Imagination to Innovation

Building Canadian Paths to Prosperity

State of the Nation 2010

Science, Technology
and Innovation Council

Canada's Science, Technology and Innovation System

Canada

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Contents

Digest of Indicators (Section 6)

Role of the Report

The Science, Technology and Innovation Council's *State of the Nation 2008* report on Canada's science, technology and innovation system set out a baseline from which Canada's innovation performance could be measured. This 2010 report allows us to track progress and continue efforts to understand how innovation happens in Canada.

Benchmarking builds an evidence base for action, puncturing complacency and prompting greater reflection. The *State of the Nation 2010* report puts a greater focus on business innovation and the ways in which other participants in the innovation system work in partnership with companies. The report delves deeper to benchmark industry sector research and development on an international basis. It looks at product, process, and organizational innovation as well as investments in information and communications technologies goods and services. Canadians face choices in innovation that will create wealth in our country and improve the quality of life for individuals. Where should we focus to make innovation gains? How can Canada's science, technology and innovation system support these efforts? How can individual actions be leveraged to strengthen our ability to innovate and compete? This report aims to inform these considerations and decisions.

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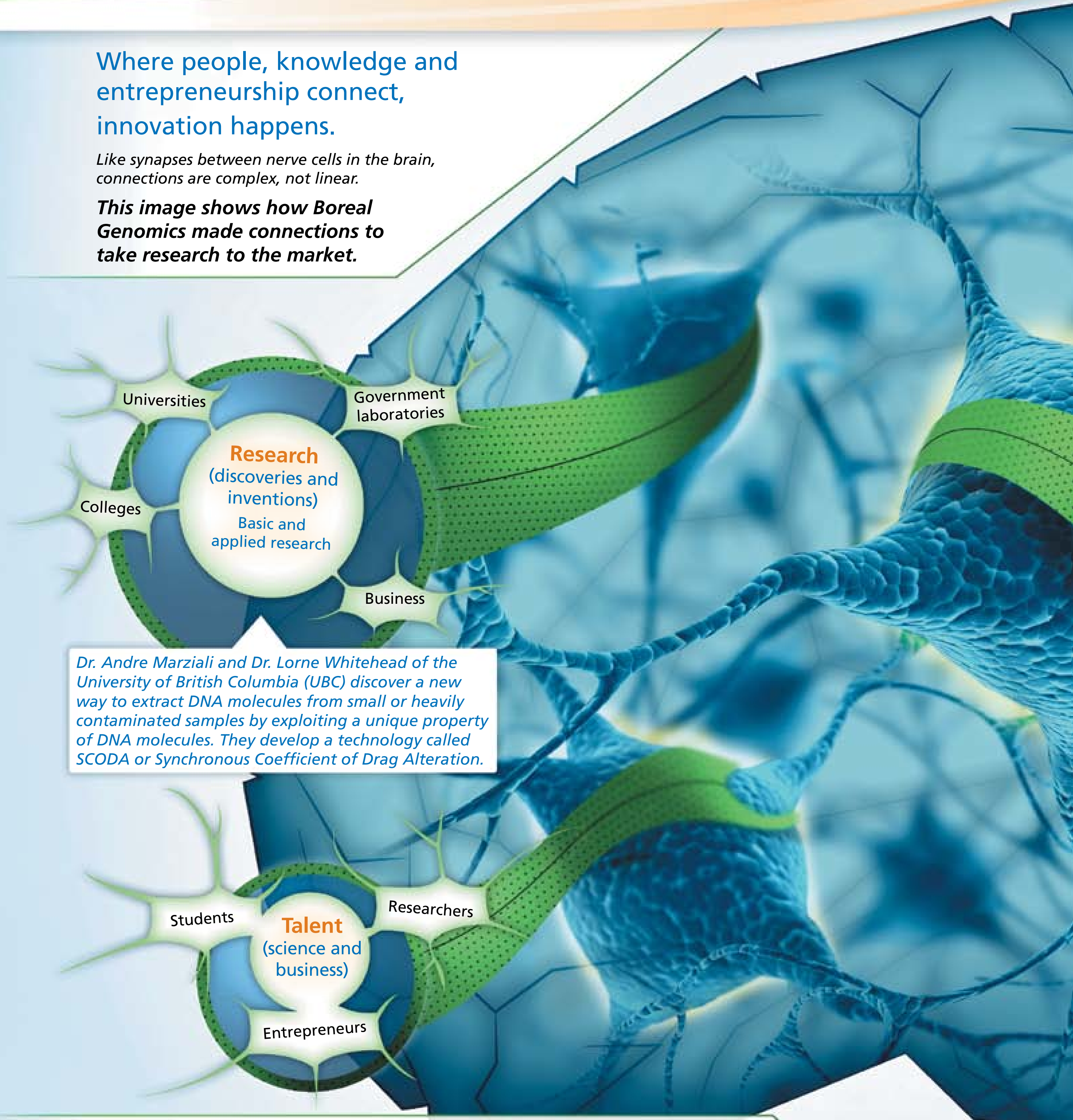
Innovation Pathways

Basic research and value creation

Where people, knowledge and entrepreneurship connect, innovation happens.

Like synapses between nerve cells in the brain, connections are complex, not linear.

This image shows how Boreal Genomics made connections to take research to the market.



Dr. Andre Marziali and Dr. Lorne Whitehead of the University of British Columbia (UBC) discover a new way to extract DNA molecules from small or heavily contaminated samples by exploiting a unique property of DNA molecules. They develop a technology called SCODA or Synchronous Coefficient of Drag Alteration.

Boreal Genomics, based in Vancouver, B.C., is a small growing company that develops and commercializes methods and instruments for DNA molecule purification, enrichment and detection.

Government Support

Framework policies

University R&D support

Commercialization support programs (funding, advice)

Shared infrastructure (labs, equipment)

Development of the SCODA technology is accomplished with financial and infrastructure support from a number of sources including the National Research Council's Industrial Research Assistance Program (NRC-IRAP), the Natural Sciences and Engineering Research Council of Canada, Genome BC, the Canadian Institutes of Health Research and the U.S. National Institutes of Health.

Boreal occupies the "Discovery Parks" business incubator facilities available at UBC.

Marketing and Sales

Market research

Sales channels development (revenues)

Global marketing strategies

Product support

The technology can be used in other scientific fields where researchers struggle with materials that are often in low abundance or too contaminated to yield quality DNA. These fields include archaeology, forensics, bio-defence and life sciences. The technology is being used to identify microbes that live in oil sands. The hope of researchers is to identify biological versus mechanical means of separating sand from oil.

In 2009, the first SCODA "alpha" machine is sold to researchers. In 2010, the second-generation "Aurora" machine is commercially available. Boreal Genomics technology is now being used by scientists in Canada, the U.S. and Norway.

Development and Commercialization

Creation of new firms

Technology transfer

Product rollout

Proof of principle

Product/process development and testing

Business expansion

In 2007, Boreal Genomics is founded as a spinoff company from Dr. Marziali's lab at the University of British Columbia (UBC). Boreal is given an exclusive licence from UBC to commercialize the technology.

With close connections to UBC, Genome BC, as well as within the San Francisco Bay area, Boreal Genomics builds a team, composed of young scientists, mixed with seasoned entrepreneurs and advisors.

In 2007 and 2008, Boreal builds and field tests early instrument prototypes of SCODA.

In 2010, Boreal applies its SCODA technology to develop extraction of specific DNA or RNA fragments from a clinical sample, allowing technicians to more quickly find a particular type of DNA in a sample not just all the DNA in that sample. This could help develop a device that would provide physicians with immediate diagnostic information.

Financing

Pre-seed/ seed and early

Initial public offering

Late stage

Working capital and expansion

Boreal Genomics grows significantly in its first few years with grants from government agencies and investment from a small group of angel investors.

In December 2010, Boreal Genomics secures its first institutional financing totalling $6.9 million. ARCH Venture Partners, Kearny Venture Partners and GrowthWorks Capital Ltd. lead the financing with participation from InQTel. These funds are being used to commercialize a second-generation technology for highly selective enrichment and diagnostics.

Definitions: Research and Development Innovation

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

The *Oslo Manual* (2005) is the basis for the OECD definition of innovation: "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations."

The Science, Technology and Innovation Council defined innovation in the *State of the Nation 2008* report as "the process by which individuals, companies and organizations develop, master and use new products, designs, processes and business methods. These can be new to them, if not to their sector, their nation or to the world. The components of innovation include research and development, invention, capital investment and training and development."

Executive Summary

Canada aims to be among the world's innovation leaders. To do so we must understand the components and connections in the science, technology and innovation (STI) system. A well-functioning STI system is built on the foundation of a strong talent pool, excellent research, public and private sector institutions that create value from research and development, strong systemic mechanisms for knowledge transfer and application, and successful commercialization of innovation within the private sector. It takes a well-functioning integrated system to move ideas from imagination to innovation to markets.

Innovation is more than research and development (R&D) — it is transforming knowledge into products and services that Canadians and others in today's global marketplace need, want and will pay for. To leverage knowledge into robust outcomes of better health, and strong and sustainable growth and jobs, we need to build and reinforce the paths to prosperity.

How good is Canada's science, technology and innovation system at delivering the outcomes we want?

Our talent pool is holding its own and the number of Canadian university graduates is rising, with especially rapid growth in doctoral degrees in science. Graduation rates in master's and doctoral science and engineering degree programs have risen substantially more than in other advanced economies and faster than the growth of advanced degrees in all fields of study. Fifteen-year-old Canadians continue to outperform most countries in reading, math and science. Canada remains in first place in the G7 in the proportion of citizens with an education beyond high school.

Broader outcome-based indicators of excellence in universities and colleges have yet to be defined and applied on an international basis. Canadian business has markedly increased the R&D it funds in universities, although this is still small — less than one tenth of overall R&D spending by business. Transferring knowledge from research institutions in universities and government to the marketplace and building a culture of innovation in business remain paths requiring attention. Generating wealth from commercialization is a valuable outcome of our commitment to science, technology and innovation (STI) — an outcome that benefits society both in economic and social terms. If we are underperforming in delivering the full value of our STI progress, we must seek to understand why and address these shortcomings.

Research and development performed by business in Canada is low by international standards. In addition, from 2007 to 2009 Canadian industry R&D declined further in both current and real dollar terms. Examinations of R&D intensity by industry, and in comparison with the same industries in other countries, indicate that in 2005, 8 out of 16 industries examined had lower R&D intensity than the OECD average. There were, however, some notable exceptions to Canadian levels of R&D performance. Business R&D intensity higher than the Organisation for Economic Co-operation and Development (OECD) average was performed in the paper, lumber and related industry; information and communications technologies (ICT) manufacturing industry; wholesale and retail trade as well as finance and communications service industries; transportation and storage industries; utilities; real estate and business services (including R&D and information technology (IT) services) industry.

Broadening the measure of innovation to include two important drivers of productivity growth — investments in machinery and equipment (M&E), and investments in information and communications technologies — revealed more challenging themes. In comparison with the United States (U.S.), over the period 2000 to 2007, M&E investment intensity in Canada has been less than three quarters of U.S. levels and ICT investment intensity was less than half of U.S. levels. However, the Canadian oil and gas extraction industry and finance, insurance, real estate and management of companies industry have registered higher M&E intensities than their U.S. counterparts. Data presented in *State of the Nation 2010: Imagination to Innovation* also suggest that it is worth considering trends in Canadian expenditures on IT services rather than only IT purchases, given their potential contribution to improving innovation and productivity.

Not all innovation is the result of R&D. Process innovation and incremental innovation can be strong contributors to productivity. Innovation success ultimately results from the ambition and attention of management teams.

Beyond benchmarking, what principles should guide efforts to strengthen Canada's innovation performance?

We must guard against complacency and continue to nurture talent at all levels. While 15-year-old Canadians' scores remained fairly stable, they fell in terms of rank in reading, science and math because others are improving faster. We must work to support students to better learn and apply their knowledge.

Research and development sub-priorities identified by the Science, Technology and Innovation Council (STIC) in 2008 can assist all innovation sectors to play from Canada's research and economic strengths. Even if one third of our resources are focused in these areas, it will help to reinforce Canadian excellence on a global scale.

Competition and peer review have led to improved Canadian R&D at international levels of excellence. The most recent example of this has been the quality and breadth of the Canada Excellence Research Chairs whose research spans basic to more applied research. The competition demonstrated that not only large but also smaller Canadian universities can carve out niches of expertise and build alliances to establish a global reputation.

Collaboration should be considered in a clusters context, among universities and colleges, and small and large companies. Support for clusters is one way to build critical mass in both short-term and long-term research areas of joint interest to companies and research organizations. Such collaborations also improve companies' ability to recruit Canada's highly qualified graduates. The participation of innovation intensive companies in such clusters and the active collaboration of the research and business communities will help ensure that Canada's world-class research can be successfully commercialized for the benefit of this country.

The Research and Development Review Expert Panel, due to report in autumn 2011, will address how we can better leverage public funds to improve innovation commercialization outcomes in industry. Its recommendations will be important for the future of Canada's STI system, and can reshape government programs to better incent private sector spending and to support entrepreneurship through simplified and better targeted assistance.

Between the *2008* and *2010 State of the Nation* reports, Canadian industry has been buffeted by a severe financial crisis. As Canada emerges from the crisis, opportunities remain to work together to achieve the innovation goals we set for ourselves and to build paths to prosperity.

The *State of the Nation 2010* report gets us closer to understanding how Canadian companies innovate. Data show that some Canadian industries are global leaders. We are also fortunate to have a strong talent pool that could deliver on high ambitions. The challenge is to deploy talent well, invest in advanced technology, integrate innovation into corporate and country strategies and leverage our efforts to deliver prosperity for all Canadians. This alignment will improve our lagging productivity growth. 2010 began with Canada's athletes inspiring the nation with their resolve and high ambition. STIC's State of the Nation reports are a starting point for benchmarking efforts in companies, universities and colleges, and governments across the country. Reflecting on the data in this report can help set ambitious goals that will put more Canadians and Canadian companies on global podiums.

1 Introduction

Canada has come through the financial crisis relatively well. But before breathing a sigh of relief, Canadians must prepare to tackle longer-term structural challenges to the economy. Our relatively strong Canadian dollar presents challenges to exporters but reduces the cost for Canadian companies to import newer advanced capital. Productivity growth is essential for an aging and smaller workforce to succeed in a highly integrated and competitive global economy. Innovation continues to matter because it can help meet these challenges.

Annual growth in Canada's labour productivity (output per hour worked) has been slowing and has been less than 1 percent for most of the last decade. In terms of growth in labour productivity, the Institut européen d'administration des affaires (INSEAD) ranked Canada 95th of 132 countries. The International Institute for Management Development (IMD) in Lausanne, Switzerland ranked Canada 45th of 58 countries. Part of Canada's low international standings in productivity growth is attributable to the fact that developing countries have a much greater potential for rapid productivity growth through technological convergence or catch-up from low productivity levels. Among 33 advanced economies in the IMD standings, Canada's productivity growth ranks 24th. As Canada's productivity continues to lag despite macro-economic reforms intended to improve economic performance, economists are increasingly focusing on a lack of innovation in Canada as a contributor to poor productivity performance.

Countries have made progress in efforts to understand how innovation occurs. In Canada, analysis is currently under way on the findings of its pilot 2009 *Survey of Innovation and Business Strategy*, some of the results of which are published in this report. The first comprehensive United States (U.S.) official statistics on innovation appeared in late 2010. The High-Level Panel on the Measurement of Innovation convened by the European Commissioner for Research, Innovation and Science issued a report in September 2010. The panel put forward two options. The first option was a list of three indicators of innovation: patent applications weighted by Gross Domestic Product (GDP); percentage of employment in knowledge intensive activities; and percentage of the value of medium- and high-tech goods as a share of both exports and imports. The second option was the share of fast growing innovative firms in the economy.

The Science, Technology and Innovation Council's (STIC) *State of the Nation 2010* report opens with commentary on progress since the *State of the Nation 2008* report, and a summary of progress on key indicators noted in the report. Section 3 proposes a list of 20 indicators to measure innovation performance going forward. These measures would serve to gauge innovation *inputs* including talent and research and development (R&D), as well as proxies for innovation *outputs* such as trademarks and licensing. Ideally these indicators would also capture the degree of collaboration between different elements in the innovation system. An indicator for future benchmarking could be based on components of Canada's technology intensive balance of payments. This would include international transactions for the use of patents, licences, trademarks, designs, technical services and industrial R&D carried out abroad. Together this short list of indicators could provide a common reference point for different parts of the innovation system.

Section 4 reviews progress on measuring innovation and Section 5 shows the flow of funds between sources and performers of R&D. Section 6 provides more detailed information on a longer list of indicators of business innovation, knowledge development and transfer, as well as talent.

2

Tracking Progress in Canada's Innovative Performance — 2010 vs. 2008

The State of the Nation 2008 *report underlined that all participants in the innovation system have a role to play in strengthening the system. In the last two years the profile of productivity and innovation issues has risen significantly in public discourse. The media have given innovation issues sustained attention. Major industry organizations like the Canadian Chamber of Commerce,[1] the Canadian Manufacturers & Exporters,[2] and the Canadian Council of Chief Executives and initiatives such as the Coalition for Action on Innovation in Canada[3] have deepened consideration of innovation by business. Organizations such as the Public Policy Forum, the Conference Board of Canada, the Canadian Science Policy Centre, the Institute for Competitiveness and Prosperity, and the Federal Partners in Technology Transfer have engaged other players in the innovation system. Participants in the innovation system are mobilizing, building new paths to innovation and prosperity.*

There have been some significant developments in key areas noted in the Science, Technology and Innovation Council's *State of the Nation 2008* report, which include:

Talent — developing a highly qualified workforce attuned to innovation opportunities

Young Canadians continue to perform well in international rankings of reading, math and science skills. The latest results from the Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA) show either sustaining or slightly declining raw scores, but Canada remains in the top tier of performers (Section 6.3.1). More Canadian students are enrolling in undergraduate science, engineering and mathematics programs (Section 6.3.5). More Canadians are enrolling and graduating from science-based doctoral programs, but other countries remain higher in terms of doctoral-level graduates per million population (Section 6.3.8). Canada also has higher unemployment levels for science-based doctoral-level graduates than other OECD countries. (Section 6.3.10).

Knowledge Development and Transfer

Since 2008, more was done to focus on research priorities and conduct research at international levels of excellence. The first recipients of the Canada Excellence Research Chairs were announced. The chairs reflect the STIC research and development sub-priority

[1] Canadian Chamber of Commerce, *Canadian Businesses Go Global for Growth*, August 2010.

[2] Canadian Manufacturers & Exporters, *Invest to Grow: Technology, Innovation and Canada's Productivity Challenge*, October 2010.

[3] Coalition for Action on Innovation in Canada, *An Action Plan for Prosperity*, October 2010.

areas disseminated in 2008. The first Vanier (Canada Graduate) Scholarships Program doctoral students were named and the new Banting Postdoctoral Fellowships Program was launched (Section 6.3.13). Canada's granting councils — Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, Social Sciences and Humanities Research Council of Canada — have used the sub-priorities to inform a number of their own programs. Competitions for Networks of Centres of Excellence have utilized the sub-priorities as a key requirement.

Knowledge transfer to business was improved since 2008 by strengthening internship programs (Section 6.2.2.1). The launch of the Government of Canada's Research and Development Review Expert Panel in October 2010 marked a commitment to examine knowledge transfer issues in a more comprehensive way. The panel is to report in autumn 2011.

Business Innovation

Total financial resources for research and development (R&D) in Canada as a percentage of GDP decreased from 2006 to 2008. Most of the world's innovating nations increased resources for R&D. A more detailed look at the performers of R&D shows that expenditures on R&D by government and the higher education sector increased from 2006 to 2009. R&D expenditures by business have decreased over the same time period (Section 5).

State of the Nation 2008 stated that low overall business R&D in Canada had been a constant feature for 40 years. Canada's business R&D intensity remains lower than the OECD average and is lower than that of China. R&D expenditure has differed by industry sectors over the years. The *State of the Nation 2010* report provides a baseline for examining R&D on an industry sector basis (Section 6.1.4.4).

Governments are pooling public funds with private funds to expand available venture capital. The Government of Canada improved the ability of Canadian businesses to attract foreign venture capital by narrowing the definition of taxable Canadian property, thereby freeing many foreign investors from the tax reporting requirements under section 116 of the *Income Tax Act*.

Measuring Innovation Performance

Canada's 2009 *Survey of Innovation and Business Strategy* (SIBS) was released in November 2010. Care needs to be taken in the future to ensure that questions in this survey align with international data on business collaboration with universities and companies obtained through the U.S. and European Union (EU) surveys.

Many industry-specific factors will have an impact on how industries in Canada innovate, and how well this innovation is measured. Research on innovation, including research by the National Endowment for Science, Technology and the Arts (NESTA) in the United Kingdom (U.K.), suggests that there is likely to be substantial hidden innovation and that the extent of hidden innovation may differ in different industries. Innovation, as defined by the OECD's *Oslo Manual* (2005), can be new to a company even if it is not new to the industry or to the world. Some innovation is user-driven and involves large scale field testing that is not defined or tracked as R&D. Other innovation involves copying best practices applied elsewhere. Until these investments are tracked separately they will remain unquantifiable and accounted for on an anecdotal basis. Data presented in this report enable better benchmarking by illuminating industry differences. Data points are, however, only tools for improving our understanding of innovation rather than the final word on Canadian industry practices.

> *If companies apply their own reality check to data presented and reflect on the relevant practices of countries and companies who are global leaders in their sectors, Canada will move ahead.*

Since 2008, both incremental and transformative actions have taken place. These have yet to raise our performance on key indicators of R&D in Canada. The following table itemizes changes in a short list of indicators tracked since the *State of the Nation 2008* report.

State of the Nation: Summary Comparison of Selected Indicators, 2008 and 2010 Reports

Section of Report / Indicator	2008 Report	2010 Report	Change on Final Year of Data from 2008 to 2010*
Resources for Research and Development (R&D)			
1. Gross domestic expenditure on R&D (GERD) as a percentage of Gross Domestic Product (GDP)	**2006** 1.97%	**2008** 1.84%	**2006 to 2008** ↓
2. GERD by performing sector (constant 2002 dollars)	**2007** $0.28 billion $14.19 billion $8.53 billion $2.21 billion	**2008** $0.30 billion $13.22 billion $8.53 billion $2.15 billion	**2007 to 2008** ↑ by provincial governments ↓ by business — by higher education ↓ by federal government
Business Innovation Indicators			
3. Business expenditure on R&D (BERD) intensity, as a percentage of GDP	**2006** 1.10% 15th place	**2008** 1.00% 18th place	**2006 to 2008** ↓ as a percentage of GDP ↓ ranking in available OECD countries
4. Direct and indirect government funding of business R&D, as a percentage of GDP	**2005** 0.21% 0.023%	**2008** 0.22% 0.022%	**2005 to 2008** ↑ indirect government funding ↓ direct government funding
5. Investment in machinery and equipment as a share of GDP	**2004** 6.2%	**2007** 6.3%	**2004 to 2007** ↑
6. Venture capital relative to GDP	**2007** 0.12%	**2008** 0.08%	**2007 to 2008** ↓

State of the Nation: Summary Comparison of Selected Indicators, 2008 and 2010 Reports (cont'd)

Section of Report / Indicator	2008 Report	2010 Report	Change on Final Year of Data from 2008 to 2010*
Knowledge Development and Transfer Indicators			
7. Higher education performance of R&D, as a percentage of GDP	**2006** 0.66%	**2008** 0.64%	**2006 to 2008** ↓
8. Share of all business-financed R&D performed by higher education sector	**2006** 5.7%	**2009** 6.3%	**2006 to 2009** ↑
9. Intramural government R&D as a share of GDP in Canada	**2006** 0.20%	**2008** 0.19%	**2006 to 2008** ↓
Talent Indicators			
10. Programme for International Student Assessment (PISA): 15 year-olds	**2006** Science: 534 3rd place Math: 527 7th place Reading: 527 4th place	**2009** Science: 529 8th place Math: 527 10th place Reading: 524 6th place	**2006 to 2009** ↓ in science score ↓ in science ranking — in math score ↓ in math ranking ↓ in reading score ↓ in reading ranking
11. Percentage of population with tertiary education: top 10 Organisation for Economic Co-operation and Development (OECD) countries	**2006** 47% 1st place	**2008** 49% 1st place	**2006 to 2008** ↑ percentage of population with tertiary education — ranking in top 10 OECD countries
12. PhD graduates per million population: OECD countries	**2002** 129.6 20th place	**2008** 145.9 23rd place	**2002 to 2008** ↑ in graduates per million population ↓ in ranking of OECD countries

*Note: Direction of arrow indicates change from years cited.

3
Going Forward —
A Core Set of Indicators to Measure Innovation

Measuring innovation is a worldwide work in progress. It has evolved from measures of research and development and talent to encompass measures of machinery and equipment, intangibles such as software and databases, and in-firm specific human and organizational capital. Section 4 describes recent developments in measuring innovation. In Section 3 we propose a set of indicators that place a premium on allowing for international comparison on a standardized basis. Some of the indicators are available for Canada only. The indicators are useful because they are more recent, and often provide significant industry-level detail and allow for analysis across time. Other innovation measures are compiled by international organizations such as the OECD, the World Economic Forum, INSEAD and others. International sources, while allowing for comparisons between countries, often do not provide the level of detail that helps countries compare or benchmark the innovative performance by industry or industry sector.

Research for the *State of the Nation 2010* report, progress in developing metrics for innovation and consultations with participants in the innovation system over the last three years, have led STIC to recommend a short list of indicators going forward. To better account for innovation that is more than R&D and to enable better benchmarking by participants in the innovation system, the following set of indicators is identified for ongoing monitoring.

Performance Indicators for Canada's Innovation System

Indicator	Year of Data	Rationale
Talent		
1. Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA): 15 year-olds	2009	Measures Canada against international sample, benchmarking talent at the secondary school level. Assesses reading, mathematics and science.
2. Percentage of population with tertiary education	2008	Measures supply of advanced skills, which can contribute to productivity gains.
3. Numbers of bachelor-degree graduates in science and engineering-related disciplines from university	2008	Measures graduates with a package of skills and knowledge that is valued in the labour market and can contribute to economic growth.
4. Number of PhDs in science, math and engineering (graduates)	2008	Measures talent pool at technology frontier.
5. Research and development (R&D) personnel in business	2007	Measures industry use of highly qualified researchers.

Performance Indicators for Canada's Innovation System (cont'd)

Indicator	Year of Data	Rationale
Research and Development		
6. Gross domestic expenditure on R&D (GERD) as a share of Gross Domestic Product (GDP)	2008	Benchmarks Canadian resources allocated to R&D against other countries.
7. GERD by performing sector in constant dollars	2008	Illustrates the state of R&D spending by business, government and higher education and highlights the trends in each.
8. Major flows of R&D funding in Canada	2009	Illustrates the links between sources of funding and R&D performers.
9. Business expenditure on R&D (BERD) intensity by country	2008	Benchmarks R&D performed in business in Canada vs. R&D performed in business in other countries. Data can be presented on an industry sector basis.
10. Direct and indirect government support to business for R&D	2008	Tracks the type of mechanisms used by government to encourage private sector investment in R&D. Benchmarking with other countries aids analysis on the efficacy of policy instruments.
11. Higher education performance of R&D, as a share of GDP	2008	Benchmarks R&D performed in universities in Canada vs. R&D performed in universities in other countries.
12. Share of all business-financed R&D performed by higher education sector and others	2009	Illustrates trends in business strategies and propensity to perform R&D in-house or through outsourcing.
13. Intramural government R&D: share of GDP in Canada and the G7	2008	Benchmarks R&D in government labs and institutes vs. R&D performed in government in other countries. Measures R&D important to achieving societal goals that would not be conducted by other parts of the innovation system.
Innovation (other than R&D)		
14. Investment in machinery and equipment, including information and communications technologies (ICT), as a share of GDP	2007	Measures inputs to innovation other than R&D. New ideas are embedded in leading-edge technologies and enable workers to produce more and higher-quality goods and services through more efficient business processes.
15. Utilization of information technology (IT) services	2005	Measures input to innovation other than R&D. Technological change is prompting changes in business processes, which result in infrastructure, intangibles such as software, and customer service being bundled as a service.
16. Venture capital relative to GDP	2008	Measures the pool of capital important for start-ups in the knowledge intensive ICT and life sciences industries. Tracks the capacity for undertaking high-risk investments.
17. Firms collaborating in innovative activities with public or private partners, government, and higher education institutions by size	2002–2004, no updates for Canada	Collaboration has become an important source of competitive advantage. Innovations are increasingly brought to the market by networks of business, academic and government partners. Regional associations can be partners in tracking collaboration within geographic clusters.
18. Number of licences from universities to businesses	2008	Measures technology transfer and potentially commercially-valuable knowledge transfer to the private sector. Indicates leveraging of public investments in higher education.
19. Trademarks	2008	Trademarks can be applied to innovation in goods and services and encompass marketing innovation. The OECD has found that trademark applications are highly correlated with other innovation indicators.
20. Technology intensive trade flows (services and goods)	2010	Measures the ability of Canadian enterprises to export goods and services and trends in the use of goods and services by Canadian companies. Measures Canadian success on a global scale (i.e., global demand for Canadian ideas and expertise). Payments reflect Canadian demand and awareness of global opportunities.

4
Recent Developments in Measuring Innovation

This section highlights progress made in the measurement of innovation that is not research and development.

New surveys are in development and in the field. A number of countries and international organizations are also working on measuring innovation that occurs as a result of changes in business processes, organization or marketing or through investments in intangible assets. Canada's 2009 *Survey of Innovation and Business Strategy* (SIBS) and the United States' 2009 *Business R&D and Innovation Survey* (BRDIS) are new surveys that made data available for analysis in 2010. Future analysis can draw on data to enable comparisons with Europe's *Community Innovation Survey* (CIS). The United Kingdom's *National Endowment for Science, Technology and the Arts* (NESTA) *Innovation Index* and the Organisation for Economic Co-operation and Development's (OECD) *Measuring Innovation: A New Perspective* (2010) explore possible future indicators. However, producing comparative analysis is some time away, as protocols have yet to be developed for standardization of data.

4.1 Canada — *Survey of Innovation and Business Strategy*

The 2009 *Survey of Innovation and Business Strategy* (SIBS) sampled over 6,000 companies. Survey questions address the motivation for innovation, spending on innovation activities, collaboration and the results expected from innovation. This survey is discussed in greater detail in Section 6.1.3.

4.2 United States — *Business R&D and Innovation Survey*

After years of absence from the measurement of innovation, the U.S. National Science Foundation's Division of Science Resources Statistics, in collaboration with the Economic Directorate of the Bureau of the Census, has conducted a new *Business R&D and Innovation Survey* (BRDIS). The stratified sample of 40,000 firms, with five or more employees, includes a census of large R&D performers, the 50 largest firms, based on payroll, in each state, and a sample of other firms drawn from the U.S. Census Bureau's Business Register. It went into the field as a pilot survey in January 2009 and R&D estimates were released in 2010.

The survey included the propensity for firms to innovate, and related variables, broken down by industry. It also referred to the number of firms that do and do not perform R&D, providing an understanding of the place of R&D in the business strategies of small, medium and large companies. Results from the new survey can be used to track the impact of new programs on the industrial distribution of innovation.

Europe's *Community Innovation Survey* (CIS) has been running at regular intervals since 1992 and provided a model for the 2005 innovation survey in Canada and for the innovation questions used in the U.S. BRDIS. CIS data are available from Eurostat, the statistical office of the European Commission. Aggregate data for the 27 European Union (EU) member states, and some other countries, are presented in the European Innovation Scoreboard, which has recently been revised to become the Innovation Union Scoreboard.

4.3 United Kingdom — Pilot *National Endowment for Science, Technology and the Arts Innovation Index*

The *National Endowment for Science, Technology and the Arts (NESTA) Innovation Index* seeks to better understand innovation at the firm level through capturing 'hidden innovation' and investigating the different ways that innovation occurs in nine industries. NESTA developed a firm-level innovation survey that was tailored to the dominant modes of innovation in each industry. Industries covered included energy production, accountancy services, specialist design, consultancy services, construction, architectural services, software and information technology (IT) services, legal services and automotive. Results were published in November 2009.

The survey asked firms about how they: obtained new ideas from elsewhere; turned ideas into products; and commercialized innovation (i.e., used innovative goods and services to make money).

The survey uncovered significant levels of hidden innovation in several industries where levels of traditional R&D investment are low, and found that hidden innovation was also important for high R&D industries. For every sector surveyed, except the energy production sector, where the effect was noted as small, innovative firms showed higher sales growth than non-innovators. This methodology is experimental and has not been used in national data-gathering efforts.

