State of the Nation 2014

Canada's Science, Technology and Innovation System

Canada's Innovation Challenges and Opportunities

Science, Technology and Innovation Council

Advisory Council to the Government of Canada

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State of the Nation 2014
Canada's Science, Technology and Innovation System: Canada's Innovation Challenges and Opportunities

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Science, Technology and Innovation Council: Mandate and Members

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 (ST&I). The Council has a dual mandate: to provide the government with confidential advice on ST&I policy issues critical to Canada's economic development and societal well-being; and to produce regular public reports — *State of the Nation* — measuring Canada's ST&I performance against international standards of excellence.

The Council would like to extend its sincere thanks to Howard Alper, Past Chair, and to Harvey Weingarten, President and CEO of the Higher Education Quality Council of Ontario, for their invaluable contributions to this report.

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CONTENTS

EXECUTIVE SUMMARY

Snapshot

Science, technology and innovation (ST&I) drive economic prosperity and fuel advances that improve societal well-being. A sustainable competitive advantage in ST&I is the path to success in the global knowledge-based economy.

Despite ongoing efforts to improve Canada's lagging business innovation performance, it has continued to deteriorate. Canada has fallen further behind its global competitors on key performance indicators, reflected most tellingly in private-sector investment in research and development (R&D). Canada's business enterprise expenditures on R&D (BERD) intensity (i.e., BERD as a share of gross domestic product) dropped further between 2006 and 2013, to the point where Canada ranked 26th among international competitors and sat at 36 percent of the threshold of the top five performing countries. Canada's most profound and urgent ST&I challenge lies in increasing the number of firms that embrace and effectively manage innovation as a competitiveness and growth strategy.

Canada maintains a solid foundation in the quality of knowledge production and its educated population. However, we cannot be complacent. Maintaining and enhancing excellence requires that our investments keep pace with those of competitor countries.

Responsibility for reversing Canada's poor business innovation performance and growing its knowledge and talent advantages rests with all players in the ST&I ecosystem — working together, working differently, in a "systems" approach characterized by collaboration, integration and strategic investment. To address Canada's ST&I performance challenges and build on our strengths, the Science, Technology and Innovation Council recommends that Canada:

- close the gap on firms' investment in innovation;
- redress the imbalance of direct and indirect government funding for business R&D, to provide greater direct support for high-risk, high-reward business R&D;
- embrace risk and ambition;
- boost higher education expenditures on R&D to keep pace with other countries' support for "intellectual infrastructure"; and
- invest strategically, further focusing government funds to build globally competitive critical mass in targeted areas.

Science, technology and innovation (ST&I) excellence is critical to Canada's wealth and well-being. Through ST&I, firms enhance their productivity and competitiveness, and transform ideas and inventions into new goods and services that power markets. With increased profitability through innovation, firms create more high-value jobs for Canadians and contribute to increased national wealth. At the same time, advances in ST&I drive solutions to society's perennial challenges, whether related to health care, the environment, hunger or poverty.

The Government of Canada mandated the Science, Technology and Innovation Council (STIC) to regularly assess and report on Canada's ST&I performance against competitor countries. In this fourth *State of the Nation* report, STIC builds on its work since the baseline 2008 report to analyze Canada's ST&I performance and progress. Most importantly, *State of the Nation 2014* addresses the way forward to position Canada as a world leader in ST&I.

As in previous *State of the Nation* reports, *State of the Nation 2014* is structured around the understanding that a robust and vibrant ST&I ecosystem is built on three pillars: i) skilled and creative talent, ii) high-quality knowledge, and iii) an innovative private sector. Talented people generate and enhance knowledge. An innovative private sector converts knowledge into new products and processes that generate wealth. *State of the Nation 2014* assesses Canada's ST&I performance by examining the components that drive success and define leadership in each of these three pillars. For each component, internationally accepted indicators are used to compare Canada's performance with that of competitor countries. Following the practice introduced in *State of the Nation 2012*, the analysis notes the world's top five performing countries on each indicator and the threshold that Canada must reach to break into their ranks.

The Performance Story

The central conclusion of the *State of the Nation 2014* analysis is disturbing: despite efforts to improve Canada's lagging business innovation performance, it has continued to deteriorate. Canada has fallen further behind comparator countries on key business innovation performance indicators, and the gap between Canada and the world's top five performers has widened.

An innovative private sector is underpinned by investments in research and development (R&D) and other knowledge assets, including talent and information and communications technologies (ICT). Canada's private sector is not investing in these assets at a globally competitive level. Of particular concern, with business investment in R&D dropping, Canada's business enterprise expenditures on R&D (BERD) intensity (i.e., BERD as a share of gross domestic product (GDP)) fell between 2006 and 2013, to the point where Canada ranked 26th among international competitors and sat at only 36 percent of the threshold of the top five performers. In addition, Canada was in the middle of the pack in ICT investment intensity (i.e., ICT investment as a share of GDP). In parallel, private sector take-up of ST&I talent was weak, with Canada ranking 15th in 2012 and positioned at 66 percent of the top five threshold in terms of researchers in industry. This was a substantial drop from seventh position in 2006.

On a positive note, data suggest that Canada's small and medium-sized enterprises (SMEs) were at the forefront internationally in introducing product and process innovations, positioning Canada fourth on this measure. In contrast, our large companies lagged global competitors, resulting in Canada's 19th position in this ranking. Finally, Canada continued to be out of step with its international competitors in the balance between direct and indirect government support for business R&D.

While business innovation lagged, Canada maintained a solid knowledge and talent foundation. Canada continued to exhibit strength in the quality of knowledge production: our universities were competitive in a second tier of countries in the global rankings; we enjoyed real "star power" in hosting leading researchers; and we continued to perform above the world average on research citation counts (relative impact index).

Canada's talent base also continued to be an asset: in 2012, we led the Organisation for Economic Co-operation and Development in the proportion of the population with a post-secondary education (due significantly to the role of colleges in Canada's education system). Although our Programme for International Student Assessment rankings slipped marginally, Canadian 15-year-olds continued to perform well in reading, math and science. In 2013, Canadian adults scored just shy of the top five threshold in literacy, numeracy and problem solving in technology-rich environments. While still underperforming competitors, Canada doubled the number of doctoral degrees granted in science and engineering (per 100,000 population) between 2006 and 2012, moving from 19th to 17th position in international rankings. Climbing from 41 percent to 69 percent of the threshold of the top five performers, this was a notable improvement in Canada's performance on this indicator.

On R&D funding indicators, however, Canada's relative ranking (i.e., its competitiveness) showed signs of erosion. Canada's total funding of R&D activities (i.e., gross domestic expenditures on R&D (GERD)) remained essentially unchanged between 2008 and 2014, while other countries increased their funding. Canada's global ranking on GERD intensity (i.e., GERD as a share of GDP) fell from 16^{th} in 2006 to 24^{th} in 2013. Although Canada's higher education expenditures on R&D (HERD) increased over time, its competitiveness on HERD intensity (i.e., HERD as a share of GDP) declined, from third position in 2006 to eighth in 2013, as other countries increased their spending more.

The Way Forward

Addressing Canada's business innovation performance gap is critical to this country's future. Canada must increase the number of firms that embrace and effectively manage innovation as a competitiveness and growth strategy. At the same time, Canada cannot afford to be complacent about its knowledge and talent advantages. Canada must keep pace with other countries that have been increasing their support for R&D at a faster rate.

All ST&I players share responsibility to reverse Canada's poor business innovation performance and grow its knowledge and talent advantages. While success requires that all players pursue excellence in their respective roles, at the same time all players must work more closely together, as a "system," to effect change.

To address Canada's ST&I performance challenges and build on our strengths, the Science, Technology and Innovation Council recommends that Canada:

Close the gap on firms' investment in innovation

It is business enterprise expenditures on R&D that is most closely linked to product and process innovation; thus it is critical that Canada's private sector significantly increase its investment in this area. A large natural resources industry is not an obstacle to achieving a higher BERD intensity. In fact, given the strategic importance of Canada's natural resources industry, this should be an area of ST&I leadership for Canada. Increased R&D investment must be accompanied by enhanced investments in other knowledge assets, especially talent and ICT.

Redress the imbalance of direct and indirect government funding for business R&D

Governments play an important role in supporting and incenting business innovation. While both direct and indirect R&D support are important, data show that Canada relies far more on indirect support than other countries. Governments in Canada should redress this imbalance, to provide more direct support for high-risk, high-reward business R&D, especially in industries of economic significance to Canada. The approach should be strategic, focused on fostering innovation in large firms and in high-growth SMEs with the potential to grow into significant players. Canada must increase the number of large, innovative firms to enhance future competitiveness and job growth, as larger firms are often more productive and tend to invest and to export more than smaller firms.

Embrace risk and ambition

Adopting innovation as a competitiveness and growth strategy demands that firms become less averse to risk and more ambitious. Canada's venture capital industry can support this by more aggressively backing high-potential Canadian firms with innovative ideas and mentoring them through the innovation process. For governments to effectively support business innovation, they must be more innovative themselves, particularly in their procurement practices, where a culture of intelligent risk taking could help stimulate product and process innovation in firms. Educational institutions, for their part, should work more closely with industry to develop curricula that better integrate science and technology knowledge with a broader set of business, entrepreneurship and commercialization skills and that nurture creativity, intelligent risk taking and ambition.

Boost HERD investment levels

Investments in R&D and talent in the higher education sector help build a strong knowledge foundation for all sectors of Canada's ST&I ecosystem. Although federal and provincial funding levels for HERD have continued to increase, growth has not been sufficient to keep pace with other countries that are committing more resources at a faster rate. Our governments must renew their commitment to investing in the "intellectual infrastructure" required to keep Canada competitive in the knowledge-based economy.

Invest strategically

Enhancing Canada's ST&I performance requires investing *differently*, in a more strategic and coherent way to maximize the impact of investments across the ST&I ecosystem. This means targeting investments to build globally competitive scale and capacity in key areas of strength and opportunity. This also means integrating organizations, activities and funding mechanisms across the ST&I ecosystem. Each government in Canada should ensure that its innovation support programs are designed to reinforce and build upon one another, while also enabling and compelling collaboration across the innovation ecosystem. Each higher education institution should plan strategically across its institution, using government programs to expand capacity in areas where it can make a substantial difference.

Conclusions

A robust and vibrant ST&I ecosystem is critical to Canada's economic prosperity and high quality of life. Canada's weak business innovation performance threatens our global competitiveness. Our knowledge and talent foundation continues to be solid, but our investments to maintain these assets are slipping. All ST&I players share responsibility to reverse Canada's poor business innovation performance and grow its knowledge and talent advantages. Effecting change is demanding and complicated; but the need is urgent and compelling. Only with concerted action can Canada achieve the ST&I success needed to secure our future. STIC believes that Canada must, and can, rise to the challenge.

CHAPTER 1: SETTING THE STAGE

1

Canadians' high quality of life depends on remaining competitive in the global knowledge-based economy. In a world where knowledge and technology, and their creative application, drive competitiveness, this demands a robust and vibrant science, technology and innovation (ST&I) ecosystem. The role of ST&I in our economy is direct and profound. Through ST&I, firms develop and implement new processes that lead to increased productivity and competitiveness, and they transform ideas and inventions into new goods and services that power markets. With increased profitability through ST&I, firms create more high-value jobs for Canadians and contribute to increased national wealth that supports public investments in education, health, infrastructure and social programs.

ST&I also directly and profoundly affect Canadians' broader well-being. In health care, for example, new and improved diagnostic techniques, therapies and medicines help combat chronic and infectious diseases and enhance preventative medicine. Advances in environmental technologies empower us to protect our planet, while allowing for responsible exploitation of natural resources. New agricultural techniques improve crop yield while introducing sustainable practices, and new understanding of the root causes of poverty help improve living standards.

Given the critical importance of ST&I to Canadians' wealth and well-being, the Government of Canada mandated the Science, Technology and Innovation Council (STIC) to regularly assess and report on Canada's ST&I performance against competitor countries. In this fourth *State of the Nation* report, STIC builds on its work since the baseline 2008 report to analyze Canada's ST&I performance and progress in business innovation, knowledge and talent.

The central conclusion of this *State of the Nation 2014* analysis is disturbing: despite efforts to improve Canada's lagging business innovation performance, it has continued to deteriorate. Canada is falling further behind comparator countries on key business innovation performance measures, and the gap between Canada and the world's top five performing countries is widening. Addressing this performance gap is critical to Canada's future.

At the same time, Canada continues to have a solid ST&I foundation: *State of the Nation 2014* reveals that our educated population and the quality of knowledge production continue to be assets. However, we cannot be complacent. Maintaining and enhancing excellence requires investment. Although federal and provincial higher education expenditures on research and development (HERD) have continued to increase, growth has not been sufficient to keep pace with other countries that are committing more resources faster.

With rapid change and escalating pressures in the global environment, ST&I competitiveness assumes increasing importance. Canada remains vulnerable to global economic disruptions, such as appreciable changes in the price of commodities such as oil, fluctuations in the value of our dollar and decreased demand in export markets. This vulnerability is intensified by increasing competition, with the rise of emerging economies, increasing mobility of talented people chasing the best opportunities, and more sophisticated consumer expectations and demands. The pace of change is unprecedented, reflected most dramatically in disruptive technologies and innovations that transform industries and societies. There is growing global demand for natural resources, from oil to fresh water, and increasing urgency to address the environmental challenges associated with resource extraction.

The Science, Technology and Innovation Ecosystem

A robust and vibrant ST&I ecosystem is built upon three pillars: i) skilled and creative talent, ii) high-quality knowledge and iii) an innovative private sector. Talented people generate and enhance knowledge. An innovative private sector converts knowledge into new products and processes that generate wealth. Governments can play a key role in creating a supportive environment for these pillars and incenting innovation across the economy. It is critical, therefore, that governments themselves be innovative.

Canada's ST&I ecosystem consists of multiple stakeholders, including governments; universities, polytechnics and colleges; firms; non-governmental organizations; communities and individuals. Each player pursues its role while connecting with other actors in a complex, dynamic and interdependent web of competition and collaboration through which knowledge is developed, shared, transferred and applied. The vitality of Canada's ST&I ecosystem is determined by the strength of both its pillars and its players. A healthy ecosystem encourages ideas to thrive, creative people to start innovative firms and existing firms to grow through innovation.

The most active participants in Canada's ST&I ecosystem are the federal and provincial governments, higher education institutions (HEIs) and the private sector.

Federal and Provincial Governments

The federal and provincial governments make significant investments in talent, knowledge and business innovation. The Government of Canada provides substantial funding for universities, polytechnics and colleges to support research projects, associated infrastructure, development of talent and creation of collaborative research and development (R&D) networks. Provincial governments, by funding the operating costs of Canada's HEIs, contribute to the overhead costs associated with research. They also support the direct costs of research and talent through various funding programs. In addition, through direct funding and tax incentives, the federal and provincial governments support R&D, uptake of talent, and commercialization activities in firms and intermediaries.

Governments also help nurture an environment conducive to innovation through policies targeted not only at ST&I specifically but at broader framework conditions. These policies cover numerous areas particularly relevant to business innovation, from competition to foreign investment, trade, immigration, labour mobility, corporate taxation and intellectual property rights.

A healthy ecosystem encourages ideas to thrive, creative people to start innovative firms and existing firms to grow through innovation.

The federal government also conducts its own R&D, oriented largely to supporting policy and regulatory functions and advancing discoveries in areas in which the private sector may not be engaged. The R&D mandates of science-based departments and agencies have been evolving, as demonstrated most visibly in the National Research Council Canada (NRC). In an effort to support business innovation, the NRC has turned to more commercially and industrially oriented R&D and related services.

Higher Education Institutions

At the heart of the innovation process are talented people who generate and enhance knowledge. They are educated and trained at universities, polytechnics and colleges, which provide the disciplinary and technical knowledge underpinning research and innovation, and the business, entrepreneurial and other skills that prepare students to be productive members of the labour force and society.

These higher education institutions also play a vital role in developing and advancing knowledge and its application. R&D has historically been a critical part of universities' mandates, and it has recently taken on more importance in polytechnics and colleges. Much of the knowledge underlying today's innovation has stemmed from research conducted in HEIs.

Although distinctions are becoming increasingly blurred, universities continue to perform a range of R&D and innovation activities from basic to applied research. Firms that partner with universities are often seeking longer term, strategic relationships to identify new, cutting-edge inventions and technologies for the future. In particular, firms are looking for access to potential future employees who can give them an edge over the competition. Polytechnics and colleges tend to engage more in applied research and experimental development through, for example, field and laboratory testing, prototype development and scale-up. Firms look to polytechnics and colleges for small, well-defined projects with short timelines and immediate relevance to product and process improvements.

Canada's HEIs also help connect us to the global pool of knowledge, technology and talent through collaborative research with international partners and attraction of world-class researchers and innovators.

Private Sector

In the private sector, firms contribute to the advancement of knowledge by conducting their own R&D and by funding research and associated infrastructure in other organizations (notably HEIs). Most critically, firms and entrepreneurs translate the discoveries and inventions that emerge from R&D (whether their own or others') into marketable goods and services that generate wealth. They also innovate to develop and implement new processes and organizational and business practices that enhance productivity, and new marketing methods that improve access to markets.

The private sector also plays a vital role in realizing the value of Canada's talent, providing opportunities for highly skilled personnel to unleash their potential. Firms develop and hone the knowledge and skills of their employees by providing them with on-the-job experience, training and learning opportunities. They help prepare students for the labour force by providing them with hands-on experience and a window on the business world through internships and co-operative education programs. Through R&D collaborations with universities, polytechnics and colleges, firms also enhance the business savvy of research faculty.

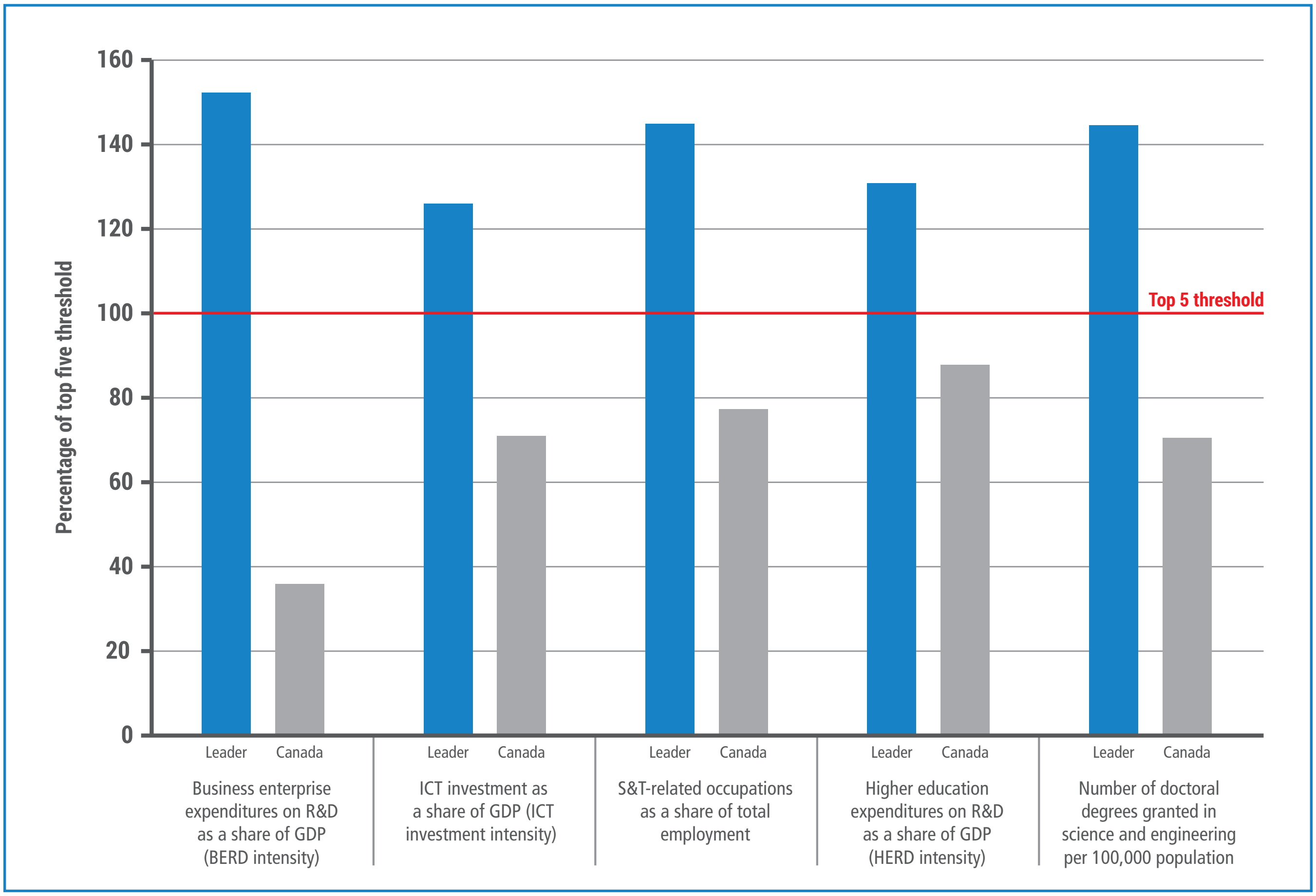
Benchmarking Canada's Performance

State of the Nation 2014 assesses Canada's ST&I performance by examining the components that drive success and define leadership in each of the three pillars: an innovative private sector, high-quality knowledge and talented people. For each component, internationally accepted indicators are used to compare Canada's performance with that of competitor countries analyzed by the Organisation for Economic Co-operation and Development. Following the practice introduced in *State of the Nation 2012*, the analysis notes the world's top five performing countries on each indicator and the threshold that Canada must reach to break into their ranks. It also looks at Canada's position relative to that of the United States, our closest partner and biggest competitor. For some of the components, as noted throughout the report, a lack of reliable data, both Canadian and international, constrains our ability to report on performance in a meaningful way. (See Annex 1 for STIC's definition of innovation and methodological notes.)

State of the Nation 2014 highlights Canada's performance on five "aspirational" indicators identified in *State of the Nation 2012* (Figure 1-1). It is in these specific areas that STIC believes Canada should aspire to join the ranks of the world's leading countries — areas where improved performance would have the most appreciable impact on harnessing ST&I for economic and societal benefits. The five indicators are found across the three pillars of Canada's ST&I ecosystem. Each indicator measures the intensity of Canada's investment, thereby allowing comparisons with competitor countries.

Given the urgency of the business innovation challenge, the analysis of Canada's performance begins, in Chapter 2, with an examination of the components that drive an innovative private sector. This is followed by an analysis of knowledge development and transfer in Chapter 3 and talent development in Chapter 4.

Figure 1-1: Aspirational Indicators



Finally, and most importantly, Chapter 5 addresses the way forward. All ST&I players share responsibility to reverse Canada's poor business innovation performance and grow its knowledge and talent advantages. STIC identifies five key strategies to drive enhanced ST&I performance. While success requires that all players pursue excellence in their respective roles, at the same time all players must work more closely together, as a "system," to effect change. Only with concerted action on these five strategies can Canada achieve the ST&I success and leadership needed to secure our future prosperity and well-being.

CHAPTER 2: AN INNOVATIVE PRIVATE SECTOR

2

An innovative private sector is critical to harnessing Canada's investments in knowledge and talent, and translating them into productivity gains and marketable products that bring prosperity and a high standard of living to Canadians.

To assess Canada's business innovation performance, three components that drive success and define leadership are examined:

- private-sector investment in innovation, as demonstrated through aspirational indicators related to investment in:
  - research and development (R&D);
  - information and communications technologies (ICT); and
  - talent;
- the funding environment for business innovation, including both government and venture capital funding; and
- introduction of product and process innovations.

The chapter concludes by considering the impact of Canada's business innovation performance on its global competitiveness.

Key Findings

- Canada invested significantly less in business research and development (R&D) as a share of gross domestic product (GDP) than many other advanced economies, falling from 18th position in 2006 to 26th in 2013.
- Canada was in the middle of the pack in information and communications technologies investment intensity, ranking 13th out of 30 countries in 2013.
- Canada performed poorly in absorbing science, technology and innovation talent into the labour force, ranking 22nd out of 43 countries in science and technology-related occupations throughout the economy.
- In 2013, Canada ranked 10th in government funding of business R&D (as a share of GDP). Its 4th-place ranking in indirect funding and 28th in direct funding reflected the federal government's greater reliance on indirect funding mechanisms.
- Low investment in business innovation hurt Canada's global competitiveness, as demonstrated by lower productivity growth.

Business Investment in Research and Development and Other Knowledge Assets

Business innovation is essential to extract value from knowledge. It requires committed investments in R&D, ICT and talent, as well as downstream investments in areas such as advanced design, intellectual property, and mineral exploration and development. A lack of reliable, internationally comparable data limits the ability to assess private-sector performance in these downstream activities. However, available data on innovation investments show that Canada's private sector is not investing in R&D and other knowledge assets at a globally competitive level. This is particularly concerning given that the higher Canadian dollar and low interest rates[1] over the past several years favoured increased investment by firms in Canada.

The decline in Canada's BERD intensity between 2006 and 2013 was among the most significant of advanced economies.

