTERPRISE EXPENDITURES ON RESEARCH AND DEVELOPMENT (BERD): Research and development (R&D) activities *performed* by firms, regardless of the origin of funding. This is to be distinguished from business enterprise R&D *funding*, which comprises the total business sector funding of R&D, whether the R&D is performed within industry, the higher education sector, government or other sectors of the economy.

BUSINESS ENTERPRISE EXPENDITURES ON RESEARCH AND DEVELOPMENT (BERD) INTENSITY: The ratio of BERD to a measure of output, usually Gross Domestic Product (GDP). Also referred to as BERD-to-GDP.

BUSINESS ENTERPRISE FUNDING OF R&D: The total business sector *funding* of R&D, whether the R&D is performed within industry, the higher education sector, government or other sectors of the economy. This is to be distinguished from BERD, which covers R&D activities *performed* by firms, regardless of the origin of funding.

CONSTANT PRICES: A common set of prices used to value the output of a firm or an economy in successive periods.

CURRENT PRICES: Measurement of economic magnitudes using the prices actually prevailing at any given time.

DEMAND-PULL KNOWLEDGE TRANSFER: Model of knowledge transfer where universities and other research organizations are solicited by industry to find solutions to production and innovation problems.

EDUCATION, CLASSIFICATION OF LEVELS: The classification of the levels of education is based on the new International Standard Classification of Education (ISCED 2011):

- **UPPER SECONDARY LEVEL:** Students typically expected to have completed nine years of education or lower secondary schooling before entry.
- **UNIVERSITY UNDERGRADUATE AND GRADUATE (MASTER'S) LEVEL:** Refers to programs classified by the OECD as tertiary-type A education, or ISCED 5A. Largely theory-based programs designed to provide sufficient qualifications for entry to advanced research programs and professions with high skill requirements, such as medicine, dentistry or architecture. Duration of these programs is at least three years full-time, though usually four or more years. These programs are not exclusively offered at universities, and not all programs nationally recognised as university programs fulfill the criteria to be classified as tertiary-type A. Tertiary-type A programs include second-degree programs, such as the master's degree.
- **COLLEGE LEVEL:** Refers to programs classified by the OECD has tertiary-type B education, or ISCED 5B. Programs are typically shorter than those of tertiary-type A and focus on practical, technical or occupational skills for direct entry into the labour market, although some theoretical foundations may be covered in the respective programs. They have a minimum duration of two years full-time equivalent at the tertiary level.
- **UNIVERSITY DOCTORAL (ADVANCED RESEARCH) LEVEL:** Refers to programs classified by the OECD as advanced research programs, or ISCED 6. These programs lead directly to the award of an advanced research qualification, often a PhD. The theoretical duration of these programs is three years, full-time, in most countries (for a cumulative total of at least seven years full-time equivalent at the tertiary level), although the actual enrolment time is typically longer. Programs are devoted to advanced study and original research.

GOVERNMENT EXPENDITURES ON INTRAMURAL RESEARCH AND DEVELOPMENT (GOVERD): R&D performed in the government sector.

GROSS DOMESTIC EXPENDITURES ON RESEARCH AND DEVELOPMENT (GERD): Total intramural expenditures on R&D performed on the national territory during a given period.

GROSS DOMESTIC EXPENDITURES ON RESEARCH AND DEVELOPMENT (GERD) INTENSITY: The ratio of GERD to a measure of output, usually GDP. Also referred to as GERD-to-GDP.

GROSS DOMESTIC PRODUCT (GDP): The total value of all final goods and services produced within a country in a given period of time (usually a calendar year). GDP is reported at both current and constant prices.

GROSS VALUE ADDED: The value of output less the value of intermediate consumption. It is a measure of the contribution to GDP made by an individual producer, industry or sector.

HIGHER EDUCATION EXPENDITURES ON RESEARCH AND DEVELOPMENT (HERD): R&D performed in the higher education sector.

HIGHER EDUCATION EXPENDITURES ON RESEARCH AND DEVELOPMENT (HERD) INTENSITY: The ratio of HERD to a measure of output, usually GDP. Also referred to as HERD-to-GDP.