4.4 Organisation for Economic Co-operation and Development — *Measuring Innovation: A New Perspective*

In its 2010 *Measuring Innovation: A New Perspective* report, the OECD presented new indicators along with novel ways of looking at traditional ones. It included measures of expenditure on "innovation" as opposed to "R&D" by firm size. Expenditure on innovation includes: total expenditure by firms on R&D that they perform in-house or externally; acquisition of other external knowledge (e.g., patents, licences and trademarks); and acquisition of machinery, equipment and software. Canadian data for this indicator were 2005 data and only for manufacturing.

Using data from 21 countries, the report concluded that firms receiving public support for innovation invested 40 percent to 70 percent more than those who did not. It is also suggested that higher levels of company investment in innovation lead to elevated sales of new-to-market products and higher productivity.[4]

New work was undertaken to capture investments in intangible assets. The OECD divided these into *computerized information*, which includes software and databases; *innovative property*, which includes scientific R&D, mineral exploration, copyright and licence costs, and product development, design and research; and *economic competencies*, which include brand equity, firm-specific human capital and organizational capital. Work in this area does not yet include standardized methods and definitions. It does show that investments in intangibles are larger than investments in machinery and equipment in the U.S. and Sweden. Estimates of the contribution of intangible assets to labour productivity growth show that these explain a good portion of multifactor productivity growth in some OECD countries.

Another highlight is the measure of "new-to-market" product innovators with and without R&D as a percentage of innovators. This indicator shows that a large share of firms develop their innovation without performing any R&D.

> *New work was undertaken to capture investments in intangible assets: computerized information, innovative property and economic competencies.*

[4] OECD (2010), *Measuring Innovation: A New Perspective*, p. 78.

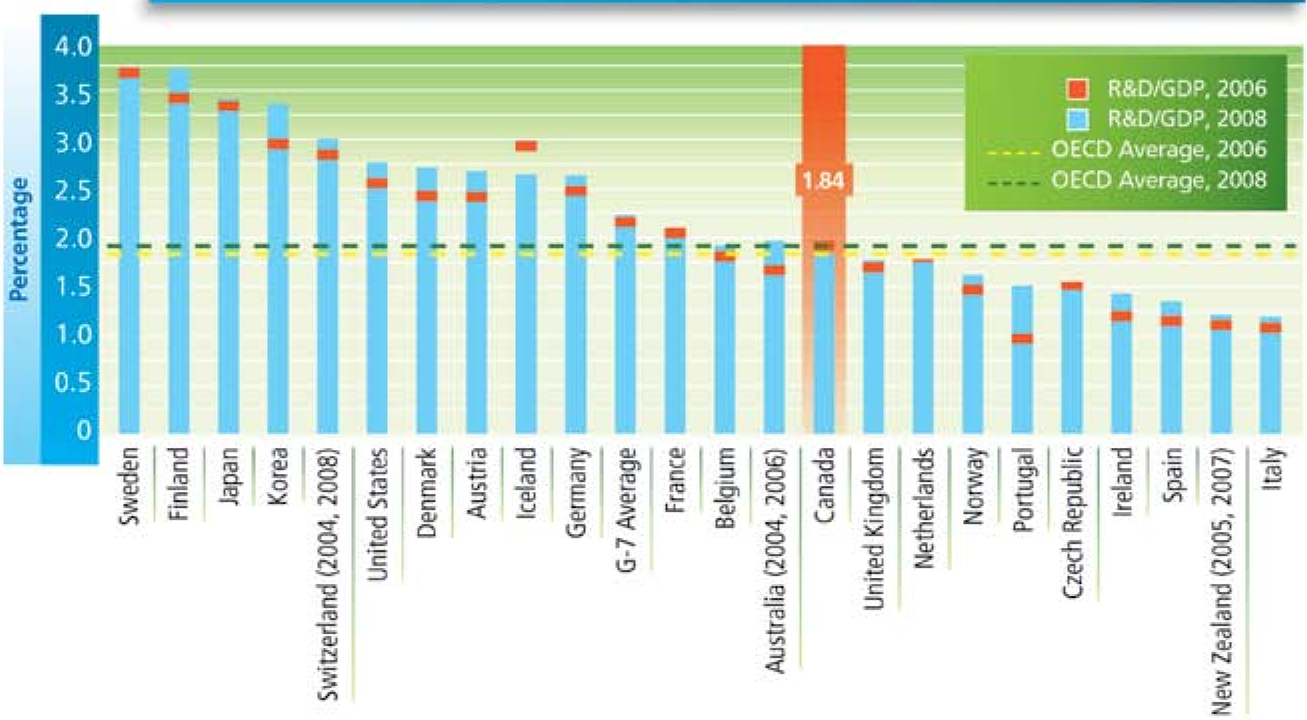
5 Resources for Research and Development

Gross domestic expenditure on research and development (GERD) is total expenditure on research and development performed in the country during a given period. Domestic performers of research and development include government (federal, provincial and provincial research organizations), business enterprise, private non-profit, and higher education. Funding for GERD comes from domestic and foreign sources.

The share of GERD relative to the size of a country's Gross Domestic Product (GDP) is a commonly used indicator of innovation performance. This has been a useful international benchmark and guides many science, technology and innovation strategies around the world.

As a share of GDP, R&D expenditures in Canada lag behind the G7 average (Figure 1). From 2006 to 2008, GERD/GDP in Canada dropped from 2.0 percent to just over 1.8 percent. This change was partly due to rapid GDP growth; however, growth in Canadian GERD also lagged that in the G7 over this period.

Figure 1 **Gross Domestic Expenditure on R&D (GERD) as a Percentage Share of GDP (2006 and 2008)**



Source: OECD, *Main Science and Technology Indicators,* 2010.

Figure 2 shows that among some of the top R&D-performing countries, including Canada, total GERD/GDP ratios over the past 10 years show mixed trends. Over this period, ratios substantially increased in Japan, China and South Korea. Canada showed a modest increase.

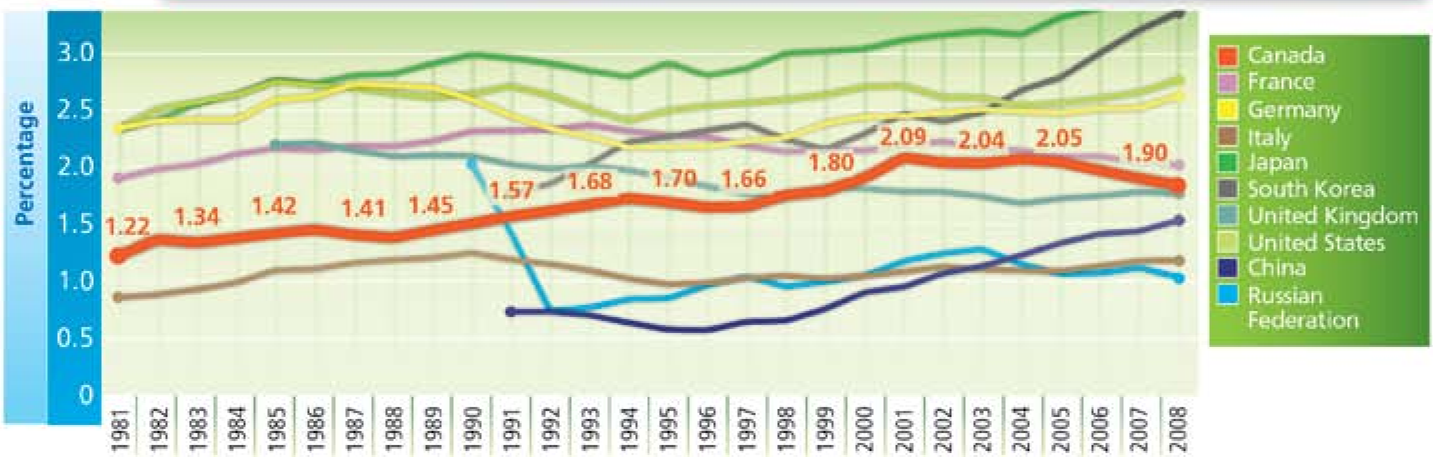
> *From 2006 to 2009, government, higher education, foreign sources and private non-profit sectors all increased their funding for R&D.*

Increasing Canada's research intensity and fostering innovation requires concerted and coordinated efforts by the three principal Canadian R&D-performing sectors: the private sector, the higher education sector and government. Figure 3 shows the R&D funding and performance that are undertaken by these three principal performing sectors and other supporting agents such as private non-profit organizations.[5]

In the period from 2006 to 2009, government, higher education, foreign sources and private non-profit sectors all increased their funding for R&D. Interestingly, the private non-profit sector increased its overall funding of R&D by just over 16 percent (in current dollars), the most over the period of 2006 to 2009 compared to the other sectors. During the same period, Canadian business expenditure on R&D declined in inflation-adjusted terms. The Government of Canada directly funded just under $6 billion of R&D performed in Canada in 2009 (in current dollars), an increase from 2006 of just under $500 million or 8.6 percent. Almost half of this $6 billion was carried out in Government of Canada institutions and labs. The remainder of about $3 billion for R&D (in current dollars) was performed by the higher education, business and private non-profit sectors. In-house government R&D as a share of GDP fell slightly to 0.188 percent in 2008 from 0.195 percent in 2006 (as reported in *State of the Nation 2008*) and the gap between Canada and the G7 (minus Japan, for which data are not provided) continued to widen.[6]

> *Canadian business expenditure on R&D declined in inflation-adjusted terms.*

Figure 2 **Gross Domestic Expenditure on R&D as a Percentage Share of Gross Domestic Product, for Selected Countries, 1981–2008**

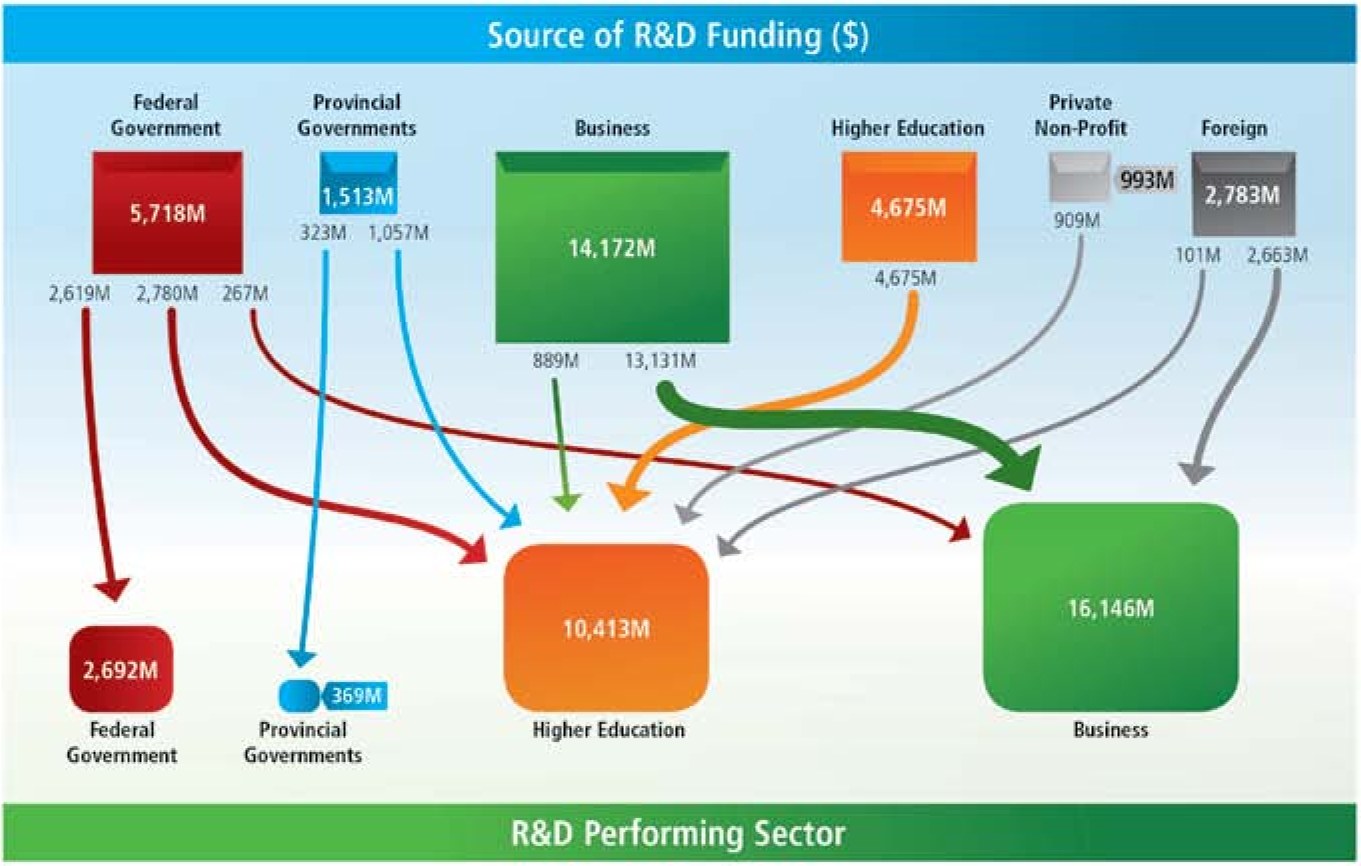


Source: OECD, *Main Science and Technology Indicators*, 2010.

5 Federal Funding of Business R&D includes direct grants and contracts from the federal government for R&D performed in the business enterprise sector in Canada. This figure does not include SR&ED tax credits, or repayable loans that may be made under certain federal programs. Foreign funding of R&D includes all funding of R&D performed in Canada, which is funded by a foreign source, if the financing of the R&D involves an international transfer of funds from a foreign country into Canada. This includes transfers of funds between, for example, foreign parent companies and their Canadian affiliates for R&D projects carried out in Canada.

6 OECD (2010), *Main Science and Technology Indicators*.

Figure 3 Major Flows of R&D Funding in Canada, 2009*



* Includes only flows and performers > $100M.

Source: Statistics Canada, CANSIM Table 358-0001, August 2010.

Figure 4 Gross Domestic Expenditure on R&D by Performing Sector, 1998–2008 (Constant 2002 Dollars)

Source: Statistics Canada, CANSIM Table 358-0001, July 15, 2010.

Figure 4 shows the trend of R&D performed by federal and provincial governments, business and higher education sectors from 1998 to 2008 in constant dollars. According to this figure, in Canada, growth in higher education R&D performance was responsible for just over half of the growth in total R&D over the period of 1998 to 2008: higher education performance of R&D grew from just under $5 billion in 1998 to just over $8.5 billion in 2008 (inflation-adjusted dollars).

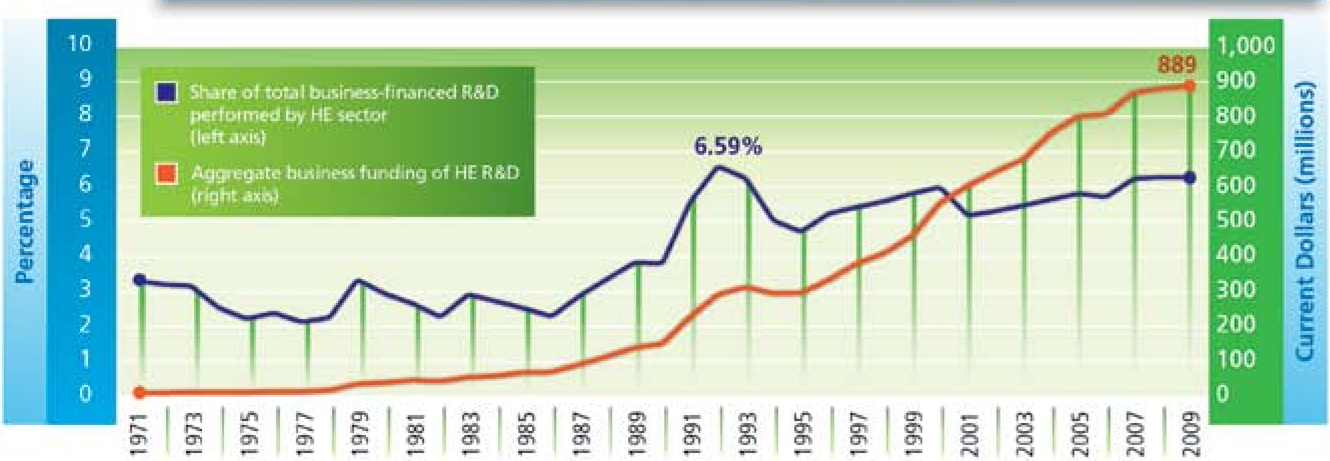
Figure 5 shows that business-financed R&D performed by universities has grown substantially in Canada, especially since the early 1990s. In 2009, university-performed R&D was 6.3 percent of total business funded R&D (which includes R&D financed and undertaken by businesses and R&D financed by business but undertaken by other sectors). This share was down from the peak of 6.6 percent in 1992, but was above the more recent peak of 2000 (preceding the tech collapse of 2001). While the growth in the share has slowed in recent years, the secular trend over the past two decades is upwards.

Business-financed R&D performed by universities has grown substantially in Canada.

Figure 6 shows that Canada is near the top of the OECD, and ranks number one in the G7, in terms of higher education research and development (HERD) as a percentage of GDP. In 2008, higher education R&D was 0.644 percent of GDP, down slightly from 0.664 percent in 2006.[7] HERD includes all research performed in higher education organizations such as universities and affiliated teaching hospitals. Canada's lead increased from 1997 to 2001 because of its investments in research infrastructure (such as laboratories), and from 2001 to 2007 because of investments in research. The spending rate and the balance of funding between infrastructure and research have remained stable over the last decade. Figure 7 shows that federal HERD expenditure consistently increased from 1997–98 to 2008–09. The level of expenditure in infrastructure increased from 1997–98 to 2001–02, and then remained relatively stable from 2001–02 to 2008–09. Announced on January 27, 2009, as part of the Government of Canada's Economic Action Plan, the Knowledge Infrastructure Program provided $2 billion to support enhancement at universities and colleges over two years.

Canada ranks number one in the G7, in terms of higher education research and development (HERD) as a percentage of GDP.

Figure 5 Business-Financed R&D Performed by Higher Education



Source: Statistics Canada, CANSIM Table 358-0001, September 2010.

[7] OECD (2010), *Main Science and Technology Indicators.*

Figure 6 Higher Education Performance of R&D

Source: OECD, *Main Science and Technology Indicators*, 2010.

Figure 7 Federal Expenditures on Higher Education R&D (Constant 2002 Dollars)[8]

Source: Industry Canada calculation based on data from Statistics Canada (Catalogue 88-204) and the Granting Councils' Funding Decision Databases.

Direct and Indirect Government Funding of Business R&D

Governments use various tools to encourage private sector investment in R&D. These tools can be classified into direct support and indirect support. Direct support encompasses grants, loans and procurement. Indirect support includes R&D tax credits, R&D allowances and reductions in R&D workers' wage taxes. The best balance of tools to use varies from country to country and is determined by the market or system failure being addressed and the type of R&D that the government wants to stimulate.[9] System failure has been described as the lack of coherence among institutions in an innovation system and in incentive structures.[10]

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8 Federal Expenditures on Higher Education R&D are defined as the three Granting Councils and the Canada Foundation for Innovation's (CFI) expenditures on R&D in the Higher Education Sector. Infrastructure includes expenditures for all CFI programs except for the Infrastructure Operating Fund (IOF), and equipment and tools programs from NSERC and CIHR. Research includes all other research grants from the granting councils and the IOF portion of CFI.

9 OECD (2010), "Firms investing in R&D," *OECD Measuring Innovation: A New Perspective*. (**http://www.oecd.org/dataoecd/29/33/45188105.pdf**)

10 Johan Hauknes and Lennart Nordgren, *Economic Rationales of Government Involvement in Innovation and the Supply of Innovation-Related Services*, The STEP Group, 1999.

Indirect support reduces the marginal cost of R&D activities.[11] Canada uses indirect funding to a greater degree than direct funding (Figure 8a). In 2009, over $3 billion in tax assistance was provided through Canada's Scientific Research and Experimental Development (SR&ED) Tax Incentive Program.[12] Based on a review of earlier studies, a 2007 evaluation of the SR&ED program by Finance Canada reported that the measure stimulated, on average, $0.91 of R&D spending per dollar of revenue foregone.[13] The authors found that while there is weak evidence that direct assistance may have a somewhat larger impact on business R&D spending, this is offset by weak evidence that indirect assistance may have a somewhat greater spillover effect.[14] The evaluation concludes that the "empirical evidence is still too ambiguous" to reach a conclusion about which type of support achieves the best results.[15]

Although Canada has one of the most generous R&D tax credit programs in the world, Canada is below the OECD average in terms of business expenditures on research and development. A number of countries with higher business expenditures on R&D provide more R&D support through direct funding. Figure 8b shows direct government funding of business R&D in a select group of OECD countries.

Direct support can leverage private financing. Public funds can, for example, complement private funds to support company initiatives that align with government priorities. Direct funding can be an effective way to support R&D in priority areas. Recent federal budgets have introduced initiatives in Canada to enhance direct funding. Budget 2009 provided an additional $200 million over two years to the National Research Council of Canada's Industrial Research Assistance Program (NRC-IRAP), which is the principal program through which

Figure 8a **Indirect Government Support through R&D Tax Incentives, 2008**

Source: OECD (2010), *Science, Technology and Industry Outlook 2010*, doi: **http://dx.doi.org/10.1787/888932333006**.

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[11] OECD (2010), "Firms investing in R&D," *OECD Measuring Innovation: A New Perspective*. (**http://www.oecd.org/dataoecd/29/33/45188105.pdf**)

[12] Department of Finance Canada, *Budget 2010: Leading the Way on Growth*, 2010, p. 86.

[13] Mark Parsons and Nicholas Philips, *An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development*, Department of Finance, 2007, p. 8. (**http://dsp-psd.pwgsc.gc.ca/collection_2008/fin/F21-8-2007-8E.pdf**)

[14, 15] Mark Parsons and Nicholas Philips, *An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development*, Department of Finance, 2007, p. 54. (**http://dsp-psd.pwgsc.gc.ca/collection_2008/fin/F21-8-2007-8E.pdf**)

direct support is delivered to small and medium-sized enterprises (SMEs). For fiscal year 2009–10, IRAP's budget included about $187 million in direct support to firms.[16] The Canadian Innovation Commercialization Program (CICP) for small and medium-sized enterprises was launched in September 2010. The CICP is a two year, $40 million pilot initiative that will support up to 20 innovative demonstration projects.

Figure 8b **Direct Government Funding of Business R&D, 2008**

Source: OECD (2010), *Science, Technology and Industry Outlook 2010*, doi: **http://dx.doi.org/10.1787/888932333006**.

> *Although Canada has one of the most generous R&D tax credit programs in the world, Canada is below the OECD average in terms of business expenditures on research and development.*

Direct funding through grants, subsidies and loans is the most common form of support for business R&D in OECD countries.[17] Finland recently reviewed its funding model, recognizing that tax incentives can complement a system traditionally dependent on direct support alone.[18] In conducting its review, Finland identified Norway as a country with a well-functioning model that employs both direct and indirect support. In 2008, the ratio of direct to indirect support in Norway was approximately two to one.

[16] National Research Council of Canada's Industrial Research Assistance Program (NRC-IRAP).

[17] OECD (2010), *Science, Technology and Industry Outlook 2010*, p.103.

[18] Anne Palkamo, *Finland Plans Tax Incentives for Companies' R&D Activities*, Tekes, 2009. (**http://www.tekes.fi/en/community/News/482/News/1344?name=Finland+plans+tax+incentives+for+companies+R%26D+activities**)

6
Digest of Indicators

6.1 Business Innovation Indicators

Private sector innovation is an engine of wealth creation. For individual firms, developing new or improved products can help preserve and capture market share, increasing revenues and profits. If these innovations merely shift market share from one company to another, consumers may benefit from added choice but overall wealth creation has not occurred. However, if innovation prompts other firms to improve their products to compete, the result can be an improvement in the quality of goods available to consumers — an improvement in consumers' net wealth. Firms may also introduce process innovation to reduce costs, which can have the effect of increasing profit margins, lowering prices for consumers, or both.

6.1.1 Going Beyond R&D Indicators to Measure Innovation

The *State of the Nation 2008* report referred to the links between innovation, productivity and our standard of living. It noted that Canadian industries invest less in R&D and machinery and equipment than comparable industries around the world. R&D expenditures are only one indicator of innovation, but an important indicator that is well correlated with other contributions to innovation.

Highly aggregated, national data can provide a useful benchmark for the innovative performance of an economy, but it can mask significant differences in industrial composition and the performance of individual industries and firms. Some industries are inherently more R&D- or ICT-intensive than others, and the relationship between these variables and productivity (as is the case with any metric of innovation) also varies by industry.

STIC's *State of the Nation 2010* explores business innovation on an industry and sector basis. This section begins by presenting data on productivity levels and growth in Canada by industry and by sector, and then compares labour productivity levels, and their determinants, with the United States. The four determinants examined include: multifactor productivity, investments in machinery and equipment (M&E), information and communications technologies (ICT) (equipment and services), and research and development.

This report also includes new innovation survey findings on how Canadian-based enterprises innovate, the place of innovation in their corporate strategies, and their expenditures on product and process innovations. The growth of technology intensive commercial services trade is also described and analyzed. Finally, the report points out sectoral differences in how much large, medium and small companies are investing in R&D and developments in the availability of venture capital for Canadian businesses.

6.1.2 Productivity Growth for Improved Standards of Living

"There are, of course, other factors besides productivity growth that affect our standard of living, such as changes in Canada's terms of trade (the prices we receive for what we sell abroad relative to the prices we pay for imports) and changes in employment rates (the proportion of the population that is actually employed). However, productivity growth is the major source of improvement in our economic well-being in the long run. Gains in productivity allow businesses to pay higher real (inflation-adjusted) wages and still keep costs down and stay profitable and competitive. So, rising productivity is vital to sustained improvements in real incomes and living standards over time."
– Bank of Canada[19]

[19] Bank of Canada, *Backgrounder on Productivity*, 2010. (**http://www.bankofcanada.ca/en/backgrounders/bg-p4.html**)

R&D Sub-Priority: Energy Production in the Oil Sands

Dr. Josephine Hill, Zandmer/Canada Research Chair in Hydrogen and Catalysis, at the University of Calgary, and recipient of the 2008 Minerva Mentoring Award for encouraging women in engineering, science and information technology.

R&D in Oil Sands and Heavy Oil

Steam-assisted gravity drainage (SAGD) technology is an example of innovation in the oil and gas industry that developed through extensive field testing. Two horizontal wells are drilled in oil sands formations to produce bitumen — which is a mixture of sand, clay, water, and a dense and viscous form of petroleum. The upper well injects steam into the formation, and the lower well collects the heated crude oil or bitumen that flows out of the formation, along with any water from the condensation of injected steam. The heat from the steam reduces the viscosity of the heavy crude oil or bitumen. This enhanced oil recovery technology is considered twice as efficient as the older cyclic steam stimulation process.

SAGD has gone through several transformations since it was first conceived by Roger Butler in the late 1960s. Alberta Innovates Technology Futures (AITF) is supporting the development of alternative SAGD produced water treatment technologies (e.g., ceramic membranes). Nexen's Long Lake Project in the Athabasca oil sands is the first to combine SAGD with an upgrader process that yields premium synthetic crude through a comparatively more efficient use of natural gas.

Research in Catalysis

Research and development sub-priorities span basic to applied research. For example, research by Josephine Hill, Zandmer/Canada Research Chair in Hydrogen and Catalysis, at the University of Calgary, examines and improves efficiencies in chemical and electrochemical processes that can have application in energy production. The work in the catalysis field has implications for: environmental impact; the development of fuel cells; hydrotreating of heavy oil; and gasification. Implications also impact the conversion of solid waste materials, such as petroleum coke and biomass into activated carbon, which can be used to clean up gas and liquid exhaust streams. The spent activated carbon can then be gasified to produce gaseous products, such as methane and syngas.

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

In Canada, labour productivity levels and their growth vary tremendously between industries. For example, Figure 9 reveals that private sector labour productivity levels in service industries were only 89 percent of the average for the entire economy. The sectors of mining and oil and gas extraction and utilities were sectors with at least three times the private sector labour productivity levels of the overall economy. Productivity in these sectors has been decreasing to an average of -4.5 percent and -1.7 percent respectively in the 2003 to 2008 period. A decrease of -2.3 percent in labour productivity was also registered in the construction sector. In contrast, above average labour productivity growth was experienced in most service industries as well as in the sector of agriculture, forestry, fishing and hunting and the manufacturing sector over the 2003 to 2008 period. Significant labour productivity growth was also experienced in the wholesale and retail trade sectors, both of which increased by 3.4 percent per year in the 2003 to 2008 period.

Economic research on the United States' productivity growth "miracle" suggests that service industries' labour productivity growth rate increased from 1.0 percent per year before 1995 to 2.3 percent per year in subsequent years.[20] Much of the famed revival of U.S. productivity growth is attributable to services productivity. U.S. labour productivity growth is actually not miraculous, but rather the result of corporate action.

The sources of the strong labour productivity growth in the U.S. service industries are attributable to high levels of ICT capital spending and rapid multifactor productivity (MFP) growth. Multifactor productivity measures joint influences on economic growth, such as technological change, efficiency improvements, and returns to scale.[21]

Figure 9 **Private Sector Labour Productivity (2008) and Private Sector Labour Productivity Growth (2003–2008), by Industry**

SECTOR or Industry	Labour Productivity,* 2008	Labour Productivity Growth (Average Annual Growth (%)), 2003–2008
GOODS SECTOR		
AGRICULTURE, FORESTRY, FISHING AND HUNTING	35.2	4.7
MINING AND OIL AND GAS EXTRACTION	117.7	-4.5
UTILITIES	135.5	-1.7
CONSTRUCTION	28.7	-2.3
MANUFACTURING	48.7	0.8
AVERAGE FOR GOODS SECTOR	47.3	-0.6
SERVICES SECTOR		
Wholesale Trade Industries	41.1	3.4
Retail Trade Industries	24.1	3.4
Transportation and Warehousing Industries	33.9	0.5
Information and Cultural Industries	64.1	2.9
Finance, Insurance, Real Estate and Leasing Industries	72.4	0.8
Professional, Scientific and Technical Services Industries	30.9	0.1
Administrative and Support, Waste Management and Remediation Services Industries	22.1	0.6
Educational Services Industries	24.2	3.2
Health Care and Social Assistance Industries	31.7	0.7
Arts, Entertainment and Recreation Industries	20.0	1.0
Accommodation and Food Services Industries	15.5	1.7
Other Services (except Public Administration) Industries	17.4	1.1
AVERAGE FOR SERVICES SECTOR	33.6	1.7
Average for all Sectors and Industries	37.8	0.7

*Private sector labour productivity is calculated as real private sector Gross Domestic Product (in CAD) divided by total hours worked.
Note: Sectors are comprised of many industries.
Source: Compilation by STIC Secretariat based on data from Statistics Canada.

[20] Barry P. Bosworth and Jack E. Triplett, *Is the 21st Century Productivity Expansion Still in Services? And What Should Be Done About It?,* Brookings Institution, Washington, D.C., January 2007.

[21] Bank of Canada, *The Virtue of Productivity in a Wicked World*, remarks delivered by Mark Carney at the Ottawa Economics Association, Ottawa, Ontario, March 24, 2010.

According to the System of National Accounts,[22] products are goods and services (including knowledge-capturing products) that result from a process of production.

Goods are physical, produced objects for which a demand exists, over which ownership rights can be established and whose ownership can be transferred from one institutional unit to another by engaging in transactions on markets.

Services are the result of a production activity that changes the conditions of the consuming units, or facilitates the exchange of products or financial assets.

While comparisons across industries within Canada are important to obtain an understanding of where productivity levels are improving, comparison with other countries' industries provides an indication of Canada's international competitiveness. Like Canada, U.S. services productivity levels lag in the manufacturing sector, but are catching up rapidly. Growth in labour productivity is essential for rising wages and increased profitability for employees and investors.

Figure 10 compares the relative performance of Canadian industries compared to the same U.S. industries for labour productivity levels, and its main determinants: multifactor productivity and capital intensities for machinery and equipment investments and ICT investments. The figure shows that there was a widening Canadian labour productivity gap with the U.S. from 2002 to 2007. Canadian productivity levels over this time period fell from 77.3 percent to 72.1 percent of U.S. labour productivity levels. While Canadian mining, oil and gas, utilities and manufacturing sectors all saw declines in labour productivity relative to the U.S., 9 out of 11 service industries also saw declines in relative productivity to the U.S. over this period. Only agriculture, forestry, fishing and hunting, construction and a few service industries (i.e., wholesale trade; finance, insurance and real estate and the management of companies industries) witnessed improvements in their productivity vis-à-vis their U.S. counterparts.