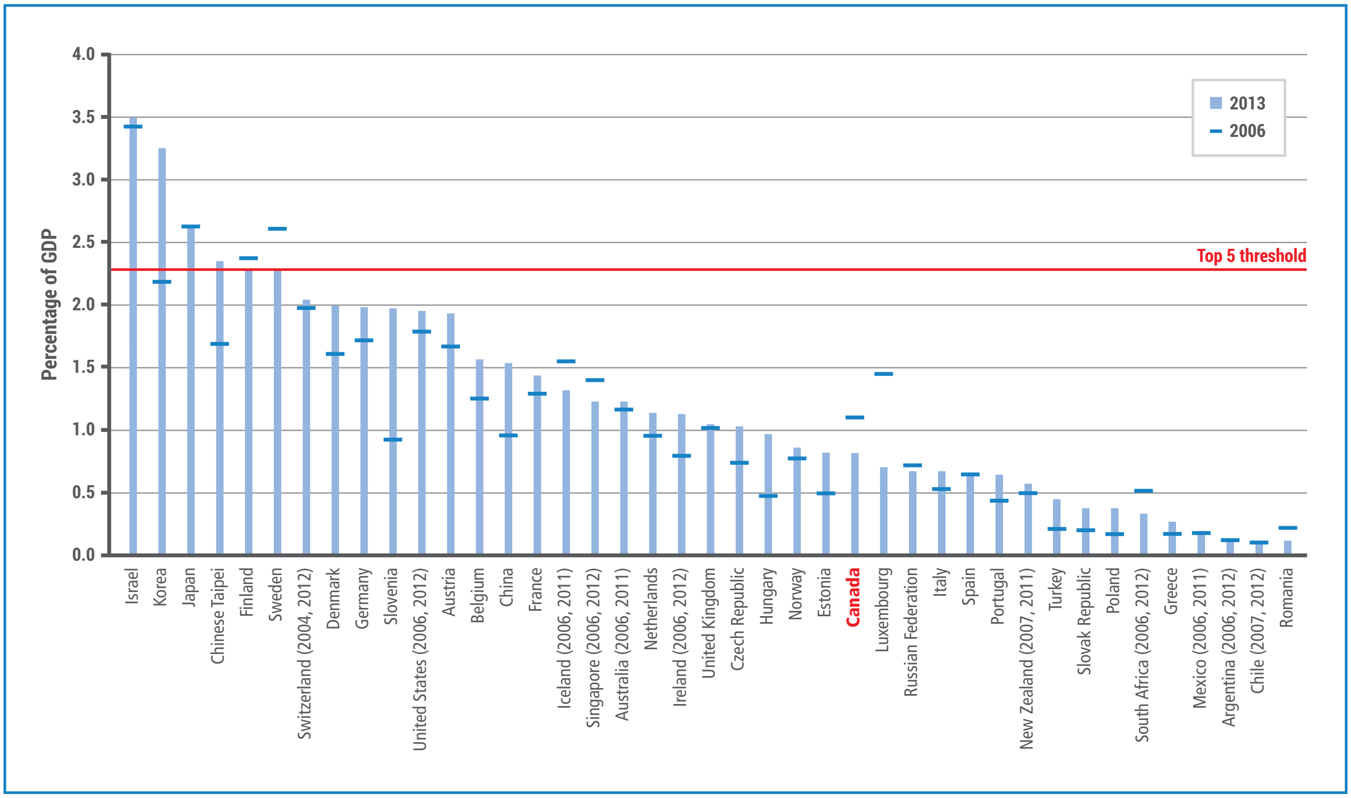
Business Investment in Research and Development

Business enterprise expenditures on research and development (BERD) intensity (i.e., BERD as a share of gross domestic product (GDP)) is an important gauge of business investment in innovation. On this aspirational indicator, Canada's performance has declined markedly against that of key competitor countries since the Science, Technology and Innovation Council (STIC) started tracking it in *State of the Nation 2008*. In contrast, most countries increased their investments over the period. As a result, many improved their BERD intensity and overtook Canada in the international ranking.

The decline in Canada's BERD intensity between 2006 and 2013 was among the most significant of advanced economies (Figure 2-1). As a result, Canada fell from 18th position in 2006 to 26th in 2013 (of 41 countries). At 0.82 percent, Canada's BERD intensity in 2013 was less than half that of 11th place United States (U.S.) (1.96 percent). Canada performed at only 36 percent (down from 48 percent in 2006) of the level needed to break into the ranks of the top five performers, Israel, Korea, Japan, Chinese Taipei and Finland, all of which are widely regarded as global innovation leaders.

[1] Malick Souare and Weimin Wang, "R&D Spending and M&E Investment in Canadian Manufacturing Industries," *Industry Canada, Economic Research and Policy Analysis Branch*, Working Paper 2009-02.

Figure 2-1: BERD as a Percentage of GDP, 2006 and 2013



Source: OECD, *Main Science and Technology Indicators*, January 2015.

International comparison of business research and development intensity by industry

Industry-level data reveal those areas where Canada's challenge is particularly acute. In 2009 (the most recent year for which data are available), Canadian industries such as computer, electronic and optical products, ICT, and coke and refined petroleum products had an investment intensity (measured here as BERD as a share of value added) above, or near, the level of their peers abroad. Other industries, however, had BERD intensities below those of their peers, including industries that typically have a high BERD intensity globally, such as pharmaceuticals, electrical equipment and motor vehicles. Canada performed at only 38 percent of the U.S. intensity for total manufacturing industries and 35 percent of the intensity of a group of other countries for which Organisation for Economic Co-operation and Development (OECD) data are available.[2]

Some observers attribute Canada's low overall BERD intensity to the relatively large size of its natural resources industry — an industry that tends to have a low BERD intensity across all countries. Most countries that rank ahead of Canada in BERD intensity have considerably smaller natural resources industries (i.e., natural resources rents as a share of GDP). However, of those countries with a BERD intensity similar to or greater than that of Canada, Australia, China and Norway have larger natural resources industries (as a share of GDP).[3] This suggests that a large natural resources industry is not necessarily an obstacle to achieving a higher BERD intensity.

2 STIC calculations based upon data from Statistics Canada and the OECD Structural Analysis Database using the International Standard Industrial Classification of All Economic Activities (ISIC) Revision 4. Other economies with data available through the OECD are Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Korea, Netherlands, Norway, Slovenia and Sweden.

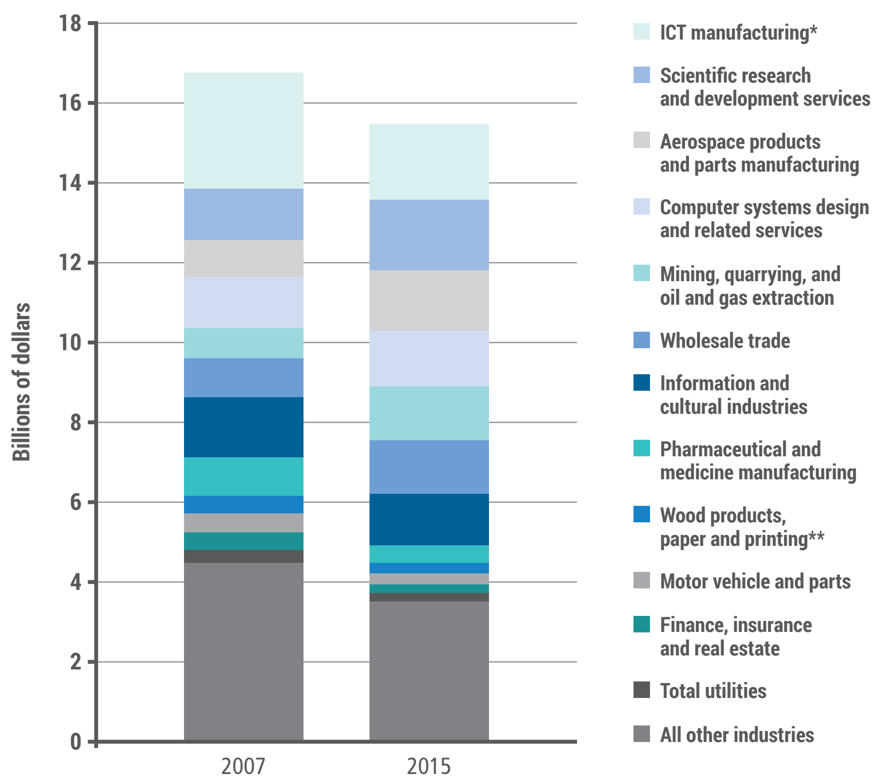
3 World Bank, *Total Natural Resources Rents (% of GDP)*, 2014.

Characteristics of business research and development in Canada

Statistics Canada data provide a more detailed and timely picture of the state of business R&D in Canada, showing a wide variation in R&D expenditures and trends across industries. From 2007 to 2015, Canada's overall business investment in R&D dropped by over $1 billion (see Annex 2 for information on Canada's BERD performance since 2000),[4] with substantial declines in a number of key industries (Figure 2-2). In particular, business R&D investment fell by 55 percent in pharmaceuticals and medicine manufacturing; 50 percent in motor vehicles and parts; 48 percent in finance, insurance and real estate; 36 percent in ICT manufacturing; and 14 percent in information and cultural industries.

Conversely, over the same period, business R&D investment increased by 63 percent in aerospace products and parts manufacturing, 41 percent in scientific R&D services and 38 percent in wholesale trade. While the mining, quarrying, and oil and gas extraction industry has typically had a relatively low R&D intensity, R&D investments in the industry increased by 74 percent from 2007 to 2015. Over the past 16 years, R&D investment in the oil and gas extraction industry rose dramatically, increasing almost fourteen fold from 1999 to 2015.[5]

Figure 2-2: BERD by Industry in Canada, 2007 and 2015



*Within ICT manufacturing, STIC includes NAICS 3341-3346.
**Within wood products, paper and printing, STIC includes NAICS 321-323.

Source: Statistics Canada, *Table 358-0024* (accessed July 16, 2015).

4 2007, rather than 2006, is used as the baseline year for this indicator because industry-level data for the aerospace industry are suppressed for 2006.

5 Statistics Canada, *Industrial Research and Development: Intentions 2015*, Catalogue no. 88-202-X.

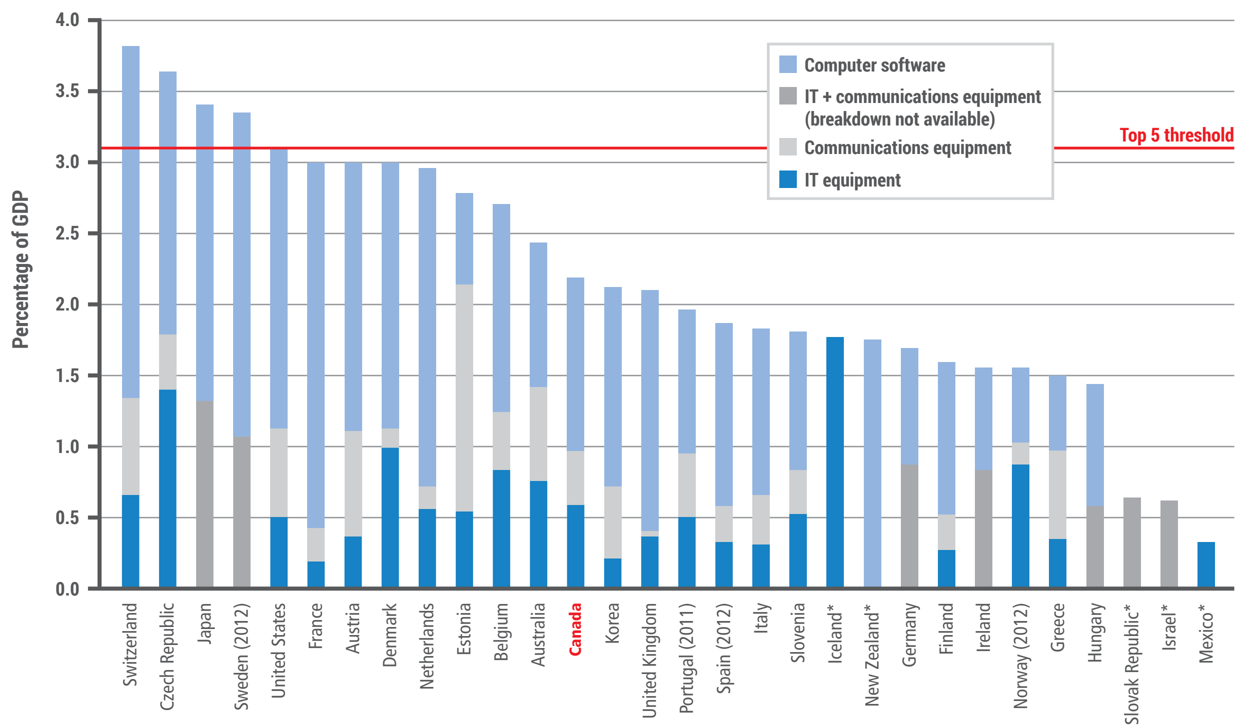
Investment in Information and Communications Technologies

Investment in machinery and equipment embodying new technologies, especially ICT, is critical to driving innovation and enhancing employees' skills, thereby contributing to firms' productivity and competitiveness.

Within the business sector, Canada's ICT investment per worker in 2013 was 51 percent of that in the U.S.[6] Historically, Canada invests less than the U.S. on this measure. Differences in industry structure may account for a meaningful share of the Canada–U.S. ICT investment gap as Canada specializes more in industries that are generally less ICT-intensive in both countries, such as mining, oil and gas.[7]

On the broader aspirational indicator of ICT investment intensity across the economy (the ratio of ICT investment to GDP; Figure 2-3), Canada ranked 13th out of 30 countries in 2013. Occupying this middle tier, Canada's investment intensity was 71 percent of that of the top five performers — Switzerland, the Czech Republic, Japan, Sweden and the U.S.[8] That said, Canada's ICT investment intensity was on par with that of France, and higher than that of Finland and Germany.

Figure 2-3: ICT Investment as a Percentage of GDP, 2013



*Note: Data for Iceland, Israel, Mexico, New Zealand and the Slovak Republic were incomplete and only represent the asset for which data were available.

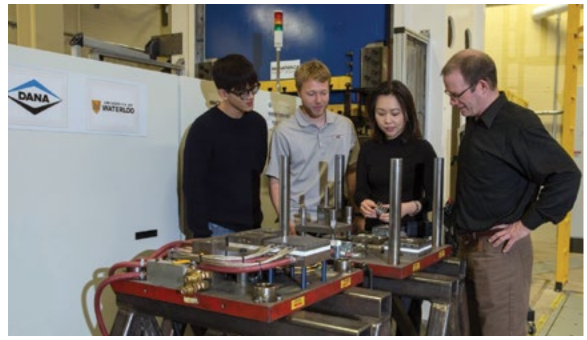
Source: OECD, *Science, Technology and Industry Scoreboard*, 2015.

6 Centre for the Study of Living Standards, *Database of Information and Communication Technology (ICT) Investment and Capital Stock Trends: Canada vs United States*, January 2014.

7 Statistics Canada, "Study: Investment Intensity in Canada and the United States, 1990 to 2011," *The Daily*, October 21, 2014.

8 An international comparison of ICT as a share of GDP over time is not possible due to a lack of longitudinal data on this measure.

Next-Generation Automotive Lightweight Materials



Dr. Sooky Winkler, Dana Canada, discusses tooling development with University of Waterloo team members Kyu Bin Han, Ryan George and Dr. Michael Worswick (left to right) in front of the warm-forming pilot line.

Market factors, such as higher fuel economy and emission standards, are driving automotive suppliers to build parts that are thinner, lighter and stronger to remain competitive in the global economy. In response, Dana Canada Corporation and the University of Waterloo are collaborating on development, assessment and commercialization of next-generation, lightweight, thermal-management systems.

The primary business of Dana, an auto parts company based in Oakville, Ontario, involves developing and manufacturing heat exchangers for car and light-truck applications in engine, transmission, battery, fuel and power-steering cooling systems. Aluminum alloys are attractive engineering materials because of their light weight and corrosion-resistant properties. However, aluminum alloys have limitations when producing thin-gauged, complex shapes using conventional methods. Forming aluminum at increased temperatures is one way to improve formability. With the support of the Natural Sciences and Engineering Research Council of Canada and Automotive Partnership Canada, Dana is working with the University of Waterloo to develop warm-forming technology.

In Phase 1, the strong commercialization potential of warm forming was demonstrated on a laboratory bench scale. Phase 2 focuses on developing and realizing commercial-scale capability of warm-forming technology for application in Dana's manufacturing system. A pilot manufacturing line developed at the university will demonstrate its feasibility under production-simulated conditions. Additional mechanical testing and residual stress analysis will be carried out at CanmetMATERIALS' technology laboratory in Hamilton, Ontario, which is also home to a unique pilot-scale metal-forming laboratory. "At the end of three years, we will have the computer modelling and process worked out to implement this technology in full production," says Dr. Michael Worswick, lead researcher on the project at the University of Waterloo. "I'm not aware of any university in North America doing such work at this scale."

Business Investment in Talent

Talent plays a key role in business innovation, and the importance of talent begins at the top of the organization. To succeed in the modern global economy, firms need leaders who understand the importance of innovation to competitiveness. With the right knowledge and the right skills, business leaders in Canada can have a better understanding of leading-edge technologies and business practice developments, and they can be more comfortable adopting these developments — and thus more likely to choose innovation-based business strategies that drive their competitiveness.

Senior managers influence a firm's innovation culture by shaping its vision and values. Innovative firms require individuals across all areas of the organization who can actively and effectively manage innovation. Conference Board of Canada research suggests that, on a variety of financial measures, firms in Canada that actively manage innovation outperform those with no innovation management.[9] Yet almost half of surveyed firms had no formal innovation management process.[10]

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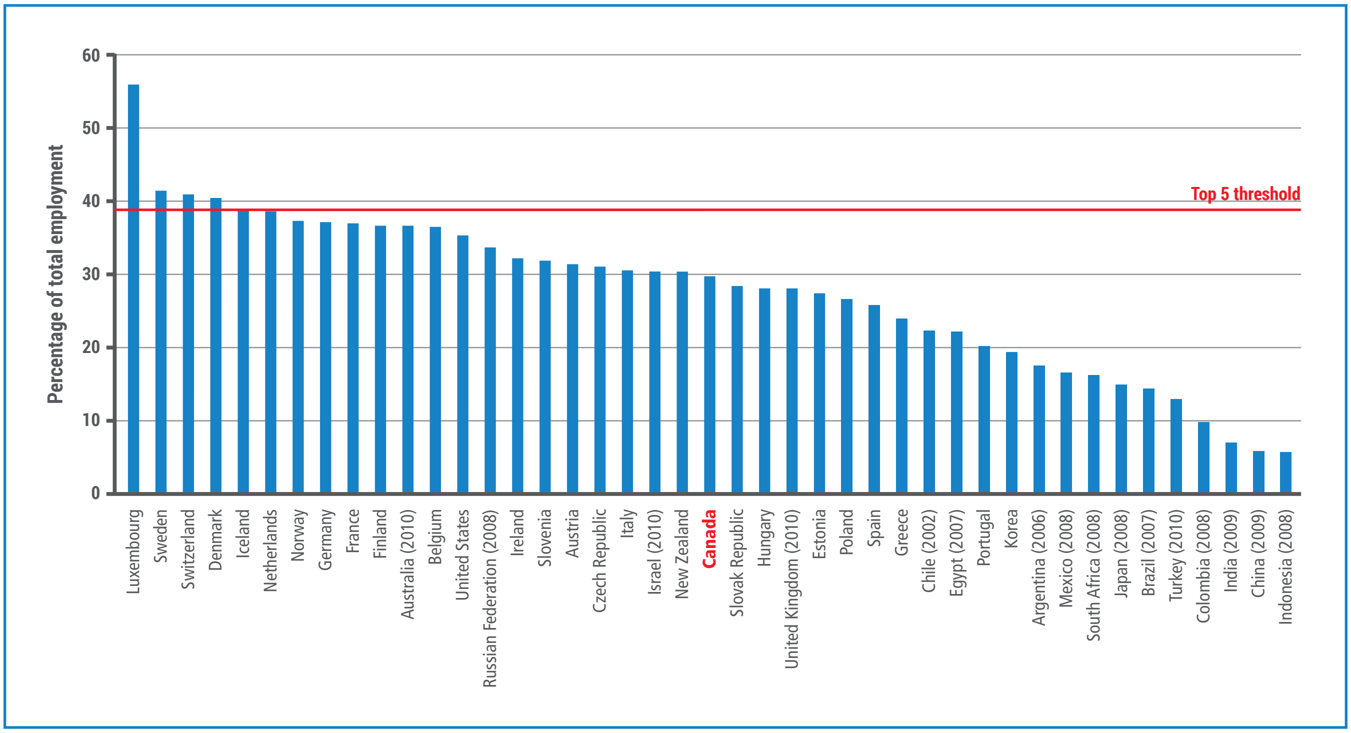
9 These measures include a five-year compound annual growth rate; growth in earnings before interest, taxes, depreciation and amortization; and market capitalization growth (for public companies).

10 Sorin Cohn and Bruce Good, "Metrics for Firm-Level Business Innovation in Canada," *The Conference Board of Canada*, December 2013.

Figure 2-4: Science and Technology-Related Occupations as a Percentage of Total Employment, 2011



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

Firms also need advanced research talent (including PhD graduates) to conceive and create new knowledge, products and processes through R&D and other innovation activities, and to make effective use of ICT to improve productivity. While Canada has made significant progress in growing the number of PhD graduates in science and engineering (as noted in Chapter 4), we have not made the same progress in effectively absorbing advanced research talent into the private sector.

In 2012, the number of business enterprise researchers per thousand employment in Canada was 6.6, down from 6.9 in 2006. This helped drive a decline in Canada's international rank from 7th position in 2006 to 15th position in 2012.[11] (This decline was also partially accounted for by the addition to the 2012 dataset of Israel and the U.S. (both of which ranked above Canada), data for which were not available for the 2006 baseline year.[12]) Canada also moved farther away from the threshold of the top five performers, falling from 85 percent to 66 percent.

Canada's poor performance in private-sector absorption of research talent was mirrored at the broader level in the aspirational indicator of science and technology (S&T)-related occupations across the economy. In 2011, S&T-related occupations accounted for 30 percent of total employment in Canada, which positioned Canada at 22nd out of 43 countries (Figure 2-4). This performance was close to that of others in the middle tier of countries, Italy, Israel and New Zealand, and better than that of the United Kingdom (U.K.) and Korea. However, Canada trailed the majority of advanced economies, at 78 percent of the threshold of the top five performers (Luxembourg, Sweden, Switzerland, Denmark and Iceland).

[11] OECD, *Main Science and Technology Indicators* (accessed February 4, 2015).

[12] OECD, *Main Science and Technology Indicators* (accessed February 4, 2015).

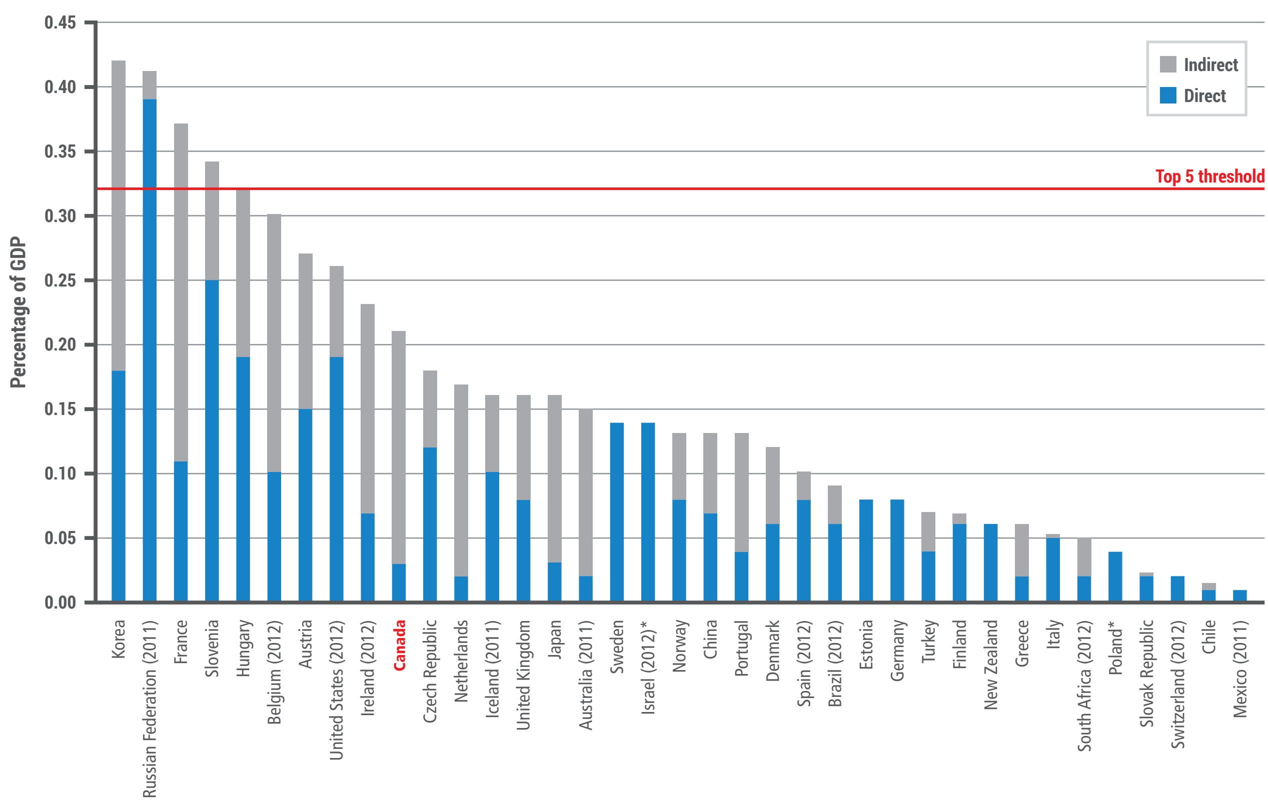
Funding Environment for Business Innovation

The decision to pursue a business strategy focused on innovation clearly rests with firms. However, firms need an environment that provides reliable access to talent, knowledge and capital to support activities to develop and commercialize ideas. Both the federal and provincial governments support business innovation by providing financial resources to firms, directly and indirectly.