HIGHER EDUCATION SECTOR: Composed of all universities, colleges of technology and other institutes of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of, administered by, or associated with higher education establishments.

HUMAN RESOURCES IN SCIENCE AND TECHNOLOGY (HRST): Persons having graduated at the tertiary level of education in a science and technology (S&T) field or employed in an S&T occupation for which a high qualification is normally required and the innovation potential is high.

INNOVATION: The process by which individuals, companies and organizations develop, master and use new products, designs, processes and business methods. These can be new to them, if not to their sector, their country or the world. The components of innovation include R&D, invention, capital investment and training and development.

INTANGIBLE ASSETS: Assets that do not have a physical or financial embodiment. Intangible assets have also been referred to as knowledge assets or intellectual capital. Much of the focus on intangibles has been on R&D, key personnel and software.

INTELLECTUAL PROPERTY (IP): A legal concept referring to creations of the mind (e.g., discoveries and inventions) for which exclusive rights are recognized for their owners. Common types of intellectual property rights include, *inter alia*, copyright, trademarks and patents.

JOB VACANCY RATE: The number of vacant positions divided by total labour demand—that is, occupied positions plus vacant positions. It corresponds to the share of jobs that are unfilled out of all payroll jobs available.

KNOWLEDGE TRANSFER: The process of transferring scientific knowledge from one organization to another for the purpose of commercialization and/or public benefit. It covers a continuum of activities, involving all sectors and actors of the science, technology and innovation ecosystem, in which knowledge is transferred back and forth between knowledge creators and users who convert knowledge into goods, services or innovation.

LABOUR PRODUCTIVITY: Productivity measures the total amount of goods and services produced in a country for each input to production, such as labour, capital or land. The most common measure of productivity is labour productivity, which measures the amount of goods and services produced by one hour of labour.

LICENCE: Agreement with a client to use the institution's intellectual property for a fee or other consideration, such as equity in a company.

MACHINERY AND EQUIPMENT (M&E): Consists of transport equipment and other M&E other than that acquired by households for final consumption.

MARKET CAPITALIZATION: The share price times the number of shares outstanding. Also known as market value.

MULTIFACTOR PRODUCTIVITY (MFP): Productivity measures the total amount of goods and services produced in a country for each input to production, such as labour, capital or land. Multifactor productivity (MFP) measures the efficiency with which the combined inputs of capital and labour are used in the production process. MFP captures such factors as improvements in technology, economies of scale, capacity utilization and managerial skills.

NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM (NAICS): A system of classification for industries based upon their primary economic activity. The governments of Canada, Mexico, and the United States developed the NAICS Manual, which became effective January 1997.

OPTION: Right to negotiate for a licence.

PERMANENT RESIDENT: An individual who has immigrated to Canada but has not yet become a Canadian citizen. A permanent resident has rights and privileges in Canada even though he/she remains a citizen of the home country. In order to maintain permanent resident status, an individual must fulfill specified residency obligations.

PRODUCTIVITY: Measures the total amount of goods and services produced in a country for each input to production, such as labour, capital or land.

RESEARCH AND DEVELOPMENT (R&D): The OECD's *Frascati Manual* (2002) defines R&D to encompass three activities: "'Basic research' is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. 'Applied research' is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. 'Experimental development' is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed."[202]

SUPPLY-PUSH KNOWLEDGE TRANSFER: Model of knowledge transfer where higher education institutions transfer academic inventions to existing firms or to new ventures via the licensing or spinoff of intellectual property.

TRADEMARK: Words, symbols or other marks that are used by firms to distinguish their products or services from those offered by others.

VENTURE CAPITAL (VC): A specialized form of private equity, characterized chiefly by high-risk investment in new or young companies following a growth path in technology and other value-added sectors.

WORK-INTEGRATED LEARNING (WIL): Student employment experiences that add practical employment-based experience to classroom learning or programs of study.

202 OECD *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, Paris (2002), p. 30.

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