Analyzing the drivers of labour productivity is an important part of understanding Canada's relative productivity growth. *Multifactor productivity* (MFP) and investments in machinery and equipment (M&E), especially ICT capital, are important drivers of labour productivity growth. Investments in M&E and ICT capital often influence labour productivity through MFP. The Council of Canadian Academies' Expert Panel on Business Innovation concluded that "…the rate of MFP growth over suitably long periods of time is primarily due to business innovation — interpreted broadly to include better organization of work, improved business models, the efficient incorporation of new technology, the payoff from R&D and the insights of entrepreneurs."[23]

MFP declined relative to the U.S. in all industry sectors and industries of the Canadian economy with the exception of agriculture, forestry, fishing and hunting; oil and gas extraction; construction and wholesale trade. The net effect brought Canada's relative MFP performance down to 68.5 percent of U.S. MFP levels. In spite of this decline, Canadian construction, oil and gas extraction, wholesale trade, administrative and waste management, and other service industries (except public administration) retained higher MFP levels than their U.S. counterpart.

> *MFP declined relative to the U.S. in all sectors and industries of the Canadian economy with the exception of agriculture, forestry, fishing and hunting; oil and gas extraction; construction and wholesale trade.*

Investments in machinery and equipment (M&E) and its ICT component were similarly lower than overall U.S. levels from 2000–07. Relative investment intensity in ICT was less than one half the U.S. levels, whereas investments in M&E were slightly under three quarters of the U.S. levels. Canadian machinery and equipment investment intensity was higher than U.S. levels in the oil and gas extraction industry and the finance, insurance and real estate (FIRE) and management of companies industry. For ICT capital, Canada's

[22] European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, World Bank, *System of National Accounts 2008*, New York, 2009.

[23] Peter Nicholson, *Innovation and Business Strategy: Why Canada Falls Short*, *International Productivity Monitor*, Centre for the Study of Living Standards, Number 18, Spring 2009.

investment intensity was higher than U.S. levels during the 2000–07 period in the arts, entertainment and recreation and other services (except public administration) industries. Gross fixed capital formation in machinery and equipment was 6.3 percent of Canada's GDP in 2007, up slightly from 6.2 percent in 2004 (as reported in *State of the Nation 2008*).[24]

6.1.3 Innovation Focus in Business Strategy

The 2009 *Survey of Innovation and Business Strategy* (SIBS) was a joint pilot project by Industry Canada, Foreign Affairs and International Trade Canada and Statistics Canada. A total of 6,233 enterprises in Canada spanning 67 industries were surveyed. The sample was limited to firms with 20 or more employees

Figure 10 **Canada–U.S. Labour Productivity, Multifactor Productivity, and Capital Intensity Comparisons (U.S. = 100)**

SECTOR or Industry	Labour Productivity		Multifactor Productivity		Machinery and Equipment*	ICT
	2002	2007	2002	2007	2000–07 Average	2000–07 Average
GOODS SECTOR						
AGRICULTURE, FORESTRY, FISHING AND HUNTING	85.5	86.4	82.8	86.2	70.5	79.1
MINING	88.9	88.0	79.3	72.5	80.0	31.2
Mining, except oil and gas industry	58.1	47.3	52.2	39.4	57.0	35.1
Oil and gas extraction industry	87.9	81.6	94.9	100.3	100.5	25.6
UTILITIES	76.5	62.7	53.9	49.0	51.0	73.6
CONSTRUCTION	149.5	192.5	151.8	196.9	79.2	14.7
MANUFACTURING	84.4	73.2	91.1	77.2	91.1	36.6
SERVICES SECTOR						
Wholesale Trade Industries	73.7	90.0	97.8	120.3	29.9	45.6
Retail Trade Industries	81.3	75.6	95.3	85.5	70.4	72.1
Transportation and Warehousing Industries	123.8	108.1	112.5	96.7	86.8	19.7
Information and Cultural Industries	64.5	46.6	69.9	52.3	82.8	98.5
FIRE** and Management of Companies Industries	70.0	72.1	75.7	74.9	105.4	72.2
Professional, Scientific and Technical Services Industries	45.4	38.6	54.0	47.6	45.7	42.3
Administrative and Waste Management Industries	113.5	107.6	144.1	126.2	39.9	49.9
Education, Health Care and Social Assistance Industries	99.4	95.9	102.0	98.0	34.2	17.8
Arts, Entertainment and Recreation Industries	39.6	39.0	49.4	47.9	39.3	128.7
Accommodation and Food Services Industries	74.1	72.2	85.2	78.8	28.3	47.1
Other Services (except Public Administration) Industries	145.3	143.8	181.6	178.3	61.1	102.1
Average for all Sectors and Industries	77.3	72.1	75.4	68.5	74.5	47.9

*Machinery and Equipment includes ICT.
** FIRE stands for Finance, Insurance, Real Estate and Leasing.
Note: Sectors are comprised of many industries.
Source: Tang, Jianmin, Someshwar Rao, and Min Li, *Sensitivity of Capital Stock and Multifactor Productivity Estimates to Depreciation Assumptions: A Canada–U.S. Comparison, International Productivity Monitor*, Number 20, Fall 2010, Ottawa, Centre for the Study of Living Standards.

[24] OECD (2009). *OECD Factbook 2009: Economic, Environmental and Social Statistics.*

and revenue of $250,000 or more. Industry-by-industry comparisons of the results from SIBS with the U.S. should be adjusted to account for the different size cut-off used in the U.S. *Business R&D and Innovation Survey*. As innovation is dependent on the size of firm, all other things being equal, Canadian results for the propensity to innovate would be expected to be higher than those of the U.S. Questionnaires integrating features from other countries' business surveys were sent to the Chief Executive Officers or senior managers of enterprises. The survey response rate was 70 percent. SIBS data provide insights into long-term strategic objectives of Canadian-based enterprises when they invest in innovation, their business innovation strategy, as well as business innovation activities and outcomes.

The survey tracks four types of innovation at the firm level, as identified in the *Oslo Manual*, for measuring innovation: product innovation, process innovation, marketing innovation and organizational innovation.

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

Process Innovation involves a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.

Marketing Innovation involves a new marketing method with significant changes in product design or packaging, product placement, product promotion or pricing.

Organizational Innovation involves introducing a new organizational method in the firm's business practices, workplace organization or external relations.

These innovations can be new to the firm, new to the market/sector or new to the world.

SIBS data revealed that the large majority of Canadian-based enterprises relies on existing products, processes, marketing and organizational practices. Only 19 percent of enterprises in all surveyed industries stated that their strategic focus was to regularly introduce new or significantly improved goods or services, and only 34 percent of firms' long-term strategic focus was to introduce new or significantly improved business activities or processes to their operations.

Thirty-one percent of enterprises' long-term strategic focus was to introduce significantly improved marketing practices or methods, while 33 percent of enterprises' long-term focus was to introduce new or significantly improved management practices or change to their organizational structure.

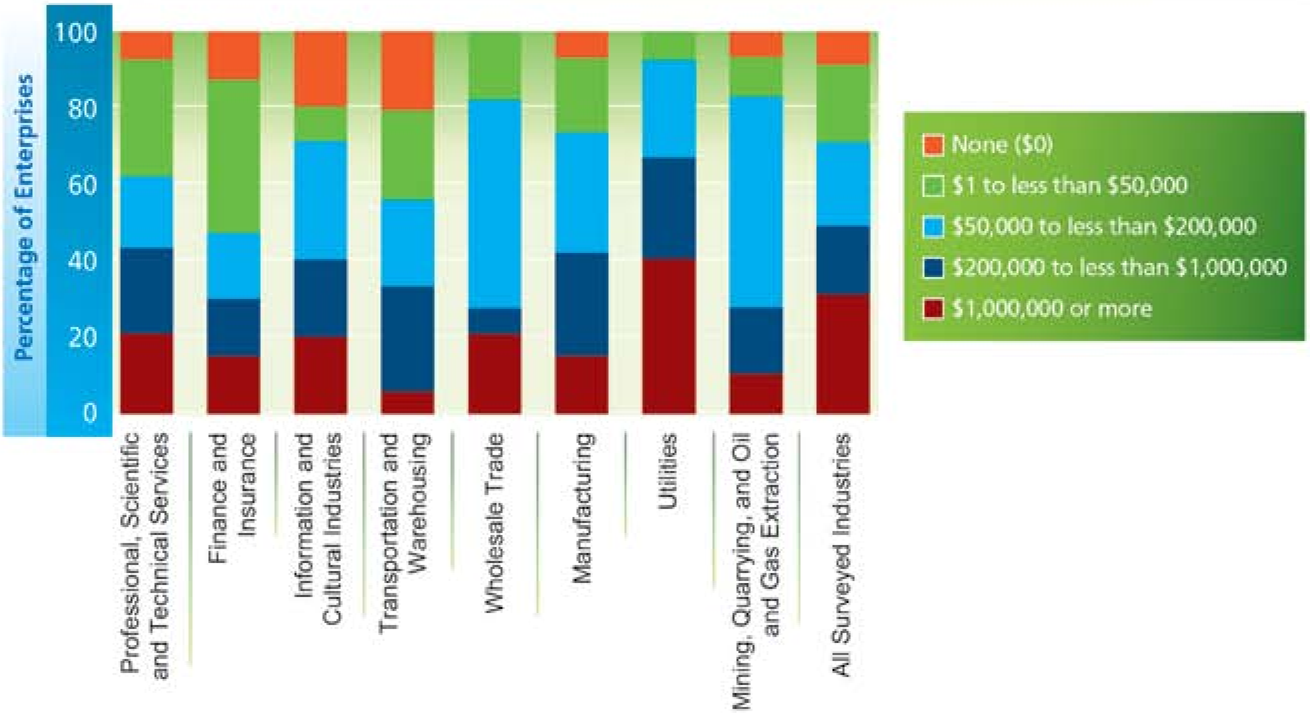
Monitoring the outcomes of innovative activities is essential to ensuring that long-term innovation strategies are successfully adopted. The survey inquired about the monitoring practices of Canadian-based enterprises to achieve their objectives. Financial objectives figured most prominently in all enterprises' measurement of long-term strategic objectives, ranging from 65 percent of enterprises monitoring gross or operating margin growth to 76 percent monitoring sales or income growth. Customer orientation indicators were the next most cited set of measures. This includes process and organization-related objectives such as improved customer satisfaction (50 percent of enterprises). Increased sales of new products and process innovation placed third in importance as to what is measured in the long-term objectives of enterprises.

6.1.3.1 Expenditures on Innovation Activities

Amongst all Canadian-based enterprises reporting innovative activities, utility enterprises have a greater incidence of spending large amounts on both product and process innovation, as shown in Figures 11 and 12. For good or service innovations, 41 percent of innovative enterprises in this industry spent more than $1 million, 26.4 percent spent the next largest amount (i.e., $200,000 to less than $1 million), 25.6 percent spent between $50,000 and $200,000, and 7.4 percent spent $1 to $50,000. There were no instances of a utility enterprise not spending anything on product innovation. In contrast, approximately 20.7 percent of innovative enterprises in transportation and warehousing industries did not spend anything on product innovation. Manufacturing followed by professional, scientific and technical services have a high incidence of spending large amounts on product innovation.

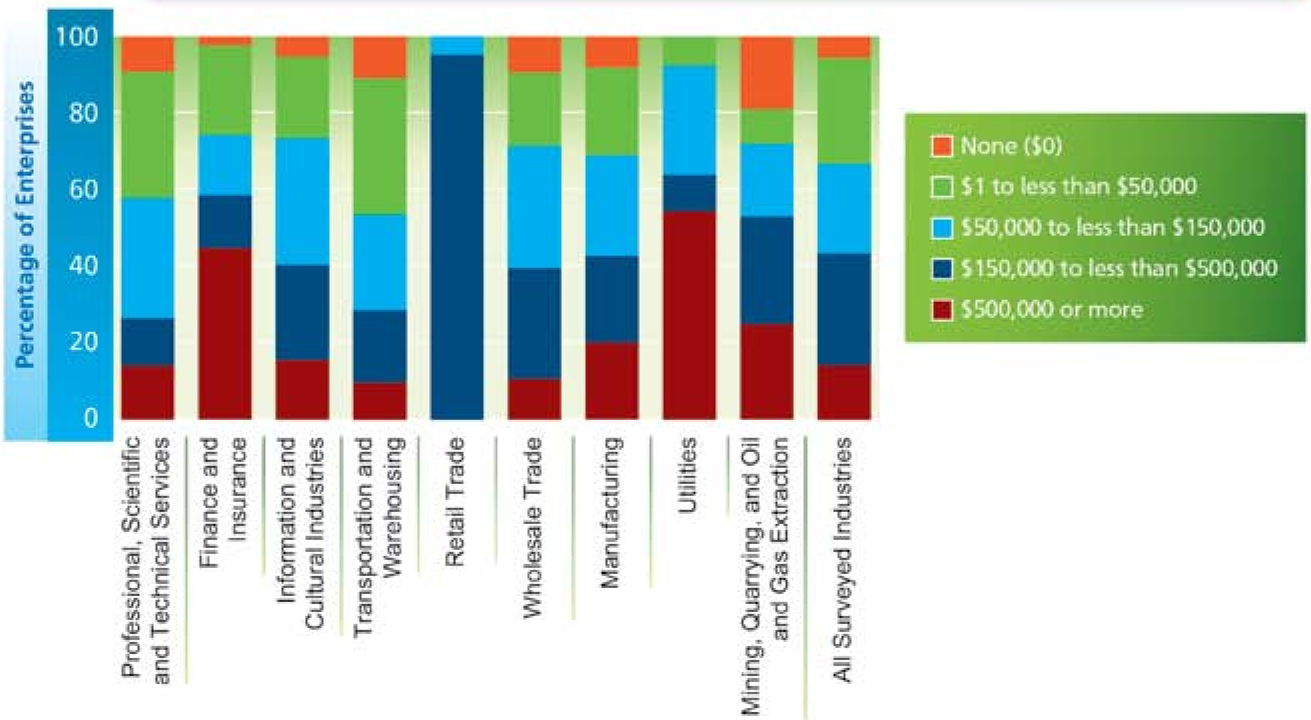
Figure 12 shows a high incidence of high expenditure levels (i.e., $500,000 or more) on process innovation was found in utilities (54.3 percent of innovative enterprises), followed by finance and insurance (44.6 percent of innovative enterprises), and mining, quarrying and oil and gas extraction (at 24.8 percent of innovative enterprises).

Figure 11 Total Expenditures on Good or Service Innovations, 2009



Source: *Survey of Innovation and Business Strategy,* 2009.

Figure 12 Total Expenditures on Process Innovations, 2009



Source: *Survey of Innovation and Business Strategy,* 2009.

A Focus on Service Industries

Services encompass a wide range of industries often serving other parts of the economy. In 2008, services accounted for 61.5 percent of private sector GDP and 72.6 percent of private sector employment in the Canadian economy. The top three service industries by employment are retail trade; finance, insurance, real estate and rental and leasing; and accommodation and food services.

Many of Canada's largest corporations in 2009, as identified in the *Financial Post* list of top 500 Canadian companies, were either service firms or manufacturing firms with large service activities. Of the 30 largest firms in Canada, by 2008 revenue size, 16 had substantial service activities, such as: Royal Bank of Canada, Power Corporation of Canada, Manulife Financial, George Weston, Scotiabank, Toronto-Dominion Bank, Bank of Montreal, Bell Canada Enterprises, Walmart Canada, Alimentation Couche-Tard, Sun Life Financial, Empire Company, Brookfield Asset Management, Canadian Imperial Bank of Commerce, Thomson Reuters, and Research In Motion.

Branham Group's 2010 list of top 250 Canadian technology companies was also heavily occupied by firms with sizeable service activities.

Examples of Service Enterprises

Thomson Reuters uses innovative technology to deliver information to decision makers in the financial, legal, tax and accounting, scientific, health-care and media markets. In 2008, the company received an R&D 100 Award from *R&D Magazine* for its intellectual property research and analysis platform.[25] The company has also earned six Technology Innovation Awards from *The CPA Technology Advisor*, including a 2010 award for its staff management tool.[26]

CGI Group offers IT management and business process services in areas such as systems integration and consulting, application management and technology management. CGI Group is one of the most R&D-intensive ICT companies in Canada, spending $76 million in 2009.[27] The company has collaborated with Bell Canada to create a centre for innovation and technology excellence,[28] and it has been recognized for important innovation in e-procurement[29] and electronic health information management.[30]

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[25] R&D Magazine, "Thomson Reuters: IP at your fingertips," *R&D 100 Awards*, 2008. (**http://www.rdmag.com/Awards/RD-100-Awards/2008/09/IP-At-Your-Fingertips/**)

[26] CPA Technology Advisor, *Honoring Innovation: Maximizing Workflow Efficiency is Latest Quest*, 2008. (**http://www.cpatechnologyadvisor.com/print/The-CPA-Technology-Advisor/Honoring-Innovation/1$2030**)

[27] RE$EARCH Infosource, *Canada's Top 100 Corporate R&D Spenders 2010*. (**http://www.researchinfosource.com/2010Top100List.pdf**)

[28] CGI, *CGI and Bell use close cooperation to create an innovative center and accelerate the development of leading-edge solutions*, Case Studies. (**http://www.cgi.com/en/case-study/electronic-customer-service-oracle-bell**)

[29] Virginia Commonwealth University, "Innovation in Government Award," *L. Douglas Wilder School of Government and Public Affairs*, 2007. (**http://wrc2003-test.vcu.edu/gov/newsandevents/default.asp?ID=169**)

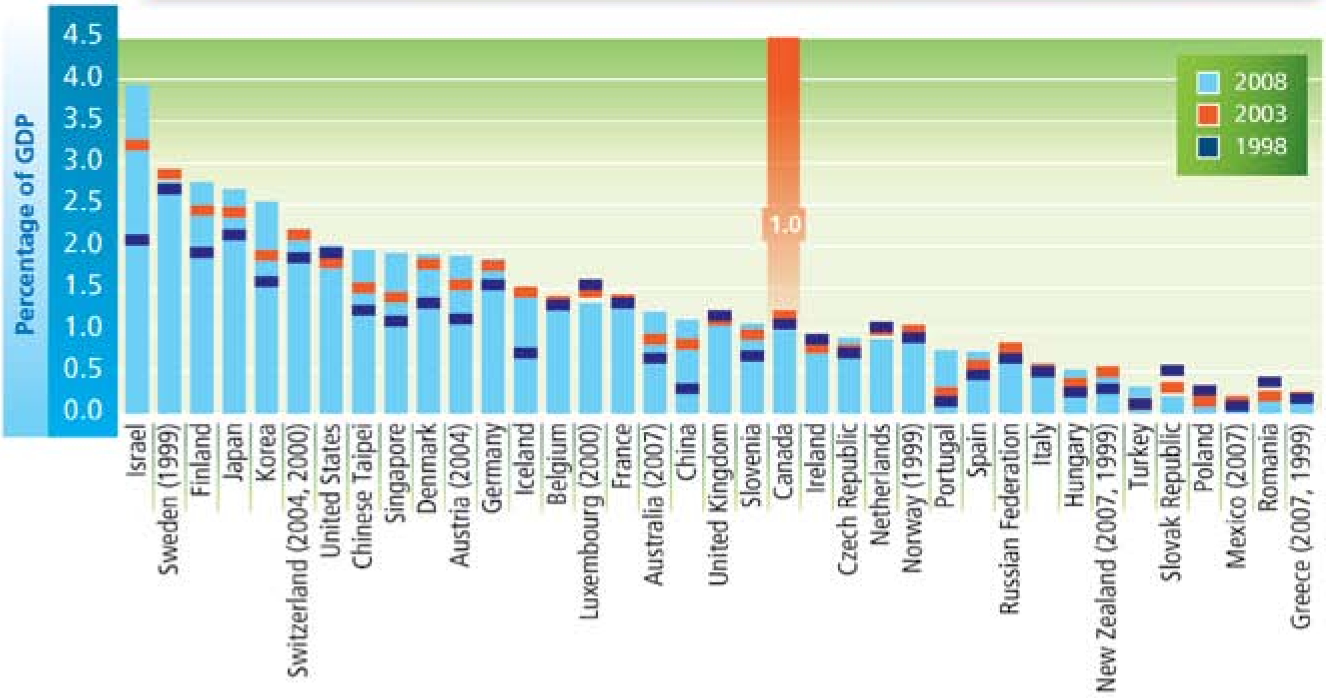
[30] Canadian Healthcare Technology, "St. Michael's to integrate paper records with HER," *News*, 2007. (**http://www.canhealth.com/News609.html**)

6.1.4 Innovation through Research and Development

6.1.4.1 Business Performance of R&D

Business expenditure on R&D (BERD) intensity is the ratio of business R&D to a measure of output. Figure 13 compares the ratio of BERD to GDP for a selection of countries in 1998, 2003 and 2008. Most countries show an increase in BERD intensity over these years, while the intensity in Canada has declined. This is not just the result of faster GDP growth in Canada, but also declining aggregate business performance of R&D (Figure 14).

Figure 13 BERD Intensity by Country, 1998, 2003 and 2008 (as a Percentage of GDP)



Source: OECD, *Main Science and Technology Indicators,* 2010.

Figure 14 BERD in Canada, 1991 to 2010

Source: Statistics Canada, CANSIM Table 358-0001, January 2011.

From 2006 to 2009, funding for R&D from federal and provincial governments, higher education, private non-profit groups and foreign sources increased. While not offsetting the decline in business performance of R&D, the private sector also directed more resources to higher education to perform R&D.

Business sector value-added, which is composed mainly of profits and wages, is essentially the business contribution to GDP. The metric of business expenditure on R&D (BERD) as a share of business value-added is a measure of how much of a business' resources is dedicated to R&D. By international standards, Canada's business R&D expenditures' share of business sector value-added was quite low in 2008 (Figure 15). The top 25 companies in Canada accounted for an estimated 33 percent of total intramural business R&D performed in 2009. This share has been fairly stable in recent years, but is down considerably from nearly 50 percent in the late 1980s. The share of the top 100 companies has similarly decreased, from nearly 70 percent of the total in the late 1980s to an estimated 53 percent in 2009. While R&D performance is still heavily concentrated in a few score of leading R&D performers, business R&D is becoming more distributed.[31]

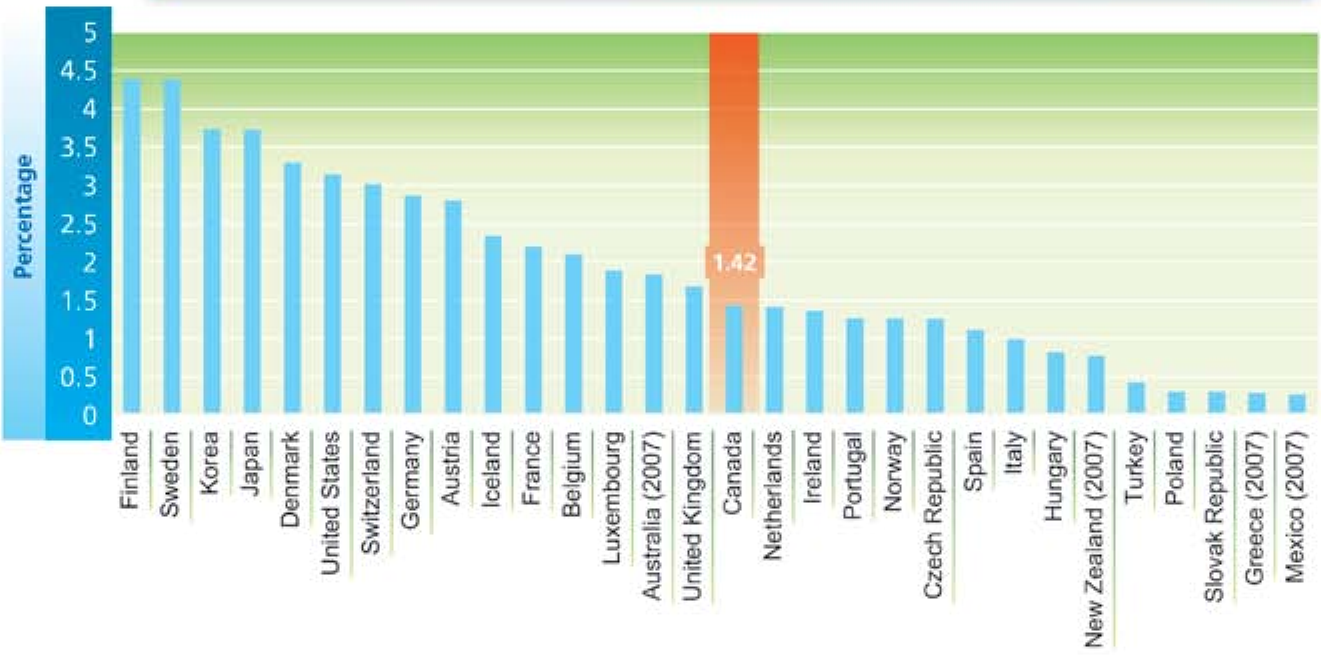
Econometric estimates of the link between R&D and productivity vary widely. Firm-level studies generally suggest a rather robust link between R&D and productivity while more aggregated industry-level data sometimes show a weaker link. Broadly speaking, however, the economic literature suggests a positive link between R&D and productivity, making R&D performed by Canadian industry an indicator of business sector innovation worth noting.[32]

6.1.4.2 Canada's Industry Structure and Business Performance of R&D

Some argue that Canada's overall low business expenditure on R&D is a reflection of Canada's industry structure. Does Canada's industry structure explain historically low business expenditure on R&D (BERD) in comparison to leading innovating countries?

Overall low business R&D can in part be explained by the relative size in Canada of industries that globally tend to invest less in R&D. For example, Canada has a relatively large energy extraction sector. Investments in product and process innovation in this

Figure 15 **BERD Share of Value-Added in Industry,* 2008**



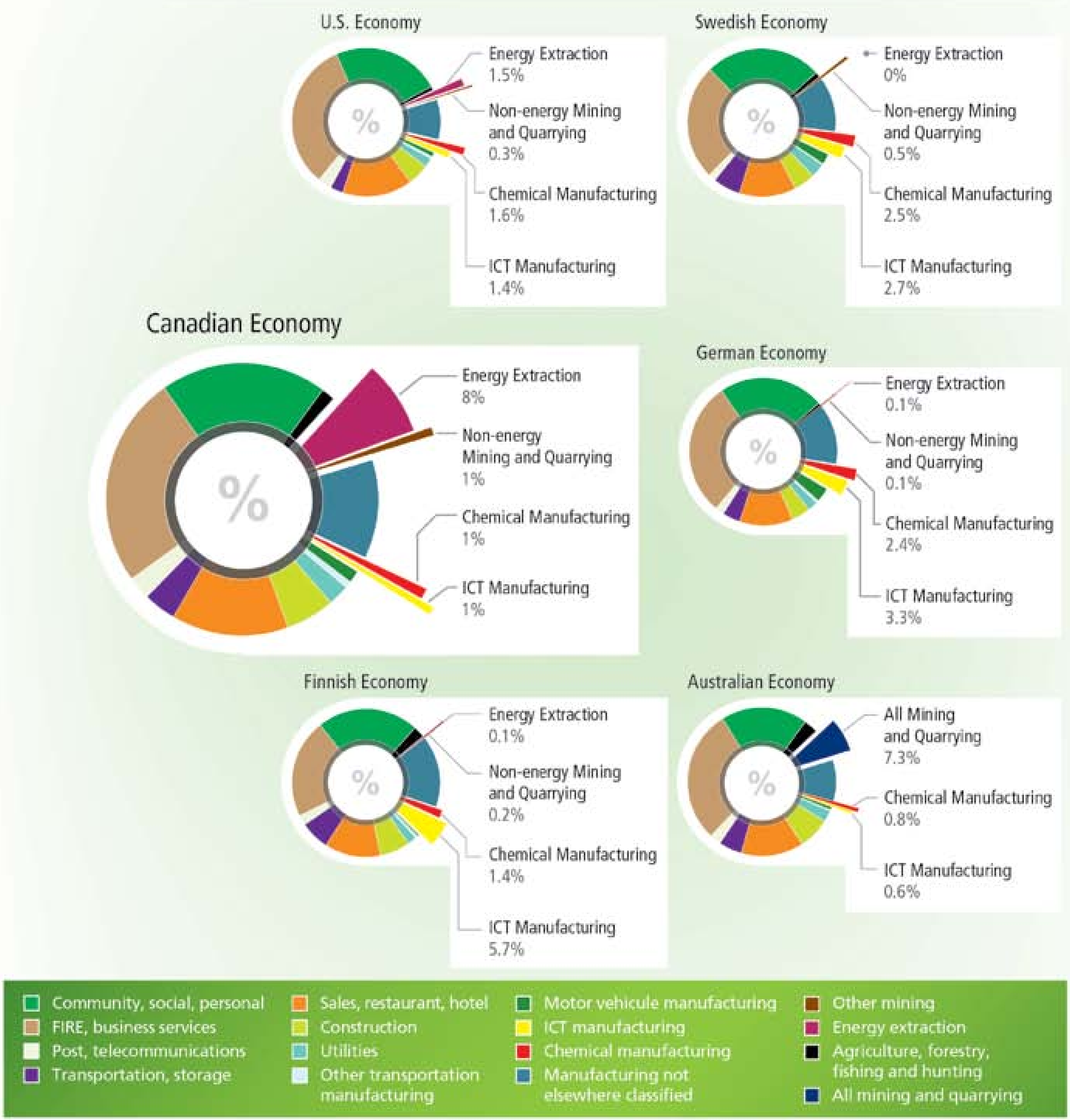
*Value-added by industry is based on gross value-added net of 'real estate activities,' 'financial intermediation services indirectly measured' and the public sector; i.e., it is a measure of private sector productive value-added.
Source: OECD, *Main Science and Technology Indicators,* 2010.

31 Statistics Canada, *Industrial Research and Development: Intentions 2009*, Catalogue no. 88-202-X, 2010.

32 Congressional Budget Office, *R&D and Productivity Growth: A Background Paper*, The Congress of the United States, June 2005, p.1, p. 32.

sector have historically involved more capital expenditure than R&D and are not always separately accounted for as R&D. Canada also has a relatively small ICT manufacturing sector in comparison to high R&D nations such as Sweden, Finland and Germany. Figure 16, based on the OECD Structural Analysis (STAN) database, illustrates the industry sector composition of the Canadian economy and the economies of the United States, Sweden, Germany, Finland and Australia.

Figure 16 **Composition/Comparison of Canadian, U.S., Swedish, German, Finnish and Australian Economies (Share of GDP), 2005**



Source: OECD STAN Database for Structural Analysis, November 2010.

> *Low business R&D can in part be explained by the relative size in Canada of industries that globally tend to invest less in R&D.*

6.1.4.3 Changes in Research and Development Performed by Industries in Canada

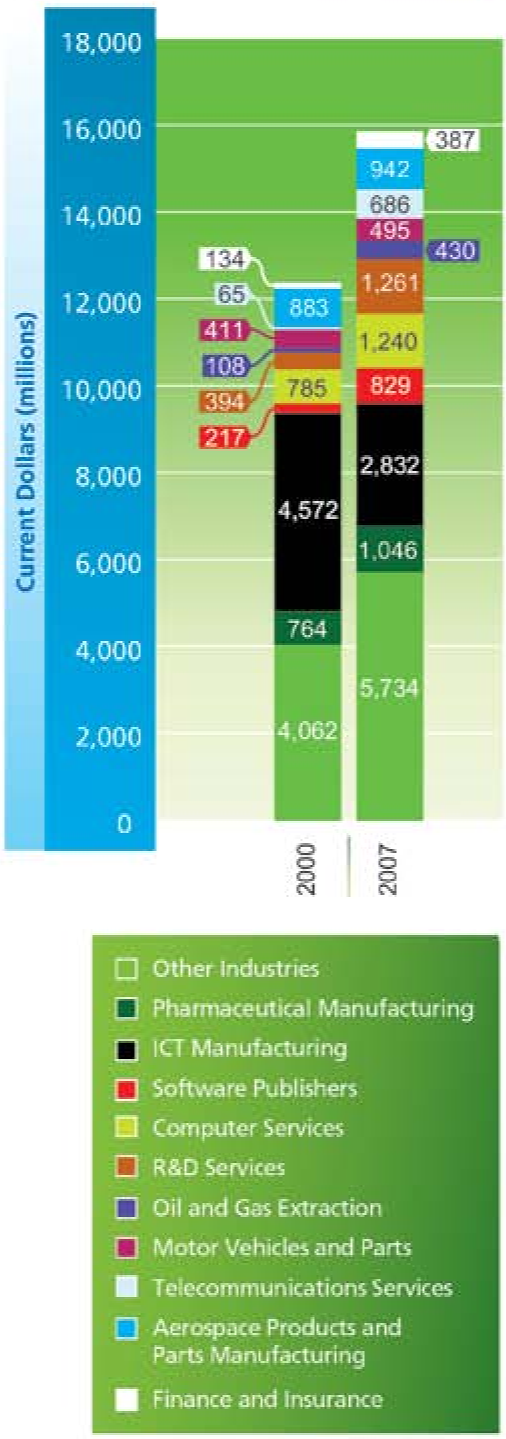
In 2007, R&D in Canada was performed primarily by the following industries, as shown in Figure 17: ICT manufacturing (18 percent); R&D services (8 percent); computer services (8 percent); pharmaceutical manufacturing (7 percent); aerospace products and parts manufacturing (6 percent); software (5 percent); telecommunication services (4 percent); motor vehicle and parts (3 percent); oil and gas extraction (3 percent) and finance and insurance (2 percent). The remaining 36 percent was spread over other industries.