In 2013, Canada ranked 10th (of 37 countries) in total (direct and indirect) government funding of business R&D as a share of GDP, performing at 66 percent of the threshold of the top five performers (Figure 2-5). Total government support of business R&D was 0.18 percent of GDP, down from 0.24 percent in 2008, when Canada ranked second (of 30 countries).[13] A number of countries pulled ahead of Canada over the period, including France, the U.S., Belgium, Austria and Ireland.

Breaking this down, the data show that Canada relied significantly more on indirect support (through the Scientific Research and Experimental Development Tax Incentive Program) than other countries. At 0.18 percent, Canada's indirect support-to-GDP ratio was the fourth highest among those countries for which comparable data were available.[14] Only France, Korea and Belgium ranked higher. This compares with 2008, when Canada's indirect support as a share of GDP was 0.22 percent and Canada ranked first on this measure.

Figure 2-5: Government Funding of Business R&D, 2013



*Note: Indirect support estimates are not available for Israel and Poland.

Source: OECD, *Science, Technology and Industry Scoreboard*, 2015.

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[13] OECD, *Science, Technology and Industry Scoreboard*, 2015; and OECD, *Science, Technology and Industry Outlook*, 2010.

[14] Indirect support data do not include estimates of R&D tax incentives at the sub-national (e.g., provincial) level.

Saltworks Technologies Inc. Innovates with Government Research and Development Support

Founded in 2008 and based in Vancouver, Saltworks Technologies Inc. is a cleantech firm providing advanced water treatment, desalination and brine management solutions. Saltworks has invented systems for some of the world's most demanding applications that require fresh water from highly impaired saline water sources. The company's technologies target global water scarcity issues, either by using saline water sources instead of freshwater sources or by reusing waste waters or produced waters.

ElectroChem EDR-RO hybrid plant operating in the field.

Saltworks has received direct R&D funding from government organizations, including Sustainable Development Technology Canada (SDTC), the Industrial Research Assistance Program (IRAP) and Natural Resources Canada (NRCan). This support has been leveraged with private investment and profit re-investment from company sales. "Support from SDTC, IRAP and NRCan has enabled Saltworks to pilot its technology on waste waters from various industries and has generated valuable intellectual property, know-how and highly skilled jobs," explains Ben Sparrow, the firm's Chief Executive Officer.

In the Alberta oil sands, Saltworks is using its SaltMaker, a low temperature evaporator crystallizer, to produce fresh water from Steam Assisted Gravity Drainage (SAGD) evaporator blowdown waste water. Successful SaltMaker pilots were completed with Suncor Energy and Cenovus Energy, demonstrating true Zero Liquid Discharge of SAGD waste water. The reliable crystallizer plant concentrates the blowdown to produce a solid waste for landfill disposal and high quality fresh water for reuse by the oil and gas industry. The results are reduced wastewater discharge, freshwater withdrawal and greenhouse gas emissions in comparison with conventional treatment technologies.

In recent years, there has been some effort in Canada to shift towards more direct support for business innovation, reflected in a marginal increase in direct support as a share of GDP from 0.02 percent in 2008 to 0.03 percent in 2013. Nonetheless, Canada ranked 28th in direct government funding of business R&D as a share of GDP in 2013 (compared with 27th in 2008), tied with Japan. Canada significantly trailed a number of competitors, including the U.S., Germany, the U.K. and the Scandinavian countries.

Venture capital, a form of equity financing, is another key source of funding for business innovation, particularly for young firms with innovation and growth potential, but untested business models and a limited track record.

In 2014, Canada was among the top five performers in venture capital investment as a percentage of GDP, ranking third out of 32 countries. Its share (0.08 percent) was exceeded only by Israel (0.38 percent) and second-place U.S. (0.28 percent), both of which have very mature venture capital markets.[15]

Venture capital investment in Canada increased significantly in 2014 over previous years, almost reaching $2.4 billion, higher than pre-2008 recession investment levels. Fundraising remained fairly steady, dropping in 2014 to $1.2 billion from $1.4 billion in 2013. Government-backed sources accounted for more than two thirds of total commitments in 2014.[16]

[15] OECD, *Science, Technology and Industry Scoreboard*, 2015. Due to sizeable fluctuations in the data reported by the OECD over time, a comparator year is not used for the international venture capital data.

[16] Industry Canada, *Venture Capital Monitor*, Q4 2014.

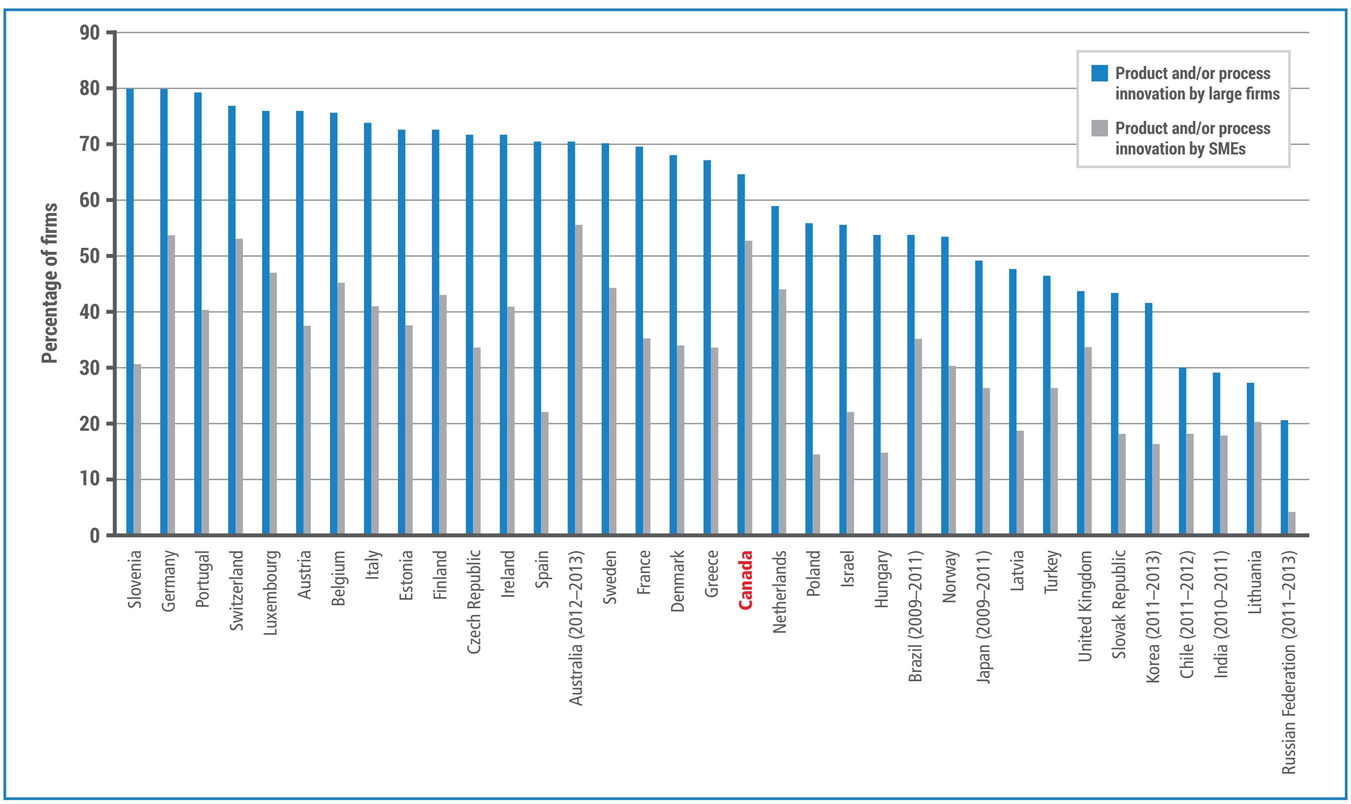
Introduction of Product and Process Innovations

Firms transform investments in R&D and other knowledge assets into product, process, marketing and organizational innovations. The most recent Canada-only data from Statistics Canada's *Survey of Innovation and Business Strategy* suggest that, between 2010 and 2012, about 35 percent of firms introduced a product innovation (comparable to the period between 2007 and 2009), while 29 percent introduced a process innovation (down from about 34 percent between 2007 and 2009). While the manufacturing industry was among the leaders in Canada in introducing product and process innovations, the share of manufacturing firms introducing these innovations declined between the periods 2007–2009 and 2010–2012. (For further analysis on the introduction of product and process innovations, see Annex 2.)

In an international comparison of firms introducing product or process innovations between 2010 and 2012, Canada's performance against 34 other countries was divided along firm size lines (Figure 2-6).[17] Small and medium-sized enterprises (SMEs) in Canada were among the world's leaders on this measure — about 53 percent of them introduced a product or process innovation during the period, exceeded only by SMEs in Australia, Germany and Switzerland. In fourth position, Canada performed at 112 percent of the threshold of the top five performers.

Conversely, a smaller share of Canada's large firms introduced innovations than their peers abroad. Canada ranked 19th, with about 65 percent of large firms introducing a product or process innovation, compared with about 76 percent in 5th-ranked Austria (putting Canada at 85 percent of the threshold of the top five performers). While Canada's large firms outperformed their peers in the U.K. and Japan, a number of key countries ranked higher than Canada, including Germany, Finland, Australia, Sweden and France.

Figure 2-6: Share of Firms that Introduced a Product and/or Process Innovation between 2010 and 2012



Source: OECD, *Science, Technology and Industry Scoreboard*, 2015.

[17] Care must be taken when comparing countries because the reference period is not the same for all countries. As well, coverage of activities and firms is not the same for all countries. For example, data for Canada only include firms with 20 or more employees and revenues of $250,000 or more.

Consistent with this finding, no Canadian company appeared on Boston Consulting Group's 2014 list of the world's 50 most innovative companies, a list dominated by large firms that have no equivalents in Canada.[18] The lack of large innovative firms may have a negative impact on business innovation in Canada. Through their pivotal role in supply chains, these firms can drive innovation in smaller firms. Their presence is critical to anchor innovation clusters and can help foster a more deeply engrained innovation culture among other cluster members. Large firms also have more resources with which to invest, innovate and export, and they tend to be more productive than small firms. Therefore, they can have a significant economic impact, driving competitiveness and job creation.

Canada's Innovation Performance and Global Competitiveness

Firms' investments in innovation reap rewards when they translate into enhanced competitiveness and success in the marketplace, especially the global marketplace. Intuitively, it can be surmised that firms that invest in innovation will be more profitable and thus contribute to the strength of the Canadian economy. The impact of Canada's business innovation performance on our global competitiveness is assessed through productivity growth and export market share in R&D-intensive industries. International comparisons reveal that Canada's performance generally lagged on these measures.

Productivity

Innovation is widely considered to be a driver of productivity, which is, in turn, essential for increased wages, profitability for investors and improved economic well-being in the long term. The most common measure of productivity is labour productivity, which measures the amount of goods and services produced in one hour of labour. Labour productivity *levels* in the business sector in Canada have significantly trailed those in the U.S. In 2014, Canada was at 71 percent of the U.S. level.[19] Since 2003, Canada has consistently performed below 80 percent of the U.S.

A key factor in Canada's poor labour productivity performance has been Canada's declining multifactor productivity (MFP) growth.[20] MFP is reflective of innovation because it captures factors such as use of new technologies, managerial skills and changes in the organization of production, as well as economies of scale.[21]

The lack of large innovative firms may have a negative impact on business innovation in Canada.

In assessing productivity *growth*, it is more meaningful to examine long periods rather than specific years. Over the period 1995–2013, Canada's average annual MFP growth was 0.6 percent, placing Canada 12th out of 19 countries. Over this period, Canada performed at 60 percent of the threshold of the top five performers (Korea, Ireland, Finland, the U.S. and Sweden) (see Figure 2C in Annex 2).[22]

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[18] The Boston Consulting Group, *The Most Innovative Companies 2014: Breaking through is Hard to Do*, October 2014.

[19] Centre for the Study of Living Standards, *Aggregate Income and Productivity Trends, Canada vs. United States*, May 2015.

[20] John R. Baldwin, Wulong Gu, Ryan Macdonald and Beiling Yan, "The Canadian Productivity Review: Productivity: What is it? How is it measured? What has Canada's performance been over the period 1961 to 2012?," *Statistics Canada*, Catalogue 15-206-X, no. 38, 2014.

[21] John R. Baldwin, Wulong Gu and Beiling Yan, "The Canadian Productivity Review: User Guide for Statistics Canada's Annual Multifactor Productivity Program," *Statistics Canada*, Catalogue 15-206XIE, no. 14, 2007.

[22] OECD, *Growth in GDP per capita, productivity and unit labour cost (ULC)* (accessed October 22, 2015).

Export Market Share

On export market share in globally R&D-intensive industries, Canada's global ranking stagnated or declined between 2006 and 2013 and the gap between Canada and the top five performers widened (see Figure 2D in Annex 2). Canada fell from 15th to 17th position (of 41 countries) in the pharmaceutical industry and was at 15 percent of the threshold of the top five performers (down from 19 percent in 2006). In the computer, electronic and optical industry, Canada fell from 15th to 19th position and sat at 12 percent of the threshold of the top five performers (down from 16 percent). Conversely, Canada ranked fifth in 2013 in the aerospace industry (unchanged from 2006).

Conclusions

While there is variation across industries, Canada's private sector overall is not investing in R&D and other knowledge assets at a globally competitive level. Of particular concern, with business investment in R&D dropping, Canada's BERD intensity fell between 2006 and 2013 to the point where Canada ranked 26th among international competitors and sat at 36 percent of the threshold of the top five performers. In parallel, private-sector take-up of ST&I talent was weak, with Canada ranking 15th in 2012 and positioned at 66 percent of the threshold of the top five performers. On a positive note, data suggest that Canada's SMEs were at the forefront in introducing product and process innovations. However, our large companies lagged global competitors, positioning Canada 19th on this measure. Finally, while there has been some shift in government funding towards more direct support for business R&D, Canada continued to be out of step with its international competitors in the balance between direct and indirect support.

CHAPTER 3: HIGH-QUALITY KNOWLEDGE

3

High-quality knowledge is part of the foundation for global competitiveness for all players in the science, technology and innovation (ST&I) ecosystem. In the science and technology (S&T) enterprise, knowledge is developed predominantly through research and development (R&D). R&D across the whole spectrum is vital: fundamental research (undertaken in both academia and industry); applied research directed towards specific objectives; and experimental development to produce new, or improve existing, products and processes.

To assess the quantity and quality of Canada's knowledge production, four components that drive success and define leadership are considered:

- the level of investment in R&D, both across the economy and, more specifically, in higher education institutions (HEIs) (wherein another aspirational indicator lies);
- the effectiveness of these investments in building critical mass in key research areas;
- the global competitiveness of the research performed and of the HEIs in which much of the knowledge is generated; and
- the extent of knowledge transfer between ST&I players.

Key Findings

- Canada's total funding of research and development (R&D) activities remained essentially unchanged between 2008 and 2014, with funding increases by the higher education sector and provincial governments offset by funding declines by the two largest sectors — business and the federal government.
- While Canada's higher education expenditures on R&D (HERD) funding has been increasing over time, its HERD intensity, at 0.65 percent of gross domestic product, has remained steady. With other countries increasing their spending more significantly, Canada fell from third position in 2006 to eighth in 2013 in HERD intensity, performing at 88 percent of the threshold of the top five performing countries, down from 105 percent in 2006.
- While the United States and the United Kingdom dominated global university rankings, Canada was competitive within a second tier of comparator countries.
- With 96 researchers ranking among the top 1 percent of the most cited in their respective fields, Canada enjoyed some real "star power," ranking sixth after countries with significantly larger populations.

Investments in Knowledge Production

The amount of funding invested in R&D significantly affects a country's ability to develop the quantity and quality of knowledge needed to be competitive with other countries. This is reflected in total R&D investment across the economy (i.e., gross domestic expenditures on R&D (GERD)) and, specifically, in HEIs and research hospitals (i.e., higher education expenditures on R&D (HERD)). While Canada sustained its level of R&D funding in relation to the size of its economy between 2008 and 2014, it lost some ground against international competitors as they invested increasingly more.

Gross Domestic Expenditures on Research and Development

GERD reflects overall support for the formal generation of knowledge. It represents the total amount of funds spent on R&D activities across all sectors of the ST&I ecosystem: business, higher education, federal and provincial/territorial governments, private non-profit and foreign.

At almost $31 billion, Canada's GERD remained essentially unchanged over the period 2008 to 2014. Modest increases in funding by the higher education sector and provincial governments were offset by declines in the two largest funding sectors — business and the federal government (see Annex 3 for more detail on sources of R&D funding

Critical Mass in Neurosciences

The sub-priority of neurosciences, in which Canada has internationally acknowledged research strength, received the most funding from the federal granting councils in fiscal year 2013–2014. Despite its priority status, however, Canada is not investing in neurosciences at a competitive scale in comparison with the United States (U.S.). Total federal funding for neuroscience research is only about 40 percent of that in the U.S., even after adjusting for the size of the U.S. economy, which is about 11 times larger than Canada's economy.

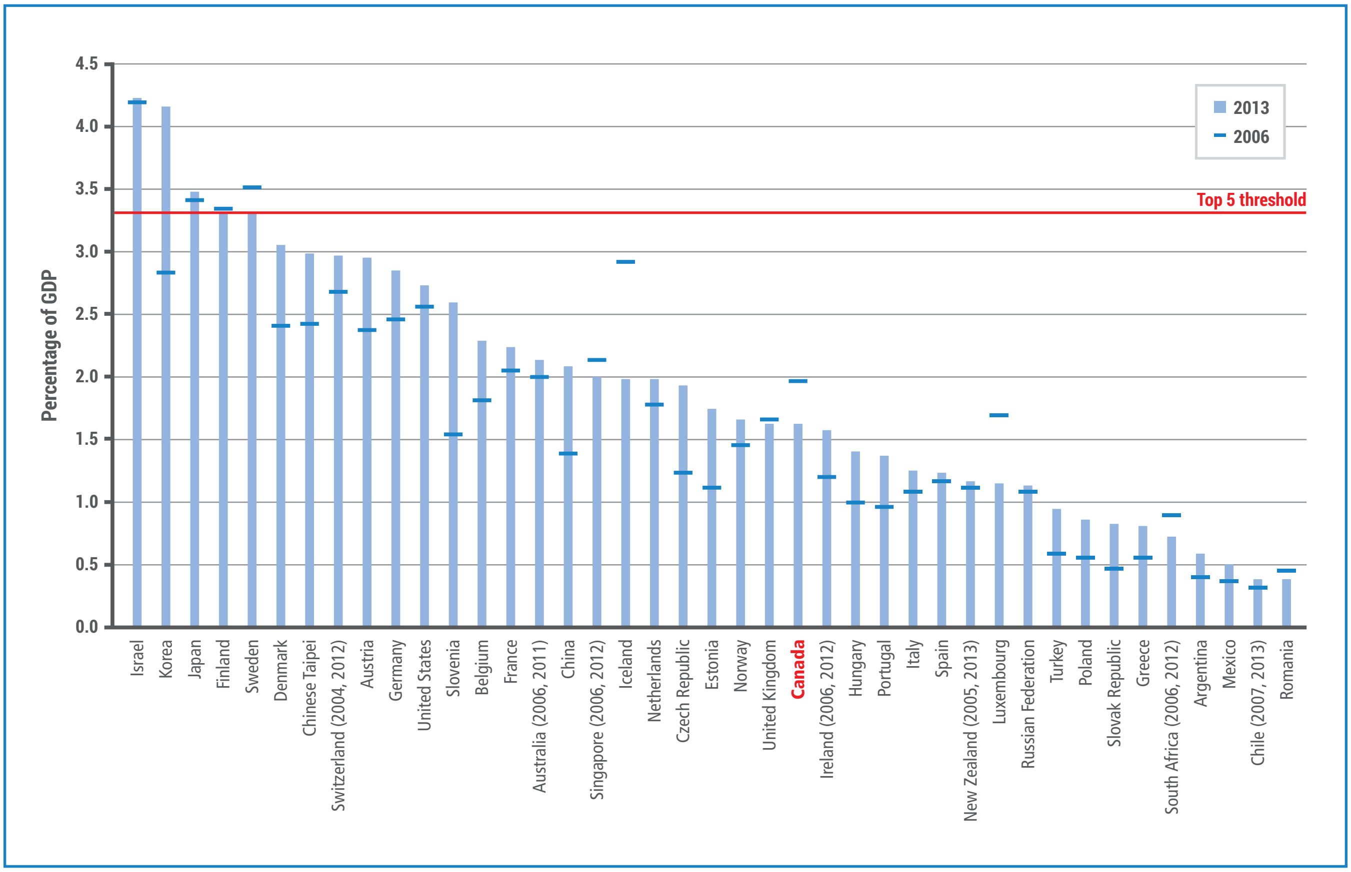
The federal government supports neuroscience research through a number of initiatives, including the Canadian Institutes of Health Research's (CIHR) Institute of Neurosciences, Mental Health and Addiction, the Natural Sciences and Engineering Research Council of Canada (NSERC), the Social Sciences and Humanities Research Council (SSHRC) and the Canada Brain Research Fund (through Brain Canada). CIHR spent an estimated $129.3 million on neurosciences research in fiscal year 2013–2014, while NSERC and SSHRC spent about $35.6 million and $23.8 million respectively. In addition, the federal government is providing up to $100 million over six years (fiscal year 2011–2012 to fiscal year 2016–2017) to Brain Canada, a national non-profit organization that develops and supports collaborative, multidisciplinary, multi-institutional research across the neurosciences. Total estimated federal spending on neurosciences research, therefore, was around $205 million in fiscal year 2013–2014.

In the U.S., the National Institutes of Health slated an estimated total of US$5,474 million for neuroscience research in its fiscal year 2014 budget. An additional US$110 million was provided through the Brain Research through Advancing Innovative Neurotechnologies initiative in fiscal year 2014, resulting in a total of US$5,584 million for neuroscience research in fiscal year 2014.

in Canada over time). Business funding for R&D peaked at $15.2 billion in 2011, then declined in 2012 and 2013, and is expected to continue trending downwards to $14.1 billion in 2014. Similarly, federal government funding for R&D trended downwards from its peak of $6.5 billion in 2010 and is expected to decline to $5.8 billion in 2014. In contrast, the higher education sector is expected to invest a record $5.5 billion in R&D in 2014, while provincial governments continued to gradually increase their R&D funding, which is expected to reach an all-time high of $2.1 billion in 2014.

While Canada's total R&D expenditures remained flat over the period, other countries increased their funding, both in dollar terms and in relation to the size of their respective economies. Canada's GERD intensity (i.e., GERD as a share of gross domestic product (GDP)) declined from 1.96 percent in 2006 to 1.62 percent in 2013, and its global ranking fell from 16th to 24th out of 41 countries (Figure 3-1). In contrast, first-place Israel increased its GERD intensity (from 4.19 percent to 4.21 percent of GDP), as did second-place Korea (from 2.83 percent to 4.15 percent of GDP). The United States (U.S.) ranked 11th in 2013, with its GERD intensity rising from 2.55 percent to 2.73 percent. In 2013, Canada performed at 49 percent (down from 67 percent in 2006) of the threshold of the top five performers, which also included Japan, Finland and Sweden.

Figure 3-1: GERD as a Percentage of GDP, 2006 and 2013



Source: OECD, *Main Science and Technology Indicators*, July 2015.