There has been significant change in industries performing R&D in Canada. Declining ICT manufacturing R&D has been in part offset by growing R&D in computer services, software and telecom services. At the same time, the R&D service industry (comprising firms whose primary activity in Canada is undertaking research activities) continues to grow in importance in the Canadian R&D landscape. R&D expenditures have also increased notably for Canada's banking and financial sector and for the oil and gas industries.

6.1.4.4 International Comparison of Research and Development Intensity by Industry Sector

Benchmarking R&D expenditures by industry on an international basis poses challenges. Comparable international data are less current and there are differences in the way statistics are collected. Canada assigns R&D figures according to the *main business activity* of the company being surveyed. Other countries assign R&D figures according to the type of research being conducted (*product field*). Product field countries include Finland, Sweden, France and the U.K. This difference in methodology has the effect of some similar R&D activities being assigned to different industries in different countries. For example, a firm that designed radio broadcast antennas but outsourced all manufacturing to a firm in another country would be classified as a telecommunications equipment firm according to the product field data collection method, but would be classified as an R&D services firm according to the main

Figure 17 Business Expenditure on R&D Contribution by Industry, 2000 and 2007



Sources: Statistics Canada tabulations for STIC; Statistics Canada, CANSIM Table 358-0024.

Note: STIC analysis is based on disaggregated data at the three- and four-digit NAICS level as of July 2010. Data revisions for a number of years were released on December 8, 2010, and are not reflected in the analysis presented.

A producer examining a pea crop.

Industry-led Innovation: Saskatchewan Pulse Growers

Peas, lentils and beans — pulse crops — are staple foods in fast growing emerging markets, and are also being used in non-food products such as fuel, lubricants and pharmaceuticals. These crops flourish best in the dry, fertile soil of the Canadian prairies. Canada is now one of the world's leading producers and exporters of peas and lentils.

Rapid expansion of pulse crop acreage in Canada combined with more intense rotations requires that the crops have broad adaptation to various conditions. Expansion increases the risk of leaf and soil diseases, which threaten the sustainability of crop production.

At the same time, growers must maintain high yield, a diverse product range and superior quality. Innovation in this industry can come from research into genetic improvement, disease resistance and nutritional and therapeutic benefits, as well as management and agronomic practices for quality control and sustainability.

Representing over 18,000 pulse crop producers in Saskatchewan, the Saskatchewan Pulse Growers' expenditures in R&D as a percentage of the total of their investments have increased to 60 percent in the 2009–10 fiscal year. These investments in innovation have ensured the competitiveness of Saskatchewan producers and profitability of the pulse industry as a whole.

The biggest successes have been the Pulse Breeding Program and the Variety Release Program, resulting from collaboration between Saskatchewan Pulse Growers and the Crop Development Centre at the University of Saskatchewan. Under these programs, the Saskatchewan Pulse Growers provide access to new pulse varieties developed by the Crop Development Centre by offering breeder seed without royalties to select-status seed growers in Saskatchewan and Alberta. In exchange for a financial commitment to research in Saskatchewan, the Saskatchewan Pulse Growers received the distribution rights to all pulse varieties developed by the Crop Development Centre. As a result, pulse producers in Saskatchewan and Alberta have a quick and steady supply of new, improved pulse crop varieties.

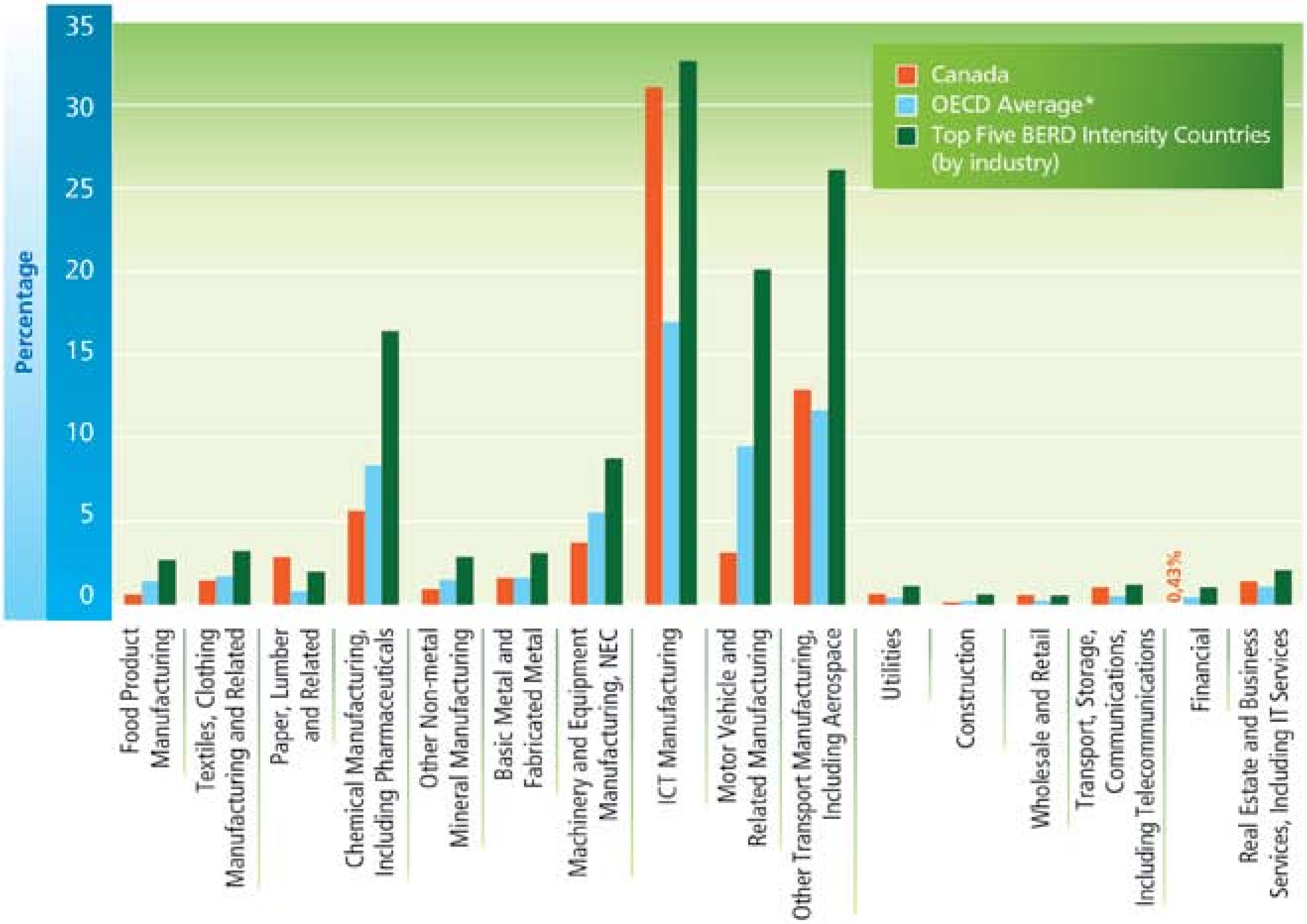
activity. This difference in methodologies should be taken into consideration for international comparisons of private sector R&D activities.

Figure 18 shows Canada's business R&D intensity as compared to the average business R&D intensity of a selected group of OECD countries as well as the average of the top five BERD-intensive counterparts by industry. By international standards, Canada tends to have a lower business R&D investment as a share of value-added in a number of industries. These include industries that employ large numbers of people, such as construction and food product manufacturing. Canada's R&D intensity is also lower in some industries that globally tend to have high R&D ratios, such as motor vehicle manufacturing and chemical manufacturing.

Business R&D as a share of value-added was higher in Canada versus comparators in industries such as ICT manufacturing; wholesale and retail;[33] transportation,

[33] U.S. ANBERD figures show a rapid decline in U.S. BERD in wholesale/retail in the mid- to late 2000s, when there was a reclassification of much of the R&D formerly classified as 'wholesale' into the pharmaceutical and ICT sectors in the United States. [OECD (2009), *Research and Development Expenditure in Industry: ANBERD 1990–2007*.] Similar reclassification has not been done in Canada, but recent data from Statistics Canada suggest that this may similarly affect Canada's wholesaling R&D intensity (Statistics Canada, *Science Statistics: Industrial Research and Development 2005–2009*, Catalogue no. 88-001, July 2009, p.12). In other words, much of the 'wholesaling' R&D figure is likely attributable to firms from highly R&D-intensive industries (such as pharmaceutical or ICT) whose principal activity in Canada happens to be wholesaling.

Figure 18 Business R&D Intensity by Industry, 2005 (BERD/Value-Added)



*Australia, Austria, Belgium (PF), Canada, Czech Rep., Denmark, Finland (PF), France (PF), Germany, Greece, Hungary, Ireland, Italy, Japan, Netherlands, Norway, Poland, South Korea, Spain, Sweden (PF), U.K. (PF), U.S.

Sources: OECD ANBERD, STAN and OFFBERD databases; KLEMS database and STIC estimates.

storage and communications, including telecommunications. In the case of forestry, paper and lumber industries (that have a low level of R&D investment globally), Canadian investment was over double the average investment for these industries. It is important to note that, in absolute terms, this may represent very small differences.

6.1.4.5 Research and Development by Sector and Firm Size

The measure of output used to scale R&D activities between firms of different sizes in the following analysis is revenues (or net sales). This metric is an indicator of how intensively firms pursue R&D activities relative to other uses. Most R&D in Canada is performed by large firms. However, for some industry sectors in Canada, SMEs (defined here as firms with revenues of $50 million or less) made important contributions to total R&D expenditures.

> *For the Canadian economy as a whole, a little more than one quarter (27 percent) of business R&D was performed by firms with less than $50 million in revenues, with around 9 percent of total expenditures undertaken by firms reporting less than $1 million in revenues.*

Figure 19 shows the contribution to total R&D in a given sector that was made by small (under $1 million in revenues), medium ($1 million – $50 million in revenues) and large (over $50 million in revenues) firms. For example, around 75 percent of total business R&D in manufacturing was performed by large firms, with small firms contributing less than 5 percent and the remainder contributed by medium-sized firms.

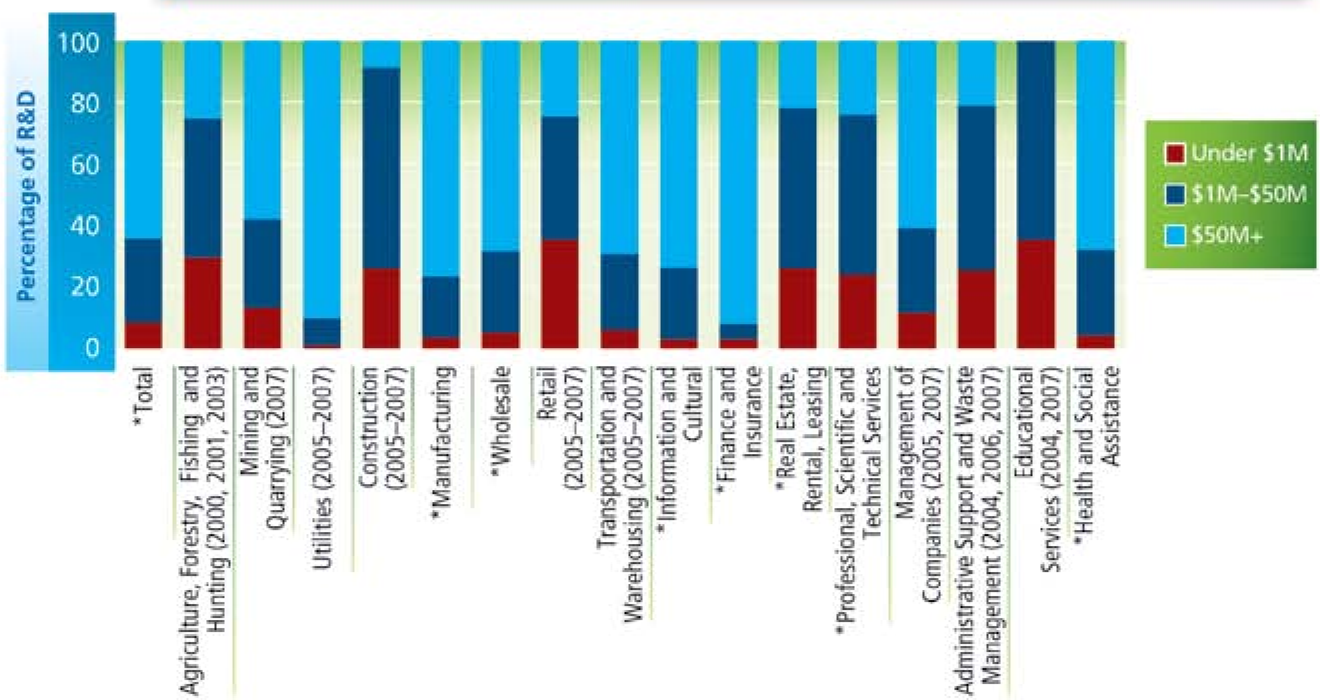
Sectors for which large firms ($50 million and more in revenues) were particularly important to total R&D expenditures included manufacturing, utilities, and the finance and insurance sectors. In the retail trade, construction, real estate and the professional, scientific and technical services sectors, small and medium enterprises (under $50 million in revenues) accounted for the majority of business R&D expenditures.

6.1.5 Innovation through Investments in Machinery and Equipment

Investment in advanced technology is one channel through which knowledge is transferred between firms; that is, it is a channel through which technology and practices diffuse. This process, sometimes called 'embodied innovation,' contributes to productivity gains, especially in the case of the adoption of information and communications technologies (ICT). Adoption of new technologies in supply chains and in production also gives rise to process innovation.

The relationship between ICT and productivity has been widely studied. Findings suggest that the effect of ICT adoption on productivity has varied between countries and industries.[34] While investments in ICT often result in productivity and competitiveness gains for adopters, adoption of ICT itself frequently requires

Figure 19 Distribution of Business Performance of R&D by Revenue Size of Firm



* Average 2004–2007
Source: Statistics Canada tabulations for STIC, November 2010.

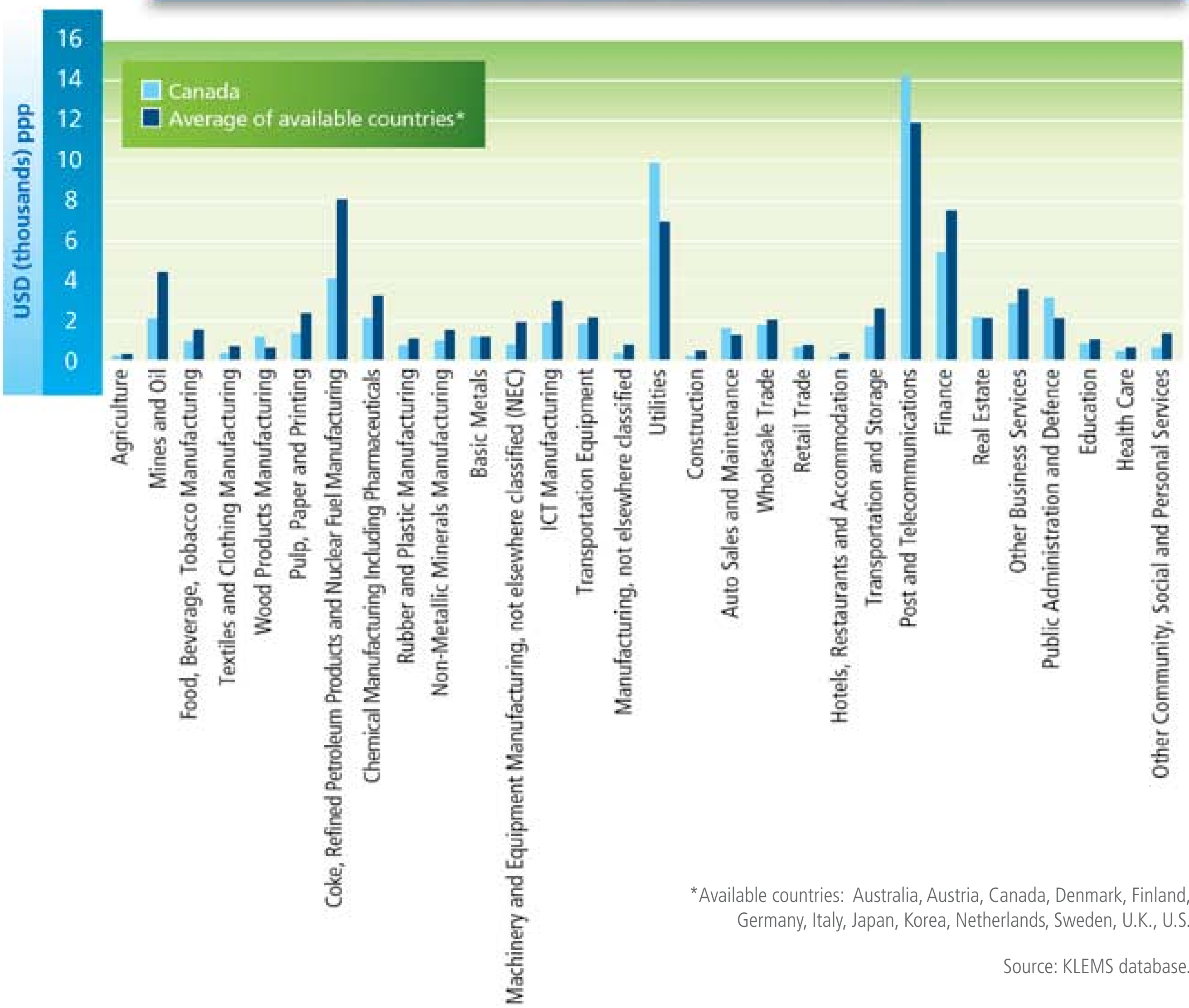
[34] OECD (2004), D. Pilat., *The ICT Productivity Paradox*, *OECD Economic Studies, No. 38*.

organizational change and demands a workforce with the skills to make use of the new technologies.[35] Furthermore, as well as being a catalyst of innovation, ICT adoption may have the strongest productivity benefits for firms that are innovative to begin with.[36]

Canadian industry seems to invest less in ICT equipment per worker than other countries. Figure 20 shows that there are some areas of higher relative Canadian ICT investment. Canada's wood products manufacturing industry, for example, seems to be more highly ICT-intensive than in many other countries, reflecting a fairly pronounced rise in ICT investments from 2000–04 (the time of the figure). Canada's post and telecommunications industries, which include the telecommunications service industries and which generally have a fairly high level of ICT investment, are also more ICT-capital intensive than average, as are Canada's utility and certain sales industries.

The *Survey of Innovation and Business Strategy* indicates that 83 percent of enterprises that adopted advanced technology purchased off-the-shelf advanced technology, 10 percent leased off-the-shelf advanced technology, and 13 percent licensed advanced technology. Many of these enterprises also customized, significantly improved, or developed their own (or in conjunction with others) advanced technologies.

Figure 20 ICT Capital Intensity (Investment per Worker, 2004)



*Available countries: Australia, Austria, Canada, Denmark, Finland, Germany, Italy, Japan, Korea, Netherlands, Sweden, U.K., U.S.

Source: KLEMS database.

[35] M. Draca, R. Sadun and J. Van Reenend, *Productivity and ICT: A Review of the Evidence*, Centre for Economic Performance Discussion Paper no. 749, London School of Economics and Political Science, August 2006; OECD (2004), D. Pilat., *The ICT Productivity Paradox*, *OECD Economic Studies, No. 38,* p. 50.

[36] OECD (2004), D. Pilat., *The ICT Productivity Paradox*, *OECD Economic Studies, No. 38,* p. 53.

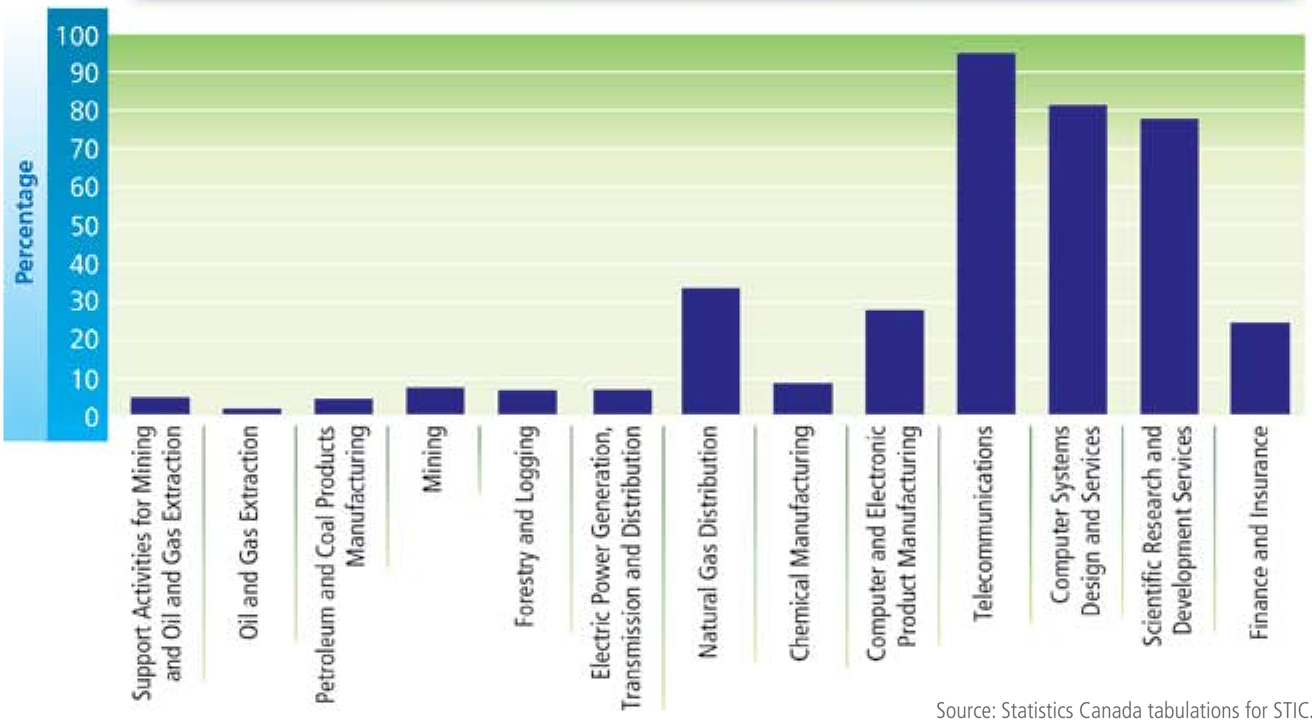
> *Canadian industry seems to invest less in ICT equipment per worker than other countries.*

The data presented in Figure 21 show industry adoption rates of 'advanced technology,' defined here as information technologies (IT), communications equipment and measuring and control instrumentation. The first two components, IT (computers and software) and communications equipment, comprise what is generally referred to as ICT capital.[37]

There are inherent differences in the rates of adoption of advanced technology between industries; some industries require greater baseline investments in technology to compete. Within the Canadian data, pronounced differences can be seen between industries in terms of the shares of machinery and equipment capital stock that are composed of advanced technology assets. The types of advanced technology adopted also vary considerably by industry (Figure 22). For example, Statistics Canada's recent *Survey of Advanced Technology* found that over 53 percent of semiconductor and electronic components manufacturing business units reported adopting some form of inspection and verification technology, compared to only 23 percent of manufacturing business units overall.

While IT tends to be the most important component of advanced technology adopted by industry, other forms of advanced technology investment are important to specific sectors. For example, while IT is over 90 percent of advanced technology capital stock in some financial sector industries, it is less than 40 percent of the total advanced technology capital stock in the R&D services industry. Research that has looked at the impact of IT equipment, software and communications equipment adoption on productivity has found that all three can play an important role in improving

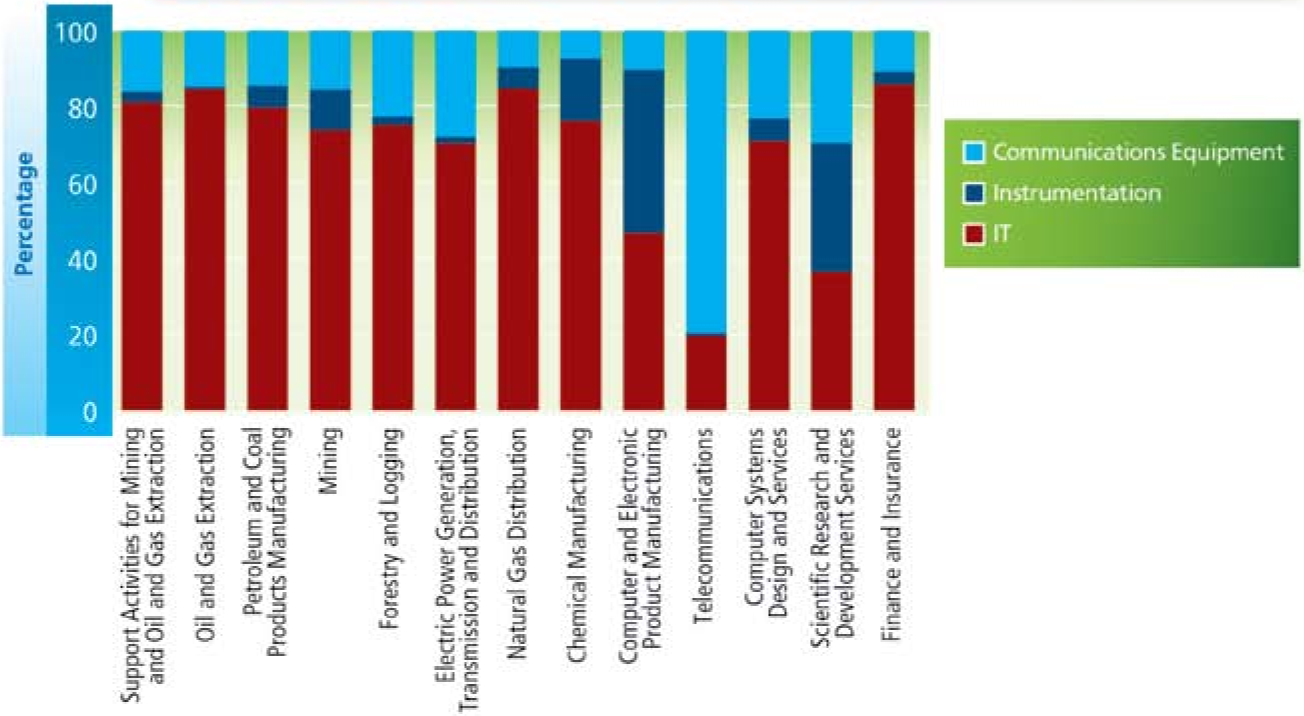
Figure 21 **Share of Advanced Technology Capital Stock in Total M&E Capital Stock, Average 2004–2008**



Source: Statistics Canada tabulations for STIC.

[37] While data on instruments are not included in the international comparison of ICT adoption rates in Figure 20, instruments are included in the definition of 'advanced technology' capital used for the Canadian inter-industry comparison. Modern monitoring and control instruments often embody significant advanced technology; indeed, the instruments manufacturing industry is included in the definition of the ICT manufacturing sector. Ultimately, monitoring and control involve the collection, transmission, and use of information. Data on investments in instruments were available for Canada. If data on instruments, as well as other ICT investments, were available for other countries, these data would have been used to make international comparisons.

Figure 22 Advanced Technology Capital Stock by Asset Type (Average 2004–08)



Source: Statistics Canada tabulations for STIC.

productivity.[38] Recent Canadian policy measures to promote the adoption of advanced technology and spur productivity growth have generally focused on IT (i.e., computers and software) and not other components of advanced technology capital noted here such as communications equipment and instrumentation.

6.1.6 Innovation and the Rise of Service Industries

In 2008, service industries accounted for 61.5 percent of real private sector GDP and 72.6 percent of private sector employment in the Canadian economy. The rise of service industries is a long-term trend, which is experienced

A Step Ahead in Technology — A Step Ahead of Financial Crime

Verafin Inc.

Verafin Inc. of St. John's, Newfoundland, was founded in 2003 by a team of electrical engineers with backgrounds in artificial intelligence and pattern recognition. Its software solution helps banks and credit unions identify fraud, money laundering and other suspicious activity on its computer networks. Today, Verafin has over 90 employees and is one of North America's leading providers of compliance, anti-money laundering and fraud detection software with more than 650 customers. Verafin was able to transfer ICT expertise and technology from a context of engineering for harsh environments to the financial industry.

38 It should be noted that this report analyzed the impact of IT and communications equipment adoption on productivity but did not specifically look at adoption of instrumentation, which is included in this State of the Nation report as a component of 'advanced technology capital.' A. Sharpe, *The Relationship between ICT Investment and Productivity in the Canadian Economy: A Review of the Evidence*, Centre for the Study of Living Standards, 2006.

throughout all advanced industrial economies. Services cover a wide and complex variety of transactions on products that are generally intangible in nature.

6.1.6.1 Innovation through Utilization of Information Technology Services

Higher rates of investment in ICT equipment have been identified as an activity that improves business productivity.[39] Some Canadian industries that under-invest in ICT equipment by international standards seem to make more intensive use of information technology (IT) services; for example, Canada's mining and quarrying sector and financial sectors as shown in Figure 23a and b. For other industry sectors, such as manufacturing and construction, the intensity of IT services use is low by international standards.

> *Some Canadian industries that under-invest in ICT equipment by international standards seem to make more intensive use of information technology (IT) services; for example, Canada's mining and quarrying sector and financial sectors.*

While the link between investment in ICT equipment and productivity has been studied in depth, less attention has been paid in the productivity literature to purchase of IT services, or IT outsourcing. Some research (using a methodology similar to the one used here)[40] has suggested a link between IT outsourcing and productivity at the industry level. The research has also suggested complementarities between IT outsourcing and investments in ICT capital.[41] Technological and business model developments such as remote hosting of data and websites, software as a service and cloud

Figure 23a **IT Services Intensity, Mining and Quarrying Industry (mid-2000s)**

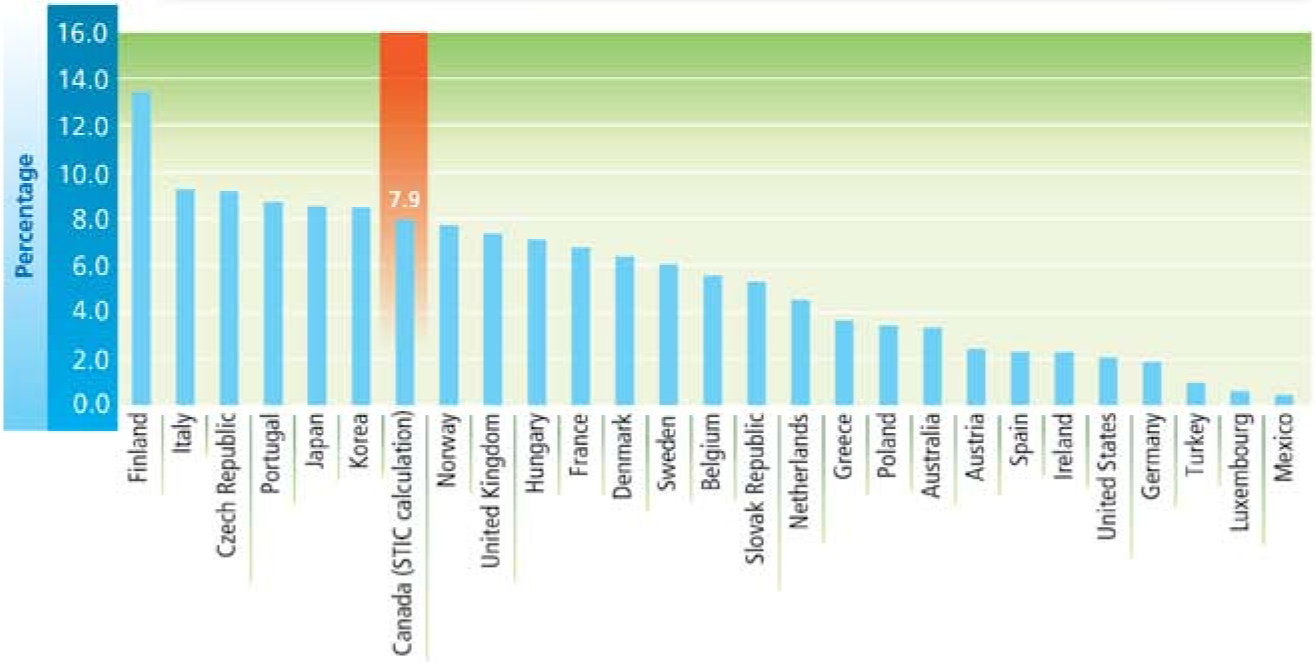
Sources: OECD STAN IO Table database; STIC calculation based on 2005 W-Level Commodity IO Table, Statistics Canada.