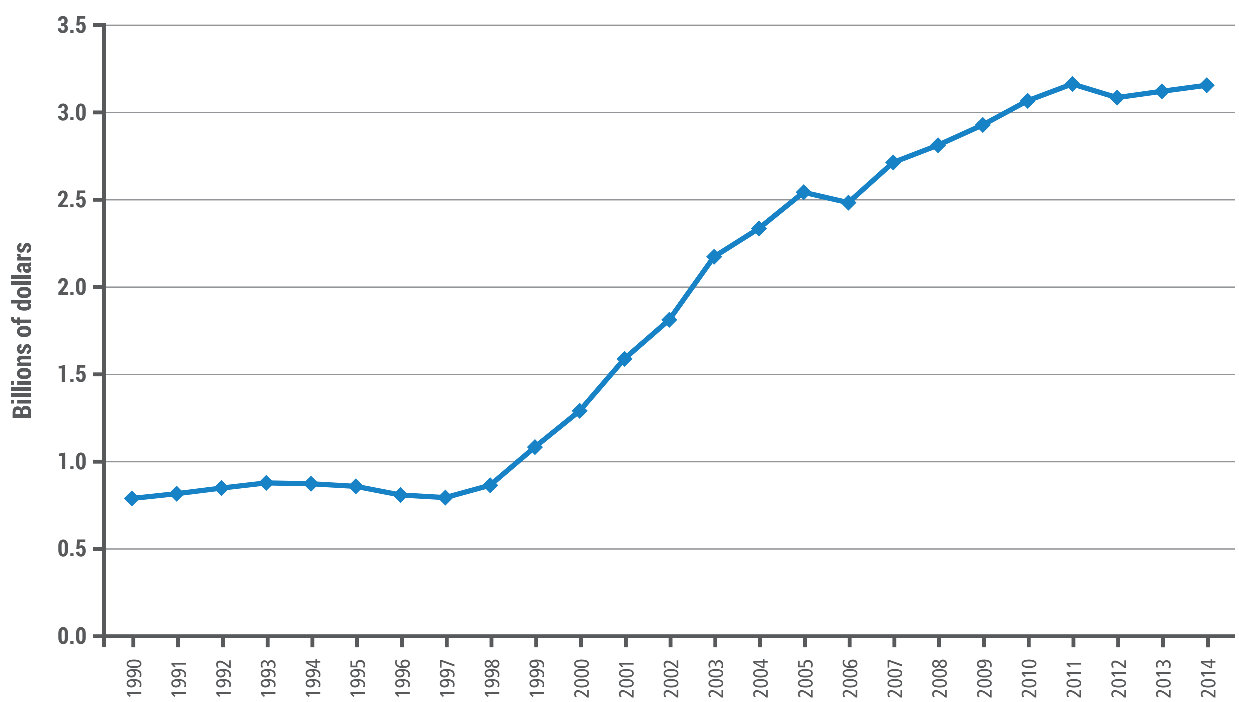
Higher Education Expenditures on Research and Development

Previous *State of the Nation* reports have shown that Canada is more reliant than other Organisation for Economic Co-operation and Development (OECD) countries on knowledge production in HEIs and research hospitals. As a result, *State of the Nation 2012* identified HERD intensity (i.e., HERD as a share of GDP) as an aspirational indicator.

Canada's HERD levels have increased over time (see Annex 3 for further detail), driven largely by growth in higher education funding and federal government funding. Federal R&D funding to the higher education sector rose rapidly from the late 1990s to 2011, at which time it levelled out and the growth rate returned to the lower levels witnessed in the early and mid-1990s (Figure 3-2).

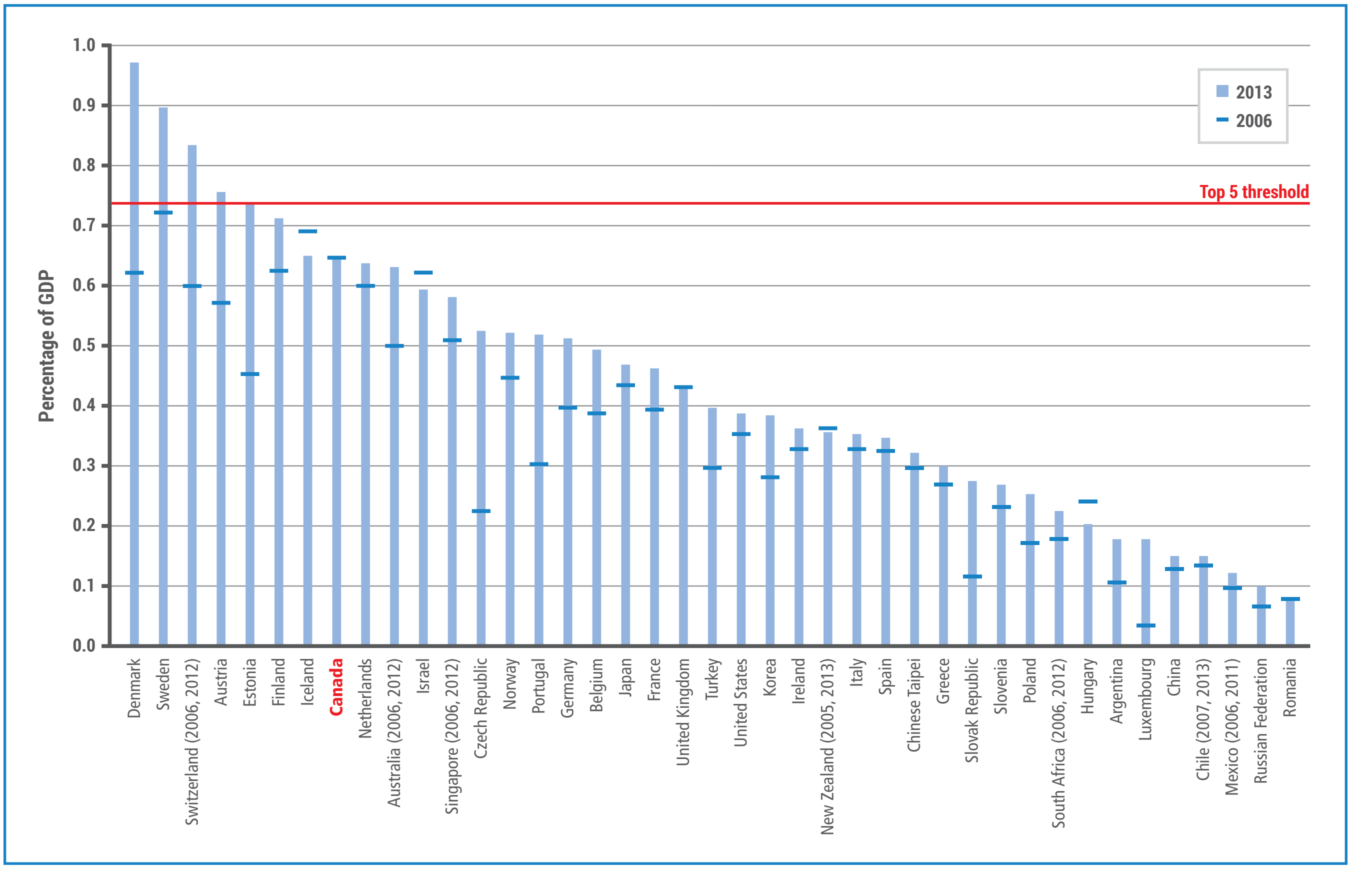
Despite the increase in HERD *levels*, Canada's HERD *intensity* in 2013, at about 0.65 percent of GDP, was unchanged from 2006. As other countries invested more in higher education R&D, Canada lost ground internationally on HERD intensity, falling from third place in 2006 to eighth in 2013 (Figure 3-3). The top five performers all increased their HERD intensities from 2006 to 2013 — Denmark (a significant increase from 0.62 percent to 0.97 percent), Sweden, Switzerland, Austria and Estonia. Canada performed at 88 percent of the threshold of the top five performers in 2013, down from 105 percent in 2006. Canada continued to outperform the U.S., whose HERD intensity of 0.39 percent of GDP positioned it at 52 percent of the threshold of the top five performers. Canada also outperformed some other notable advanced economies, including Germany (with a HERD intensity of 0.51 percent), Japan (0.47 percent), France (0.46 percent) and the United Kingdom (U.K.) (0.43 percent).

Figure 3-2: Federal Government Funding of R&D to the Higher Education Sector, 1990–2014



Source: Statistics Canada, *Table 358-0001* (accessed July 28, 2015).

Figure 3-3: HERD as a Percentage of GDP, 2006 and 2013



Source: OECD, *Main Science and Technology Indicators*, July 2015.

Research and Development Investments for Critical Mass

It is not only *how much* a country invests in ST&I, but *how* it invests that determines excellence and international competitiveness. Not all areas of knowledge are equally critical to Canada's future. To maximize the impact of Canada's investments, R&D funding must be strategic, focused and coordinated, to build capacity and critical mass in select areas.

To create critical mass and accelerate knowledge development, many countries identify R&D priorities to which they target concentrated resources. In Canada, the 2007 federal S&T Strategy[23] identified four research priority areas: environmental science and technologies, natural resources and energy, health and related life sciences and technologies, and information and communications technologies (ICT). To provide further focus, the government adopted the list of 13 research sub-priorities identified by the Science, Technology and Innovation Council (STIC) in 2008. In 2014, with the release of its new ST&I strategy, the government updated the priorities and sub-priorities (now called "focus areas"), adding advanced manufacturing as a new research priority area and expanding the existing environmental science priority area to include agriculture. (See Annex 3 for the 2008 list of research sub-priorities and the updated 2014 list of focus areas.)

Insufficient international data prevent reliable comparisons of Canada's funding for R&D priority and sub-priority areas with that of other countries. For Canada only, the scale of federal government R&D funding for priorities and sub-priorities can be assessed, in part, through granting council funding to these areas.

[23] Government of Canada, *Mobilizing Science and Technology to Canada's Advantage*, 2007.

Granting Council Funding for Research Priorities and Sub-Priorities

STIC used data provided by the three federal granting councils (i.e., Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, and Social Sciences and Humanities Research Council) to assess funding support for academic research in priority and sub-priority areas between fiscal year 2011–2012 and fiscal year 2013–2014.[24] Assessment of the data reveals that federal funding for priorities and sub-priorities remained largely static during this period.

Of the four 2007 research *priority areas*, health and life sciences received the largest amount of granting council funding in fiscal year 2013–2014, at $1,099.5 million, comparable to $1,110.3 million in fiscal year 2011–2012. This was followed by environment at $214.7 million (up from $199.1 million), ICT at $183.1 million (down from $203.0 million), and natural resources and energy at $164.7 million (down from $168.1 million). Declines in

Achieving Cost-Effective Air Emission Reductions from Oil and Gas Production and Processing

Development of cleaner fossil fuels and related environmental technologies is essential to Canada's energy and environment objectives. Natural Resources Canada's CanmetENERGY research facility in Devon, Alberta, leads collaborative research with academia and industry to develop technologies and methods to detect, quantify and reduce emissions from oil and natural gas production and processing.

In oil and gas operations, flaring (the controlled burning of natural gas), venting (the controlled release of gases into the atmosphere) and fugitive equipment leaks create emissions of methane, volatile organic compounds and black carbon particulates that contribute significantly to global greenhouse gas (GHG) and pollutant emissions. Demonstration of efforts to address environmental impacts related to hydrocarbon projects is becoming increasingly important in obtaining "social license" to proceed with such projects. CanmetENERGY-Devon has shown that collaborative development and deployment of technologies and practices can reduce both GHG and pollutant emissions and costly hydrocarbon losses.

With funding support from international organizations, including the World Bank and the United Nations, and Canada's Fast-Start Financing commitment, CanmetENERGY-Devon recently led flaring and venting mitigation projects in Colombia and Mexico. Undertaken in collaboration with the Petroleum Technology Alliance Canada and Clearstone Engineering Ltd. of Calgary, these projects employed various demonstration technologies and practices that showed great promise for reducing both emissions and costs. The project at an oil production facility in Colombia identified the potential for a reduction of 150 kilotonnes of annual GHG emissions and for savings of US$50 million per year from avoidable hydrocarbon losses. The project at a refinery facility in Mexico identified the potential for a reduction of 1.3 megatonnes of annual GHG emissions and for savings of US$237 million per year from avoidable hydrocarbon losses. With support from Canada's commitment to the United Nations' Climate and Clean Air Coalition, Clearstone Engineering is now collaborating with stakeholders in Colombia and Mexico on plans to design emission reduction and hydrocarbon conservation implementation projects.

[24] Given that the most recent granting council data available are for fiscal year 2013–2014, the 2007 list of federal priority and sub-priority areas is used for these calculations.

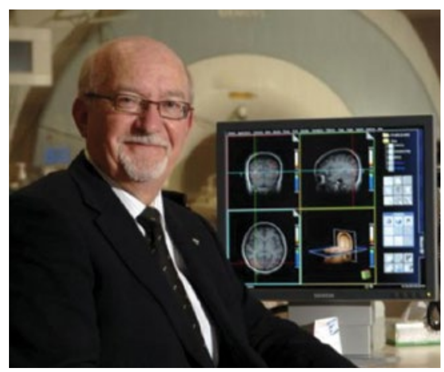
absolute funding to priority areas reflect the marginal decline in total granting council funding, which fell from $2,326.2 million in fiscal year 2011–2012 to $2,301.6 million in fiscal year 2013–2014. The combined *share* of granting council funding to the four priority areas in fiscal year 2013–2014, at 72.2 percent, remained the same as in fiscal year 2011–2012 (72.2 percent).

Funding for the 13 *sub-priorities* identified in 2008 accounted for 26.5 percent of total granting council funding in fiscal year 2013–2014, again essentially unchanged from 26.7 percent in fiscal year 2011–2012. In dollar terms, in the same period, funding for sub-priorities slipped from $621.7 million to $610.0 million. Among the sub-priority areas, neuroscience, at 7.2 percent, garnered the largest share of funding in fiscal year 2013–2014, up marginally from 7.0 percent in fiscal year 2011–2012. This was followed by health in an aging population at 4.8 percent (unchanged from fiscal year 2011–2012) and biomedical engineering and medical technologies at 3.0 percent (down slightly from 3.1 percent). (Breakdowns by granting council and sub-priority are presented in Annex 3.)

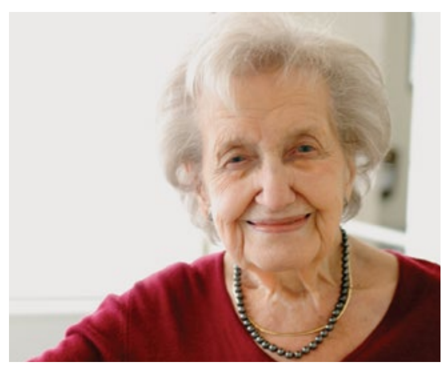
Outstanding Contributors to Brain Research – Dr. Donald T. Stuss and Dr. Brenda Milner

Regarded internationally as a leader in brain research, Canada ranks high on measures of top-cited international researchers in related fields, such as neurology and psychology. Toronto and Montréal are key centres of brain research, with two leading universities, University of Toronto and McGill University, respectively, and their affiliated hospital research institutes. Areas of research strength in Canada include brain and nervous system development, genetics of the brain, cognition and behaviour, neurodegeneration, brain plasticity and repair, learning and memory, motor control and sensory function.

Dr. Donald Stuss (Ontario Brain Institute) and Dr. Brenda Milner (Montreal Neurological Institute and Hospital) have made outstanding contributions to global brain research. Dr. Stuss is a pioneer in human frontal lobe research, with a career spanning over 35 years. His work focuses on researching and treating the cognitive functions and personality changes that occur after strokes and that result from traumatic brain injury or dementia. As a world-leading neuropsychologist, his research has had a profound impact on neuropsychology and cognitive neuroscience at both the theoretical and practical levels.



With a career extending over 50 years, Dr. Milner is still an active researcher. Her work, which focuses on cognitive function in human frontal and temporal lobes, has had an extraordinary influence on the shape of neuroscience and on the work of scientists around the world. The origins of modern cognitive neuroscience of memory can be traced directly to her rigorous and imaginative studies. She uses positron emission tomography and functional magnetic resonance imaging to identify the brain regions involved in language processing, including in patients with brain lesions in close proximity to areas critical for language. In 2014, Dr. Milner won the Kavli Prize in Neuroscience for outstanding achievement in advancing knowledge and understanding of the brain and nervous system, the first Kavli Prize ever awarded to a Canadian.



Competitiveness of Research and Higher Education Institutions

To have a real impact, the research conducted in Canada's ST&I ecosystem must be of high quality and the organizations within which it is conducted — HEIs, government laboratories and firms — must be competitive internationally.

Although obtaining a meaningful and rigorous measure of the quality of research and host institutions is challenging, available data suggest that Canada remained competitive within a second tier of comparator countries regarding the quality (and perceived quality) of our universities and that a considerable amount of world-class science continued to take place in these institutions. While Canada continued to hold its own, we nonetheless made no progress in advancing our universities into the world's highest tier.

Global University Rankings

Globally competitive universities act as magnets to attract world-class talent and firms to Canada. Three key international university ranking systems are used to compare institutions across countries: the Graduate School of Education, Shanghai Jiao Tong University Academic Ranking of World Universities (the "Shanghai ranking"); the Times Higher Education (THE) World University Rankings; and the Quacquarelli Symonds (QS) World University Rankings. These ranking systems assess universities on indicators such as bibliometric data, prizes and awards won, and reputation among peers.[25]

The 2015 results from all three ranking systems show that U.S. and U.K. institutions are in a class of their own, continuing to dominate the top 10 lists. Notable in 2015, for the first time another country achieved that distinction — Switzerland's Swiss Federal Institute of Technology (Zurich) placed ninth in the THE and QS rankings. Canada was competitive in a second tier of countries, noteworthy for hosting two universities on the combined top 25 lists. The University of Toronto ranked 25th in the Shanghai ranking and 19th in the THE ranking, while McGill University ranked 24th in the QS ranking. The only other countries (other than the U.S. and U.K.) that ranked universities on the combined top 25 lists were Switzerland and Singapore (both with two universities), and Australia, China, France and Japan (each with one university).

Looking at the top 100 rankings, in the Shanghai index, Canada held its own against all countries except the U.S. and U.K. Australia and the Netherlands clearly outperformed Canada in the THE and QS top 100 rankings, both in absolute numbers and in the number of universities relative to population.

Overall, between *State of the Nation 2008* and this report, Canada made no progress in moving its ranked universities closer to the top 10 nor in growing the number of universities in the top 25 and top 100 lists.

Bibliometric Impact Indicators

Bibliometric impact indicators measure the visibility or influence of Canada's researchers as reflected by citation counts. The more a journal article is cited, the more it can be said to have influenced later scientific research. The *relative impact index* is the ratio between the world share of citations for a given country and its world share of publications. When a country's relative impact index is greater than one, its relative impact is better than the world average.

At 1.10, Canada's relative impact index in 2012 (over the preceding two-year period) was above the world average, which placed Canada in ninth position (tied with France), behind Switzerland (1.51), the U.S. (1.40), Denmark (1.38), Netherlands (1.37), Germany (1.26), the U.K. (1.25), Sweden (1.17) and Belgium (1.14). Canada's relative impact index rose by about 9 percent between 2002, when it was at 1.01, and 2012; however, our ranking slipped slightly, from eighth position, as Belgium moved ahead. (The year 2002 is used as a baseline as it is the only year for which a complete comparison with other countries is possible.)

[25] Of the three ranking systems, the Shanghai ranking places its emphasis almost exclusively on quantitative research indicators, whereas the THE and the QS rankings assign significant weighting to teaching indicators and reputation for excellence (as determined by surveys) respectively.

Enhancing Global Recognition for Canadian Research Excellence

International science, technology and innovation prizes and awards, especially Nobel Prizes, are a reflection of a country's research excellence and its profile on the global stage. In 2015, Arthur McDonald, professor emeritus at Queen's University and Director of the Sudbury Neutrino Observatory, became the co-winner of the 2015 Nobel Prize in Physics. Dr. McDonald, along with Takaaki Kajita of the University of Tokyo, demonstrated that subatomic particles called neutrinos change identities, dispelling the long-held notion that they were massless. This discovery transformed our understanding of the innermost workings of matter and showed the need for a new kind of physics beyond the so-called Standard Model of fundamental particles.

Before Dr. McDonald's win, the last Nobel laureate in the sciences* affiliated with a Canadian university, research institution or firm dated back to 1994. In comparison, people from 15 other countries have won Nobel Prizes in the sciences over the 20-year period between 1994 and 2014. The U.S. claimed 144 prizes, the U.K. 19, Japan 11, and Germany and France 10 each. Israel, with about a quarter of Canada's population, garnered five, while Australia, Belgium, China, Denmark, Netherlands, Norway, Russia, Sweden and Switzerland each earned between one and three.

In the belief that Canada's Nobel performance during that 20-year period was not an accurate reflection of the quality of Canadian science, His Excellency the Right Honourable David Johnston, Governor General of Canada, introduced an initiative to enhance the visibility of Canada's contributions to international research. This initiative, "Enhancing Global Recognition for Canadian Research Excellence," involves the heads of universities, hospitals, research institutes, and corporate and government laboratories, as well as a canvassing committee and the presidents of Canada's three federal granting councils. Under this initiative, concerted efforts are being made by different parties to support nominations of Canada's leading scholars and scientists for major international scientific prizes and awards.

*This includes laureates in physics, chemistry, physiology or medicine, and economic sciences.

A breakdown of the 2012 data by field of study reveals that Canada's relative impact index exceeded the international average in all scientific fields. Canada obtained its best relative impact index score in chemistry, at 1.32. Other areas of Canadian strength included physics (1.21), applied biology and ecology (1.20), and medical research (1.17).

It is useful to look at the number of leading researchers that a country hosts to obtain a better sense of a country's research excellence and profile on the global stage. In 2014, Thomson Reuters assessed papers indexed between 2002 and 2012 in 21 broad fields of study, identifying 3,144 researchers with the greatest number of articles ranked in the top 1 percent most cited in their respective fields and who, as such, were the "stars" of scientific research.[26] On other measures throughout this report, Canada's rank is typically adjusted for country size (whether by GDP or population), to allow meaningful comparisons with other jurisdictions. Considered from this perspective, in the 2014 Thomson Reuters list, Canada ranked 12th in the number of highly cited researchers relative to population, as many smaller countries with solid HEI research systems punched above their weights.

When it comes to top researchers, however, the higher the absolute number, the greater the ability to attract other top talent and to develop high-profile international research collaborations. Thus, on this indicator, it is more meaningful to compare Canada's performance in absolute numbers. By this measure, Canada, with 96 highly cited researchers in 2014, enjoyed some real "star power," ranking sixth after the U.S., the U.K., China, Germany and Japan. Canada was short of fifth-place Japan by only seven researchers (Table 3-1 shows the top 15 countries). This performance is impressive, given that Canada's population is significantly smaller than that of the top five performers.

[26] Thomson Reuters, *The World's Most Influential Scientific Minds*, 2014.

Table 3-1: Number of Most Highly Cited Researchers by Country, 2014

Country	Number
U.S.	1,726
U.K.	371
China	171
Germany	163
Japan	103
Canada	96
France	86
Netherlands	82
Switzerland	77
Australia	75
Italy	52
Spain	43
Saudi Arabia	34
Denmark	33
Belgium	32

Knowledge Transfer

Knowledge gains value when it is shared. Knowledge transfer — between and among individuals, firms, educational and other institutions, and governments — can accelerate the pace of scientific and technological developments. In firms, it can lead to commercialization of discoveries and inventions that introduce new products and processes to the market.

Knowledge can be transferred informally, "on two feet," through the complex, organic and constantly shifting movement and interplay of people. While no indicator captures the extent and impact of this phenomenon, it occurs when, for example, researchers move from jobs in one sector to another, students undertake internships and co-operative work terms with private- and public-sector employers, researchers hold cross-appointments in government laboratories and university faculties, and business people lecture at HEIs.

North American Research Collaboration in Mathematics: Banff International Research Station

Established in 2003 in Banff, Alberta, the Banff International Research Station (BIRS) for Mathematical Innovation and Discovery is a North American initiative that focuses on collaborative and cross-disciplinary research in the mathematical sciences and applications in the sciences and industry. BIRS is modelled after one of the most successful mathematical institutes in the world, Germany's Mathematisches Forschungsinstitut.

"BIRS embraces all aspects of quantitative and analytic research," explains the Director, Dr. Nassif Ghoussoub. "Its programs span almost every aspect of pure, applied, computational and industrial mathematics, statistics and computer science." BIRS competitively selects and runs about 175 weekly workshops per year that attract physicists, biologists, engineers, economists and financial analysts. In 2014, Mexico approved a proposal to build a facility in Oaxaca, Casa Matemática Oaxaca, where BIRS will host around 25 additional workshops per year.

BIRS represents a breakthrough for North American scientific cooperation. It is funded by the Natural Sciences and Engineering Research Council of Canada, the United States' National Science Foundation, Mexico's Consejo Nacional de Ciencia y Tecnología, and the Alberta Ministry of Innovation and Advanced Education. As the first research facility to involve four governments in a partnership of this scale, BIRS provides exciting new opportunities for North American students and researchers, and access to international counterparts at the highest levels and across many disciplines. According to Dr. Ghoussoub, "The unique impact of BIRS is the role it plays as a catalyst of research collaborations and as a multiplier of opportunities that underscores how international cooperation adds up to more than what any nation could accomplish alone."

There are also more formal mechanisms through which knowledge is transferred, including collaboration on scientific papers and technology licensing. Although reliable Canadian and international data on these mechanisms are limited, available statistics suggest that Canada's knowledge transfer performance continued to be lacklustre.

Intersectoral Co-Publications

Comparative international data regarding collaboration on scientific papers are not available. However, in Canada, the Observatoire des sciences et des technologies measures the number of co-publications authored by university researchers and researchers from other ST&I sectors. In 2013, 24.2 percent of Canadian university researchers' publications were co-authored by at least one researcher from another sector, up from 20.4 percent in 2004.[27] From 2004 to 2013, hospital researchers were by far the most frequent collaborators, having co-authored 13.1 percent of all university researchers' publications. The second most important collaborating sector was the federal government (4.5 percent), followed by industry and provincial governments (both at 2.6 percent).

Consistent with the large number of collaborations between university and hospital researchers over the period, the highest collaboration rates were in the fields of clinical medicine (35.6 percent), biomedical research (26.6 percent) and biology (26.0 percent). Among other fields, the only noteworthy collaboration rate was in earth and space sciences (20.7 percent).

Licensing Technologies

Another formal means of transferring knowledge is for academic and government researchers and institutions to license their technologies to firms. This can be facilitated by intermediaries, such as technology transfer offices and commercialization centres, and by governments, through programs supporting commercialization of research.

The Association of University Technology Managers (AUTM) publishes data on knowledge transfer activities in Canada and the U.S. based upon a sample of universities and affiliated research hospitals in each country. Although not comprehensive, and thus not authoritative, the data provide an indication of Canadian and U.S. activity. The most recent AUTM numbers show that the U.S. continued to be more successful than Canada at creating licences and earning licensing income.

In 2012, Canadian HEIs surveyed created approximately 16 licences per institution compared with about 35 in the U.S.[28] The number of licences created increased marginally in Canada between 2007 and 2009 and then declined through to 2012. As a result, the creation of new licences and options decreased by 5.9 percent[29] from the 2007 baseline. In contrast, the creation of new licences and options increased by 25 percent in the U.S. over the same period.

Licensing *incomes* at both Canadian and U.S. institutions increased steadily between 2009 and 2012, but the American HEIs surveyed generated significantly more revenues. In 2012, a Canadian institution received, on average, approximately C$2.2 million from licensing income compared with US$13.5 million for a U.S. institution. The difference between the two was roughly the same as in 2007, when a Canadian institution received, on average, approximately C$1.6 million from licensing income and a U.S. institution approximately US$12.6 million.

27 Observatoire des sciences et des technologies, *Bibliometric Indicators on Intersectoral Collaboration of Canadian Universities (2004–2013): Methodological Note and Short Analysis*, February 2015.

28 Association of University Technology Managers, *Canadian Licensing Activity Survey: FY2012* and *U.S. Licensing Activity Survey: FY2012*, 2013. For Canada, the sample included 33 institutions. For the U.S., the sample included approximately 190 institutions.

29 All percentages here and below have been calculated based upon normalization of the numbers of reporting institutions for the years compared.

Conclusions

Canada continued to exhibit strength on measures related to the quality of knowledge production: our universities were strong performers in a second tier of countries in the global rankings; we enjoyed real "star power" in hosting leading researchers; and we continued to perform above the world average on research citation counts (relative impact index). However, we must not be complacent about our achievements — our investments in R&D (GERD and HERD) have begun to lag those of competitor countries. We must keep pace, to remain competitive and to give Canada's universities and researchers the support they need to excel on the global stage.

CHAPTER 4:
TALENTED PEOPLE

4

Global competition is fierce for talent with the advanced knowledge and skills necessary to harness science, technology and innovation (ST&I) and meet the needs of diverse employers. To assess whether Canada is keeping pace in this domain, three components that drive success and define leadership are reviewed:

- the ability to develop talent with the right knowledge and skills, including science and engineering doctoral graduates (wherein another aspirational indicator lies);
- the educational foundation for children and youth; and
- the strength of linkages to the global pool of talent and knowledge.

Talent with the Right Knowledge and Skills

Canada's highly educated population is an asset, as education is the foundation of discovery and innovation. Canada continued to lead the Organisation for Economic Co-operation and Development (OECD) in 2012 in the proportion of the population with a post-secondary education.[30] The comparatively high share of the population that had attained a college level education contributed significantly to Canada's leadership position on this indicator.

Key Findings

- Canada doubled the number of doctoral degrees granted in science and engineering (per 100,000 population) between 2006 and 2012, moving from 19th to 17th position in international rankings. Climbing from 41 percent to 69 percent of the threshold of the top five performing countries, this was a notable improvement in Canada's performance on this aspirational indicator.
- Although Canada experienced 7 percent growth in the number of graduates (not including PhDs) in science, engineering, business and health over the period between 2006 and 2012, its global ranking slipped from 14th to 16th.
- Canada ranked fifth among comparator countries in 2012 (down from second in 2008) in the number of college graduates in business, engineering, science and health.
- Canadian adults performed strongly in international tests on literacy, numeracy and problem solving. Canadian 15-year-olds continued to score well in reading, math, science and creative problem solving, although Canada slipped marginally in its international rankings.
- The proportion of international students at Canadian universities and colleges rose from 7.7 percent in 2007 to 8.2 percent in 2012. Despite this increase, Canada dropped from fifth position among international competitors in 2007 to seventh position in 2012.

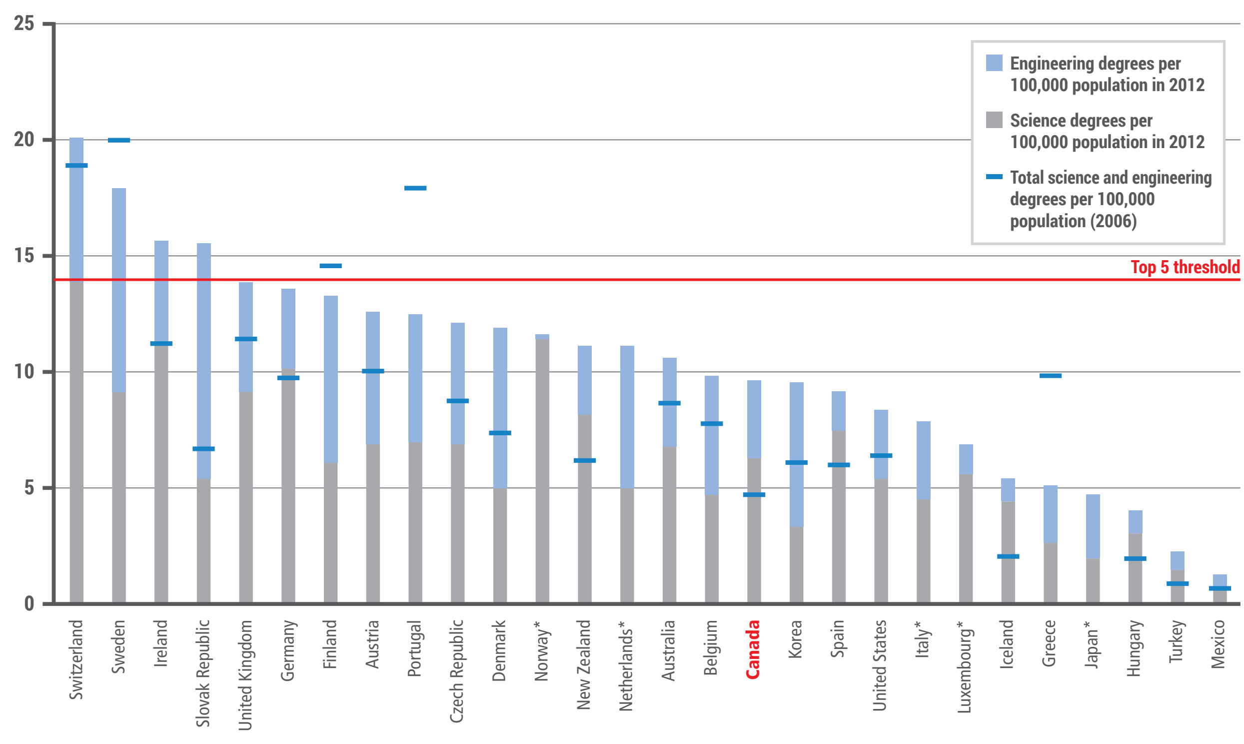
The Right Knowledge

Doctoral graduates represent top talent in a world where the creation and application of new knowledge drive economic growth and societal advances. Although Canada remained around the middle of the pack in the number of science and engineering doctoral degrees granted per 100,000 population in 2012, our growth rate on this measure was significant. Between 2006 and 2012, Canada more than doubled the number of science and engineering doctoral degrees granted, from 4.6 to 9.6 per 100,000 population (with science disciplines accounting for about two thirds of the total number and engineering for about one third in 2012). As a result of this growth, Canada rose from 19th of 23 countries in 2006 to 17th of 28 countries in 2012, ahead of the United States (U.S.), which ranked 20th.

Although Canada remained around the middle of the pack in the number of science and engineering doctoral degrees granted per 100,000 population in 2012, our growth rate on this measure was significant.

Most notably, this strong growth drove an improvement in Canada's position relative to the top five performing countries (Switzerland, Sweden, Ireland, the Slovak Republic and the United Kingdom (U.K.)), from 41 percent to 69 percent of the threshold required to break into their ranks (Figure 4-1).[31]

Figure 4-1: Science and Engineering Graduates at the Doctoral Level per 100,000 Population, 2012



* Note: Data for total science and engineering degrees per 100,000 population in 2006 are not available for Norway, Netherlands, Italy, Luxembourg and Japan.

Source: OECD, *Graduates by Field of Study* and *Population,* October 2014.

[30] OECD, *Education at a Glance*, 2014.

[31] OECD, *Graduates by Field of Study* and *Population*, October 2014.

Grand Challenges Canada: Loving the Loo – Innovation in Design and Business Strategy Improves Sanitation in Rural Nepal

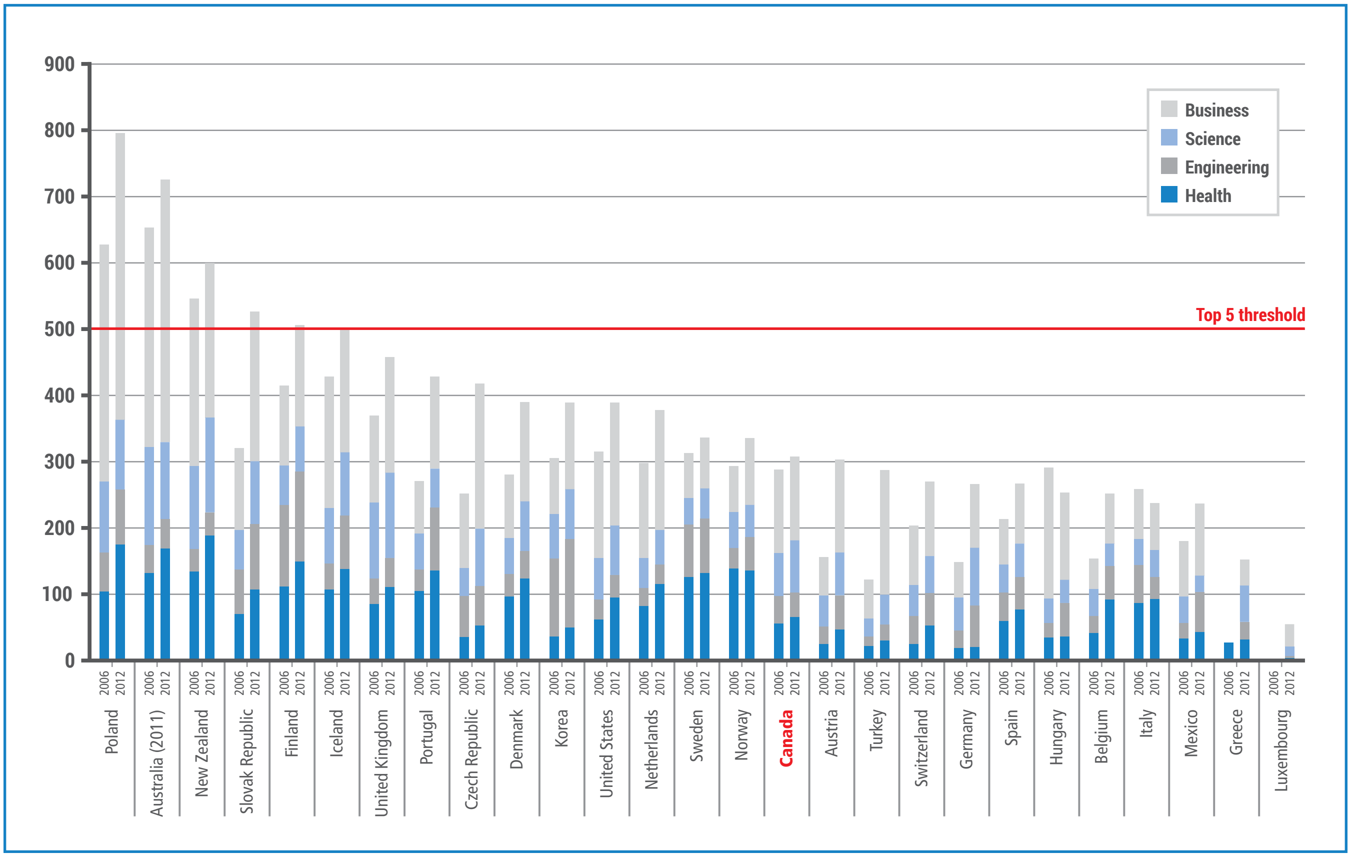
Some 2.5 billion people worldwide lack adequate sanitation and hygiene, resulting in extensive health problems and even death. As part of its efforts to address this issue, Grand Challenges Canada (GCC), which funds innovators in low- and middle-income countries and Canada, is supporting iDE Canada in a sanitation project in Nepal. iDE Canada, a Winnipeg-based non-profit organization that supports small businesses in the developing world, is strengthening the capacity of local entrepreneurs in Nepal to develop a sustainable market for latrine products. A key aspect of this innovative approach is marketing simple, low-cost toilets as a status symbol and sanitation as an affordable source of pride.

"The traditional approach — standard public health messages coupled with give-away programs that sideline local businesses — is not working," says Stu Taylor, iDE's Director of Performance Measurement. "Our experience shows that when you make sanitation affordable and desirable for users — and profitable for businesses — it just takes off." iDE's marketing approach is complemented by training for small-scale local producers and entrepreneurs to produce and sell simple-design, low-cost latrines that can be easily installed within a few hours.

In just one year, iDE has helped facilitate the production and sale of over 15,000 latrines. Over the course of three years, the project is projected to reach a total of 50,000 latrines, improving the lives of an estimated 250,000 people in Nepal, while demonstrating a viable social entrepreneurship model to tackle this urgent public health crisis.

iDE is a powerful example of GCC's concept of "integrated innovation": coordinated application of scientific/technological, social and business innovation to develop solutions to complex challenges. This approach underscores the synergies that can be realized by aligning these three types of innovation.

Figure 4-2: University (Tertiary-A) Graduates in Health, Engineering, Science and Business per 100,000 Population, 2006 and 2012



Source: OECD, *Graduates by Field of Study* and *Population*, October 2014.

Looking at PhD graduates by gender reveals that 32.9 percent of Canada's science and engineering PhD graduates were women in 2012, up from 27.2 percent in 2006. This share was significantly lower than that of the leading countries, the U.K. (49 percent) and the U.S. (46 percent), with which Canada often compares itself. In 2012, Canada ranked 20th (of 28 countries) on this measure, a slight improvement from 21st (of 23 countries) in 2006. While this reflects a gender imbalance in Canada, the growth trend in female PhD graduates is encouraging. Over the 2006–2012 period, the number of female doctoral graduates in science per 100,000 population grew by 144.8 percent,[32] outpacing growth in all other OECD countries except Turkey. The number of female doctoral graduates in engineering per 100,000 population grew by 163 percent,[33] a faster rate than Australia, the U.K. and the U.S., among others.

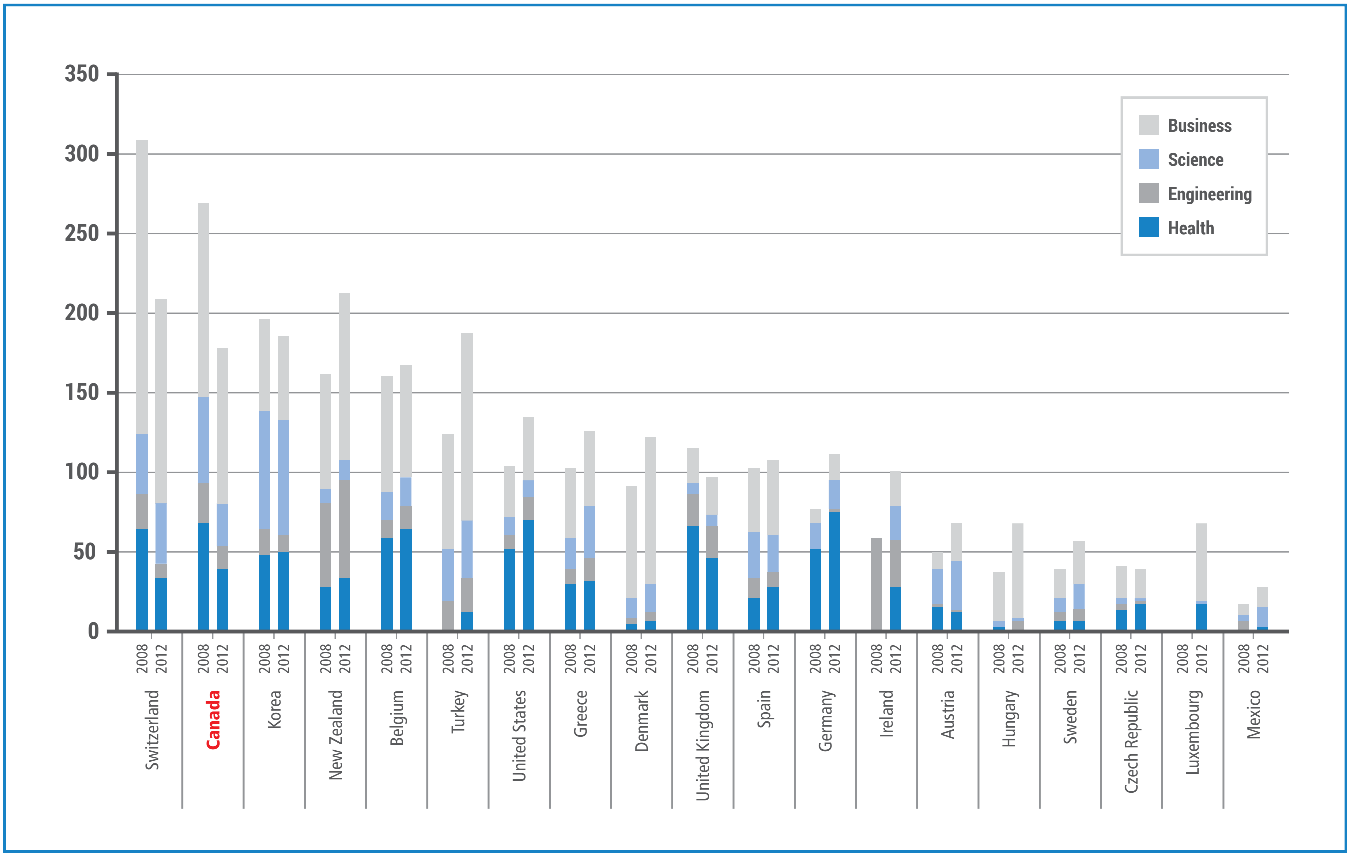
Looking at other university levels, Canada produced fewer graduates (not including PhDs) per 100,000 population in science, engineering, business and health than many other countries. Although Canada experienced 7 percent growth in this area over the period between 2006 and 2012, most other countries saw more substantial growth. Thus Canada's global ranking on this measure slipped from 14th in 2006 to 16th in 2012 (Figure 4-2).[34] The gap between Canada and the top five performers also widened, with Canada at 61 percent of the threshold of the top five performers in 2012, down from 69 percent in 2006. While outperforming Switzerland and Germany, Canada lagged other key competitors such as the U.S., the U.K. and the Nordic countries.

[32] STIC tabulations based on data from OECD, *Graduates by Field of Study*, October 2014.

[33] STIC tabulations based on data from OECD, *Graduates by Field of Study*, October 2014.

[34] OECD, *Graduates by Field of Study* and *Population*, October 2014.

Figure 4-3: College (Tertiary-B) Graduates in Business, Engineering, Science and Health per 100,000 Population, 2008 and 2012



Source: OECD, *Graduates by Field of Study* and *Population*, October 2014.

At the college level, in 2012, Canada ranked fifth among comparator countries in the number of graduates (per 100,000 population) in business, engineering, science and health (Figure 4-3),[35] outperforming most OECD countries on this measure. This was down from 2008, when Canada ranked second. It reflected the 33 percent drop in college graduates in Canada in these areas between 2008 and 2012.

The Right Skills

To meet the needs of ST&I employers across the economy, and to prepare people to start and grow their own innovative firms, disciplinary and technical knowledge must be complemented with a broader range of skills. These include basic cognitive skills, such as literacy and numeracy; higher order cognitive skills, including creative problem solving and critical thinking; business and management skills; and teamwork and communication skills. Although these skills are in high demand, a lack of reliable data — both Canadian and international — constrains our ability to report on Canada's performance in a meaningful way.

The 2012 results of the OECD's Programme for the International Assessment of Adult Competencies (PIAAC) provide some insights into the skills of Canada's adults (16 to 65 years of age). In literacy, Canada ranked 10th (mean score), performing at approximately 98 percent of the threshold of the top five performers (Japan, Finland, Netherlands, Australia and Sweden) and ahead of ST&I leaders such as Korea, the U.K., Germany and the U.S.[36] In numeracy and problem solving in technology-rich environments, Canada ranked 13th and 7th respectively.

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[35] OECD, *Graduates by Field of Study* and *Population*, October 2014.

[36] STIC calculations based on data extracted from the OECD (October 2012) and Statistics Canada, Employment and Social Development Canada, and the Council of Ministers of Education, Canada, *Skills in Canada: First Results from the Programme for the International Assessment of Adult Competencies (PIAAC)*, Catalogue no. 89-555-X, 2013.

On both of these indicators, Canada sat at approximately 95 percent of the threshold of the top five performers. (The top five performers in numeracy were Japan, Finland, Netherlands, Sweden and Norway, while the top five in problem solving in technology-rich environments were Sweden, Finland, Netherlands, Norway and Denmark.) Canada had a larger proportion of adults at the lowest proficiency levels in all three skills (compared with the OECD average), especially among Aboriginal adults living in Nunavut and the Northwest Territories. (See Annex 4 for more detail on the PIAAC results.)

Gender Differences in Choosing a Science, Technology, Engineering and Math (STEM) University Program

Research from Statistics Canada in 2013 showed that young men were more than twice as likely as young women to opt for a STEM program as their first choice in university. Young women were much more likely to choose a first program in social sciences. Even those with higher Programme for International Student Assessment (PISA) scores were less likely to choose a STEM program than young men with lower PISA scores (23 percent versus 39 percent). Social sciences were preferred by most females, regardless of mathematical proficiency. In contrast, males were always more likely to choose a STEM program, even those with a lower proficiency in mathematics according to PISA results.

Source: Darcy Hango, "Gender Differences in Science, Technology, Engineering, Mathematics and Computer Science (STEM) Programs at University," *Statistics Canada*, Catalogue no. 75-066-X, December 2013.

A Strong Educational Foundation

Improving a country's production of high-quality talent requires a strong educational foundation for children and youth. Canada continued to perform well in the OECD's Programme for International Student Assessment (PISA), which measures the abilities of 15-year-olds in reading, math and science.

According to the 2012 PISA results, Canada still ranked among the leaders, although its relative position deteriorated slightly. In 2012, Canada ranked 8th in reading (down from 6th in 2009),[37] 13th in math (down from 10th in 2009) and 9th in science (down from 8th in 2009) (see Annex 4 for in-depth PISA breakdowns).[38] As with many other countries, notable gender differences continued to exist in Canada, with girls outperforming boys in reading and boys outperforming girls in both math and science.

In reading, test results showed that Canadian 15-year-olds performed at approximately 97.6 percent (down from 99.6 percent in 2009) of the threshold of the top five performers (Japan, Finland, Netherlands, Australia and Sweden) and ahead of ST&I leaders such as Korea, the U.K., Germany and the U.S. Canada was at 93.5 percent of the threshold of the top five performers in math (down from 97 percent in 2009), well ahead of the U.S., but behind the leaders (Shanghai-China, Singapore, Hong Kong-China, Chinese Taipei and Korea). In science, Canada sat at around 96 percent of the threshold of the top five performers (Shanghai-China, Hong Kong-China, Singapore, Japan and Finland), down from 98 percent in 2009.

People who excel in science, technology, innovation and entrepreneurship tend to be creative problem solvers who are open to new ideas, take intelligent risks, and use intuition and ambition to pursue opportunities. The PISA results showed that, in 2012, students in Singapore, Korea and Japan, typically ST&I leaders, scored higher in problem solving (with scores ranging from 552 to 562) than students elsewhere, including Canada. With a score of 526, Canadian students nonetheless scored well above those in some other ST&I leading countries, namely Germany, the U.S. and Norway.[39]

[37] Changes in the countries represented in PISA in 2012, 2009 and 2006 significantly impact our ability to compare Canada's performance with others; thus 2009 is used as the baseline year for PISA comparisons.

[38] OECD, *PISA 2012 Results: What Students Know and Can Do — Student Performance in Mathematics, Reading and Science*, Volume I, Revised Edition, February 2014.

[39] OECD, "Are 15-Year-Olds Creative Problem-Solvers?," *PISA in Focus*, April 2014.

Globally Connected Talent

In high demand around the world, accomplished people are increasingly willing and able to go where the best opportunities lie. With a limited population and thus a relatively small pool of domestic talent, Canada needs to be competitive in connecting with the "best and the brightest" throughout the world. These international connections can bring knowledge, skills, experience and networks that enhance Canada's ST&I enterprise.