39 Tiff Macklem, *Canada's Competitive Imperative: Investing in Productivity Gains,* Speech, Ottawa, February 2011.

40 To estimate international variation in IT outsourcing, this report uses OECD Input-Output data (STAN IO database) and calculates the ratio of IT services inputs (ISIC 72) as a ratio of total inputs to production for various industries. During these calculations, STIC became aware of some discrepancies between the STAN data and the IO data from Statistics Canada, which was found to be attributable to the use of the highly aggregated L-level tables to do the ISIC-NAICS concordance of industries. Consequently, STIC has replaced the Canadian figures that would be obtained from using STAN data with data based on the W-Level rectangular IO tables from Statistics Canada.

41 Kunsoo Han and Robert J. Kauffman, *Does IT Outsourcing Pay Off? Evidence from Industry-Level Data*, 2005.

Figure 23b **IT Services Intensity, Finance and Insurance (mid-2000s)**



Sources: OECD STAN IO Table database; STIC calculation based on 2005 W-Level Commodity IO Table, Statistics Canada.

computing may contribute to an increasingly blurry line between what constitutes a purchased IT service and what constitutes an investment in capital. Research on productivity and the interplay between IT services outsourcing and ICT capital investments, such as whether or not these are complements or substitutes for each other, could further our understanding of this area.

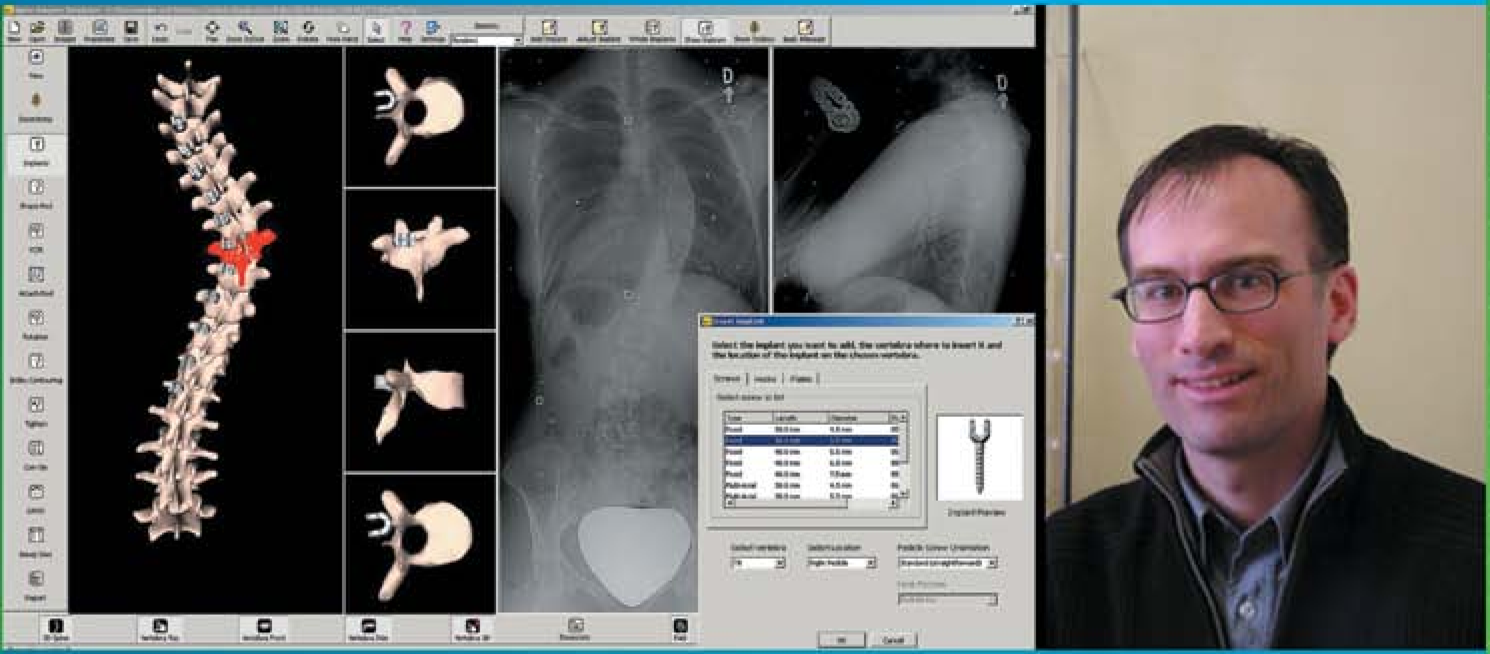
6.1.6.2 Technology Intensive Trade Flows (services and goods)

With the rise of service industries, one would expect a growing trade in commercial services between countries. International transactions in commercial services are compiled as exports (or receipts, i.e., revenue derived from services sold abroad) and imports (or payments, i.e., expenses for services received from abroad), and include the following types of services:

- communications services;
- construction services;
- insurance services;
- other financial services;
- computer and information services;
- royalties and licence fees;
- management services;
- research and development services;
- architectural, engineering and other technical services;
- other miscellaneous services to business; and
- audiovisual services.

Other broad categories of services transaction, in addition to commercial services, are travel, transportation and government services.

In order to gauge the most technology intensive aspects of commercial services trade, Figure 24 combines transactions for the computer and information services; royalties and licence fees; research and development services; and architectural, engineering and other technical services from 1990 to the third quarter of 2010. While many other aspects of services trade may involve research and development activities, these four categories[42] were chosen because they reflect explicit payments or receipts for technology transfers and the cross-border trade in research and development intensive activities.



Dr. Carl-Éric Aubin and his teams of engineers and researchers are designing the next-generation technologies for advanced treatment of young patients with scoliosis.

Engineering the Spine

The École Polytechnique engineers and the researchers of Sainte-Justine University Hospital are working together to develop next-generation technologies for the treatment of spinal pathologies. Different simulators make it possible to design and optimize spinal braces and surgical instrumentation that are personalized and optimized. An integrated "operating room of the future" combining imaging applications, navigation technologies and a surgical simulator will assist the surgeons during the operation. A trans-disciplinary team of engineers, orthopaedists and biologists are developing fusionless implants that are minimally invasive and intelligent for the advanced treatment of young patients with scoliosis.

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[42] Computer and Information Services: According to Statistics Canada, computer services cover the design, engineering and management of computer systems (exclusive of the value of hardware). Also covered are the development and production of original software (including operating software). Computer processing services as well as equipment maintenance and repair are covered here. This category also includes consulting and training related to the provision of computer services. Information services cover online information retrieval services, including database services (the development of subject matter through to storage and dissemination) and computer-assisted document searches and retrievals and news agency services (such as syndicated reporting services to the media).

Royalties and Licence Fees: This is defined as the use of intellectual property rights, for the following sub-categories:

- Patents and industrial design: royalty or licence fees for the use of patents, industrial designs, industrial know-how or manufacturing rights, as well as payments for non-patented industrial processes.
- Trademarks: royalties or fees for the use of trademarks, that is, words, symbols, designs or combinations thereof that distinguish the holder's products or services from those of another provider.
- Franchises: contractual privileges granted by an individual or corporation to another, permitting the sale of a product or service in a specified area or manner.
- Copyrights and related rights: royalty or licence fees for the use of original artistic, literary, dramatic or musical works; for example, to stage productions or performances, or to make recordings or films.
- Software: royalties for software and other computer-related items, including fees for the right to replicate, distribute or otherwise use software, whether custom or pre-packaged.

Research and Development Services: This includes charges related to systematic investigation through experiment or analysis to achieve a scientific or commercial advance for, or through, the creation of new or significantly improved products or processes. Research and development extends to the social sciences and humanities but excludes market research and technical studies.

Architectural, Engineering and Other Technical Services: This includes a range of architectural and engineering activities together with a diverse group of scientific and technical services and specific services related to mineral extraction, processing and the environment.

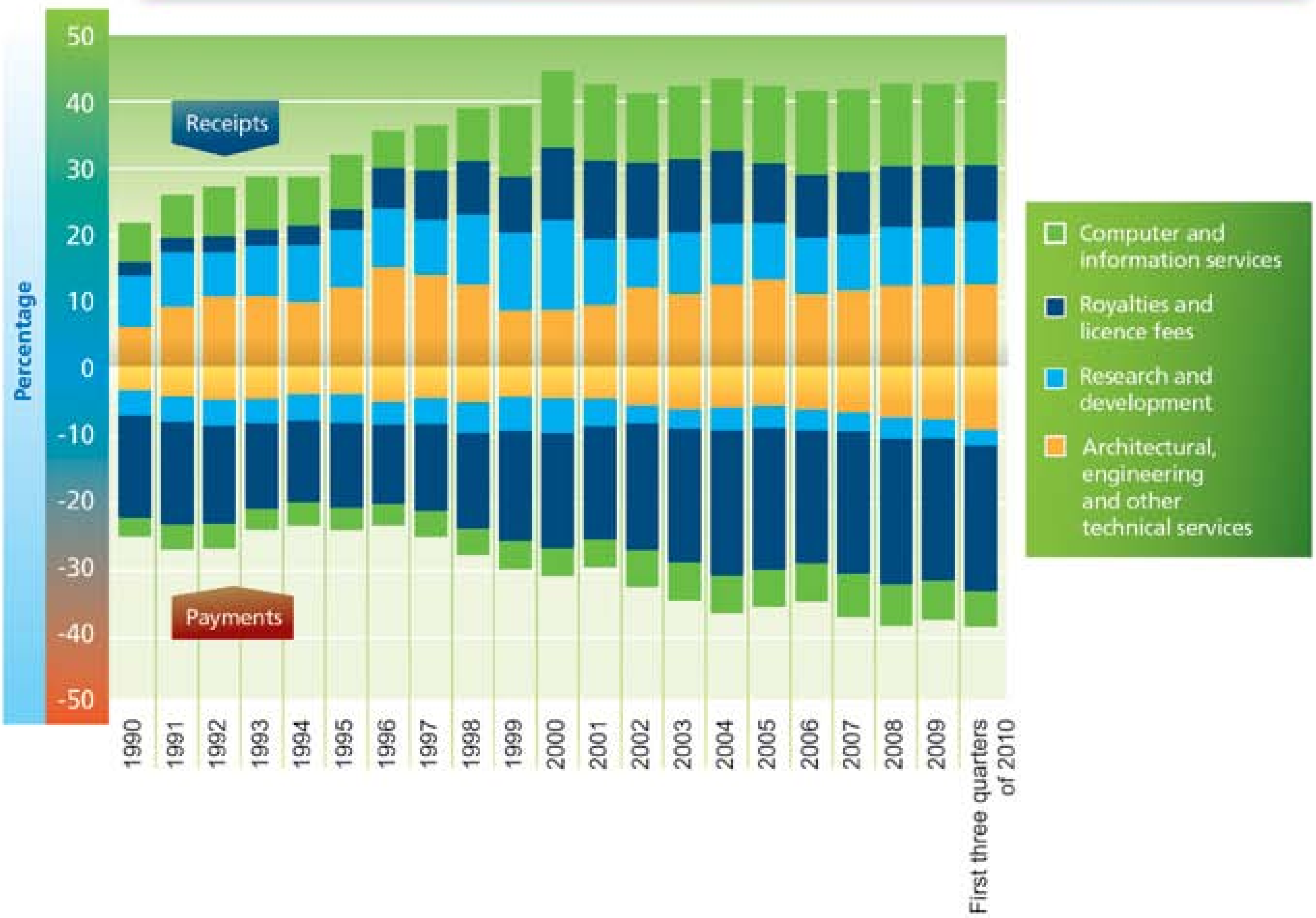
Figure 24 highlights that, over time, technology intensive services transactions (both receipts and payments) are a growing share of total commercial services transactions. This growth of the technology intensive share is substantial given that for the past two decades total receipts from commercial services transactions grew from $9 billion in 1990 to just under $40 billion in 2009 whilst payments grew from $13 billion to $41 billion over the same period. That is, technology intensive commercial services — both exports and imports — are a growing share of a rapidly growing pie. In spite of the recent recession, which reduced total commercial services trade by 4.8 percent for receipts and 2.7 percent for payments, the share of technology intensive service transactions largely sustained their contributions.

The largest component of technology intensive commercial service exports was in computer and information services (at 12.7 percent) followed closely by architecture, engineering and other technical services (at 12.5 percent) in the third quarter of 2010. Exports of R&D services in the third quarter of 2010 were 9.4 percent and 8.4 percent for royalties and licence fees. The largest category of imports of technology intensive commercial services was royalties and licence fees (21.9 percent) followed by architectural, engineering, and other technical services (9.5 percent) by the third quarter of 2010.

Figure 24 does not separate out transactions within multinational enterprises (i.e., intra-firm between parent companies and their affiliates) and arm's-length service transactions. Data indicate that the value of intra-firm transfers within multinational enterprises accounts for the majority of these payments for services.

The four categories of technology intensive service transactions (computer and information services; royalties and licence fees; research and development services; and architectural, engineering and other technical services) — both exports and imports — have been added to the *State of the Nation 2010* report as

Figure 24 Technology Intensive Services Trade — Receipts of and Payments for — as a Percentage of Total Commercial Services



Source: Compilation by STIC Secretariat based on data from Statistics Canada.

its newest international measure for traded technological intensive services. It captures both the ability and desire of Canadian enterprises to export their locally produced technology intensive service activities abroad, but also Canadian enterprises' desire to benefit from the technology intensive service activities produced abroad. Given the increasing role of services in advanced economies, the growing complementarities between goods and services, and the increasing internationalization of Canadian corporate strategy, it is an innovation related measure well worth monitoring in the future.

In addition to technology intensive services trade, imports and exports of high-technology products also warrant monitoring in the future. High-technology products are identified as products, or groups of products, that have a high R&D expenditure in relation to their sales. Using high-technology product definitions in combination with high-technology industry definitions is beneficial for many reasons. It allows countries to determine the true proportion of high-technology products in their economy and identify whether such high-technology products originate in high-, medium- or low-technology industries. It also allows benchmarking of these results with other countries, providing a more detailed analysis of trade and competitiveness.

6.1.7 Financing Innovation through Venture Capital

Venture capital (VC) firms play an important role in the financing of innovation. New technology firms depend on VC to fund R&D and fund growth since they are often perceived as too high-risk for traditional institutional funding.[43] A study released in 2009 based on 2004 data shows that, in Canada, equity financing accounted for 44.3 percent of the total financing received by innovative[44] SMEs compared to 8.7 percent for non-innovative SMEs.[45] Ninety percent of the total equity financing received by innovative SMEs was provided by angel investors and VC firms compared to only 42.3 percent for non-innovative SMEs.[46]

The Impact of the Economic Downturn

The economic downturn has been the principal story in the VC industry since the *State of the Nation 2008* report. Data from 2008 and 2009 show a dramatic decline in absolute financing along with declines in the number of firms financed and the amount of investment per company. Total venture capital investment in 2009 was the lowest since 1996, falling to $1.035 billion, or about half of the value reached in 2007.[47] Compared to other countries in the OECD, Canada ranked seventh in 2008 (the most recent ranking available) in terms of absolute VC investment.[48] The largest amount of VC investment occurred in the U.S., which accounted for almost half of the OECD total.[49] That said, VC investment in the U.S. has experienced a decline similar to that suffered by Canada (Figure 25). In European countries, the investment volume also dramatically declined, falling between 20 percent and 83 percent in 2009 compared to the five-year average.[50] In terms of total deals and average deal size, Canada ranked second in the world in 2009 for the number of deals, behind only the U.S., yet ranked 21st in average deal size.[51]

While global VC investment declined during the recession, Canada's VC industry was hit particularly hard. In 2008, Canada ranked 17th in the OECD in terms of VC as a percentage of GDP.[52] This was a decline from 2003 and 2005 when Canada ranked in the top 10.[53] Canada's share of VC to GDP also fell from

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

44 Innovative firms are defined as those that spend more than 20 percent of their total investment expenditures on R&D.

45, 46 Shunji Wang, "Financing Innovative Small and Medium-Sized Enterprises in Canada Working Paper," *Industry Canada SME Financing Data Initiative*, 2009, p. 24.

47 CVCA and Thomson Reuters, *Canada's Venture Capital Industry in 2009,* 2010. (**http://www.cvca.ca/files/Downloads/Final_English_Q4_2009_VC_Data_Deck.pdf**)

48, 49 OECD (2009), *Science, Technology and Industry Scoreboard 2009*, p. 23, doi: **http://dx.doi.org/10.1787/741702681416**.

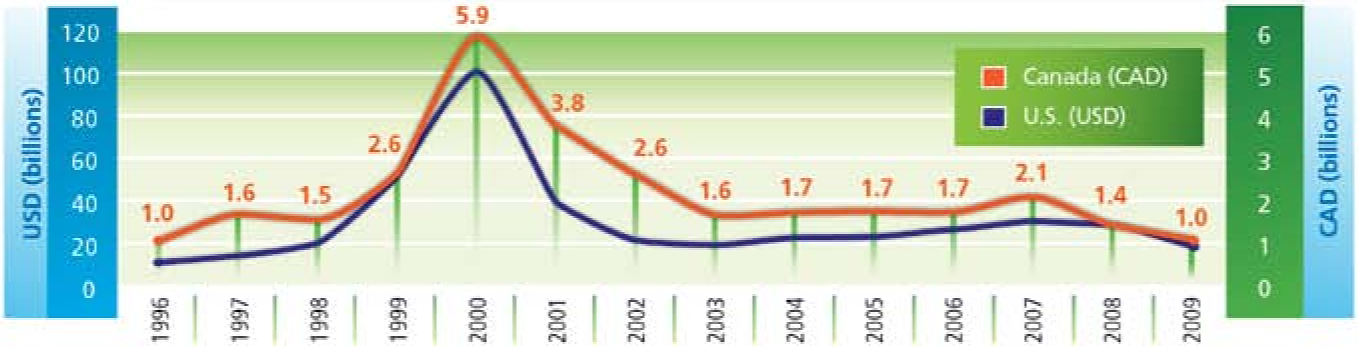
50 Deutsche Bank Research, *Venture Capital Adds Economic Spice,* 2010. (**http://www.dbresearch.com/PROD/DBR_INTERNET_EN-PROD/PROD0000000000262487.PDF**)

51 Thomson Financial, *Canadian Venture Capital Overview,* 2010. (**http://www.canadavc.com/files/public/UofT,%20Jan%202010.pdf**)

52 OECD (2010), *Science, Technology and Industry Outlook 2010*, p. 110, doi: **http://dx.doi.org/10.1787/888932333044**.

53 OECD (2007), *Science, Technology and Industry Scoreboard 2007*, p. 39, doi: **http://dx.doi.org/10.1787/117030452887**. It should be noted that there is inconsistency with the country definitions of VC and some countries have remarked that Canada includes types of funding that are not to be considered "venture capital."

Figure 25 Trend in VC Investment (U.S. and Canada)



Sources: Canada — Thomson Reuters *VC Reporter* 2010;
United States — PricewaterhouseCoopers/National Venture Capital Association MoneyTree based on data from Thomson Reuters.

0.12 percent in 2007 to 0.08 percent in 2008.[54] In contrast, 2008 world VC investments were the highest since 2000, and the major global decline did not occur until 2009.[55]

Looking forward, Deloitte's *2010 Global Venture Capital Survey* reported that half of Canadian venture capitalists expect the money available for investments over the next five years to moderately increase (1 percent to 30 percent) while the other half anticipate a decline or no change from the present.[56] This compares favourably against the more negative outlook of respondents from France, Israel, the U.K. and the U.S.

Exit Values and Rates of Return

Exit values and rates of return are important measures of the wealth generated through VC and they are key factors in the attraction of VC investment. An exit value is the price received for the liquidation of a stake in a business, such as through mergers and acquisitions or initial public offerings. Due to inconsistencies in the national definitions of venture capital and the lack of compiled data, it is difficult to compare other countries' exit performance with Canada. The number of VC-backed mergers and acquisitions and initial public offering exits fell across Canada, the U.S. and Europe during the recession. In Canada, the 21 mergers and acquisitions (M&A) exits in 2008 were the lowest since 2003.[57] The number of exits through initial public offerings (IPO) declined even more dramatically, with only one in both 2008 and 2009 (compared to 12 in 2007).[58] In terms of values, the average M&A transaction sizes in Canada and the U.S. were relatively high in 2009 compared to previous years, reaching $120 million in Canada and US$142.9 million in the U.S.[59] Conversely, Canada's average IPO offering size of $29 million in 2009 was relatively low,[60] and it paled in comparison to the average offering size in the U.S. in 2009, which was US$136.8 million.[61]

Rates of return of Canadian and European VC funds have been historically much lower than those of U.S. VC funds.[62, 63] It may be argued that the traditionally

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[54] OECD (2010), *Science, Technology and Industry Outlook 2010*, p. 110, doi: **http://dx.doi.org/10.1787/888932333044**.

[55] Thomson Reuters, *State of the Market: The Venture Capital and Private Equity Industries in the World Today* (presentation), 2009. (**http://www.canadavc.com/files/public/Thomson%20Reuters,%20State%20of%20the%20Market,%20The%20VC%20&%20PE%20Industries%20in%20the%20World%20Today,%2010-09.pdf**)

[56] Deloitte and NVCA, *Results from the 2010 Global Venture Capital Survey,* 2010.

[57, 58, 59, 60] CVCA and Thomson Reuters, *Canada's Venture Capital Industry in 2009*, 2010. (**http://www.cvca.ca/files/Downloads/Final_English_Q4_2009_VC_Data_Deck.pdf**)

[61] NVCA and Thomson Reuters, *News Release*, January 2010. (**www.nvca.org/index.php?option=com_docman&task=doc_download&gid=534&Itemid=93**)

[62] Reuven Brenner, *Venture Capital in Canada: Lessons for Building (or Restoring) National Wealth, Journal of Applied Corporate Finance*, Vol. 22:1, 2010, p. 90.

[63] Ulrich Hege et al., *Venture Capital Performance: The Disparity Between Europe and the United States*, 2008. (**http://www.eu-financial-system.org/fileadmin/content/Dokumente_Events/Second_Symposium/11_Hege_Palomino_Scwienbacher_VC_Performance_the_Disparity_between_US_and_Europe.pdf**)

higher rates of return in the U.S. are a result of greater financing for growth, which can lead to more profitable exits. The expansion stage has typically received a greater share of total VC investment in the U.S. than in Canada, although recent data suggest the share of expansion financing in the U.S. is declining to similar levels found in Canada. In 2003, expansion stage financing accounted for about 47 percent of total financing in Canada[64] and about 71 percent of total financing in the U.S.[65] This can be compared to 2009 when expansion stage financing accounted for about half of total financing in both countries.[66, 67]

The lower rates of return in Canada may also be due to the historical significance of retail funds (primarily labour-sponsored funds), which accounted for almost a quarter of all VC investment in 2009.[68] Compared to private independent funds, which usually receive capital from institutional investors, labour-sponsored funds receive capital from individual investors who collect tax credits on their contributions.[69] The performance of labour-sponsored funds has been disappointing, and some argue that this poor performance results from the lack of oversight provided by retail fund managers, who are responsible for almost three times as many companies as private fund managers.[70]

Collaboration in Action

Nexterra Systems Corp.

Nexterra Systems Corp. is a small enterprise based in Vancouver, British Columbia (B.C.). It develops and manufactures biomass gasification systems that use renewable fuels such as wood waste. Nexterra's customers include the United States Department of Energy's Oak Ridge National Labs, Johnson Controls Inc. and Kruger Products. In 2010, the company was named as one of Canada's 50 fastest growing technology companies by Deloitte. Nexterra has grown with the help of several government, university and industry partners. Nexterra's technology was first commercialized with financial support from the National Research Council's Industrial Research Assistance Program, Natural Resources Canada and Sustainable Development Technology Canada. Nexterra also received funding from the Innovative Clean Energy Fund, and the BC Bioenergy Network to support new applications of its technology. Nexterra is collaborating with GE Jenbacher, FPInnovations and the University of British Columbia (UBC) to demonstrate a new heat and power application. The UBC's Bioenergy Research and Demonstration Project is a first of its kind biomass fuelled cogeneration (heat and power) system that will provide clean, renewable heat and electricity for the campus, while offering a platform for bioenergy research. In March 2011, Nexterra secured its fifth round of financing with $15 million in equity financing from Tandem Expansion Fund and ARC Financial. The Tandem Expansion Fund itself is a collaborative effort between the Export Development Corporation, the Business Development Bank of Canada and Teralys Capital, a private technology-focused fund of funds. The Tandem Expansion Fund provides late-stage capital for technology entrepreneurs and announced its first closing of $300 million in December 2009.

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64 CVCA, Thomson Reuters and Macdonald & Associates Limited, 2002–2010. (**http://www.cvca.ca/resources/statistics/**)

65 PwC/NVCA MoneyTree based on data from Thomson Reuters, 2010. (**http://www.nvca.org/index.php?option=com_docman&task=doc_download&gid=543**)

66 CVCA, Thomson Reuters and Macdonald & Associates Limited, 2002–2010. (**http://www.cvca.ca/resources/statistics/**)

67 PwC/NVCA MoneyTree based on data from Thomson Reuters, 2010. (**http://www.nvca.org/index.php?option=com_docman&task=doc_download&gid=543**)

68 CVCA and Thomson Reuters, *Canada's Venture Capital Industry in 2009,* 2010. (**http://www.cvca.ca/files/Downloads/Final_English_Q4_2009_VC_Data_Deck.pdf**)

69 Douglas Cumming and Jeffrey MacIntosh, *Comparative Venture Capital Governance: Private versus Labour Sponsored Venture Capital Funds*, *University of Toronto*, July 2003. (**http://www.rotman.utoronto.ca/cmi/news/CummingMacintosh3.pdf**)

70 Reuven Brenner, *Venture Capital in Canada: Lessons for Building (or Restoring) National Wealth*, *Journal of Applied Corporate Finance*, Vol. 22:1, 2010, p. 90.

Significant Foreign Component in Canada's VC Industry

The significance of foreign funds is also a central feature of the Canadian VC industry. Canada, along with China, Sweden, the U.K., France and India, is a major net importer of VC.[71] Foreign investment has accounted for at least 20 percent of total VC investment in Canada since 1999.[72] In 2009, foreign VC accounted for about 30 percent of total VC investment, yet only 16 percent of deals in Canada had foreign participation.[73] In 2009, the average deal size with foreign participation was $5.3 million compared to the $2.3 million of all-domestic deals.[74] On average, foreign investors invested three times that of domestic investors.[75]

Another consistent feature of the Canadian VC industry is the dominance of the IT sector that has received on average almost 50 percent of total VC investment during the past decade.[76] In 2009, 48 percent of all VC in Canada was invested in IT (compared to 45 percent in the U.S.[77]) while 21 percent was invested in life sciences and 10 percent was invested in energy and environmental technologies.[78] The life sciences industry in Canada was particularly affected by the recession with its share of total investment declining 30 percent in 2009 from its level in 2007.[79] The biggest gains belonged to the traditional sectors, primarily consumer and business services, which rose from a 9 percent share in 2007 to a 19 percent share in 2009.[80]

Seizing Opportunities

While 2010 saw the first year-over-year increase in investment levels since 2007, investments remain weak and fundraising is the lowest it has been in 16 years.[81] As a result, it is more imperative than ever to seize opportunities. Although Canada borders the U.S. which has the largest VC industry in the world, it places 8th in the ranking of countries invested in by American funds.[82] In a 2007 survey by Deloitte & Touche, 40 percent of U.S. investors identified Canada as having the least favourable treatment of investors of any country they had dealings with.[83] The survey also noted the extremely low returns on Canadian VC investment. Dealing with regulatory barriers, like the elimination of the reporting requirements under Section 116 of the *Income Tax Act* (as announced in the federal budget 2010), along with improving performance of investments in Canada (such as through the promotion of later-stage investment[84]) may help Canada's position in this ranking improve.

6.1.7.1 Debt Financing of Small and Medium-Sized Enterprises

While venture capital plays an important role in the financing of innovation, over 180,000 small and medium-sized enterprises (SMEs) in Canada received formal debt financing in 2007 (an average of roughly $0.26 million per company) compared to 404 firms that received VC in the same year (an average of $5.1 million per company).[85] About 13 percent of SMEs applied for financing from a lending institution in 2007

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71 Joshua Aizenman and Jake Kendall, *The Internationalization of Venture Capital and Private Equity*, *National Bureau of Economic Research*, Working Paper 14344, September 2008, p. 3.

72 CVCA, *Why Venture Capital is Essential to the Canadian Economy*, 2009, p. 14. (**http://www.cvca.ca/files/Downloads/CVCA_Impact_Study_ENGLISH_March_2009.pdf**)

73 Thomson Reuters, *VC Reporter*, 2010.

74, 75 CVCA and Thomson Reuters, *Canada's Venture Capital Industry in 2009,* 2010. (**http://www.cvca.ca/files/Downloads/Final_English_Q4_2009_VC_Data_Deck.pdf**)

76 CVCA, Thomson Reuters and Macdonald & Associates Limited, 2002–2010. (**http://www.cvca.ca/resources/statistics/**)

77 PwC/NVCA MoneyTree based on data from Thomson Reuters, 2010. (**http://www.nvca.org/index.php?option=com_docman&task=doc_download&gid=543**)

78 CVCA and Thomson Reuters, 2009 *VC Investment Activity by Sector*, 2010. (**http://www.cvca.ca/files/Downloads/2009_VC_Investment_Activity_by_Sector.pdf**)

79, 80 CVCA, Thomson Reuters and Macdonald & Associates Limited, 2002–2010. (**http://www.cvca.ca/resources/statistics/**)

81 CVCA and Thomson Reuters, *Canada's Venture Capital Market in 2010*, 2011. (**http://www.canadavc.com/files/Q42010EnglishOverview.pdf**)

82 Thomson Financial, *Canadian Venture Capital Overview*, 2010. (**http://www.canadavc.com/files/public/UofT,%20Jan%202010.pdf**)

83 Deloitte and Touche, *Global Trends in Venture Capital 2007 Survey*, December 2007, p. 53. (**http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/dtt_tmt_globaltrendsVC_2007.pdf**)

84 One way this may be achieved is through Tandem Expansion, a large new private growth capital fund with significant investments from the Business Development Bank of Canada (BDC), Export Development Canada (EDC) and Teralys Capital.

85 Calculations based on data from the Industry Canada SME Financing Data Initiative (2009) and Thomson Reuters (2010).

with about $51 billion authorized.[86] Chartered banks are the primary source of debt financing and received 68 percent of total financing requests from SMEs in 2007.[87] Along with traditional financing methods, SMEs (especially start-ups) also tend to use informal financing sources such as personal savings (73 percent of start-ups and 54 percent of all SMEs) and loans from friends and family (9 percent of all SMEs).[88]

The Business Development Bank of Canada (BDC) has also emerged as a major financier of SMEs. During the fiscal year that ended on March 31, 2010, the value of loans given out by the BDC, which totalled $4.4 billion, was higher than in any other year in the Crown corporation's history.[89]

Nearly half of SMEs that applied for loans did so to increase their working capital.[90] For the most part, SMEs did not use debt financing for technology-related investments, such as computer equipment and software (11 percent) and R&D (5 percent).[91] Clear exceptions are knowledge-based industries (i.e., knowledge producers, such as science and technology-based firms, and high-knowledge users, such as business innovators and large scale knowledge-user firms) with an estimated 22 percent of debt financing intended for R&D.[92] Manufacturing was also above the average at 10 percent.[93]

6.2 Knowledge Development and Transfer Indicators

6.2.1 Advancing the Frontiers of Knowledge through Science and Technology

The development of knowledge is the root of a country's innovation ecosystem. The quality and quantity of knowledge that is generated is difficult to quantify, more so as the Internet has allowed for free and open collaboration at unprecedented levels. This report uses bibliometric indicators and university rankings to examine Canada's performance in knowledge development through research.