International Students

Attracting international students to Canada's universities, polytechnics and colleges is an excellent way to strengthen linkages to the global ST&I enterprise. In 2012, 8.2 percent of all students in Canada were international, up from 7.7 percent in 2007 and more than twice the proportion in the U.S. (3.5 percent). Despite this increase, Canada's international ranking dropped from fifth in 2007 to seventh in 2012, and Canada sat at 53 percent of the threshold of the top five performers (Australia, the U.K., Switzerland, New Zealand and Austria).

Immigration

Skilled and highly educated immigrants can also make important contributions to innovation in Canada. U.S.-based research has shown that immigrants are overrepresented as business owners, founders of high-tech start-ups, patent holders, Nobel Prize winners and exporters.[40] Unfortunately, similar Canadian data have not been collected. New and improved data that measure the role and outcomes of immigrants in Canada's ST&I ecosystem are needed to assess performance and contribute to a more comprehensive understanding of ecosystem dynamics.

Cross-Border Study of Beaufort Sea Ecosystem: Stantec (Newfoundland)

In 2014, Stantec Newfoundland, an arm of Stantec Inc., was selected by the United States (U.S.) Bureau of Ocean Energy Management and the National Oceanographic Partnership Program to play a lead role in the Marine Arctic Ecosystem Study (MARES). This exciting project aims to provide a more comprehensive understanding of the Beaufort Sea, especially the interrelationships of its physical, biological, chemical and human systems, and to advance scientific prediction capabilities for linkages between marine life, human uses, sea ice, atmospheric and oceanic processes, and river discharge. The research will enhance knowledge in several areas, including environmental protection, climate change, food security, biodiversity, exploration and discovery, and ecosystem services. This knowledge will facilitate decision making by governments, industry and communities related to regulations, resource management, economic development and environmental protection.

MARES will cross the U.S.–Canada border along the Beaufort Sea shelf from Barrow, Alaska, to the Mackenzie River delta. It will integrate research from 10 disciplines (seven led by Stantec) and involve the Inupiat and Inuvialuit communities and more than 25 universities, environmental research organizations, consulting firms and independent scientists. The study will use multiple sampling platforms, including ships, drones, satellites and snow machines; multiple sampling techniques, such as ice and snow sensors, acoustics and nets; and multiple ocean, ice and air modelling approaches.

According to Diane Ingraham, Canadian project manager, "It's a pretty spectacular opportunity for us to take some of the expertise we've learned in offshore oil and gas and managing big projects in harsh environments …. we're able to take that expertise and use it to execute this project in the Beaufort Sea off of Alaska."

[40] World Intellectual Property Organization, *U.S. High-Skilled Immigration, Innovation and Entrepreneurship: Empirical Approaches and Evidence*, Economic Research Working Paper No. 16, 2014.

International Co-Publications

Collaborative research with peers and institutions abroad, reflected in international co-publications, is another important way to link to the global pool of talent and knowledge. In 2012, international co-publications accounted for 45.2 percent of Canada's total publications, compared with 42.1 percent in 2006.[41] This increase continued the steady upward trend evident since 1980.

Despite this increase, Canada ranked 12th (of 30 countries) on this measure in 2012, standing at 79 percent of the threshold of the top five performers, a drop from 4th place and 102 percent of the top five threshold in 2006. Seven of the countries that significantly outscored Canada were small European countries aggressively seeking international collaboration: Switzerland, Austria, Belgium, Denmark, Sweden, Netherlands and Finland. Other countries that outranked Canada, but by a less significant margin, were (with one exception) larger countries: France, Portugal, the U.K. and Germany.

Conclusions

Canada's talent base continues to be an asset. In 2012, we led the OECD in the proportion of the population with a post-secondary education, driven by the comparatively large share of Canadians with a college education. Also in 2012, although our PISA rankings slipped marginally, Canadian 15-year-olds performed just shy of the threshold of the top five performers in reading, math and science. Similarly, in 2013, Canadian adults scored just shy of the top five threshold in literacy, numeracy and problem solving in technology-rich environments. Although still underperforming competitors, Canada also made significant progress by 2012 in growing the number of PhD graduates in science and engineering. However, Canada's talent performance showed some signs of erosion, as our ranking on university graduates in science, engineering, business and health (excluding PhDs) dropped to 16th in 2012.

While developing talent is critical, it is equally important that we understand how talent is deployed across the economy. Despite a lack of data tracking the career outcomes of university and college graduates, and PhD graduates in particular, it is clear from the analysis in Chapter 2 that Canada's private sector is not absorbing advanced research talent to the degree seen in competitor countries.

[41] Observatoire des sciences et des techniques, *Tableaux d'indicateurs de référence et rapports à télécharger,* 2014.

CHAPTER 5: CONCLUSION – SHAPING CANADA'S FUTURE THROUGH SCIENCE, TECHNOLOGY AND INNOVATION

5

Science, technology and innovation (ST&I) drive productivity and competitiveness, and generate solutions to health, environmental and social challenges. Proactively pursuing and achieving a sustainable competitive advantage in ST&I and joining the ranks of the world's top performers is the path to higher living standards and a superior quality of life for Canadians.

State of the Nation 2014 confirms what previous *State of the Nation* reports have found: Canada has a solid foundation in its educated population and the quality of its knowledge production. Canadians can rightfully be proud of this, but we must not be complacent about it. Maintaining and enhancing excellence requires investment. In recent years, other countries have been increasing their research and development (R&D) funding at a faster pace than Canada — a reality reflected in the erosion of Canada's relative ranking, i.e., its competitiveness, on R&D funding indicators. Canada must keep pace by boosting its investments, to protect and grow our knowledge and talent advantages.

Canada is not globally competitive in business innovation. In the components that define success in this area, Canada is falling further behind its global competitors...

It is in relation to business innovation that Canada faces its most profound and urgent ST&I challenge. The analysis in this report confirms a disturbing conclusion: Canada is not globally competitive in business innovation. In the components that define success in this area, Canada is falling further behind its global competitors and facing a widening gap with the world's top five performing countries.

Business innovation is crucial to translating our knowledge and talent advantages into the productivity gains and marketable products that bring prosperity. Canada must increase the number of firms that embrace and effectively manage innovation as a competitiveness and growth strategy. However, our collective efforts to address poor business innovation performance appear to have had little or no impact. It is clear that doing the same things in the same ways will not work; we must significantly change our approach if we are to make material gains in improving Canada's business innovation performance.

Responsibility for reversing Canada's poor business innovation performance and growing its knowledge and talent advantages rests with all players. The ST&I ecosystem is characterized by a complex, dynamic, interdependent web of competition and collaboration. While success requires that all players pursue excellence in their respective roles, at the same time all players must work more closely together, as a "system," to effect change. This is not simply a matter of collaborating more; it is about better *integrating* organizations, activities and funding mechanisms into a more coherent, coordinated whole. It is about governments, higher education institutions (HEIs) and firms developing and using programs and policies more strategically. By adopting a "systems" approach, we can realize more impact from the ST&I investments we make.

Informed action to enhance Canada's ST&I performance requires an in-depth understanding of our ST&I progress, challenges and opportunities. As noted throughout this report, a lack of reliable Canadian and international data on some components constrains this understanding. Thus collection and analysis of Canadian and international ST&I data need to be significantly improved. In health care, for example, the federal government established the Canadian Institute for Health Information, which collects relevant and useful data in a standardized format from all provinces and territories. This information provides a better understanding of the state of Canadian health care, i.e., areas for improvement and intervention, and progress made towards a better system. It is time to establish a similar initiative on ST&I data collection and analysis, to provide meaningful and relevant measures of Canada's performance. What is not measured cannot be managed.

The Way Forward

Business Innovation

Canada's top ST&I priority must be to increase the number of firms that embrace and effectively manage innovation as a competitiveness and growth strategy. This is, first and foremost, the responsibility of the private sector, but governments play an important role in incenting innovation. To be effective in fostering innovation, governments themselves must build their own internal culture of innovation and embrace the importance of ST&I.

Canada's top ST&I priority must be to increase the number of firms that embrace and effectively manage innovation as a competitiveness and growth strategy.

Three core strategies should drive action to enhance Canada's business innovation performance:

Close the gap on firms' investment in innovation

In the increasingly competitive knowledge-based economy, innovation is the key to expanding market share and boosting profits. It is business enterprise expenditures on research and development (BERD) that is most closely linked to product and process innovation; thus it is critical that Canada's private sector significantly increase its investment in R&D (reflected in the aspirational indicator of *BERD intensity*). As demonstrated in Chapter 2, a large natural resources industry is not an obstacle to achieving a higher BERD intensity. In fact, given the strength and strategic importance of Canada's natural resources industry, this should be an area of ST&I leadership for Canada.

Business investment in information and communications technologies (ICT) must also increase (reflected in the aspirational indicator of *ICT investment intensity*), as ICT enables innovation and contributes to productivity growth. Increased investments in R&D and ICT will, in turn, drive more demand in industry for advanced talent and enhance firms' capacity to use that talent to the best advantage. This will be reflected in improved Canadian performance on the aspirational indicator of *human resources in science and technology* and the subset of *researchers in industry*.

Canada's business associations should be more proactive in helping member firms understand the role of innovation and how to effectively manage it, and in providing networks and tools to support it. Specific initiatives could include:

- "matchmaking" services to encourage large firms to procure new technologies from innovative small and medium-sized enterprises (SMEs);
- mentoring, where experienced business people provide hands-on guidance to entrepreneurs and SMEs on commercializing ideas and growing innovative companies; and
- "bridging" opportunities to help firms (especially SMEs) identify and hire ST&I talent.

Redress the imbalance of direct and indirect government funding for business R&D

While the decision to invest in innovation rests with firms, governments can use their direct and indirect R&D support mechanisms to support and incent private-sector R&D. While both direct and indirect support are important, Canada relies far more on indirect support, i.e., the tax system, than other countries. The federal and provincial governments should redress the imbalance of direct and indirect support, to provide more direct support to firms for high-risk, high-reward R&D projects. Through direct support, governments can share risk with the private sector in the pursuit of next-generation products and processes. Direct support, allocated on the basis of competitive excellence, can also better incent innovation by rewarding only the most innovative firms.

In redressing the imbalance of direct and indirect funding for business R&D, governments should focus incremental support where it will have the most impact. At the industry level, this means focusing on industries of economic significance to Canada, building on existing R&D and innovation strengths. At the firm level, governments need to study more closely the performance of large firms and SMEs in introducing product and process innovations. Data indicate that Canada's large firms lag their international competitors, while our SMEs are among the world's leaders. This suggests that governments in Canada should focus on improving the innovation performance of large firms and supporting and incenting the growth of innovative SMEs. Canada must increase the number of large, innovative firms to enhance future competitiveness and job growth, as larger firms are often more productive and tend to invest and to export more than smaller firms.

Embrace risk and ambition

Adopting innovation as a competitiveness and growth strategy inherently demands that firms become less averse to risk and more ambitious. Underpinning this approach is the capacity to understand and to comprehensively and effectively manage innovation through all phases of firm growth.

Again, this responsibility ultimately lies with firms, but others in the ST&I ecosystem can help drive it. Canada's home-grown venture capital industry can help foster a business innovation culture of intelligent risk taking and ambition by more aggressively backing high-potential Canadian firms with innovative ideas and mentoring them through the innovation process. As noted above, the federal and provincial governments can encourage ambition by helping to mitigate the risks associated with R&D through increased direct support for high-risk, high-reward projects. For governments to effectively support innovation in industry, they must embrace innovation. In particular, the federal and provincial governments can help drive innovation and ambition in firms through more innovative, risk-tolerant use of procurement. For inspiration, Canadian governments can look to managers at the United States' Defense Advanced Research Projects Agency, who are not only encouraged but also mandated to pursue high-risk technologies even where there is a reasonable chance of failure.

Education is fundamental to nurturing the type of innovation culture necessary for securing Canada's competitiveness. Innovation and entrepreneurship should be required core competencies at all levels of education. Educational institutions, working in close concert with the private sector, should develop curricula that integrate science and technology knowledge with a broader set of business, entrepreneurship and commercialization skills, and that nurture creativity, intelligent risk taking and ambition. Formal learning should be complemented by "hands-on," work-integrated learning that only employers can offer. Governments at all levels should enhance incentives that encourage firms to provide work-integrated learning opportunities to students and graduates and that offer "bridging" opportunities to help firms, especially SMEs, hire ST&I talent.

Knowledge and Talent

While urgently addressing Canada's business innovation challenge, we cannot be complacent about the other two key pillars of our ST&I ecosystem: we can and must do more to protect and grow our knowledge and talent advantages. Two core strategies should drive action in this area:

Boost higher education expenditures on research and development (HERD) investment levels

Investments in R&D and talent in the higher education sector help build a strong knowledge foundation for all sectors of Canada's ST&I ecosystem. Although federal and provincial funding levels for HERD have continued to increase, growth has not been sufficient to keep pace with other countries that are committing more resources and at a faster rate. Our governments must renew their commitment to higher education R&D. This commitment, manifested in the aspirational indicator of ***HERD intensity***, is vital to ensuring the "intellectual infrastructure" required to keep Canada competitive in the knowledge-based economy.

Invest strategically

It is not just about investing more. The type of improved ST&I performance that the Science, Technology and Innovation Council (STIC) is calling for requires investing *differently*, in a more strategic and coherent way that will maximize the impact of investments across the ST&I ecosystem. This begins with a fundamental shift in attitude and approach.

Firstly, given Canada's limited size, targeted investments are required to build globally competitive scale and capacity in key areas of strength and opportunity. While the principle of excellence must always be respected, this nonetheless requires a sharper focus on priorities, and hard decisions on reallocation of some existing resources to areas where they will have the greatest impact.

Some promising federal initiatives have been introduced in recent years that may contribute to enhancing capacity in key areas. Notable examples include the Canada Excellence Research Chairs and the Canada First Research Excellence Fund, both designed to support world-class researchers and ambitious research programs at HEIs. However, while these initiatives are an important step, they are not sufficient to achieve the scale that Canada needs to be truly competitive internationally. More is required, including increasing investment in those universities with the greatest potential of joining the ranks of the world's top research institutions.

Secondly, investing differently is grounded in the "systems" approach described above, in integrating organizations, activities and funding mechanisms across the ST&I ecosystem in a more coherent way. Each government in Canada should ensure that its own R&D and innovation support programs are designed to link research, talent, infrastructure and commercialization mechanisms to reinforce and build upon one another. The federal and provincial governments should work more closely together to design and deliver R&D and innovation support programs focused on outcomes. In addition, government programs should both enable and compel collaboration among academic, industrial and government researchers, with funding mechanisms that do not impose (sometimes unintended) hurdles to partnerships. This type of "systems" approach should be mirrored at the program user level. Each HEI should plan strategically across its institution, using government programs to expand capacity in areas where it can make a substantial difference. HEIs should also reach across institutional boundaries to collaborate more with one another and with researchers in both industry and government.

Conclusions

A robust and vibrant ST&I ecosystem is critical to Canada's economic prosperity and high quality of life. All ST&I players share responsibility to reverse Canada's poor business innovation performance and grow its knowledge and talent advantages. Effecting change is demanding and complicated; but the need is urgent and compelling. STIC believes that Canada must, and can, rise to the challenge.

ANNEX 1: INTRODUCTION – SETTING THE STAGE

Summary and Comparison of Indicators

Indicators	Value		% of the Top 5 Threshold		Rank		
	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	
CHAPTER 2: AN INNOVATIVE PRIVATE SECTOR							
Business Investment in Research and Development (R&D) and Other Knowledge Assets							
Business enterprise expenditures on research and development as a share of GDP (BERD intensity)	1.11% of GDP	0.82% of GDP (2013)	48%	36% (2013)	18th of 41 countries	26th of 41 countries (2013)	↓
Information and communications technologies investment as a share of GDP (ICT investment intensity)		2.2% of GDP (2013)		71% (2013)		13th of 30 countries (2013)	
S&T-related occupations as a share of total employment		30% of total employment (2011)		78% (2011)		22nd of 43 countries (2011)	
Business enterprise researchers per thousand employment in industry	6.9 per 100,000 population	6.6 per 100,000 population	85%	66%	7th of 33 countries	15th of 33 countries	↓

Indicators	Value		% of the Top 5 Threshold		Rank		
	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	
Funding Environment for Business Innovation							
Overall government funding for business R&D as a share of GDP	0.24% of GDP (2008)	0.21% of GDP (2013)	115% (2008)	66% (2013)	2nd of 30 countries (2008)	10th of 37 countries (2013)	↓
Direct federal funding as a share of GDP	0.02% of GDP (2008)	0.03% of GDP (2013)	19% (2008)	17% (2013)	27th of 30 countries (2008)	28th of 37 countries (2013)	↓
Indirect federal funding as a share of GDP	0.22% of GDP (2008)	0.18% of GDP (2013)	240% (2008)	113% (2013)	1st of 30 countries (2008)	4th of 35 countries (2013)	↓
Venture capital investment as a share of GDP		0.08% of GDP (2014)		134% (2014)		3rd of 32 countries (2014)	
Introduction of Product and Process Innovations							
Firms introduced a product innovation	35% (2007–2009)	35% (2010–2012)					–
Firms introduced a process innovation	34% (2007–2009)	29% (2010–2012)					↓
Share of SMEs introducing a product or process innovation		53% (2010–2012)		112% (2010–2012)		4th of 35 countries (2010–2012)	
Share of large firms introducing a product or process innovation		65% (2010–2012)		85% (2010–2012)		19th of 35 countries (2010–2012)	

Indicators	Value		% of the Top 5 Threshold		Rank		
	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	
Canada's Innovation Performance and Global Competitiveness							
Multifactor productivity (MFP) growth, average annual change		0.6% (1995–2013)		60% (1995–2013)		12th of 19 countries (1995–2013)	
Export market share in globally R&D intensive industries							
Pharmaceutical industry	1.51% of market share	1.08% of market share (2013)	19%	15% (2013)	15th of 41 countries	17th of 41 countries (2013)	↓
Computer, electronic and optical industry	1.02% of market share	0.62% of market share (2013)	16%	12% (2013)	15th of 41 countries	19th of 41 countries (2013)	↓
Aerospace industry	4.77% of market share	3.48% of market share (2013)	100%	100% (2013)	5th of 41 countries	5th of 41 countries (2013)	–
CHAPTER 3: HIGH-QUALITY KNOWLEDGE							
Investments in Knowledge Production							
Gross domestic expenditures on R&D as a share of GDP (GERD intensity)	1.96% of GDP	1.62% of GDP (2013)	67%	49% (2013)	16th of 41 countries	24th of 41 countries (2013)	↓
Higher education expenditures on R&D as a share of GDP (HERD intensity)	0.65% of GDP	0.65% of GDP (2013)	105%	88% (2013)	3rd of 41 countries	8th of 41 countries (2013)	↓

Indicators	Value		% of the Top 5 Threshold		Rank		
	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	
Competitiveness of Research and Higher Education Institutions							
Relative impact index	1.01 (2002)	1.1	93% (2002)	87%	8th of 30 countries (2002)	9th of 30 countries	↓
Most highly cited researchers		96 highly cited researchers (2014)		93%		6th of 15 countries (2014)	
Knowledge Transfer							
Share of Canadian university researchers' publications that were co-authored	20.4% (2004)	24.2% (2013)					↑
Licences created per higher education institution	16.9 per institution (2007)	16.3 per institution (2013)					↓
CHAPTER 4: TALENTED PEOPLE							
Talent with the Right Knowledge and Skills							
Number of doctoral degrees granted in science and engineering per 100,000 population	4.6 per 100,000 population	9.6 per 100,000 population	41%	69%	19th of 23 countries	17th of 28 countries	↑
Share of female Canadian science and engineering PhD graduates	27.2%	32.9%	69%	72%	21st of 23 countries	20th of 28 countries	↑

Indicators	**Value**		**% of the Top 5 Threshold**		**Rank**		
	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	
Talent with the Right Knowledge and Skills (continued)							
University (Tertiary-A) degrees granted in health, engineering, science and business per 100,000 population	285.7 per 100,000 population	305.8 per 100,000 population	69%	61%	14th of 27 countries	16th of 27 countries	↓
Health	54 per 100,000 population	63.9 per 100,000 population	49%	47%	16th of 27 countries	17th of 27 countries	↓
Engineering	40.8 per 100,000 population	36.1 per 100,000 population	66%	43%	11th of 27 countries	20th of 27 countries	↓
Science	64.8 per 100,000 population	78.9 per 100,000 population	78%	82%	7th of 27 countries	9th of 27 countries	↓
Business	126.1 per 100,000 population	126.9 per 100,000 population	63%	58%	9th of 27 countries	17th of 27 countries	↓
College (Tertiary-B) degrees granted in business, engineering, science and health per 100,000 population	268 per 100,000 population (2008)	178.4 per 100,000 population	168% (2008)	100%	2nd of 19 countries (2008)	5th of 19 countries	↓
Business	121.4 per 100,000 population (2008)	98.6 per 100,000 population	170% (2008)	110%	2nd of 19 countries (2008)	4th of 19 countries	↓

Indicators	Value		% of the Top 5 Threshold		Rank		
	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	
Talent with the Right Knowledge and Skills (continued)							
Engineering	54.5 per 100,000 population (2008)	27.4 per 100,000 population	180% (2008)	90%	2nd of 19 countries (2008)	6th of 19 countries	↓
Science	25.1 per 100,000 population (2008)	14.9 per 100,000 population	120% (2008)	100%	3rd of 19 countries (2008)	5th of 19 countries	↓
Health	67 per 100,000 population (2008)	37.5 per 100,000 population	130% (2008)	80%	1st of 19 countries (2008)	6th of 19 countries	↓
Programme for the International Assessment of Adult Competencies (PIAAC)							
Literacy				98%		10th (2013) of 20 countries	
Numeracy				95%		13th (2013) of 20 countries	
Problem solving				95%		7th (2013) of 20 countries	

Indicators	**Value**		**% of the Top 5 Threshold**		**Rank**		
	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	Baseline Data (2006 unless otherwise noted)	*State of the Nation 2014* (2012 unless otherwise noted)	
A Strong Educational Foundation							
Programme for International Student Assessment (PISA)							
Reading	524 (2009)	523	99.6% (2009)	97.6%	6th of 74 countries (2009)	8th of 65 countries	↓
Math	527 (2009)	518	97% (2009)	93.5%	10th of 74 countries (2009)	13th of 65 countries	↓
Science	529 (2009)	525	98% (2009)	96%	8th of 74 countries (2009)	9th of 65 countries	↓
Globally Connected Talent							
Share of international students at Canadian universities and colleges	7.7% (2007)	8.2%	100% (2007)	53%	5th of 16 countries (2007)	7th of 22 countries	↓
Share of international co-publications of Canada's total publications	42.1%	45.2%	102%	79%	4th of 30 countries	12th of 30 countries	↓

Concepts and Methodology

Defining Innovation

Based on the Organisation for Economic Co-operation and Development's (OECD's) *Frascati Manual* (2002) and *Oslo Manual* (2005), the Science, Technology and Innovation Council (STIC) has defined innovation throughout the *State of the Nation* reports as the process by which individuals, firms 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 research and development (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 an impact or greater over time on individual firms and the overall economy. The essential ingredient is that something new or improved is introduced to an organization or directly to the marketplace.

Methodology

The indicators examined in this report 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, many of the data used in this report are for 2012 and 2013.

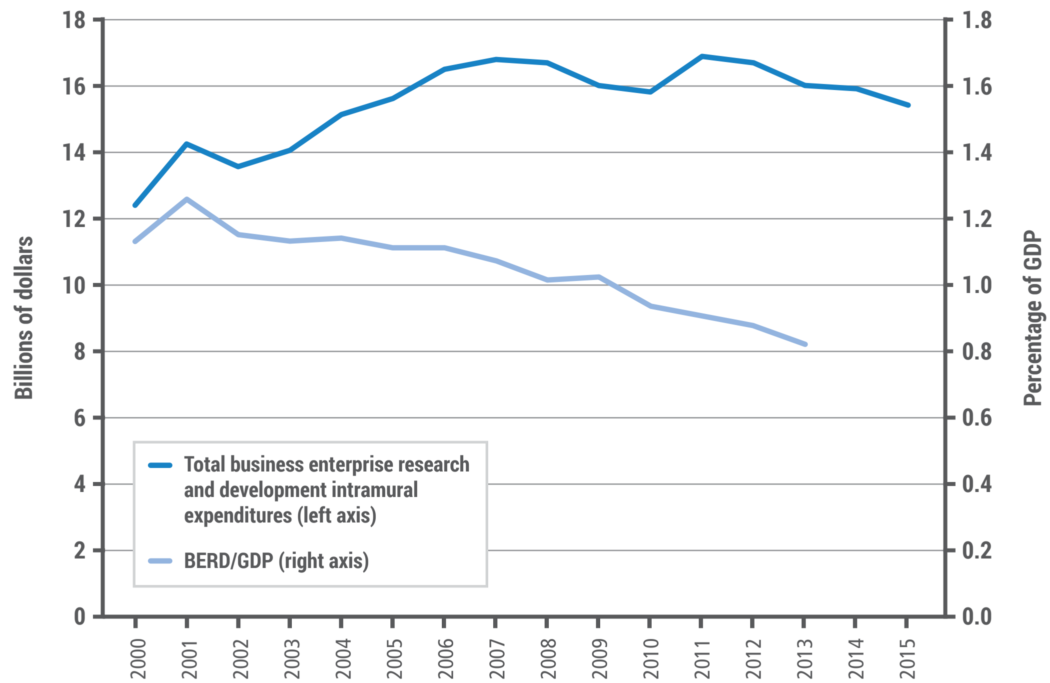
Consistent with statistical conventions, data reported in previous editions of *State of the Nation* have been updated in cases where final data have been released to replace original estimates. In international comparisons, when statistics were not available for a particular country for the year(s) used in the analysis, the most recent data available for that country were used instead, rather than omitting the country from the comparison.

A number of indicators used in this report are expressed as a percentage of the size of each country's economy, i.e., gross domestic product (GDP). This is a commonly used and accepted international convention, and it allows comparison of science, technology and innovation indicators across countries of different economic sizes. As with many measures, these ratios could be influenced by changes either in the indicator itself or in the country's GDP. Nevertheless, all other things being equal, such considerations do not materially affect Canada's international rankings on these indicators.

All data are in current Canadian dollars unless otherwise noted.

Business Enterprise Expenditures on Research and Development (BERD) and BERD Intensity in Canada

Figure 2A: BERD and BERD Intensity in Canada, 2000–2015



Sources: Statistics Canada, *Table 358-0024* (accessed July 16, 2015); OECD, *Main Science and Technology Indicators*, January 2015.

For almost a decade, business enterprise expenditures on research and development (BERD) in Canada have generally been in decline. As noted in Chapter 2, from 2006 to 2015, BERD declined by more than $1 billion, reflecting a decrease of about 6 percent over the period. Although BERD reached $16.894 billion in 2011, a gradual decrease began in 2012, with BERD falling to $15.462 billion in 2015.

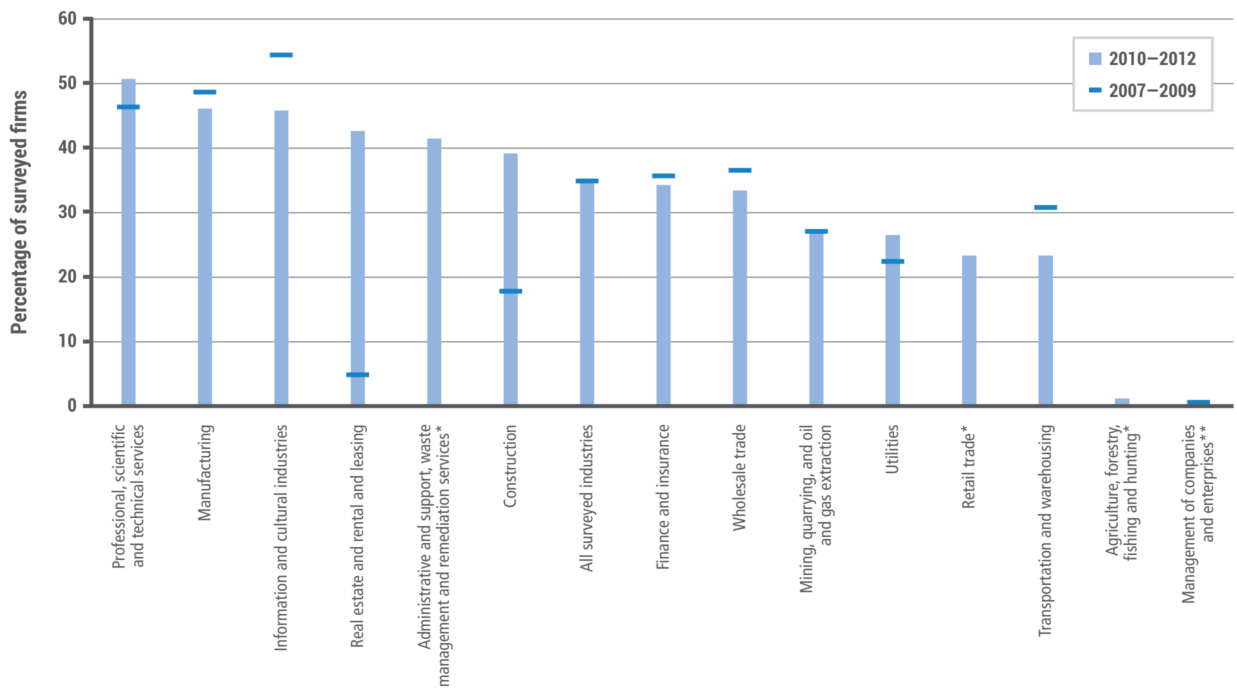
The percentage of firms in Canada that perform research and development (R&D) (i.e., the R&D participation rate) remained steady since the 2006 baseline at 2.2 percent in both 2006 and 2012 (the most recent year for which data are available). The R&D participation rate was much higher among manufacturing firms than service firms (17.3 percent compared with 1.6 percent). However, many manufacturing industries saw decreases in the R&D participation rate from 2006 to 2012, including the pharmaceutical industry (from 50.6 percent in 2006 to 47.5 percent in 2012) and the communications equipment industry (from 55.7 percent in 2006 to 52.3 percent in 2012).[42] Overall, the R&D participation rate of manufacturing firms decreased by about 1 percent from 2006 to 2012; conversely, the R&D participation rate of service firms increased by about 2 percent.

Among service industries, scientific research and development services had the greatest R&D participation rate (41 percent in 2011), followed by computer system design and related services (12.5 percent) and information and cultural industries (10.3 percent). Firms in other service industries had far lower R&D participation rates, including those important to the Canadian economy (e.g., the finance, insurance and real estate industry, at 0.6 percent).

[42] Statistics Canada, *Industrial Research and Development: Intentions 2013*, Catalogue no. 88-202-X; and Statistics Canada, *Industrial Research and Development: Intentions 2015*, Catalogue no. 88-202-X.

Product and Process Innovation in Canada, by Industry

Figure 2B-1: Product Innovation by Industry



*2007–2009 data unreliable.
**2010–2012 data unreliable.

Source: Statistics Canada, *Table 358-0221* (accessed October 20, 2014).

While Chapter 2 provided an international comparison of the introduction of product and process innovation, the data provided here dig deeper into the performance of different industries within Canada, using Statistics Canada's *Survey of Innovation and Business Strategy* (SIBS). The survey has been conducted twice, first looking at innovations introduced during the 2007–2009 period and, most recently, at those innovations introduced between 2010 and 2012.

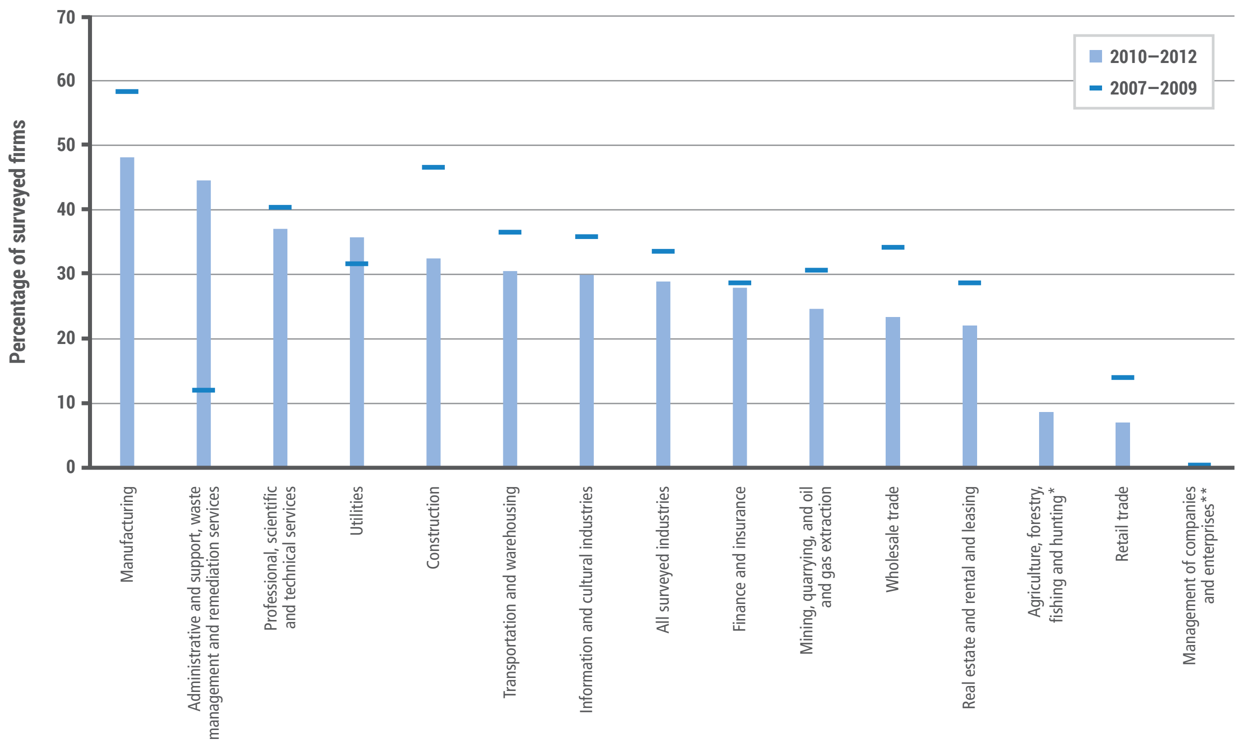
While firm investment in R&D is critical, data on BERD do not necessarily capture all innovating firms in Canada as R&D is not always a necessary input to innovation. Some of the most innovative firms in the world are not among the top R&D spenders globally.[43] While only 2.2 percent of all firms in Canada performed R&D in 2012,[44] 35.1 percent of firms participating in the SIBS reported introducing a product innovation between 2010 and 2012 (up slightly from 34.8 percent between 2007 and 2009) and 29 percent reported introducing a process innovation (down from 33.5 percent).[45]

43 Strategy&, *The Top Innovators and Spenders*, 2015.

44 Statistics Canada, *Industrial Research and Development: Intentions 2015*, Catalogue no. 88-202-X.

45 Because the SIBS excludes firms with fewer than 20 employees, a large number of non-innovating firms may not be captured in the SIBS data. As a result, the total share of firms innovating in Canada is likely to be lower than the share reported by the SIBS.

Figure 2B-2: Process Innovation by Industry



*2007–2009 data unreliable.
**2010–2012 data unreliable.

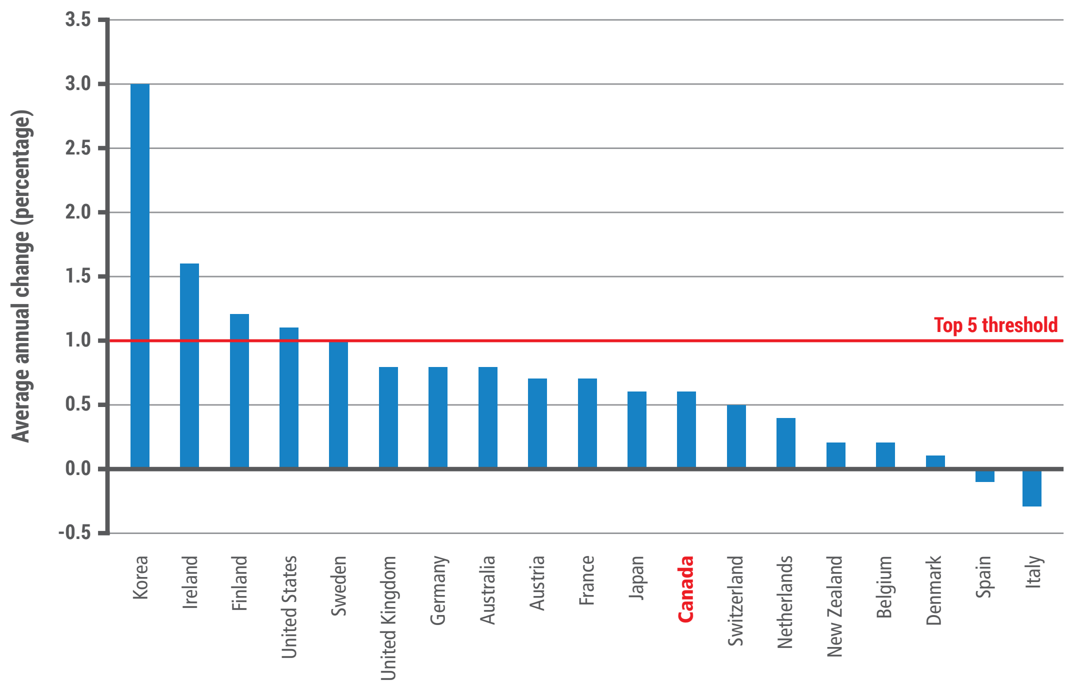
Source: Statistics Canada, *Table 358-0221* (accessed October 20, 2014).

In Canada, the share of firms introducing innovations differs considerably by industry. Some industries are more oriented towards product innovation and others towards process innovation. The performance of a number of industries in introducing product *and* process innovations declined between 2007 and 2009 and between 2010 and 2012, including manufacturing, information and cultural industries, wholesale trade, and transportation and warehousing. The share of firms introducing *process* innovations declined in almost all industries between the two periods.

Natural resources industries are often cited as an area in which a lot of innovation may be occurring that is not captured in R&D-based indicators. Yet within mining, quarrying and oil and gas extraction, about one quarter of firms reported introducing either a product or process innovation between 2010 and 2012. This is below the percentage reported for all surveyed firms in Canada. Those industries that reported introducing product and process innovations above the percentage reported for all surveyed firms in Canada tend to be related to professional, scientific and technical services; manufacturing; and information and cultural industries.

International Comparison of the Change in Multifactor Productivity

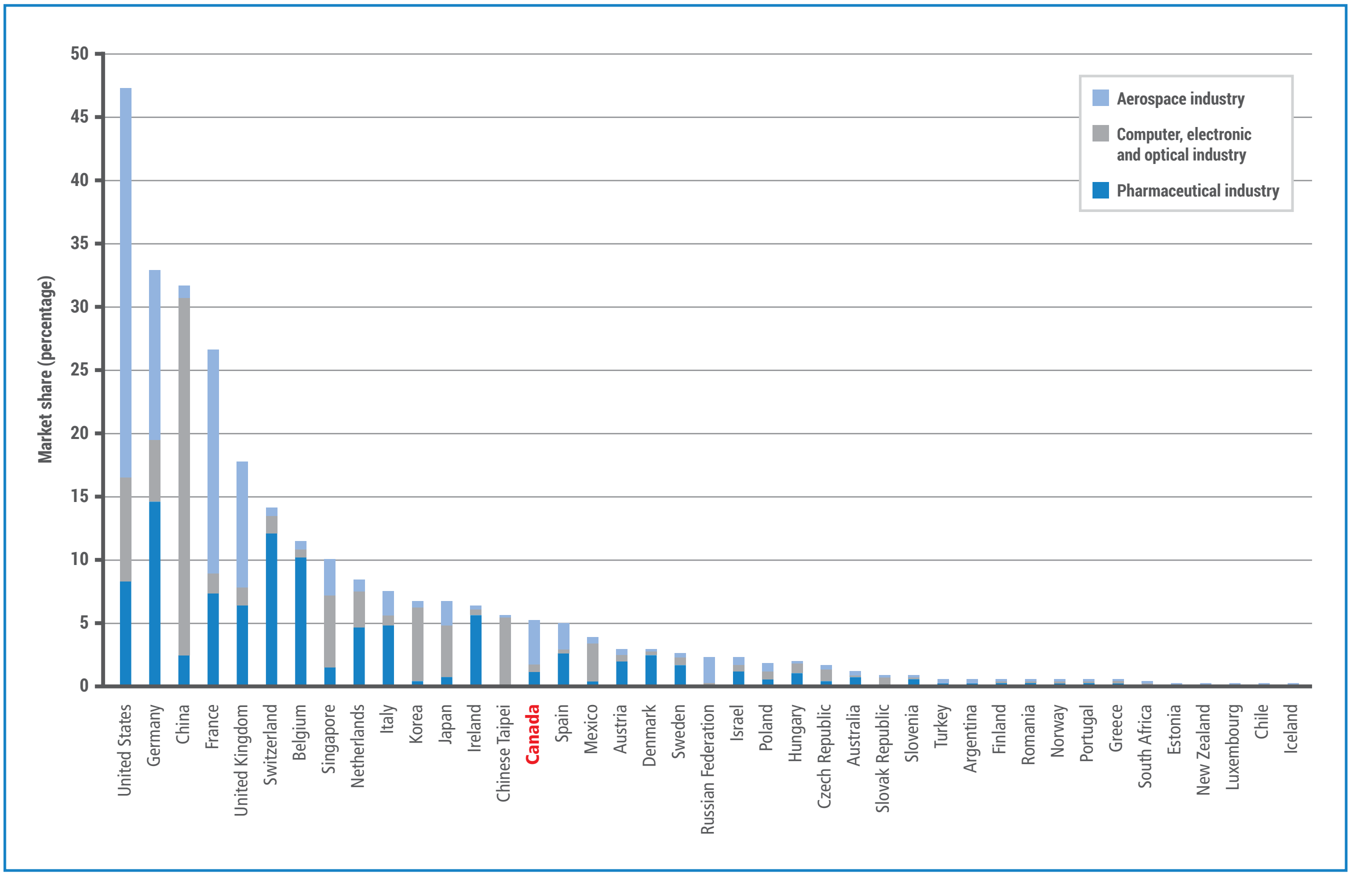
Figure 2C: International Comparison of the Change in Multifactor Productivity, 1995–2013



Source: OECD, *Growth in GDP per Capita, Productivity and Unit Labour Cost (ULC)* (accessed October 22, 2015).

International Comparison of Export Market Share in R&D-Intensive Industries

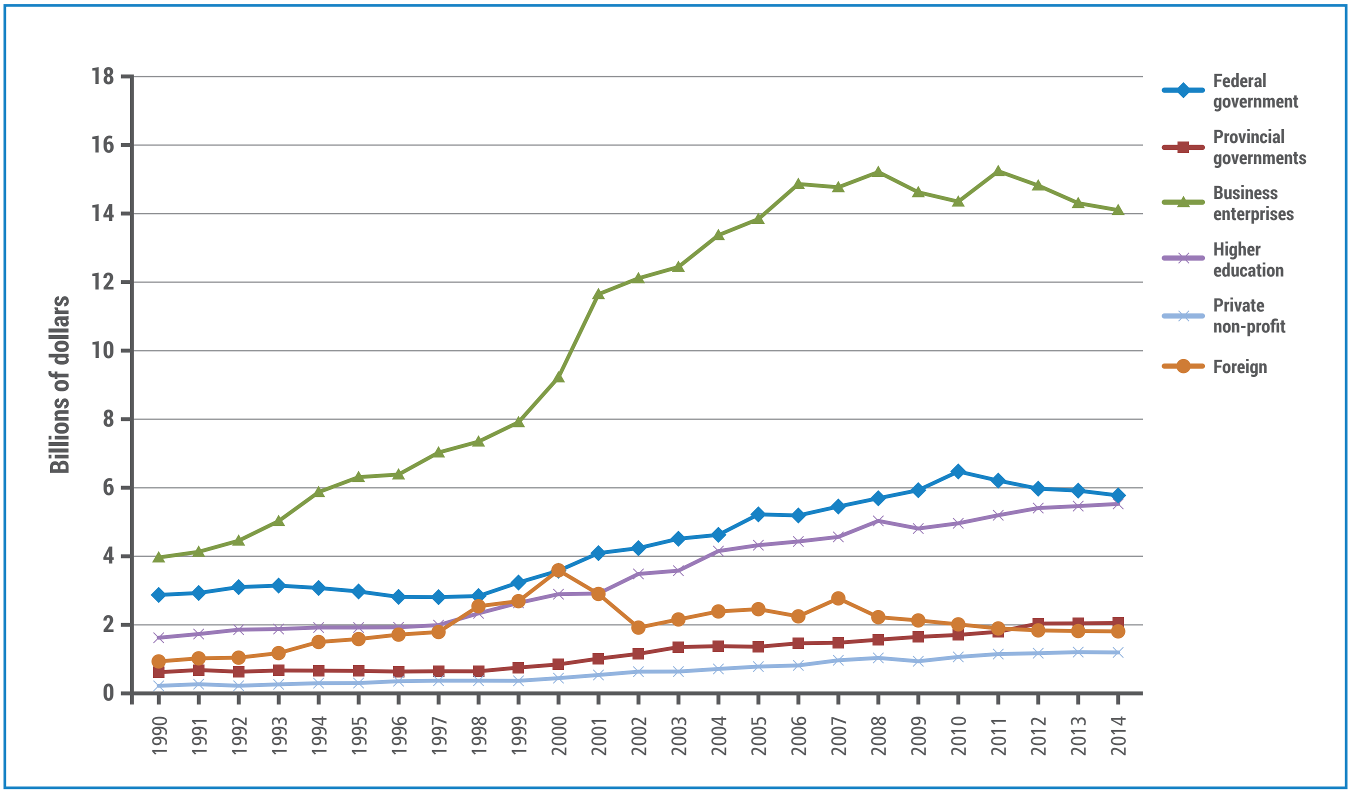
Figure 2D: International Comparison of Export Market Share in R&D-Intensive Industries, 2013



Source: OECD, *Main Science and Technology Indicators*, January 2015.

Canadian Sources of R&D Funding

Figure 3A: Canadian Sources of R&D Funding by Funding Sector, 1990–2014



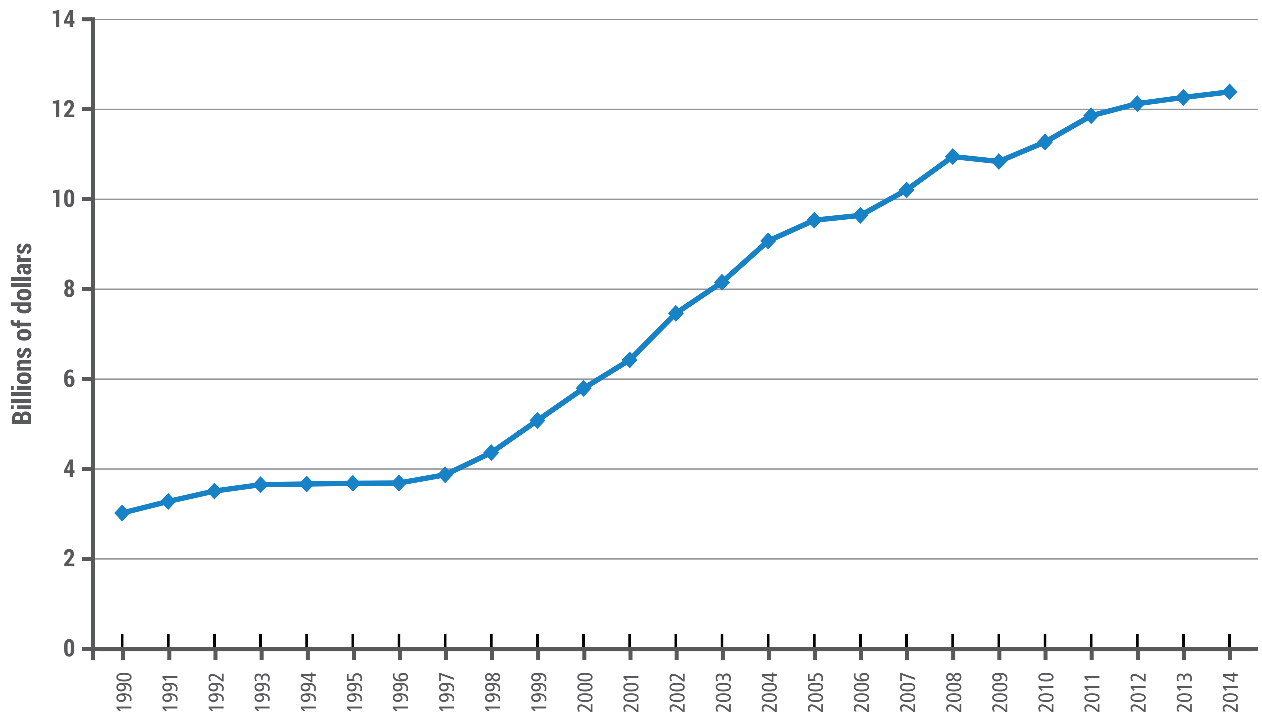
Source: Statistics Canada, *CANSIM Table 358-0001* (accessed October 20, 2014).

Breaking down Canada's gross domestic expenditures on research and development (GERD) funding, as reported in Chapter 3, identifies the trend over time in the contributions of various sectors to research and development (R&D) funding. While the federal government is the second-largest funder of R&D in Canada, it funds less than half the amount that the first-place business sector funds. Both sectors have reduced their R&D funding over the past few years. While business funding first declined then rose over the course of the financial recession, peaking at $15.2 billion in 2011, it declined in 2012 and 2013 and is expected to continue trending downwards to $14.1 billion in 2014. Similarly, federal government funding has trended downwards from its peak of $6.5 billion in 2010 and is expected to decline to $5.8 billion by 2014.

All other sectors in Canada are expected to increase their funding of R&D activities in 2014. The higher education sector is expected to hit a record $5.5 billion in R&D funding in 2014, almost reaching the federal government's contribution. Provincial governments continue to gradually increase their R&D funding, and they are expected to contribute an all-time high of $2.1 billion in 2014. R&D funding from the private non-profit and foreign sectors is expected to be $1.2 billion and $1.8 billion, respectively, relatively unchanged from 2013.