6.2.1.1 Measuring Outputs of Research through Bibliometric Indicators

Bibliometric indicators are the most widely used indicators in international comparative studies on the outputs of research. They fall into five main categories: the number of publications, specialization in a particular scientific discipline, the number of citations, relative impact and the level of international cooperation, as revealed by the volume of co-publications.[94]

Number of publications — International data published by the *Observatoire des sciences et des techniques* in Paris show that in 2008 Canada, with a share of only 0.5 percent of global population, accounted for 3.3 percent of scientific publications in the world. In absolute terms, this places us in 8th position after the United States, China, Japan, Germany, the United Kingdom, France and Italy. It is worth noting that between 2003 and 2008 China increased its

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86 Statistics Canada, *Survey on Financing of Small and Medium Enterprises 2007*, 2009.

87 Industry Canada SME Financing Data Initiative, *Key Small Business Financing Statistics*, 2009, p. 3. (**http://www.sme-fdi.gc.ca/eic/site/sme_fdi-prf_pme.nsf/vwapj/KSBFS-PSFPE_Dec2009_eng.pdf/$FILE/KSBFS-PSFPE_Dec2009_eng.pdf**)

88 Industry Canada SME Financing Data Initiative, *Key Small Business Financing Statistics*, 2009, p. 4. (**http://www.sme-fdi.gc.ca/eic/site/sme_fdi-prf_pme.nsf/vwapj/KSBFS-PSFPE_Dec2009_eng.pdf/$FILE/KSBFS-PSFPE_Dec2009_eng.pdf**)

89 Business Development Bank of Canada, *BDC increased financing for entrepreneurs by 53% during financial crisis*, News Releases, August 19, 2010. (**http://www.bdc.ca/en/about/mediaroom/news_releases/Pages/BDC_increased_financing_for_entrepreneurs_during_financial_crisis.aspx**)

90 Industry Canada SME Financing Data Initiative, *Key Small Business Financing Statistics*, 2009, p. 13. (**http://www.sme-fdi.gc.ca/eic/site/sme_fdi-prf_pme.nsf/vwapj/KSBFS-PSFPE_Dec2009_eng.pdf/$FILE/KSBFS-PSFPE_Dec2009_eng.pdf**)

91 Industry Canada SME Financing Data Initiative, *Key Small Business Financing Statistics*, 2009, p. 4. (**http://www.sme-fdi.gc.ca/eic/site/sme_fdi-prf_pme.nsf/vwapj/KSBFS-PSFPE_Dec2009_eng.pdf/$FILE/KSBFS-PSFPE_Dec2009_eng.pdf**)

92, 93 Statistics Canada, *Survey on Financing of Small and Medium Enterprises 2007*, 2009.

94 Observatoire des Sciences et des Techniques, *Bibliometrics as a tool for the analysis of the scientific production of a country*, 2009, p. 2.

share of publications by 93 percent. China is now the second largest producer of publications in the world between the United States and Japan.[95]

In 2006, 82.4 percent of Canadian scientific publications came from the higher education sector (up from 77.6 percent in 1996). Researchers working in hospitals, federal government laboratories, private sector firms and provincial government laboratories added to Canada's total output as well. Ontario (45.8 percent) and Quebec (23.6 percent) contributed approximately 70 percent of Canadian publications.[96]

Scientific specialization — Publications data can also be used to get a rough idea of the scientific specialization of a country.[97] Overall, European countries are not heavily specialized, with relatively equal shares of publications in specific fields that do not differ much from their total publications shares. Asia and North America, by contrast, display much greater concentration of scientific research. As a rule, Asian countries tend to specialize in physics, chemistry and engineering science but under-specialize in the life sciences. Conversely, in North America, there tends to be a specialization in biology and medical research but an under-specialization in physics and chemistry. Canadian researchers account for 4 percent of world publications in basic biology, but only for 2 percent and for 2.1 percent respectively in physics and chemistry. The same degree of specialization also holds for the United States. Canada also has a number of specializations that do not reflect North American trends and so may be regarded as comparative advantages, especially over the U.S. In particular, Canadian researchers account for 4.3 percent of world publications in applied biology and ecology, and 4.2 percent in astronomy, astrophysics and cosmology, as well as 3.9 percent in engineering science.[98]

Citations — Metrics based on the number of publications, however, only give part of the story. It is also useful to look at the number of times scientific papers are cited as sources.[99] A calculation done in 2007 by the *Observatoire des sciences et des technologies de l'Université du Québec à Montréal*, using the Thomson Reuters database, shows that, in terms of volume of citations received by scientific papers over a two-year period following publication, Canada ranks 4th in the world behind the United States, U.K. and Germany.[100] Since, as we have seen, Canada ranks 8th in terms of number of publications, this means that on average Canadian scientific papers are cited more than the world average.

Relative impact — According to the relative impact index published by the *Observatoire des sciences et des techniques,*[101] in 2008, Canada's relative impact index over a two-year period was 1.09, which makes us — among the twenty countries that account individually for at least 1 percent of world publications — one of only nine countries with a relative impact index greater than one, behind the United States (1.47), Switzerland (1.44), the Netherlands (1.33), Denmark (1.32), the U.K. (1.25), Germany (1.20), Sweden (1.17) and Belgium (1.10).[102] Interestingly Canada, even though we under-specialize in chemistry in terms of volume of publications, has a specialized relative impact index for this discipline that is higher than for any other discipline (1.29). This may suggest that Canadian publications in this field are of a high quality, and that Canada's under-specialization in it should not necessarily be interpreted as an area of scientific weakness.

International co-publication — Over the past ten years, the science communities in a number of industrializing countries have begun to make an impact. For instance, China, South Korea, India and Turkey are now making significant contributions to the global total of

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95 Observatoire des Sciences et des Techniques, *Indicateurs de sciences et de technologies*, 2010, p. 403.

96 Observatoire des sciences et des technologiques, *L'observation S&T. Note no. 21*, Septembre 2008, p. 2.

97 This is done by comparing the share of publications in a field produced by a given country to its world share of publications for all disciplines.

98 Observatoire des Sciences et des Techniques, *Indicateurs de sciences et de technologies*, 2010, p. 406.

99 The number of times a country's scientific papers are cited is essentially an indicator of the scientific *visibility* of the country, but it can also be interpreted as a rough indicator of the quality of scientific papers it produces and their impact on scientific advancement. Indeed Y. Gingras in *Le classement de Shanghai n'est pas scientifique*, *La recherche*, no. 430, May 2009, p. 48 has shown that there is a correlation between citations received and the likeliness of researchers obtaining international prizes and awards.

100 Y. Gingras, *Le classement de Shanghai n'est pas scientifique*, *La recherche*, no. 430, May 2009, p. 48.

101 The *relative impact index* is defined as the ratio between world share of citations for a given country and its world share of publications. Therefore, according to this indicator, when a country's relative impact index is greater than 1, its visibility is better than the world average.

102 Observatoire des Sciences et des Techniques, *Indicateurs de sciences et de technologies*, 2008, pp. 391, 396.

published scientific literature. The emergence of these countries is an opportunity for Canadian researchers to network globally, especially through scientific co-publications. Between 2001 and 2006, the percentage of world scientific publications that are international co-publications (i.e., involving researchers from at least two different countries) has risen from 16.3 percent to 19.1 percent, which represents a 17 percent increase in the total number of co-publications. Over the same period, Canada has kept pace with the general increase of co-publications throughout the world with an 18 percent increase in its total number of co-publications. In 2006, 42.1 percent of Canada's total publications were co-publications compared with 35.8 percent in 2001. This puts us in the top tier of international co-publishers, with Switzerland (57.7 percent), South Africa (46.6 percent), Mexico (43.8 percent) and Israel (41.2 percent).[103]

6.2.1.2 Measuring the Performance of Canada's Universities

Along with bibliometric indicators, rankings of world universities have grown in popularity as measures of a country's performance in research. There are three commonly cited sources for measuring the quality of universities: the Graduate School of Education, Shanghai Jiao Tong University (GSE-SJTU) Academic Ranking of World Universities (the "Shanghai ranking");[104] the Quacquarelli Symonds (QS) World University Rankings, and the Times Higher Education ranking (THE). Many strong criticisms have been raised by experts about the methodology and validity of these rankings.[105] Despite their possible methodological flaws, university rankings now play a major role in influencing the international reputation of our higher education sector. Reputation helps an institution recruit and retain the best researchers, enhances opportunities for collaboration and networking and can improve its ability to attract research funding and funding for scholarships.

Canada ranks fifth on the list of countries with the greatest number of universities in the top 100.

Shanghai Jiao Tong University (GSE-SJTU) — In 2010, according to GSE-SJTU, Canada had four universities in the top 100: University of Toronto (27th place), University of British Columbia (36th place), McGill University (61st place) and McMaster University (88th place).[106] Overall, Canada had 23 universities ranked in the Shanghai ranking top 500. These results are similar to the ones obtained in 2008. While it may still be disappointing that no Canadian university figures in the ranking's top 10 or top 20, Canada nevertheless ranks 5th (out of 39 countries) on the list of countries with the greatest number of universities in the top 100, and 6th on the list of countries with the greatest number of universities in the top 500. On both lists, only much larger countries rank ahead of us. Canadian universities account for 4.0 percent of universities ranked in the top 100 and for 4.6 percent of the ones ranked in the top 500. We achieve these results with a share of only 0.5 percent of global population. This means that, with a ratio of 8.0 for the percentage of universities in the top 100 relative to the share of global population, we clearly outperform countries such as Germany, Japan and France. Our results are even better for the top 500. With a ratio of 9.2 for the percentage of universities in the top 500 relative to the share of global population, Canada outperforms the United States and United Kingdom.

A different weighting of the Shanghai ranking's indicators placing greater emphasis on indicators of current rather than past performance would place Canadian universities higher. The Shanghai ranking's first two indicators (total number of alumni and staff having won Nobel Prizes and Fields Medals) have a combined weight of 30 percent. These indicators take into account Nobel Prizes and Fields Medals won in past decades. In contrast, the Shanghai ranking's indicator that focuses the most on the current research

103 Observatoire des Sciences et des Techniques, *Indicateurs de sciences et de technologies*, 2008, p. 402.

104 The GSE-SJTU Academic Ranking of World Universities evaluates universities on four criteria: quality of education, quality of faculty, research output and size of institution. These are all based on six homogenous indicators, such as awards per faculty member and citations.

105 Y. Gingras, *Le classement de Shanghai n'est pas scientifique, La recherche*, no. 430, May 2009. J.C. Billaut, D. Bouyssou and P. Vincke, *Should you believe in the Shanghai ranking? an MCDM view*, Laboratoire d'Informatique, Université François-Rabelais, 2009. Contrary to bibliometric indicators, which are homogenous and easy-to-interpret indicators, university rankings are heterogeneous indicators, aggregating measures that may in fact be fundamentally different in nature and very difficult to add up in a meaningful way.

106 Graduate School of Education (formerly the Institute of Higher Education), Shanghai Jiao Tong University, *Academic Ranking of World Universities-2009*.

R&D Sub-Priority: Regenerative Medicine

Dr. Mick Bhatia, director of the Stem Cell and Cancer Research Institute (SCC-RI) at McMaster University, and Canada Research Chair in Human Stem Cell Biology, and his team, have found a way to create blood from a patch of a person's own skin.

Turning Skin into Blood — A Canadian Researcher Develops New Opportunities for Cancer Treatment

Dr. Mick Bhatia, and his team, published research findings in the prestigious scientific journal *Nature* (November 7, 2010), which demonstrated — for the first time — that human skin cells could be directly converted into blood cells.

The impact of this research could mean that patients requiring blood for surgery, cancer treatments or treatments for blood conditions, could create blood from their own skin. This could revolutionize cancer treatment approaches, for bone marrow transplants for example, by eliminating the need to find a donor match, and in turn reducing time and treatment costs.

Dr. Bhatia is a recognized leader in the field of human hematopoietic stem cell biology and pluripotent stem cells. He is also the current director of the Stem Cell and Cancer Research Institute (SCC-RI) at McMaster University, and Canada Research Chair in Human Stem Cell Biology. His discovery builds on pioneering research by other Canadians, Dr. Jim Till and Dr. Ernest McCulloch, who first published evidence of the existence of stem cells in 1963.

Dr. Bhatia's research was funded by the Canadian Institutes of Health Research, Canadian Cancer Society Research Institute, Stem Cell Network and Ontario Ministry of Research and Innovation.

performance of universities has a weight of 20 percent. It takes into account the total number of papers indexed in the Science Citation Index-Expanded and the Social Sciences Citation Index in the previous year. Canadian universities score substantially higher for this indicator than in total scores. For example, the University of Toronto performs remarkably well, ranking third on the complete list, behind only Harvard University and the University of Tokyo. Ranked 18th, the University of British Columbia is on par with Cambridge University.

Rankings by Field and Subject — Since 2007 and 2009 respectively, the GSE-SJTU has also been producing rankings of universities according to five different fields (natural sciences and mathematics; engineering/technology and computer sciences; life and agriculture sciences; clinical medicine and pharmacy; and social sciences) as well as five different subjects (mathematics; physics; chemistry; computer science; and economy/business). The methodology behind these specialized rankings differs from the one used to build the overall ranking. It places less weight on the indicators pertaining to the total number of alumni and staff having won Nobel Prizes and Fields Medals (25 percent instead of 30 percent), and more on bibliometric indicators (75 percent instead of 60 percent). Since bibliometric indicators better reflect the current research performance of universities, Canadian universities generally fare better in the specialized than in the overall rankings. Canadian universities appear 23 times in the combined five top 100 rankings related to fields, which makes Canada the 3rd most represented country in these specialized rankings behind the United States (with 284) and United Kingdom (with 44). With a total of 27, Canada also ranks 3rd (tied with China) on the list of countries with most universities in the combined five top 100 rankings related to subjects, trailing once again only the United States (with 265) and United Kingdom (with 37). Only the University of Toronto achieves a top 20 ranking in one of the five lists related to fields and in one of the five lists related to subjects, ranking 19th in engineering/technology and computer sciences and 8th in computer science.

Quacquarelli Symonds (QS) World University Rankings — Until 2009, the QS World University Rankings were published in collaboration with Times Higher Education and referred to as the Times Higher Education–QS World University Rankings. In 2010, QS assumed sole publication of the ranking based on the same methodology as in 2008.[107] According to the 2010 edition, Canada has four universities in the top 100: McGill University (19th place), University of Toronto (29th place), University of British Columbia (44th place), and University of Alberta (78th place). This is one less than in 2008, but the wide discrepancies in the performances of many Canadian and foreign universities between the 2008, 2009 and 2010 editions of the ranking raise questions about the validity of the findings.

Times Higher Education Ranking — After their split with Quacquarelli Symonds, the Times Higher Education (THE) developed a new methodology for its 2010 ranking. In the top 100 universities for 2010, the THE ranking includes four Canadian universities: University of Toronto (17th place), University of British Columbia (30th place), McGill University (35th place) and McMaster University (93rd place). Overall, Canada has nine universities listed in the 2010 THE ranking, of 200 universities. This places Canada fifth in countries with universities ranked.

***Financial Times* Global MBA School Rankings —** Management skills are a key complement to science and engineering skills in a knowledge-based economy. In the *Financial Times* annual Global Masters in Business Administration rankings, the number of Canadian business schools in the top 100 has not increased since 2004. Figure 26 shows that the majority of Canadian business schools remain lower in the ranks than their 2004 peak with the exception of the University of Alberta. The École des hautes études commerciales Master of Science Program in Administration ranked 34th in the *Financial Times* Master in Management Ranking 2010.

Figure 26 Ranking of Canada's Top MBA Schools

School	2004	2007	2008	2009	2010
University of Toronto	21	27	40	47	45
University of Western Ontario	29	41	53	47	49
York University	22	49	48	49	54
University of British Columbia	67	77	92	71	82
University of Alberta	97	-	88	77	86
McGill University	39	90	96	-	95

Source: *Financial Times*, Business School Rankings.

[107] This ranking methodology includes quantitative measures, like the Shanghai Ranking, but also qualitative ones, such as the opinion of surveyed academics.

6.2.2 Transferring Knowledge into Innovation

In an economy focused on knowledge, research is no longer performed solely within the walls of large institutions or corporations. Collaboration is a new and important source of competitive advantage. Interactions between diverse actors across a diverse range of knowledge transfer activities have increased the possibility of research outcomes that are more relevant to the users of that knowledge. In such a scenario, knowledge is transferred back and forth between knowledge creators and knowledge users who convert knowledge into products, services or innovation.

Knowledge transfer, and its success and impact, are difficult to measure because the relationship between research, knowledge transfer and economic development is complex. Licensing income and start-ups have been the standard metrics for knowledge transfer. The U.K.'s Unico and the United States' STAR METRICS project are developing a broader set of knowledge transfer metrics focused on quality (along with quantity)[108, 109] to represent knowledge transfer activities of a university. The Lattes Platform in Brazil is an example of new infrastructure for tracking and reporting knowledge transfer. This standardized database compiles information on researchers (uniquely identified), their research and their institutions. Knowledge transfer activities discussed in this report focus on those involving universities and the private sector.

While the 2009 *Survey of Innovation and Business Strategy* examined collaboration on product and process development with other enterprises and institutions, it did not include a specific question on university-industry collaborations. A question that would allow for comparability with other OECD data would be a useful addition to future surveys. According to a recent World Economic Forum's *Global Competitiveness Report*, a relatively low share of Canadian executives gave positive reviews of the state of university-industry cooperation in Canada.[110] In the 2009–10 survey executives ranked Canada ninth out of 139 countries in terms of university-industry collaboration in R&D, which is an improvement from 14th place in the 2008–09 survey.

A 2010 survey of business leaders by the Board of Trade of Metropolitan Montreal[111] examined the relationship between business and academia in Quebec. Over half (53 percent) of the respondents stated that they had "collaborated" with a university in the last three years. Internships (39 percent) were by far the most widespread type of collaboration. However, the more "scientific" type of collaboration is less common, with few companies participating in collaborative research (9 percent), contract research (6 percent), association with a research chair (3 percent) or incubator projects (3 percent). While the vast majority (83 percent) of those that "collaborated" with a university in the last three years intend to do so again in the future, two thirds of the companies that did not collaborate with academia in the last three years did not foresee any collaboration in the years ahead.

6.2.2.1 Knowledge Transfer through Internships

Internships allow students to apply their studies to real world issues. This is an important tool for universities and community colleges in fulfilling their primary

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108 Unico, *Metrics for the Evaluation of Knowledge Transfer Activities at Universities.*

109 STAR METRICS project. (**https://www.starmetrics.nih.gov/**)

110 World Economic Forum, *Global Competitiveness Report 2008–2009,* 2008. (**http://www.weforum.org/reports/global-competitiveness-report-2008-2009?fo=1**)

111 Survey conducted in 2010 by Leger Marketing on behalf of the Board of Trade of Metropolitan Montreal, *The Quebec university system: business weighs in.*

mission — educating students to create, analyze and think for themselves. An internship can also better prepare students for the workplace and for the demands to deliver on time and on budget.

The Government of Canada has strengthened internship programs through commitments in recent budgets, including additional support for the Industrial Research and Development Internship program (Budget 2009) and the Career Focus component of the Youth Employment Strategy (Budget 2010). This further increases receptor capacity, which is the capacity to see potential applications of research to solve problems and achieve performance targets and cost savings.

> *Where companies do not have large in-house research capacities with dedicated resources, internships and co-operative education can allow companies to gain insight into the latest scientific and technical thinking and to identify sources of expertise.*

6.2.2.2 Knowledge Transfer through Contract Research

In 2008, Canadian universities undertook research contracts worth almost $2 billion, representing a significant 55 percent increase from 2007.[112] The federal government and provincial and other levels of government maintained their respective share of that amount (a fifth and a quarter respectively) while Canadian businesses and non-profit organizations accounted for a third of the total value of those research contracts.

6.2.2.3 Knowledge Transfer through Research Collaboration and Partnerships

The number of university-industry co-authored scientific articles increased by 80 percent between 1990 and 2005 and the average number of citations of co-authored papers in 2005 was greater than non-collaborative papers.[113]

In terms of management, business, and finance research in Canada, the Council of Canadian Academies has noted that collaboration was observed primarily between universities; collaborations between universities and private sector or public sector entities comprised only 10 percent of the total number of collaborative papers.[114]

6.2.2.4 Licensing Technologies and Trademarking Innovations

Licences are an indicator of technologies ready for commercialization. According to Statistics Canada's *Survey of Intellectual Property Commercialization in the Higher Education Sector* (2008), 81 percent of responding (101) Canadian universities and affiliated teaching hospitals were engaged in IP management, a number that has remained steady since 2005.

In 2007–08, Canada's 42 academic health-care organizations initiated over 1,500 new clinical trials with a potential value of over $300 million; and created nearly 300 licences and 200 disclosures. In addition, between 2003 and 2006, they generated approximately $30 million in licence and technology transfer income. Since 1995, they have created at least 100 world-first discoveries and 65 new spinoff companies.[115]

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[112] Statistics Canada, *Survey of Intellectual Property Commercialization in the Higher Education Sector 2008*, 2010.

[113] OECD (2007), *Science, Technology and Industry Scoreboard*.

[114] Canadian Council of Academies, *Better Research for Better Business*: *Report of the Expert Panel on Management*, *Business, and Finance Research*, May 2009.

[115] Data from ACAHO.

Innovequity Inc., with a $50,000 voucher from the Alberta Innovation Voucher Program, and technical expertise from novaNAIT, developed the Geometric Construction System that will automate up to 70 percent of the construction process.

Alberta Innovation Voucher Program Speeds Ideas to Market

Alberta's Innovation Voucher Program was launched in 2008. It is one part of *Alberta's Action Plan: Bringing Technology to Market*. In the first two rounds of awards, almost 400 vouchers worth approximately $11 million were awarded to small companies across Alberta. Available in $10,000 and $50,000 denominations, vouchers are intended for business services such as marketing, planning, or business formation, as well as for technology development activities such as product prototyping, laboratory verification and field testing.

During the early stages of product development, many promising businesses have difficulty securing funding because "proof of concept" may not exist and investors are not yet willing to commit resources. Alberta's Innovation Voucher Program enables connections with supportive agencies and access to business and product development expertise and services.

In 2009, Innovequity Inc. received a $50,000 Alberta Innovation Voucher to develop its automated construction system for factory-built houses. Innovequity used their voucher to access the technical expertise available at novaNAIT, an innovation support centre of the Northern Alberta Institute of Technology. The Geometric Construction System will automate up to 70 percent of the construction process, increasing efficiency and enhancing competitiveness for companies that use it. This could result in tremendous cost savings for North America's $20-billion annual factory-built housing industry.

The OECD has found that the number of trademark applications is highly correlated with other innovation indicators. Because trademarks can be applied to a multiplicity of goods and services, they can convey information on product innovations as well as marketing innovations and innovations in the services sector.[116] Typically, countries with larger services sectors tend to protect intellectual property more frequently through trademarking than those that are strong in manufacturing or specialized in ICT (which favour patenting).[117] In terms of service-related trademarks as a percentage of total trademark filings, Canada ranked 14 out of 41 countries in 2008.[118]

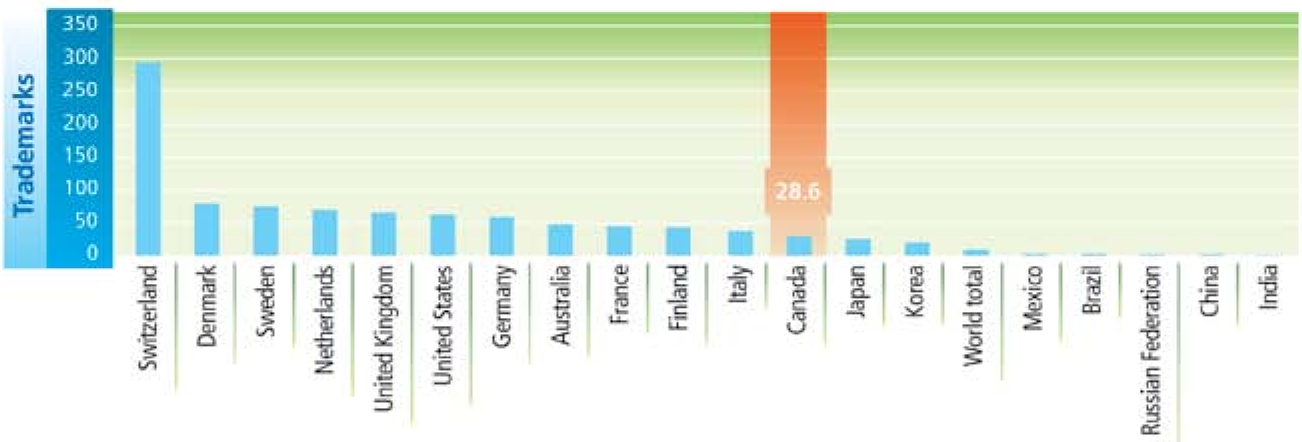
In 2007 data from the World Intellectual Property Organization, Canada ranked 17 out of 162 countries in the total number of direct resident trademark applications.[119] A more useful measure, however, may be the number of cross-border trademarks (Figure 27), since direct resident trademark numbers reflect the

116,117 OECD (2010), "Protection of innovation," *OECD Measuring Innovation*: *A New Perspective*. (**http://www.oecd.org/dataoecd/50/2/45184357.pdf**)

118 OECD (2010), "Trademarks," *OECD Measuring Innovation: A New Perspective*, doi: **http://dx.doi.org/10.1787/834583000800**.

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

Figure 27 Cross-Border Trademarks per Million Population (Selected Countries, Average 2005–07)



Source: OECD (2010), "Protection of innovation," *OECD Measuring Innovation: A New Perspective*, doi: **http://dx.doi.org/10.1787/834561767368**.

tendency of firms to file trademarks first in their home country.[120] According to this measure, Canada ranks 19 out of 38 countries for the period 2005–07.[121]

6.2.2.5 Spinning Off New Companies to Move Technology to Market

For 2008, the estimates of new companies formed from Canadian universities range from 19[122] to 39.[123] Figure 28 shows the numbers from the Association of University Technology Managers (AUTM) *Canadian Licensing Activity Survey* of spinoff companies broken down by year of incorporation from 2005 to 2008. According to Statistics Canada the total number of incorporated companies spun off by reporting institutions to date since 1999 is 1242.[124]

6.2.2.6 Networks and Open Innovation — New Approaches to Collaboration

Innovations are increasingly brought to the market by networks or clusters, partners selected according to their comparative advantages, and that operate in a coordinated manner. The Internet is also giving businesses new opportunities to tap into the knowledge of customers, partners and employees.

The Business-Led Networks of Centres of Excellence and Centres of Excellence for Commercialization and Research programs administered by Canada's granting councils are examples of how the federal government distributes grants that involve research and encourages collaboration between researchers in universities and businesses. In 2009–10, the Networks of Centres

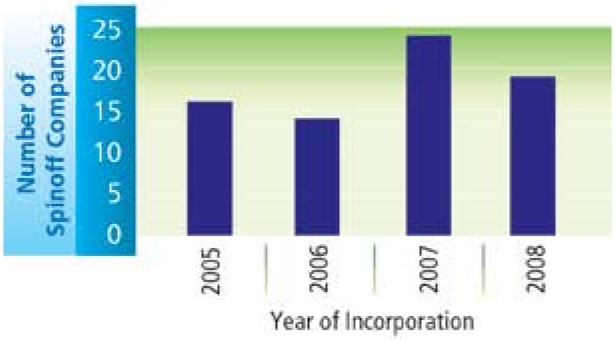
[120] Cross-border trademark counts correspond to the number of applications filed at USPTO except for Australia, Canada, Mexico, New Zealand and the United States. For those countries counts were based on OHIM, German PTO and JPO distributions.

[121] OECD (2010), "Protection of innovation," *OECD Measuring Innovation: A New Perspective*, doi: **http://dx.doi.org/10.1787/834561767368**.

[122] Association of University Technology Managers, *Canadian Licensing Activity Survey: FY2008*.

[123,124] Statistics Canada, *Survey of Intellectual Property Commercialization in the Higher Education Sector 2008*, 2010.

Figure 28 **Number of University Spinoff Companies by Year of Incorporation, 2005–08**



Source: AUTM *Canadian Licensing Activity Survey.*

of Excellence stimulated $27.8 million (or 17 percent of the program) in cash and in-kind investments from private sector companies[125] that were used to encourage research, training, knowledge translation and commercialization.

Many companies are trying new ways to reduce R&D costs by adopting new approaches such as open innovation, open source, outsourcing, and intellectual property (IP) sharing into their business models. They are posting their challenges and their "unused" knowledge on various Internet-based open innovation service companies such as InnoCentive, Innoget, PRESANS and

R&D Sub-Priority: Health in an Aging Population

Research Network: Healthcare Support through Information Technology Enhancements (hSITE)

Ten years ago, 12 percent of Canadians were over 65 years old. By 2026, that cohort will have ballooned to 20 percent of the population. With this demographic shift comes an increased strain on the country's health-care system, as more and more Canadians are forced to deal with the injuries and chronic diseases that are a hallmark of aging.

To better serve Canada's older population — and to meet other challenges, such as increased costs and decreased personnel — the Healthcare Support through Information Technology Enhancements (hSITE) network is creating cost-effective new IT designed to boost workflow efficiency and reduce costs.

Established in 2009, hSITE brings together the front line clinicians who need new IT technologies with the electrical and computer engineering researchers who can create it. The project is one of nine strategic research networks funded by the Natural Sciences and Engineering Research Council, with contributions from Canadian partner companies. McGill is the hub of the hSITE network, which spans seven universities, eight health-care organizations and industrial partners such as RIM, IBM and Nortel.

Whether it's delivering a child's X-ray to an emergency room doctor's hand-held e-reader, or a senior citizen's blood test results to a home-care nurse's laptop, hSITE is dedicated to getting the right information to the right person at the right time, while providing affordable, quality health care for all Canadians.

125 Networks of Centres of Excellence of Canada, *Annual Report 2009/2010.*

IdeaConnection. For example, pharmaceutical companies are looking for collaboration with other pharmaceutical companies, academia and other outside sources for sharing talent, resources, tools and technologies, such as high-throughput screening assays, for identifying drug targets for a particular disease. They are also posting the knowledge gained through their research that did not result in the successful development of a drug, so that others may use it.

Industry partners can form consortia to drive R&D that is more focused on a specific challenge. Governance mechanisms in consortia can ensure that research is demand-driven.

Many companies are trying new ways to reduce R&D costs by adopting new approaches.

6.2.2.7 Clusters — An Environment for Innovation to Flourish

A cluster is a recognized critical mass of geographically concentrated and interconnected companies, educational institutions and government research

Pratt & Whitney — A Leader in Developing Strategic Relationships

Pratt & Whitney Canada (P&WC) is one of the largest aircraft engine manufacturers in the world. Founded in 1928 and located in Longueuil, Quebec, Pratt & Whitney Canada (P&WC) is the company lead for worldwide small engine development and manufacturing. P&WC is the number one research and development investor in Canadian aerospace and top five in all industries, with over $400 million invested annually.

Research Relationships — P&WC has worked with over 20 Canadian universities on more than 250 university and National Research Council research projects. The company invested approximately $15 million in universities in 2008. Aside from directly funding research projects, resources have also gone towards the establishment of three Industrial Research Chairs,[126] the establishment of eight research fellows,[127] a number of Centres of Excellence, and the creation of four undergraduate university aerospace institutes.[128] The institutes are designed to train the next generation of aerospace engineers by promoting awareness of industry demands and training opportunities. In recent years, P&WC has moved away from one-on-one collaboration and towards more participation in consortiums composed of industry, university and government.

Recruiting Talent — In an average year, approximately 400 students work in P&WC facilities through co-operative education programs, internships and research contracts. Forty students are hired as employees after their term.

Encouraging Clustering — Before 2003 there was no Canadian expertise in aircraft-quality resin transfer moulding of composites. Pratt and Whitney Canada, Bell Helicopter Textron Canada, Delastek, Concordia University and the École Polytechique de Montréal collaborated to develop a local supply chain. With the assistance of the National Research Council's Aerospace Manufacturing Technology Centre on manufacturing and moulding, the companies worked together to produce the bonded composite wing box, paving the way for future projects that leveraged the expertise available in different parts of the aerospace cluster.

126 P&WC Industrial Research Chair in Virtual High-Performance Machining at University of British Columbia; J. Armand Bombardier, NSERC/P&WC Industrial Research Chair in Integrated Design toward Efficient Aircraft (IDEA) at École Polytechnique (contribute $500,000 of $2 million in funding) and the NSERC Industrial Research Chair in Aviation Acoustics at Sherbrooke.

127 Dr. Wagdi G. Habashi, McGill University (Computational Fluid Dynamics); Dr. Steen A. Sjolander, Carleton University (Experimental Aerodynamics); Dr. Yusuf Altintas, University of British Columbia (Manufacturing); Dr. Kamran Behdinan, Ryerson University (Design Optimization); Dr. Clement Fortin, Ecole Polytechnique de Montreal (Product Life Management); Dr. Suong V. Hoa, Concordia University (Composites); Dr. Robert J. Martinuzzi, University of Calgary (Compressor Aerodynamics); Dr. Prakash C. Patnaik, National Research Council (Structures and Materials).

128 The Concordia Institute of Aerospace Design and Innovation, l'Institut de conception et d'innovation en aérospatiale de l'ÉTS, Ryerson Institute for Aerospace Design and Innovation, l'Institut d'innovation et de conception en aérospatiale de Polytechnique.

organizations. Clusters usually involve enterprises from the same sector, having similar characteristics or products or holding complementary positions in a value chain, including professional services firms, as well as government and educational institutions. The forms and boundaries of clusters are dynamic, build upon existing private sector strengths, and evolve over a period of 15 to 20 years.

Entrepreneur-driven companies and individuals within the cluster compete, but also cooperate with each other. Taking advantage of the "spillover effects" that enhance the prospects of individual cluster firms as well as the overall productivity and success of the group, the companies and institutions within the cluster are typically able to enhance productivity and get greater access to outside financing, including venture capital. Always client focused, clusters typically undertake research and development activities and encourage risk-taking as well as interdisciplinary work. They are also characterized by a high degree of mobility between cluster participants. Clusters have a regional and national economic impact.

In clusters, smaller companies that have established links with larger ones typically have shorter times to market because they benefit from both better market knowledge and access of larger companies. Larger companies benefit from the innovative ideas and flexibility of smaller companies. Companies of different sizes also draw on specialized expertise that exists in universities, colleges and research institutions but in different ways and on different scales.

6.3 Talent Indicators

A successful innovation system requires a mix of factors including individuals who have the necessary skills to spur growth and development. The indicators in this section track efforts to nurture talent at all levels from secondary school to attracting and maintaining connections with world-class researchers. This section also includes some best practices in deploying talent.

Canada faces twin demographic challenges of an aging population and declining birth rate. Fewer individuals participating in the labour force will support a relatively larger group of retired citizens who will live longer lives. This trend, coupled with more complex interdisciplinary innovation processes, poses new challenges and opportunities for Canada in developing its pool of Highly Qualified People (HQP). Immigration and training policies can assist in enhancing the pool of people with needed skills.

The *State of the Nation 2008* report identified some areas where Canada was excelling, but also some gaps and emerging trends. The 2008 report noted Canadian primary school children placed third in the world in terms of the OECD's Programme for International Student Assessment (PISA) 2006 science scores. Canada has a highly educated population, and in 2006, 47 percent of the adult population (aged 25–64) attained a university or college education; the highest among OECD countries.[129] In terms of percentage of the population with a university education, Canada ranked sixth in the world. These trends have translated into an internationally recognized strong talent pool. Many of the results tracked in the talent section of the *State of the Nation 2008* report, where updated data were available, have not changed significantly for the *State of the Nation 2010* report — though relative to other countries — Canada has lost some ground as other countries have made gains.

6.3.1 Science, Math, Reading Skills of 15 Year-Olds

Every three years the OECD's PISA measures the abilities of 15 year-olds in reading, math and science. In 2006, Canadian 15 year-olds scored comparatively high when ranked against their international counterparts, ranking third with only Finland and Hong Kong (China) scoring better.

PISA 2009 results released in 2010, demonstrate that Canadian 15-year-old students continue to perform well internationally and have strong skill sets in reading, mathematics and sciences (Figure 29). While Canada continues to be ranked near the top in the OECD in each of these skill sets, Canada's scores have remained stable between 2000 and 2009 and its relative ranking declined in all three assessment domains in 2009. This decline can be attributed to improvements in the performance of other countries, and the introduction of Shanghai (China) and Singapore, which had high performance levels.

Further analysis of PISA 2006 data was also released in 2010, which correlated computer use and PISA science scores. Data findings identified that students who have been using a computer for a longer time received higher science scores than their peers (Figure 30).

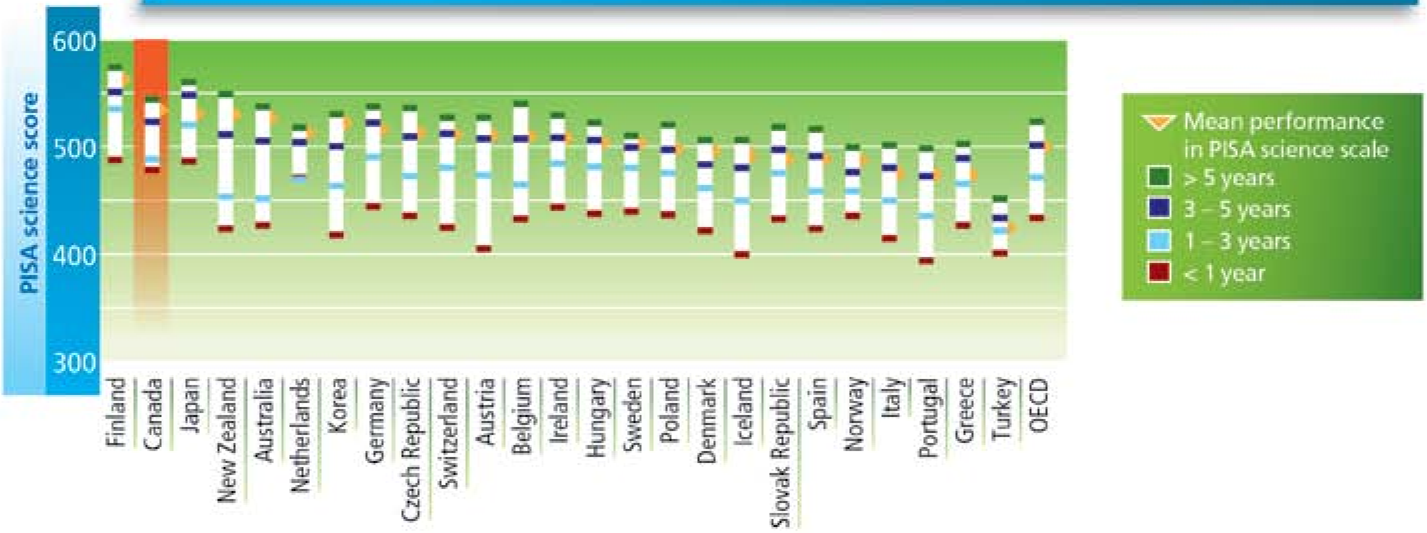
[129] OECD (2010), *Education at a Glance 2009.*

Figure 29 PISA Science, Mathematics and Reading Scores (Selected from Top 25 by 2009 Average Reading Score)

	Average Reading Score	On the Reading Subscales					Average Math Scale	Average Science Scale
		Access and Retrieve	Integrate and Interpret	Reflect and Evaluate	Continuous Texts	Non-Continuous Texts		
Shanghai – China	556 (1)	549 (1)	558 (1)	557 (1)	564 (1)	539 (2)	600 (1)	575 (1)
Korea	539 (2)	542 (2)	541 (2)	542 (2)	538 (2)	542 (1)	546 (4)	538 (6)
Finland	536 (3)	532 (3)	538 (3)	536 (4)	535 (4)	535 (4)	541 (6)	554 (2)
Hong Kong – China	533 (4)	530 (5)	530 (4)	540 (3)	538 (3)	522 (8)	555 (3)	549 (3)
Singapore	526 (5)	526 (6)	525 (5)	529 (7)	522 (6)	539 (3)	562 (2)	542 (4)
Canada	**524 (6)**	**517 (9)**	**522 (6)**	**535 (5)**	**524 (5)**	**527 (6)**	**527 (10)**	**529 (8)**
Japan	520 (8)	530 (4)	520 (7)	521 (9)	520 (7)	518 (9)	529 (9)	539 (5)
Australia	515 (9)	513 (11)	513 (9)	523 (8)	513 (9)	524 (7)	514 (15)	527 (10)
Netherlands	508 (10)	519 (8)	504 (10)	510 (11)	506 (10)	514 (10)	526 (11)	522 (11)
Norway	503 (12)	512 (12)	502 (14)	505 (13)	505 (11)	498 (21)	498 (21)	500 (25)
United States	500 (17)	492 (25)	495 (22)	512 (10)	500 (15)	503 (16)	487 (31)	502 (23)
Sweden	497 (19)	505 (16)	494 (23)	502 (17)	499 (16)	498 (20)	494 (26)	495 (29)
Germany	497 (20)	501 (20)	501 (16)	491 (27)	496 (23)	497 (22)	513 (16)	520 (13)
France	496 (22)	492 (26)	497 (20)	495 (23)	492 (25)	498 (19)	497 (22)	498 (27)
United Kingdom	494 (25)	491 (28)	491 (26)	503 (14)	492 (27)	506 (14)	492 (28)	514 (16)

Note: Rank for each indicator is given in brackets.
Source: OECD (2010): *PISA 2009 Results: What Students Know and Can Do: Student Performance in Reading, Mathematics and Science* (Volume I).

Figure 30 Length of Time Students Have Been Using a Computer and Mean PISA Science Score, 2006



Source: OECD (2010), *Educational Research and Innovation — Are New Millennium Learners Making the Grade?: Technology Use and Educational Performance in PISA*, doi: **http://dx.doi.org/10.1787/812186814126**.

Canadian 15-year-old students continue to perform well internationally and have strong skill sets in reading, mathematics and sciences.

6.3.2 Pursuing Formal Education (15 to 19 Year-Olds)

Enrolment rates of 15 to 19 year-olds provide an indicator of participation in upper secondary education. Since 1995 there has been an average increase of 8 percentage points, from 74 percent in 1995 to 82 percent in 2008, of 15 to 19 year-olds enrolled in education in OECD countries. In Canada, 80 percent of youth aged 15 to 19 were pursuing a formal education in 2008. This result was slightly lower than the OECD average and has remained unchanged since 1995.

Statistics Canada noted provincial and territorial differences. The proportion of youth aged 15 to 19 no longer in formal education ranged from 14 percent in New Brunswick to 26 percent in Alberta. Data for the territories ranged from 25 percent to 34 percent.[130]

6.3.3 Share of the Population with Post-Secondary Education

The share of the population with a tertiary education is regarded as an indicator of a country's supply of advanced skills, which can contribute to productivity gains, innovation and growth.[131] As shown in Figure 31, in 2008, Canada continued to rank first in the educational attainment of its adult population (aged 25–64).[132, 133]

Seeking Information by Questioning

Inquiry-based learning is an innovative method of teaching that allows students to question their way towards useful findings and solutions through experimentation and the accumulation of data. Students learn how to effectively problem-solve rather than simply 'memorize the facts.' While there are variants of the method of inquiry-based learning, a global curriculum is in practice in many countries. Individual schools and networks of schools in Canada are increasingly adopting inquiry-based learning programs.

Smarter Science is a framework for teaching and learning science in grades 1–12 and for developing the skills of inquiry, creativity, and innovation in a meaningful and engaging manner. The framework enables teachers to develop classroom activities for students that reflect the investigative, creative and social nature of science for any curriculum unit. Smarter Science was piloted in 50 schools in Ontario between 2006 and 2010 and is now part of Youth Science Canada's program for engaging youth in inquiry and critical thinking through science. In 2011 the organization will celebrate 50 years of developing and promoting Canadian youth science and technology.

Calgary-based Galileo Educational Network is another non-profit organization promoting inquiry-based learning. Through research and the creation of 21st Century learning environments, Galileo educators have influenced curriculum and classroom delivery both internationally and across Canada. Teaching for deeper understanding in all classroom subjects is a primary goal. This is accomplished by supporting new and experienced teachers and leaders through individualized professional development. The result is an educational environment where digital technologies are used in inquiry-based projects, allowing for students to learn in creative and thoughtful ways.

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130 Statistics Canada, *Education indicators in Canada: An international perspective*, September 7, 2010.

131 Leitch Review of Skills, *Prosperity for all in the global economy — world class skills*, December 2006. p. 8.

132 OECD (2010), *Education at a Glance 2009*.

133 Tertiary education is defined as programs that are classified under the International Standard Classification of Education's (ISCED) levels 5A, 5B and 6. Level 5A is considered to be more theory-based and designed to train students for their entry into advanced research programs and high-skill professions. Level 5B programs focus more on practical skills. Level 6 is the second stage of tertiary education and it includes advanced studies and programs that require original research. Due to some *Labour Force Survey* (LFS) limitations, ISCED 5A and 6 cannot be disentangled in Canada. The proportion recorded for tertiary-type B programs (ISCED level 5B) may be somewhat overestimated because this category includes, for example, some Collège d'enseignement général et professionnel (CEGEP) or college university transfer program graduates which, under the international system, would be placed in ISCED level 4 (programs that straddle the boundary between upper-secondary and post-secondary education).

Figure 31 Percentage of 25–64 Year-Old Population with Tertiary Education, Top 12 OECD Countries, 2008

Source: OECD (2010), *Education at a Glance 2009*.

6.3.4 College and University Graduation Rates

Graduation from a college or university program provides individuals with a package of skills and knowledge. In Canada the graduation rate of college students, at 29.6 percent, is much higher than the OECD average of 10 percent. As shown in Figure 32, although some advances have been made since 2000, first-time bachelor's degree graduation rates in Canada were 34 percent in 2008, which remains lower than the OECD average of 38 percent.[134]

Non-completion of a degree does not mean skills and competencies acquired are lost or not valued by the labour market. In addition, students who do not complete a program may leave, gain employment and then decide to continue their studies at a later date. Data also capture enrolments of individuals, such as part-time students, who enter a program to improve knowledge and skill levels.

6.3.5 Science and Engineering Education for Growth and Prosperity

Recent efforts to boost science and engineering skills in Canada have resulted in significant gains. According to newly released data shown in Figure 33, from 2005 to 2008, there was a 13 percent increase in the number of undergraduate degrees, with a 28 percent and 9.1 percent increase in science and engineering graduates respectively.[135]

Figure 34 shows that since 1992 in Canada, there has been an increase in enrolments and degrees granted in physical and life sciences, and architecture and engineering related programs, while math, computer and information sciences program enrolments and degrees granted have been decreasing since 2001. This decrease is likely in response to the high-technology industry boom and decline in North America in the late 1990s and early 2000s.

6.3.6 Information and Communications Technologies Skills; Access and Use of ICT

Canada has strengths in information and communications technologies (ICT) skills, access and use among the general population. Access and skills are pre-conditions to ICT use. According to the International Telecommunication Union,[136] while Canada ranked only 18th, 22nd, and 20th respectively for access, skills and use in 2008 amongst 159 countries, particular sub-components were higher for Canada. For example, for ICT skills — which include adult literacy rates, secondary gross enrolment ratio, and tertiary gross enrolment ratio — the Canadian ICT skills index rating was 8.65 compared to the first-placed Republic of Korea at 9.84. For the components of ICT use, Canada ranked 11th for Internet users per 100 inhabitants, 10th for fixed broadband Internet subscribers per 100 inhabitants, and 56th for mobile broadband subscriptions per 100 inhabitants.

According to Statistics Canada's *Canadian Internet Use Survey* of 2009, 80 percent of Canadians aged 16 and older, or 21.7 million people, used the Internet for personal reasons. This is up from 73 percent in 2007 when the survey was last conducted.[137]

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[134] Statistics Canada, *Education indicators in Canada: An international perspective*, 2010.

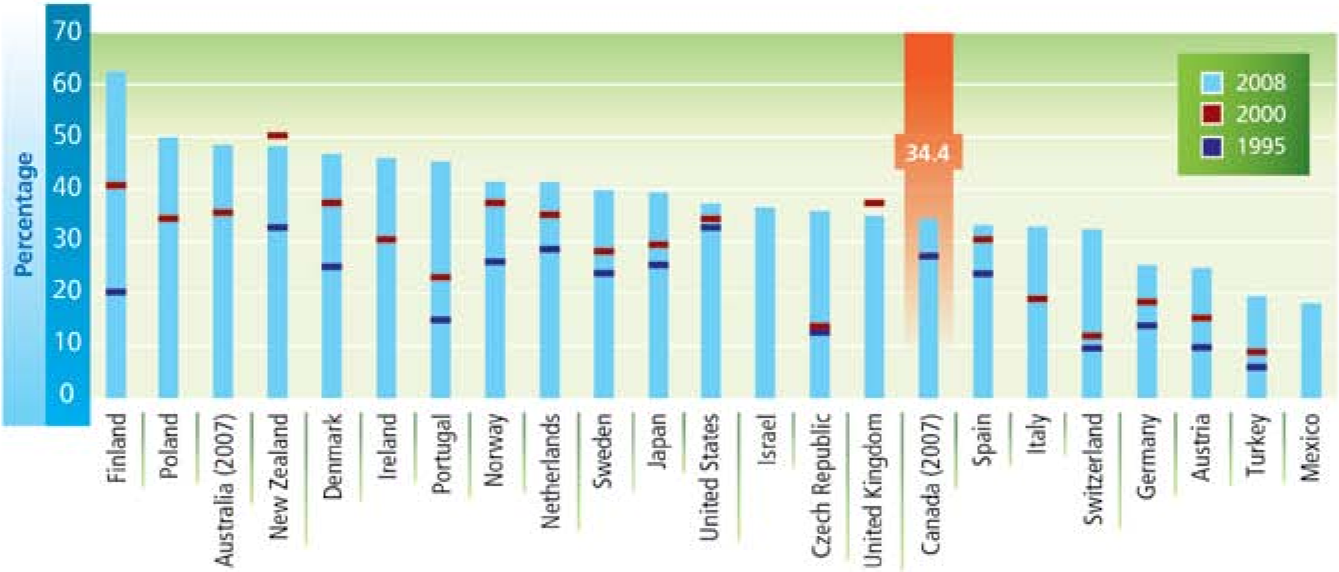
[135] In 2003, Ontario eliminated the Ontario Academic Credit (OAC) program, or fifth year of secondary education, resulting in a "double cohort" graduating class. Although undergraduate enrolment and graduation trends have been increasing in Canada, the policy change in Ontario may account for some of the increase in 2008.

[136] International Telecommunications Union, *Measuring the Information Society 2010*, Switzerland, 2010.

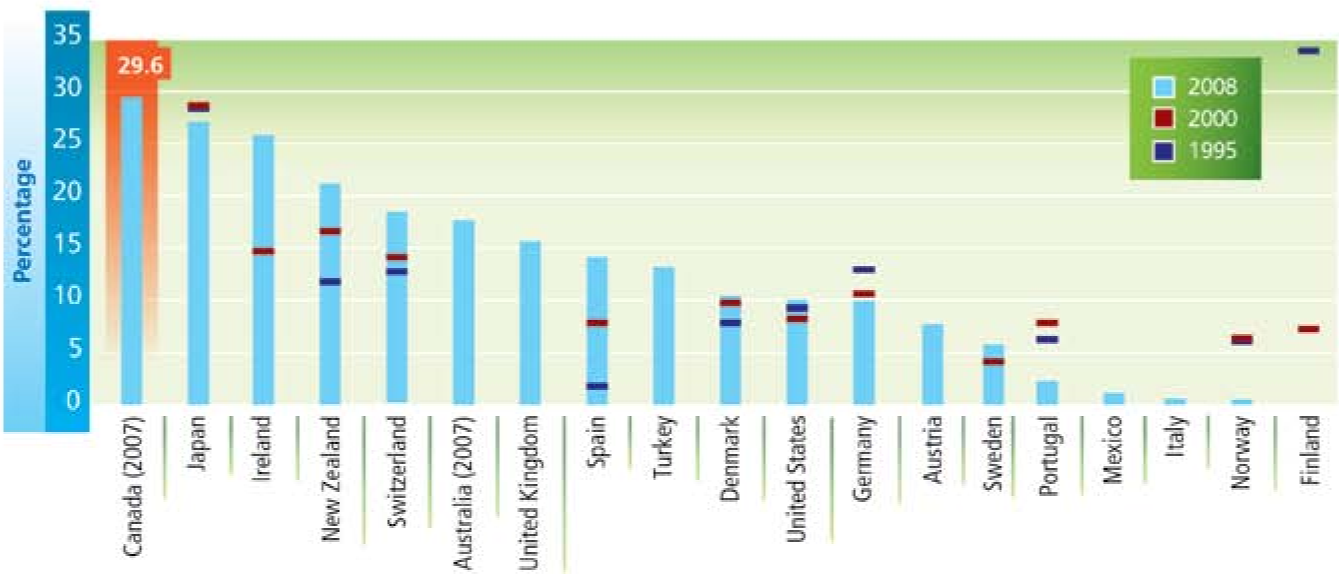
[137] Statistics Canada, *Canadian Internet Use Survey*, 2009.

Figure 32 Graduation Rates from Tertiary Education (1995, 2000, 2008)

University-level education



College-level education



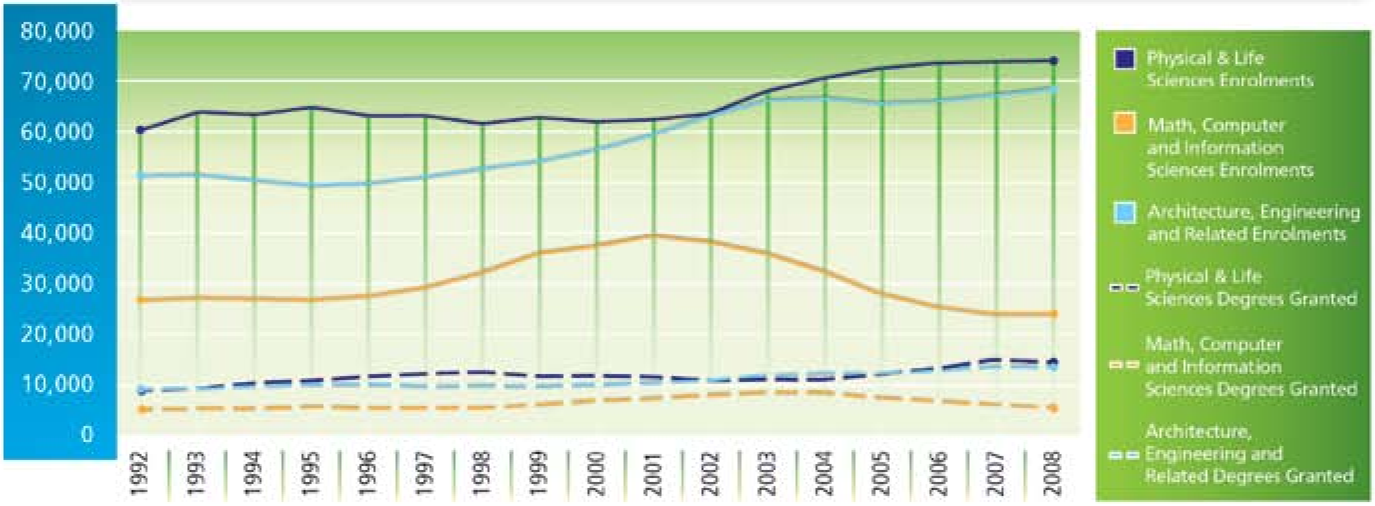
Source: OECD (2010), *Education at a Glance 2010*, doi: **http://dx.doi.org/10.1787/888932310130**.

Figure 33 Selected OECD Countries by Total Number of Degrees Granted in Tertiary Science, Engineering, and All Fields of Study for 2008; and Percentage Change from 2005 to 2008

Country	Science		Engineering		All Fields of Study	
	Number of Degrees 2008	Growth from 2005 to 2008	Number of Degrees 2008	Growth from 2005 to 2008	Number of Degrees 2008	Growth from 2005 to 2008
United States	190,987	1.2	134,351	3.5	2,279,805	8.5
Japan	28,771	1.9	125,934	-1.7	654,768	2.8
United Kingdom	68,123	-3.0	45,879	11.9	520,117	7.8
France	51,973	-20.9	53,781	-1.0	401,421	-11.5
Mexico	40,464	2.1	56,013	9.7	392,783	10.5
Korea	37,122	16.2	90,150	12.0	388,128	30.6
Germany	54,074	79.1	43,417	21.3	344,309	60.8
Australia	26,567	-11.1	16,077	1.3	230,878	3.4
Canada	28,372	28.0	18,241	9.1	222,541	13.0
Netherlands	7,373	-1.4	8,947	6.7	121,014	16.6
Finland	6,619	118.5	8,700	9.6	58,072	56.3
Sweden	2,969	-17.3	7,963	-11.9	49,929	0.9

Source: Data compiled by STIC Secretariat based on data from OECD.stat, "Graduates by Field of Study."

Figure 34 Annual Number of Persons Enrolled and Degrees Granted in Canadian University Undergraduate Science, Engineering, Math, Computer, Information Sciences and Related Programs



Source: OECD (2009), *Science, Technology and Industry Scoreboard 2009*, p. 133.

R&D Sub-Priority: New Media, Animation, Games

Ryerson University's Digital Media Zone

Inspiring Young Entrepreneurs to Innovate

Strengthening Canada's digital media industries

The Digital Media Zone (DMZ) at Ryerson University is a multidisciplinary workplace designed for entrepreneurship. The DMZ provides the environment for digitally-inspired ideas with sound business plans to incubate and accelerate into market-ready products, services or solutions. It is unique in the way it cultivates the concept of being a company within a company. Participants benefit from resources such as *StartMeUp*, a program created by Students In Free Enterprise (SIFE Ryerson), that nurtures entrepreneurial success by giving new business creators information and advice on business planning, funding, patents, marketing and more. The DMZ has been open since early 2010. Business projects range from digital technology fields including mobile/web applications to social media, virtual reality, 3-D, gaming and interactive marketing.

6.3.7 Education for Entrepreneurial Success

Entrepreneurship helps create the economy builders of the future. Educational institutions can offer a training ground to foster entrepreneurship, and some institutions have been successful at integrating training and mentorship activities into their program offerings in order to promote student entrepreneurial results.

6.3.8 PhDs — Country Comparisons[138]

Knowledge economies rely on a highly-skilled workforce and a PhD represents the height of academic achievement. The number of doctoral degrees is also an indicator of the labour force potential to engage in cutting-edge research and training the next generation. Relative to other countries, Canada produces fewer doctoral graduates per million population. Since *State of the Nation 2008*, Canada has slipped from 20th to 23rd when compared to other OECD countries (Figure 35).

State of the Nation 2008 reported data from 2005, and since then there has been a significant increase in the number of doctoral (advanced research program) degrees granted by Canadian universities and percentage growth has outpaced other countries (Figure 36). The percentage increase from 2005–08 in Canada surpassed comparator countries in growth of science doctoral degrees (63.7 percent) and was second to Sweden in growth of engineering doctoral degrees (42.1 percent).

[138] Labelled "advanced research programmes" by the OECD or ISCED level 6.

Figure 35 Graduates of Doctoral (Advanced Research) Programs per Million Population[139]

Sources: 2008 data — OECD (2010), "Graduates by field of education," *OECD Education and Skills* (database); 2002 data — OECD (2006), *Science, Technology and Industry Outlook 2006*, doi: **http://dx.doi.org/10.1787/803731418563**.

Figure 36 Total Number of Degrees Granted in Doctoral (Advanced Research) Programs, 2008

Country	Science		Engineering		All Fields of Study	
	Number of Degrees 2008	Growth from 2005 to 2008	Number of Degrees 2008	Growth from 2005 to 2008	Number of Degrees 2008	Growth from 2005 to 2008
United States	14,780	23.3	8,366	23.4	63,712	21.1
Germany	6,954	3.9	2,541	8.4	25,604	-1.3
United Kingdom	4,910	-1.7	2,358	4.7	16,606	5.2
Japan	2,652	10.3	3,636	8.8	16,296	6.6
France	5,370	21.1	1,274	35.4	11,309	18.1
Korea	954	7.8	2,242	-1.4	9,369	10.9
Australia	1,530	23.3	846	33.0	5,749	17.7
Canada	1,704	63.7	891	42.1	4,827	17.3
Sweden	842	44.7	962	53.7	3,625	30.5
Mexico	593	11.7	340	39.3	3,498	43.8
Switzerland	977	-0.2	395	16.2	3,426	3.7
Netherlands	489	-3.7	563	1.1	3,214	11.6
Finland	415	1.2	380	-1.6	1,951	-0.3

Source: Data compiled by STIC Secretariat based on data from OECD. stat, "Graduates by Field of Study."

[139] *State of the Nation 2008* reported on OECD, *Science, Technology and Industry Outlook*, 2006 data, which referenced 2000/2002 PhD graduate data. The OECD Education Database and OECD, *Science, Technology and Industry Scoreboard 2009* now reference 'Advanced Research Programs.'

6.3.9 Enrolment and Graduation in Science-Based Doctoral Programs by Canadian Students

The number of Canadians enrolled and graduating from science-based doctoral programs in Canadian universities has been increasing steadily in most programs since 1999 (Figure 37).

6.3.10 Unemployment Rates of Doctorate Holders

More Canadians are graduating from science and engineering doctoral programs; however, in 2006 Canada had higher levels of unemployment rates of doctorate holders by field of science when compared to other countries (Figure 38).[140]

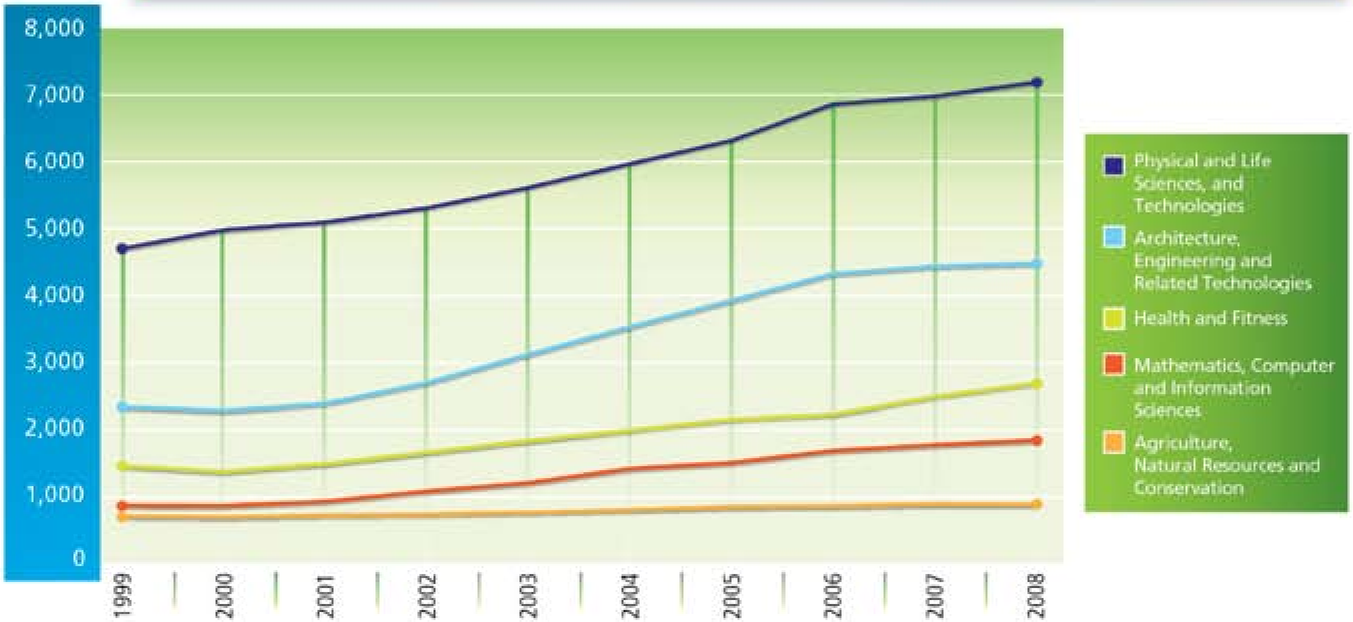
> *Additional uptake of doctorate holders within private, higher education, and public sectors could create incentives for more individuals to pursue a PhD program and increase innovation capacity at the highest levels.*

6.3.11 Internships and Co-ops for Enhanced Opportunities

Internship and co-op programs provide valuable experiences for students to enhance their employment opportunities and mitigate capacity issues within organizations. Recently released research has also identified that co-op students: typically earn more than non-co-op students; were in more prestigious jobs than their non-co-op peers; and assessed themselves as having better computing, mathematical and problem-solving skills. These results may point to benefits for both individuals who pursue co-op and internship programs and organizations who participate in such programs.[141]

The Canadian Association for Co-operative Education (CAFCE) is comprised of 74 member institutions across Canada that have worked in partnership since 1973. CAFCE is currently developing a statistical database on co-op enrolments covering its members with plans to release findings in the spring of 2011.