Higher Education Expenditures on R&D

Figure 3B: Funding for R&D Performed in the Higher Education Sector, 1990–2014



Source: Statistics Canada, *CANSIM Table 358-0001* (accessed October 20, 2014).

As noted in Chapter 3, the level of funding for R&D performed in Canada's higher education sector continues to grow, albeit at a slower pace between 2011 and 2014 than between 1998 and 2008. From 1998 to 2008, higher education expenditures on research and development (HERD) more than doubled, from $4.4 billion to $10.9 billion. Since 2009, HERD has increased from $10.8 billion to an all-time high of $12.4 billion (projected) in 2014.

Government of Canada Priority Research Areas

To guide its science, technology and innovation (ST&I) investments, the Government of Canada outlined four broad research priority areas in its 2007 Science and Technology Strategy, *Mobilizing Science and Technology to Canada's Advantage*. To provide further focus, in September 2008, the Minister of Industry announced 13 research sub-priorities, as recommended by the Science, Technology and Innovation Council (STIC). The table below breaks down granting council funding by priority (and corresponding sub-priority) area, as discussed in Chapter 3.[46]

Table 3A: Estimates of Granting Council Funding of the 2007 Priorities and 2008 Sub-Priorities: Fiscal Years 2011–12 and 2013–14

<table>
<tr><th rowspan="2">ST&I Priorities and Sub-Priorities</th><th colspan="2">CIHR ($ 000)</th><th colspan="2">NSERC ($ 000)</th><th colspan="2">SSHRC ($ 000)</th></tr>
<tr><th>2011–12</th><th>2013–14</th><th>2011–12</th><th>2013–14</th><th>2011–12</th><th>2013–14</th></tr>
<tr><td>Environment</td><td>16,495.5</td><td>20,939.7</td><td>161,203.1</td><td>169,465.6</td><td>21,390.7</td><td>24,306.3</td></tr>
<tr><td>Water, health</td><td>16,495.5</td><td>20,939.7</td><td rowspan="2">19,568.5</td><td rowspan="2">29,438.0</td><td>678.7</td><td>548.4</td></tr>
<tr><td>Water, security</td><td></td><td></td><td>409.8</td><td>133.7</td></tr>
<tr><td>Water, energy</td><td></td><td></td><td></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></td><td></td><td>10,740.6</td><td>8,254.6</td><td></td><td></td></tr>
<tr><td>Natural Resources and Energy</td><td>3,544.0</td><td>4,454.4</td><td>162,219.0</td><td>158,912.4</td><td>2,364.2</td><td>1,386.7</td></tr>
<tr><td>Energy production in the oil sands</td><td></td><td></td><td>14,449.2</td><td>11,305.2</td><td>287.0</td><td>24.0</td></tr>
<tr><td>Arctic, resource production</td><td></td><td></td><td>2,181.7</td><td>2,165.5</td><td></td><td></td></tr>
<tr><td>Arctic, climate change adaptation</td><td>3,544.0</td><td>4,454.4</td><td rowspan="2">24,589.3</td><td>24,241.1</td><td></td><td></td></tr>
<tr><td>Arctic, monitoring</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Biofuels, fuel cells and nuclear energy</td><td></td><td></td><td>30,809.5</td><td>26,374.4</td><td></td><td></td></tr>
<tr><td>Health and Life Sciences</td><td>930,690.5</td><td>918,561.1</td><td>165,319.1</td><td>170,403.6</td><td>14,264.6</td><td>10,583.5</td></tr>
<tr><td>Regenerative medicine</td><td>75,365.8</td><td>72,411.8</td><td>5,939.8</td><td>5,177.0</td><td>46.5</td><td>20.0</td></tr>
<tr><td>Neuroscience</td><td>128,691.5</td><td>129,346.2</td><td>33,392.9</td><td>35,646.4</td><td></td><td>23.8</td></tr>
<tr><td>Health in an aging population</td><td>111,357.3</td><td>110,894.5</td><td></td><td></td><td>217.2</td><td>200.0</td></tr>
<tr><td>Biomedical engineering and medical technologies</td><td>20,233.7</td><td>17,125.2</td><td>49,339.3</td><td>50,246.8</td><td>2,864.1</td><td>2,815.6</td></tr>
<tr><td>Information and Communications Technologies</td><td></td><td></td><td>177,889.7</td><td>159,389.0</td><td>25,158.2</td><td>23,746.3</td></tr>
<tr><td>New media, animation and games</td><td></td><td></td><td>8,255.5</td><td>8,508.4</td><td>4,564.2</td><td>3,735.7</td></tr>
<tr><td>Wireless networks and services</td><td rowspan="2" colspan="2"></td><td rowspan="2">34,674.7</td><td rowspan="2">30,425.1</td><td>1,731.7</td><td>78.3</td></tr>
<tr><td>Broadband networks</td><td>171.0</td><td>255.4</td></tr>
<tr><td>Telecom equipment</td><td></td><td></td><td>21,092.7</td><td>15,225.2</td><td></td><td></td></tr>
<tr><td>Total Extramural Funding to Sub-Priority Areas</td><td>355,687.8</td><td>355,171.9</td><td>255,033.8</td><td>247,007.9</td><td>10,976.1</td><td>7,835.0</td></tr>
<tr><td>Total Extramural Funding to Priority Areas</td><td>950,730.0</td><td>943,955.3</td><td>666,631.0</td><td>658,170.6</td><td>63,177.7</td><td>60,022.8</td></tr>
<tr><td>Total Granting Council Funding</td><td>950,730.0</td><td>943,955.3</td><td>1,036,166.0</td><td>1,018,905.0</td><td>339,324.6</td><td>338,735.3</td></tr>
</table>

[46] There are more than 13 sub-priority areas listed in the table because the sub-priorities of water and the Arctic have been subdivided further.

In 2014, the Government of Canada launched *Seizing Canada's Moment: Moving Forward in Science, Technology and Innovation 2014*. This renewal of the 2007 strategy identified updated priorities and sub-priorities (now called "focus areas") based, in part, on advice from STIC. The most notable amendments to the 2007 list are the addition of advanced manufacturing as a new priority area and the inclusion of agriculture within the existing environment priority area.

Table 3B: Updated Priorities and Focus Areas Identified in the 2014 Federal ST&I Strategy

Priorities	Focus Areas
Environment and Agriculture	• Water: health, energy, security • Biotechnology • Aquaculture • Sustainable methods of accessing energy and mineral resources from unconventional sources • Food and food systems • Climate change research and technology • Disaster mitigation
Health and Life Sciences	• Neuroscience and mental health • Regenerative medicine • Health in an aging population • Biomedical engineering and medical technologies
Natural Resources and Energy	• Arctic: Responsible development and monitoring • Bioenergy, fuel cells and nuclear energy • Bio-products • Pipeline safety
Information and Communications Technologies	• New media, animation and games • Communications networks and services • Cybersecurity • Advanced data management and analysis • Machine-to-machine systems • Quantum computing
Advanced Manufacturing	• Automation (including robotics) • Lightweight materials and technologies • Additive manufacturing • Quantum materials • Nanotechnology • Aerospace • Automotive

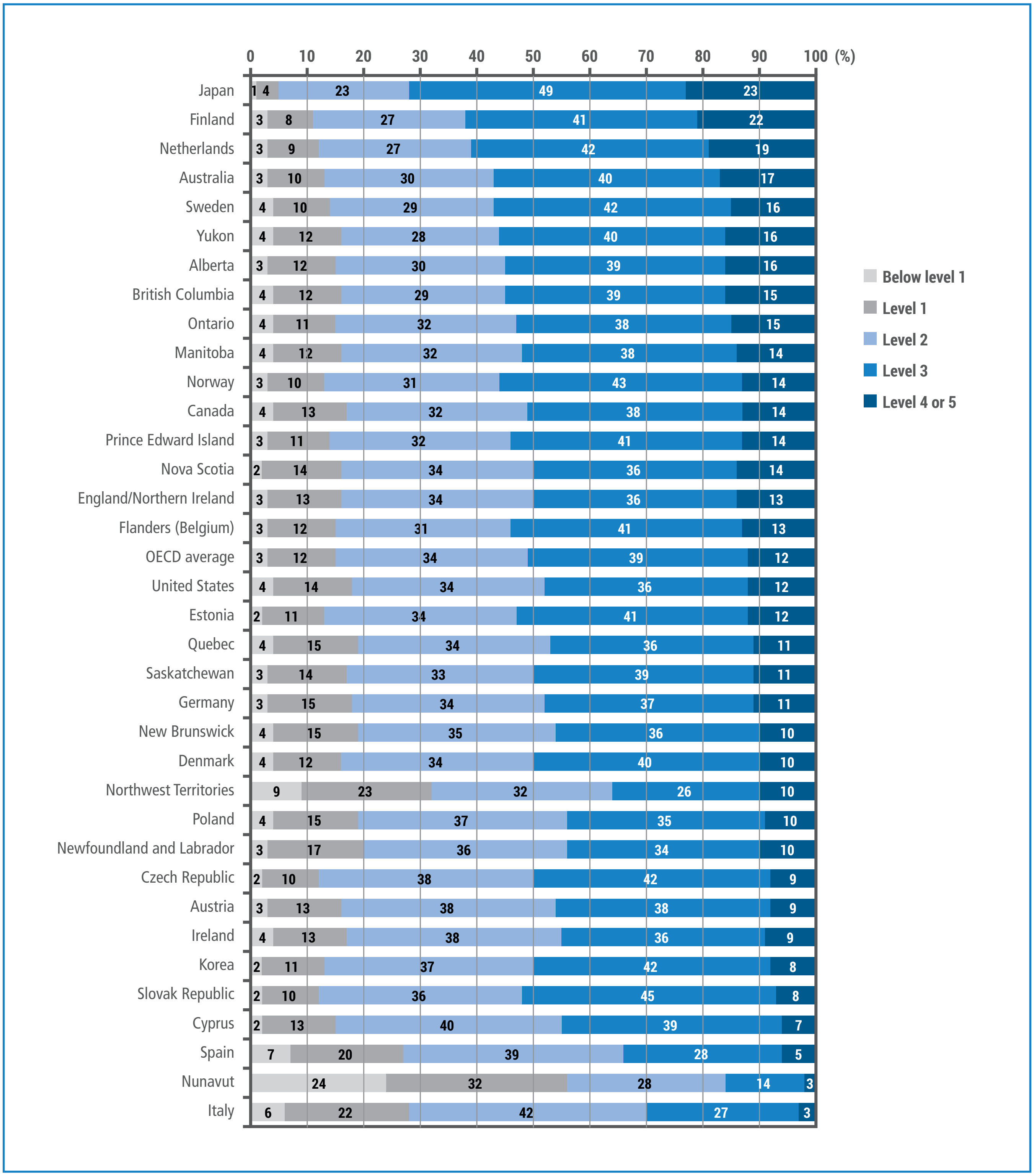
ANNEX 4: TALENTED PEOPLE

Programme for the International Assessment of Adult Competencies (PIAAC)

As noted in Chapter 4, the Organisation for Economic Co-operation and Development's (OECD's) PIAAC provides internationally comparable measures of literacy, numeracy and problem solving in technology-rich environments for adults 16 to 65 years of age. The data show that Canada achieved the OECD average in literacy, with an average score of 273.5, and just below the OECD average in numeracy, with an average score of 265.5.

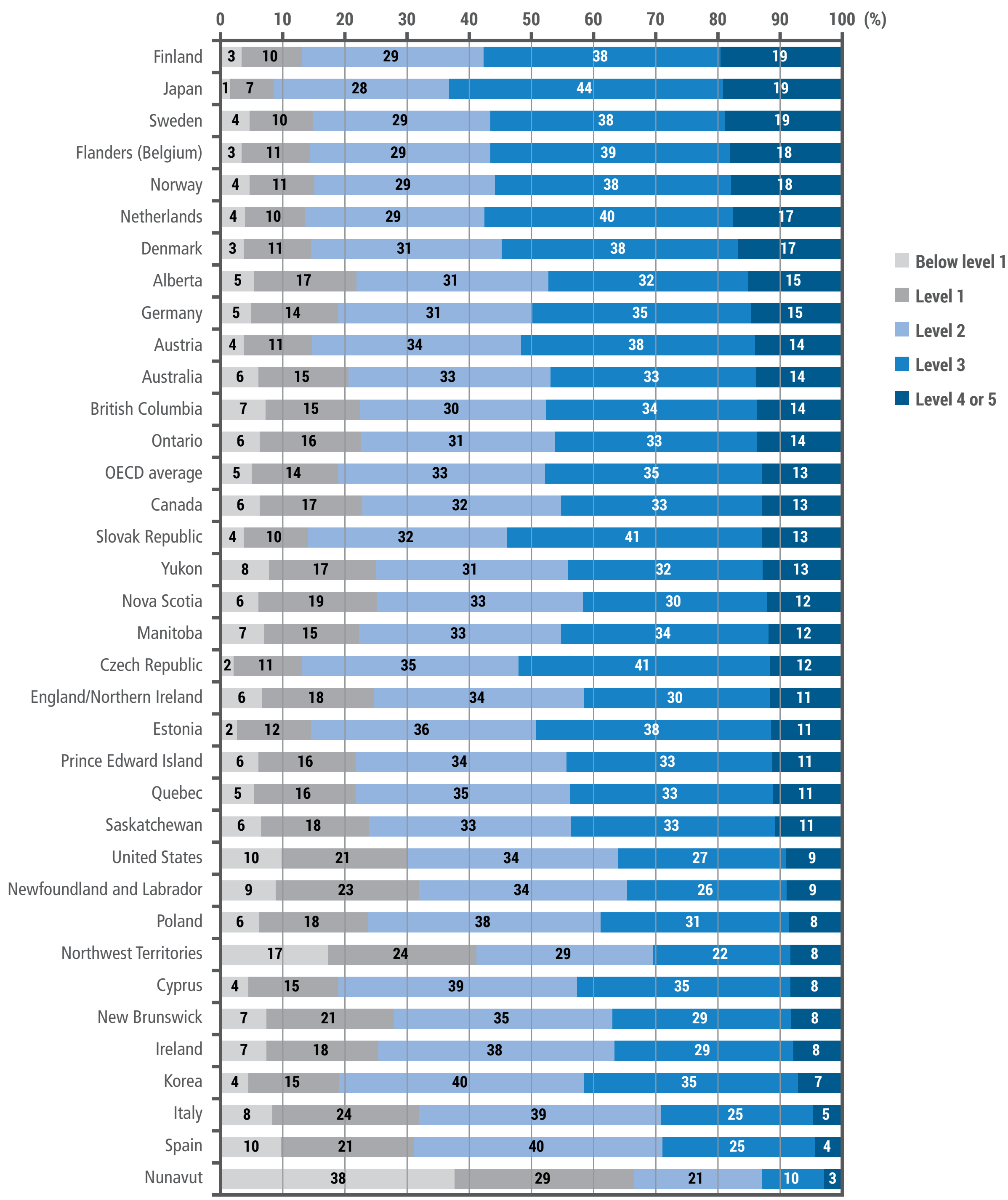
On the problem solving in technology-rich environments scale, 37 percent of Canadians surveyed scored at the highest levels, above the OECD average of 34 percent. Within Canada, this held true for all provinces and territories, except Nunavut (11 percent) and Newfoundland and Labrador (29 percent). Other countries scoring above the OECD average included Sweden (44 percent), Netherlands (44 percent), Finland (42 percent), Norway (41 percent) and Australia (38 percent). Countries scoring below the OECD average included the United States (31 percent), Korea (30 percent) and Ireland (25 percent).

Figure 4A-1: Literacy—Comparative Distribution of Proficiency Levels of the Population Aged 16 to 65 Years, Countries, Provinces and Territories, 2012



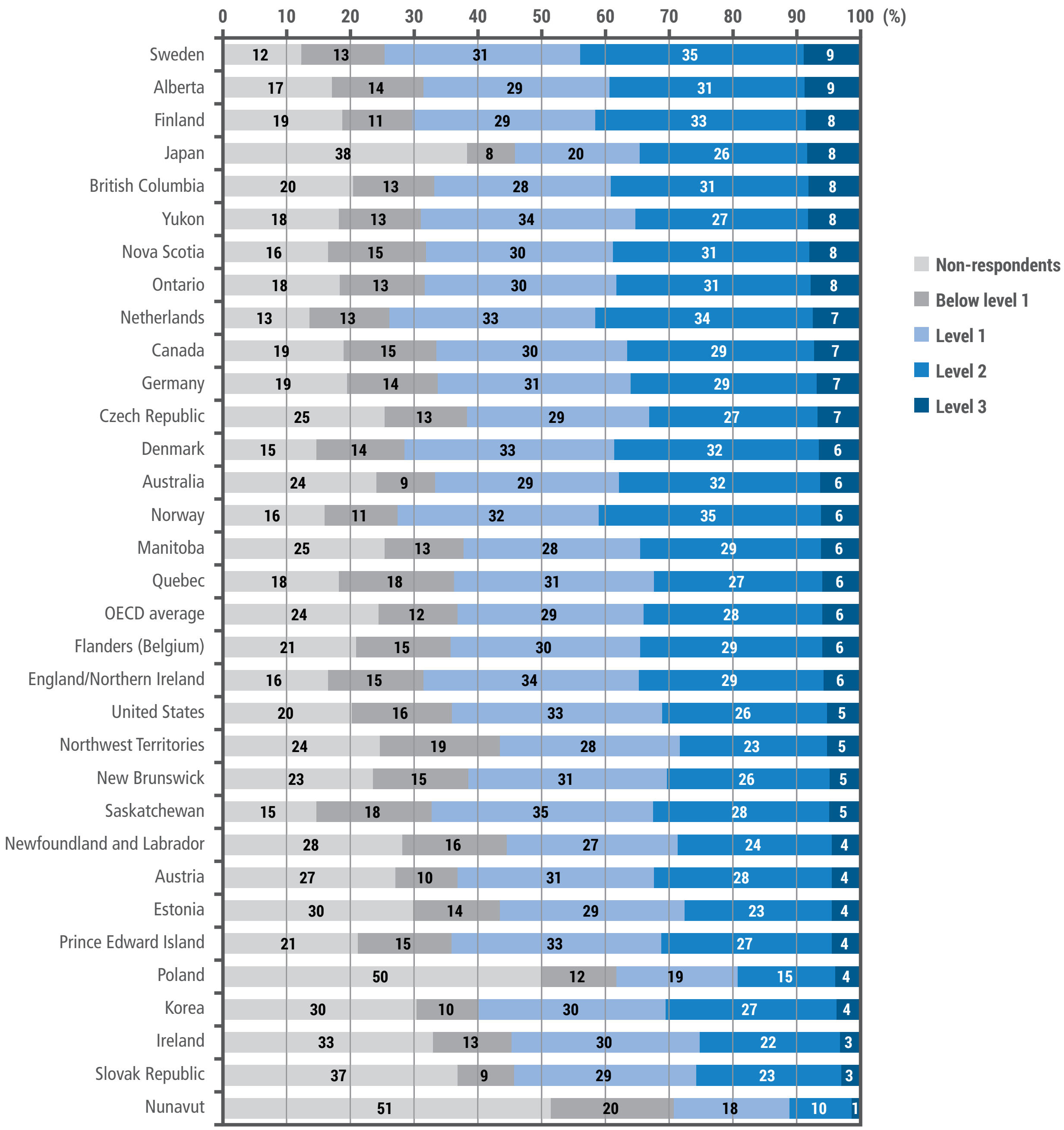
Sources: OECD, Programme for the International Assessment of Adult Competencies, 2012; and Statistics Canada, Employment and Social Development Canada, and the Council of Ministers of Education, Canada, *Skills in Canada: First Results from the Programme for the International Assessment of Adult Competencies (PIAAC)*, Catalogue no. 89-555-X, 2013.

Figure 4A-2: Numeracy—Comparative Distribution of Proficiency Levels of the Population Aged 16 to 65 Years, Countries, Provinces and Territories, 2012



Sources: OECD, Programme for the International Assessment of Adult Competencies, 2012; and Statistics Canada, Employment and Social Development Canada, and the Council of Ministers of Education, Canada, *Skills in Canada: First Results from the Programme for the International Assessment of Adult Competencies (PIAAC)*, Catalogue no. 89-555-X, 2013.

Figure 4A-3: Problem Solving in Technology-Rich Environments—Comparative Distribution of Proficiency Levels of the Population Aged 16 to 65 Years, Countries, Provinces and Territories, 2012



Sources: OECD, Programme for the International Assessment of Adult Competencies, 2012; and Statistics Canada, Employment and Social Development Canada, and the Council of Ministers of Education, Canada, *Skills in Canada: First Results from the Programme for the International Assessment of Adult Competencies (PIAAC)*, Catalogue no. 89-555-X, 2013.

Programme for International Student Assessment (PISA)

A more in-depth analysis of the PISA data reported in Chapter 4 shows that, among Canadian students, 21.9 percent attained the highest levels in one of the three assessment areas (reading, math and science) and can thus be called "top performers" in that area. Fewer (6.5 percent) are academic "all-rounders," students who achieve the highest proficiency in all three areas. With these results, Canada compares well with other countries. Eleven of 65 economies that participated in the PISA had more "top performers" than Canada (Shanghai-China, Singapore, Chinese Taipei, Hong Kong-China, Korea, Japan, Liechtenstein, Macao-China, Finland, Netherlands and Belgium). For each of these economies, except Japan, "top performers" were concentrated only in math. Eight economies (Shanghai-China, Singapore, Japan, Hong Kong-China, Korea, New Zealand, Australia and Finland) had more "all-rounders" than Canada.

As indicated in Chapter 4, notable gender differences exist in student performance. Across OECD countries, girls outperform boys in reading by an average of 38 points; in Canada, the difference is 35 points. In science, girls outperform boys by one point across the OECD and by three points in Canada. Conversely, boys outperform girls in mathematics by 11 points across OECD countries and by 10 points in Canada.

Table 4A: Programme for International Student Assessment (PISA), 2012

Math			Reading			Science		
	2009 Score (Rank)	2012 Score (Rank)		2009 Score (Rank)	2012 Score (Rank)		2009 Score (Rank)	2012 Score (Rank)
Shanghai-China	600 (1)	613 (1)	Shanghai-China	556 (1)	570 (1)	Shanghai-China	575 (1)	580 (1)
Singapore	562 (2)	573 (2)	Hong Kong-China	533 (4)	545 (2)	Hong Kong-China	549 (3)	555 (2)
Hong Kong-China	555 (3)	561 (3)	Singapore	526 (5)	542 (3)	Singapore	542 (4)	551 (3)
Chinese Taipei	543 (5)	560 (4)	Japan	520 (8)	538 (4)	Japan	539 (5)	547 (4)
Korea	546 (4)	554 (5)	Korea	539 (2)	536 (5)	Finland	554 (2)	545 (5)
Macao-China	525 (20)	538 (6)	Finland	536 (3)	524 (6)	Estonia	528 (9)	541 (6)
Japan	529 (9)	536 (7)	Ireland	496 (21)	523 (7)	Korea	538 (6)	538 (7)
Liechtenstein	536 (7)	535 (8)	**Canada**	**524 (6)**	**523 (8)**	Poland	508 (19)	526 (8)
Switzerland	534 (8)	531 (9)	Chinese Taipei	495 (23)	523 (9)	**Canada**	**529 (8)**	**525 (9)**
Netherlands	526 (11)	523 (10)	Poland	500 (15)	518 (10)	Liechtenstein	520 (13)	525 (10)
Estonia	512 (16)	521 (11)	Estonia	501 (13)	516 (11)	Germany	520 (12)	524 (11)
Finland	540 (6)	519 (12)	Liechtenstein	499 (18)	516 (12)	Chinese Taipei	520 (14)	523 (12)
Canada	**527 (10)**	**518 (13)**	New Zealand	521 (7)	512 (13)	Netherlands	522 (11)	522 (13)
Poland	495 (24)	517 (14)	Australia	515 (9)	512 (14)	Ireland	508 (20)	522 (14)
Belgium	515 (13)	515 (15)	Netherlands	508 (10)	511 (15)	Australia	527 (10)	521 (15)
Germany	513 (15)	514 (16)	Belgium	506 (11)	509 (16)	Macao-China	511 (18)	521 (16)
Austria	–	505 (17)	Switzerland	500 (14)	509 (17)	New Zealand	532 (7)	516 (17)
Australia	514 (14)	504 (18)	Macao-China	487 (28)	509 (18)	Switzerland	517 (15)	515 (18)
Ireland	487 (31)	502 (19)	Germany	497 (20)	508 (19)	Slovenia	512 (17)	514 (19)
Slovenia	501 (19)	501 (20)	France	496 (22)	505 (20)	U.K.	514 (16)	514 (20)
Denmark	503 (18)	500 (21)	Norway	503 (12)	504 (21)	U.S.	502 (23)	497 (27)
New Zealand	519 (12)	500 (22)	U.S.	500 (17)	498 (23)			
Iceland	507 (17)	493 (26)	Sweden	497 (19)	483 (35)			
U.S.	487 (30)	481 (35)	Iceland	500 (16)	483 (36)			

Source: OECD, *PISA 2012 Results: What Students Know and Can Do — Student Performance in Mathematics, Reading and Science*, Volume I, Revised Edition, February 2014.

http://www.stic-csti.ca/

State of the Nation 2014

Canada's Science, Technology and Innovation System

Canada's Innovation Challenges and Opportunities

Science, Technology and Innovation Council

Advisory Council to the Government of Canada