Figure 37 **Doctoral Students Who Were Canadian Residents and Enrolled in Canadian University Science-Based Programs**

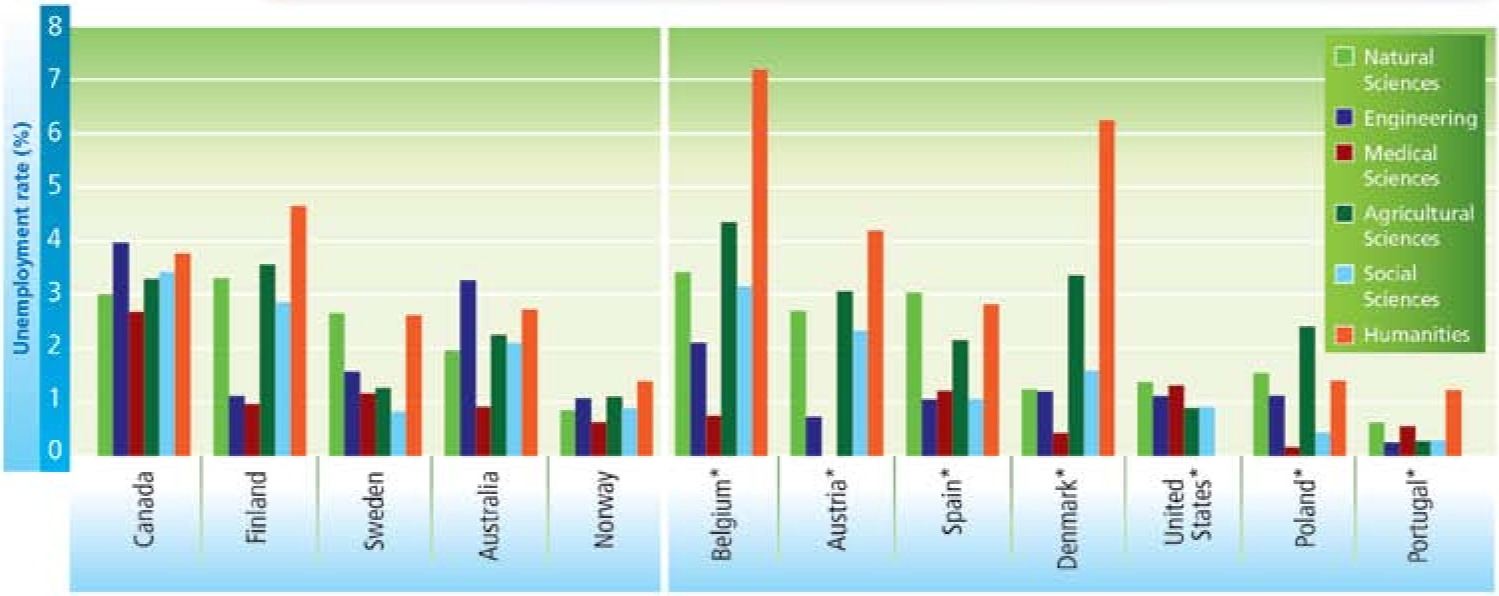


Source: Statistics Canada, *Postsecondary Student Information System (PSIS)*, 2010.

[140] OECD (2010), Science, Technology and Industry Working Papers, *Careers of Doctorate Holders: Employment and Mobility Patterns*.

[141] M. Drysdale, J. Goyder and A. Cardy, *The Transition from University to the Labour Market: The Role of Cooperative Education – Phase 3*, presentation made at the Cooperative Education and Internship Association (CEIA) Annual Conference, Portland, USA (April 20, 2009).

Figure 38 2006 Unemployment Rates of Doctorate Holders by Field of Science



Note: 2005 data for Belgium, Finland and Norway; 1987–2005 graduates and 2005 data for Denmark.
* Unemployment rates for these countries are for PhD holders who received their degrees between 1990 and 2006.
Source: OECD, 2009 OECD/UIS/Eurostat data collection on careers of doctorate holders.

6.3.12 Returns on Obtaining Post-Secondary Education

The private rate of return to an individual for obtaining a tertiary education in Canada is shown in Figure 39 and is slightly lower but comparable to the OECD average.

The private internal rate of return represents a measure of the returns obtained, over time, relative to the costs of the initial investment in education and is equal to the discount rate that equalizes the costs of education during the period of study to the gains from education thereafter.

When compared internationally, Canadian economic returns data may be under-represented as Canadian tertiary education graduate statistics include university, college, and also post-secondary programs with a shorter duration (e.g., CEGEP in Quebec, and short career training or development programs).

Canada found that graduates from university programs earned more, 75 percent more on average, than high school or trade/vocational program graduates.[142]

Employment prospects also increase with education level. In 2008, the employment rate for Canadians 25 to 64 who had not completed high school was 58 percent, compared with 83 percent for college and university graduates.[143]

6.3.13 Attracting Great Talent to Canada

Canada is one of the top destinations in the world for skilled immigrants and top-ranked foreign students. Canada continues to attract a significant share of foreign students in the world. The percentage of foreign students enrolled in Canada, when compared to total foreign student enrolments internationally, has remained fairly stable since 2000, though there has been a slight increase to 5.5 percent (2008), from 5.1 percent (2006) as reported in *State of the Nation 2008*.[144, 145]

[142, 143] Statistics Canada, *Education Indicators in Canada: An International Perspective*, 2010.

[144] OECD (2010), *Education at a Glance 2009.*

[145] Graduate data are more difficult to track, which means that between 25–100 students per year in each program are not identified as either "Canadian" or "International" students. In 2008, information on socio-demographic characteristics was unknown for a large number of students in Ontario. This may account for the apparent decrease in the number of Canadian PhD graduates. The total number of PhD graduates has been increasing in nearly all science-based programs since 1999.

Figure 39 **Private Internal Rate of Return for an Individual Obtaining Tertiary Education as Part of Initial Education, 2006**

Source: OECD (2010), *Education at a Glance 2009.*

Research excellence is defined at an international level, and the competition for research talent is global. As a mid-sized, open, trading economy, Canada's orientation must be global if it is to access scientific knowledge generated outside our borders.

Since 2008, Canada has created a number of programs that strive to put talented Canadians in the company of the best from around the world. These programs have included creating:

- The Vanier (Canada Graduate) Scholarships Program in 2008, which offers three year scholarships of $50,000 per year, tax free, to top Canadian and international doctoral students.
- The Canada Excellence Research Chairs (CERC) program was created in 2008 to attract and retain the world's most accomplished and promising researchers to establish ambitious research programs at Canadian universities in Canada's R&D priority and sub-priority areas. Chairs were identified through a highly competitive two-phase process. In May 2010, 19 inaugural recipients were announced. For each Chair, universities will receive up to $10 million over seven years to support chair holders and their research teams.

Canada — A Magnet for Talent

Canada Excellence Research Chairs

Nineteen world-leading international university researchers have chosen to pursue their research in Canada, thereby providing Canadian researchers the opportunity to learn and make new discoveries.

The Canada Excellence Research Chairs (CERC) program, created by the Government of Canada, is helping to position Canada as a global centre of excellence in research and higher learning. The cutting-edge research conducted by these global leaders in Canada's R&D priority and sub-priority areas, from neuroscience to water security, energy production and information processing, spur innovation and contribute positively to Canada's competitiveness and future prosperity.

The CERC program significantly adds to the hundreds of federally-funded Canada Research Chairs who have already transformed Canadian research. Besides drawing international talent to Canada, the program brings many important benefits to Canada's universities and to all Canadians, preparing Canada's next generation of graduates — master's, doctoral and post-doctorate students, including the finest foreign students. It is forging strong international partnerships in research and business.

The ultimate goal of the program is to nurture Canada's own, homegrown research stars, enrich the country's tradition of science and innovation, and raise productivity and living standards.

Canada Excellence Research Chairs

R&D Priority and Sub-Priority Area	Canada Excellence Research Chair	Researcher	Came from
Environment			
Water	Ecohydrology — University of Waterloo	Philippe Van Cappellen	Georgia Institute of Technology; Utrecht University, Netherlands
	Aquatic Epidemiology — University of Prince Edward Island	Ian A. Gardner	UC Davis School of Veterinary Medicine; the University of California, USA
	Ocean Science and Technology — Dalhousie University	Douglas Wallace	Leibniz Institute of Marine Sciences, Germany
	Water Security — University of Saskatchewan	Howard Wheater	Imperial College London, United Kingdom
Cleaner extracting, processing, utilizing hydrocarbons	Hybrid Powertrain — McMaster University	Ali Emadi	Electric Power and Power Electronics Centre at the Illinois Institute of Technology, USA
Natural Resources and Energy			
Energy production in the oil sands	Oil Sands Molecular Engineering — University of Alberta	Thomas Thundat	University of Tennessee, USA; University of Burgundy, France
Arctic	Remote Sensing of Canada's New Arctic Frontier — Université Laval	Marcel Babin	Laboratoire d'Océanographie de Villefranche, France
	Arctic Resources — University of Alberta	D. Graham Pearson	Durham University, United Kingdom
	Arctic Geomicrobiology and Climate Change — University of Manitoba	Søren Rysgaard	University of Southern Denmark; Climate Research Center, Greenland

Canada Excellence Research Chairs (cont'd)

R&D Priority and Sub-Priority Area	Canada Excellence Research Chair	Researcher	Came from
Health and Life Sciences			
Neuroscience	Neurogenetics and Translational Neuroscience — University of British Columbia	Matthew Farrer	Mayo Clinic, USA
Neuroscience	Cognitive Neuroscience and Imaging — The University of Western Ontario	Adrian Owen	Medical Research Council's Cognition and Brain Sciences Unit in Cambridge, United Kingdom
Neuroscience; Health in an aging population	Structural Neurobiology — University of Toronto	Oliver Ernst	Charité - Universitätsmedizin, Germany
Health in an aging population	Virology — University of Alberta	Michael Houghton	Epiphany Biosciences, USA
Regenerative medicine; Health in an aging population; Neuroscience; Biomedical engineering and medical technologies	Diabetes — University of Alberta	Patrik Rorsman	University of Oxford, United Kingdom
Biomedical engineering and medical technologies	Integrative Biology — University of Toronto	Frederick Roth	Harvard Medical School, USA
Information and Communications Technologies (ICT)			
Broadband networks; Telecommunications equipment	Quantum Nonlinear Optics — University of Ottawa	Robert W. Boyd	University of Rochester, USA
New media, animation and games; Wireless networks and services; Broadband networks; Telecommunications equipment	Quantum Information Processing — University of Waterloo	David Cory	Massachusetts Institute of Technology, USA
Broadband networks; Telecommunications equipment	Enabling Photonic Innovations for Information and Communication — Université Laval	Younès Messaddeq	Universidade Estadual Paulista, Brazil
New media, animation and games; Telecommunications equipment	Quantum Signal Processing — Université de Sherbrooke	Bertrand Reulet	Laboratoire de physique des solides at the Université Paris-Sud XI, France

- The Banting Postdoctoral Fellowships Program, launched in July 2010, provides $45 million over five years to attract and retain top-level talent to Canada. At a steady state, 140 fellowships will be supported annually, with 70 new awards each year. Awards are tenable for two years, with a value of $70,000 per year. These fellowships are open to both Canadian and international researchers who have recently completed a PhD, PhD-equivalent or health professional degree, and up to 25 percent of Canadian awardees are eligible to go to a foreign research institution.
- In November 2010, the Ontario provincial government announced that it will be offering full scholarships for foreign PhD candidates, each worth $40,000 annually for four years. Starting in 2011–12, scholarships will be divided among the province's universities, and funded two thirds by the government and one third by the various educational institutions.

> *As a mid-sized, open, trading economy, Canada's orientation must be global if it is to access scientific knowledge generated outside our borders.*

These programs have received international attention and resulted in attracting some of the best researchers in the world to Canada, as shown on the previous pages. The targeted nature of these programs will help promote research impact on an internationally competitive basis throughout Canada.

6.3.14 Education: A Lifelong Pursuit

Adult literacy scores remain an area where it has been difficult to make progress in Canada. The Programme for the International Assessment of Adult Competencies (PIAAC) is a multi-cycle international program of assessment of adult skills and competencies initiated by the OECD that will build upon testing completed in 2003 for the *International Adult Literacy and Skills Survey* (IALSS). The IALSS tracked the knowledge and skills of 16–65 year-old Canadians in prose and document literacy, numeracy and problem solving. The OECD, in coordination with Statistics Canada, will initiate PIAAC data collection in 2011, and findings will be reported in 2013. Four areas of competence will be assessed in the PIAAC: problem-solving in a technology-rich environment; literacy; reading component measures; and numeracy.

In 2008, organizations spent an average of $787 per employee on training, learning and development (TLD) with two thirds of full-time employees taking training. This is up from 2006, when $699 per employee was spent, but still down from 1996 when the investment per employee was $842. Changes are also taking place in the type of learning employees are provided with and informal learning now accounts for 56 percent of learning, which is up significantly from 2004.[146]

An aging population, and growth in the immigrant labour force, may also further require increasing use of non-traditional sources of skill development and a lifelong approach to learning. Employers and training providers may need to adopt new approaches for specific segments of the labour force. In terms of potential gaps in the future a recent report by the Conference Board of Canada has identified that "though organizations use TLD to deal with skills shortages, few see it as a tool to retain and retrain mature workers or integrate new Canadians into their workforce."[147]

New trends in lifelong learning also have the potential to change enrolment patterns in universities, colleges and other educational institutions in Canada. Students coming out of secondary education may gradually cease to be the primary clientele of tertiary education institutions. Universities and colleges may need to organize themselves to accommodate the learning and training needs of a very diverse clientele, which may include: working, mature, stay-at-home, travelling, part-time, day, night, and weekend students. The U.S. is already noticing this change. Almost half of the student population in the U.S. consists of mature and part-time students, which is a dramatic shift from the previous generation.[148]

6.3.15 Human Resources in Science and Technology

Human resources in science and technology (HRST) is defined as persons having graduated at the tertiary level of education or employed in a science and technology occupation for which a high qualification is normally required and the innovation potential is high. The international comparison of HRST share in the labour force

[146] Conference Board of Canada, *How Canada Performs: A Report Card on Canada*, *June 2007*.

[147] Conference Board of Canada, *How Canada Performs: A Report Card on Canada, June 2007*, p. I.

[148] Tamara Knighton, Filsan Hujaleh, Joe Iacampo and Gugsa Werkneh, *Lifelong Learning Among Canadians Aged 18 to 64 Years: First Results from the 2008 Access and Support to Education and Training Survey*, 2009.

MW Canada Ltd in Cambridge encourages research and development and staff education and training to increase productivity and business.

Investing in Technology and Training

MW Canada Ltd in Cambridge, Ontario reinvented itself over the last few years by focusing on engineered materials for customer-specific end uses. The company produces decorative and functional materials for the home decorative and institutional contract markets. Advanced solutions and value-added properties are key to satisfying their customers' needs. Combining materials to get the desired results requires new ways of thinking, and new technologies. Culture change, comprehensive training initiatives, innovation, R&D and commercialization are the road to the future.

A strategic decision was made in 2005 when MW Canada's training room "The ER" (Education Room) was constructed with the help of the Textiles Human Resources Council (THRC). The investment in upgrading the skills of employees to ensure they have the technical expertise for the future, made good business sense. The company encourages education and training initiatives that position employees in line with company strategy. There is a commitment to investing in the current workforce, people who know the history, and are ready to embrace the future.

Over the past five years, MW Canada has been building training programs both in-house, and in partnership with external organizations such as The Literacy Group of Waterloo Region. A full-time R&D position was created in 2009 to coordinate outside proprietary initiatives. The company is currently working on R&D projects with universities on the development of: new solar materials, energy storage materials, self-cleaning and antibacterial finishes. Research is also being done into reflective materials, insulating materials, and materials created using nanotechnology techniques.

All of these projects are long term and require ongoing funding. Company, academic, community and government partnerships are critical to the collective success of these projects.

presented in Figure 40 utilizes a broad classification of HRST, which includes all professionals, technicians, and similar occupations, and shows that these employees are more concentrated in services than in manufacturing.[149] In addition, Figure 41 demonstrates that growth in HRST employment in Canada has increased for services and manufacturing industries.

6.3.16 Business Researchers

The OECD defines researchers as professionals engaged in the conception and creation of new knowledge, products, processes, methods and systems who are directly involved in the management of projects. The average annual growth rate in the number of business researchers from 1997 to 2005 was just under 6 percent in Canada (Figure 42).

6.3.17 Making Use of Highly Skilled People to Improve Productivity Growth

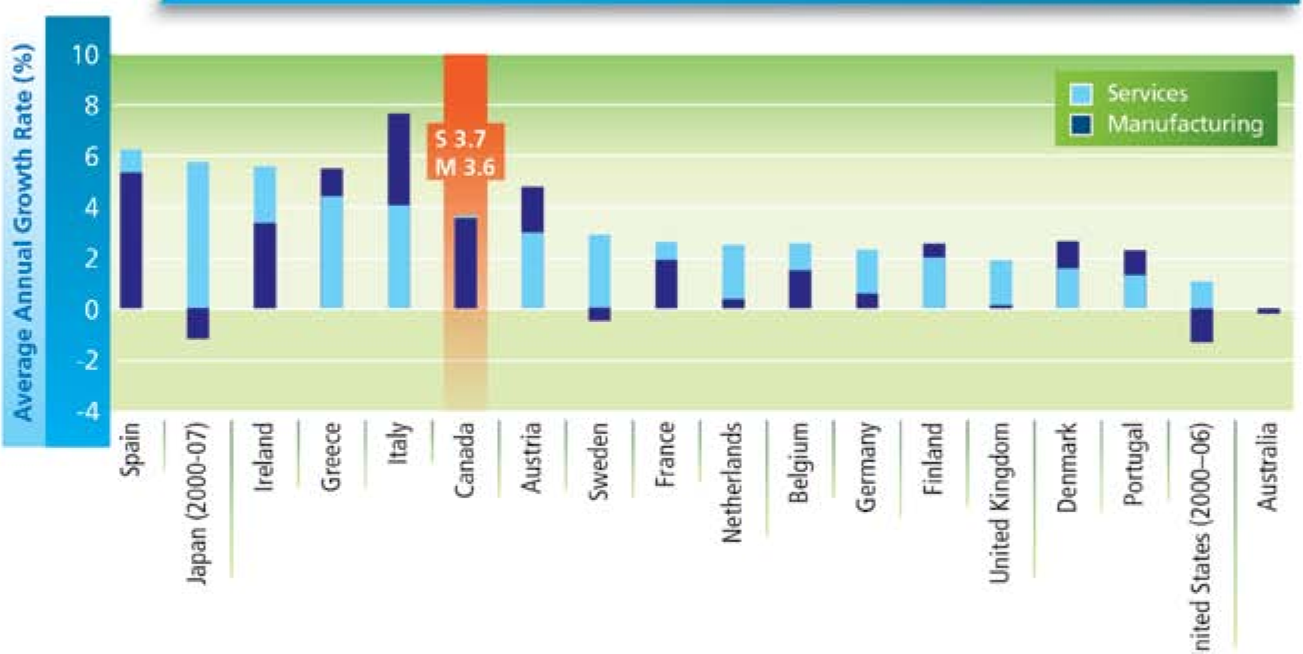
The share of the population with a university education (i.e., highly skilled people) is regarded as an indicator of a country's supply of innovative talent. The employment of highly skilled people is central to firms using the most advanced technologies and creating innovative products, services, and putting in place the best organizational practices. Canadian firms make less use of highly skilled people than the United States but more than the European Union (Figure 43). Moreover, data collection differences may overestimate the degree to which Canadian companies use highly skilled people.[150]

[149] The classification and chart come from the OECD's *Science, Technology and Industry Outlook 2010*, and are based on the International Standard Classification for Occupations-88 (ISCO-88). The definition includes all professionals, technicians and related occupations and is consequently much broader than what would usually be considered occupations involved in science and technology. For example, police, insurance salespeople, travel agents, and accountants are included in this definition, as are engineers, chemists, and robotic equipment controllers.

Figure 40 Share of Human Resources in Science and Technology (HRST) Employees by Industry, 2007

Source: OECD (2009), *Science, Technology and Industry Scoreboard.*

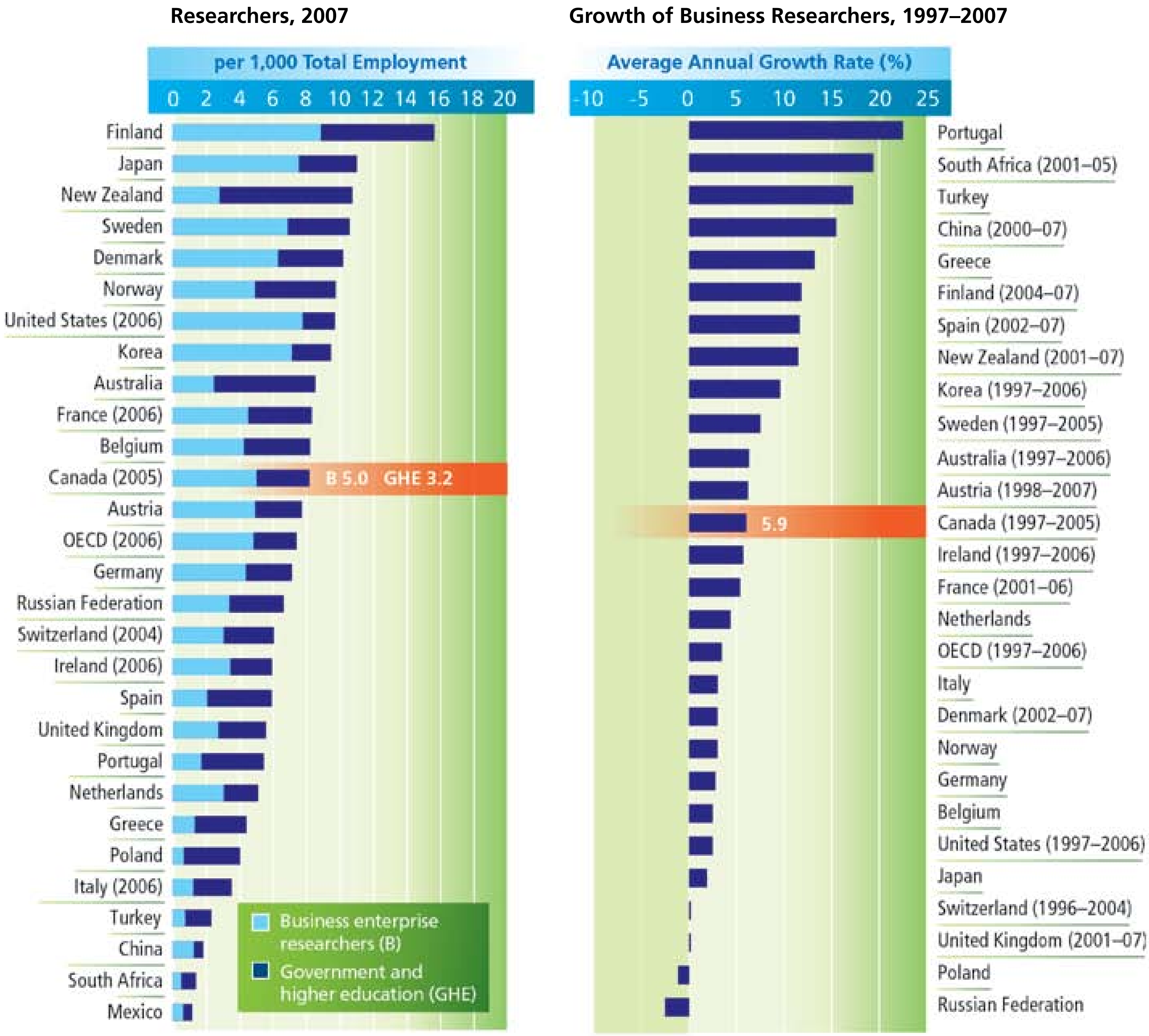
Figure 41 Growth of HRST Employees by Industry, 1997–2007



Source: OECD (2009), *Science, Technology and Industry Scoreboard 2009*, p. 137.

150 The EU KLEMs database uses the following definitions: High skill — College graduate and above; Medium skill — High school and some years of college (but not completed); Low skill — Less then high school and some years of high school (but not completed). Due to slight differences in national classifications international comparability may be affected. When comparing, for example, Canadian, U.S. and EU data there may be an underestimation of 'high skilled' data from the EU.

Figure 42 Researchers, 2007 and Growth of Business Researchers, 1997–2007



Source: OECD (2009), *Science, Technology and Industry Scoreboard 2009*, p. 41. (**http://dx.doi.org/10.1787/742515411553**) and (**http://dx.doi.org/10.1787/742528481768**)

Figure 43 Share of Total Hours Worked by Skill Level, Canada, United States and EU15ex*, 2004

Industry or SECTOR	Canada		United States		EU15ex	
	High Skill	Medium Skill	High Skill	Medium Skill	High Skill	Medium Skill
GOODS SECTOR						
AGRICULTURE, FORESTRY, FISHING AND HUNTING SECTOR	5.22	81.14	15.03	61.55	3.70	61.59
MINING AND QUARRYING SECTOR	13.31	84.55	20.57	66.60	11.83	69.76
UTILITIES SECTOR	20.87	78.65	32.18	64.90	12.78	72.75
CONSTRUCTION SECTOR	6.89	88.48	11.68	66.68	4.72	66.12
MANUFACTURING SECTOR	15.72	79.39	23.15	63.01	9.04	68.95
SERVICES SECTOR						
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel industries	4.65	89.73	11.30	74.29	6.14	71.53
Wholesale trade and commission trade, except of motor vehicles and motorcycles industries	17.79	79.95	29.74	62.49	6.39	72.37
Retail trade, except of motor vehicles and motorcycles; repair of household goods industries	11.41	85.75	20.26	68.92	6.01	70.33
Hotels and restaurants industries	9.44	86.02	12.90	65.21	5.10	69.57
Transport and storage industries	9.69	85.69	18.54	69.64	5.95	71.90
Post and telecommunications industries	19.88	78.85	42.04	56.43	12.06	71.13
Financial intermediation industries	32.60	66.98	44.35	53.91	22.56	71.10
Real estate activities industries	21.14	76.14	37.82	56.54	26.12	55.47
Renting of M&E and other business activities industries	45.50	53.98	47.31	46.75	29.98	54.27
Public administration and defence; compulsory social security industries	40.22	58.79	30.71	66.16	19.68	67.58
Education industries	41.57	57.45	68.54	29.05	47.52	44.32
Health and social work industries	35.65	62.78	39.50	55.83	19.90	66.30
Other community, social and personal services industries	23.60	73.68	32.43	58.99	14.75	62.38
Private households with employed persons industries	7.86	88.57	8.34	58.31	6.59	72.18
AVERAGE FOR SERVICE SECTOR	22.93	74.60	31.70	58.75	16.34	65.75
Average of all Industries and Sectors	**20.16**	**76.66**	**28.76**	**60.28**	**14.26**	**66.30**

* EU15ex consists of Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Spain and the United Kingdom.
Source: Compilation by STIC Secretariat based on data from EU KLEMS.

7 Conclusion

An excellent talent pool and increased efforts by government, higher education and some industries are not preventing stagnation in Canada's overall innovation performance. This assessment is based on an evaluation of indicators that measure more than R&D expenditure and is reflected in slowing productivity growth in many industries.

Despite an overall economic performance the past two years that has exceeded that of its major trading partners, the current level of effort by all performing sectors has not been sufficient to bring Canada's expenditures in R&D to the G7 average. As a country we have seen our R&D to GDP ratio decline. Expenditures on R&D in China and Korea have outpaced strong GDP growth in those countries (Figure 2).

In real terms, R&D expenditures by the higher education sector have been increasing. Funding to higher education is the largest component of federal R&D expenditures and this component continues to increase in real terms (Figure 7).

Canada's low private sector research and development participation limits overall innovation performance. While higher education R&D continues to increase, business R&D expenditures have been decreasing in real terms since 2006 (Figure 4). Canada's business R&D spending in many industries is also low by international standards. OECD data in 2005 indicate that, in 8 of 16 industries it tracks, Canadian businesses' performance of R&D falls below the OECD average in the same industry. Canada's lagging business R&D is a function of both its industrial structure, in which research-based industries comprise a relatively small part of the economy, and of the relatively lower R&D expenditures of other industries.

Canadian industry also tends to invest significantly less in ICT equipment than selected comparator countries — exceptions being in utilities, post and telecommunications, wood manufacturing, and public administration and defence. R&D and investment in ICT both contribute to productivity-enhancing innovation.

While investment in ICT by Canadian industries generally lags such investments in other countries, some Canadian sectors, such as the finance and insurance sector and the mining and quarrying sector, seem to purchase more IT services compared with the same sectors in other countries. Some companies may benefit from ICTs through the purchase of IT services, as well as investment in ICT capital. This indicator bears watching.

Industry clusters are a promising area for building paths for knowledge transfer and product development. Large companies play a smaller role in funding R&D in Canada than in other leading innovative countries. This may indicate a weak receptor capacity for spotting and using R&D or inadequate consideration of innovation opportunities in corporate strategies. Small technology intensive companies have strong receptor capacity and could benefit from the marketing and financing know-how in large companies. Both large and small companies can source talent and ideas by building strategic relationships with higher education institutions and with each other.

Current best efforts are not getting us to where we want to be. Looking ahead to a period of government restraint around the globe, Canada has the best opportunities to move forward provided industry seizes leadership in doing so. The job of those who partner with industry (including governments and higher education and research institutions) is to enable performance gains by adapting, consolidating and simplifying the policy instruments and mechanisms for collaborating with the private sector on innovation. The *2012 State of the Nation* report will measure the outcomes of these efforts.

Appendix A: Research and Development Sub-Priorities

Recommended by the Science, Technology and Innovation Council and endorsed by the Minister of Industry in 2008

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

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

Appendix B: *State of the Nation 2008* Areas for Attention

Talent — developing a highly qualified workforce attuned to innovation opportunities

- Young Canadians are excelling in science, mathematics and reading in comparison to their peers around the world, ranking in the top five in each of these categories. We must keep up with others who are improving their rankings.
- In comparison to those in other OECD countries, few Canadian students are completing master's and doctoral programs in areas that drive discovery and innovation. Companies, governments, and universities can encourage more Canadians to complete advanced degrees by educating students on the range of S&T careers and providing students with career opportunities in S&T development, application, management and financing.
- Canadians in the workplace who apply and adapt new technologies can drive innovation to new levels. Canada has not made progress in a decade in increasing the proportion of Canadians with basic literacy and numeracy skills. Governments and employers must champion adult literacy and technology training to address this skills deficit.

Knowledge development and transfer

- In Canada, governments at different levels and the private sector have chosen to build research capacity at institutions of higher learning. Focusing resources of all sectors on research priorities, conducting research at international levels of excellence and better using research facilities at universities and colleges to train students in state-of-the-art facilities can help improve innovation performance and benefit companies.
- Turning R&D excellence into jobs and a better quality of life depends on building strong connections among customers and suppliers, scientists and managers and managers and teachers. We need to advance the transfer of knowledge between science and business.

Business innovation

- Canadian companies do not invest as much as their competitors around the world in R&D. We have made little progress in understanding why these competitors are more likely to see investments in the lab and on the shop floor as contributing to their business goals. This understanding is fundamental to evaluating the efficacy of policy instruments to stimulate innovation.
- How Canadian technology companies finance their ventures and the availability of different sources of risk capital at different stages of business development can have a significant impact on commercialization success. Business associations and the venture capital industry can assist in the understanding of this area.

Tracking progress

- More resources and greater effort must be devoted within the innovation system to capturing data, which better explain how individuals, companies and other institutions innovate. This can be done through business R&D and innovation surveys, sector-specific technology surveys and user surveys on information technologies and their applications. Without the tools to understand how innovation happens, we will be unable to formulate appropriate strategies for improving innovation performance.

All participants in the innovation system have a role to play in strengthening Canada's innovation capabilities. In the STIC's view, Canada has strong foundations on which to build. Many Canadians are leading the way with the support of all levels of government. If we adapt international best practices for Canada, focus our domestic efforts, maintain a watch on key indicators for success, relentlessly test the efficacy of our innovation support mechanisms, and act quickly to address areas of weakness, Canada will be able to compete with the best.