

Momentum: The 2008 report on university research and knowledge mobilization

A PRIMER

CHAPTER 1: Canadian R&D investments and activities

In 2007, an estimated \$29 billion was invested in research in Canada.

- In 2007, the private sector invested an estimated \$13.8 billion in R&D representing 47.8 percent of Canada's overall research funding.
- The federal government invested an estimated \$5.4 billion in 2007, or 18.8 percent of Canada's overall research funding.
- Universities are also major supporters of research, funding an estimated \$4.8 billion in 2007, or 16.4 percent of overall research investments in the country.
- Funding from foreign sources for research accounted for an estimated \$2.6 billion in Canada in 2007 (nine percent).
- In 2007, provincial governments provided an estimated \$1.5 billion in research funding (5.1 percent) while the not-for-profit sector contributed \$850 million (2.9 percent).

All domestic funders of research have increased their investments over the last 15 years, though the overall rate of growth has slowed significantly since 2001.

- Over the period from 1992 to 2007, combined investments by the six sectors profiled increased at an average rate of 4.5 percent annually in real dollar terms. Investments increased by 93 percent overall over the period, though this growth was by no means constant.
- In the early 1990s, R&D investments were affected by a serious economic downturn and the federal government's focus on eliminating a growing budget deficit and reducing the public debt.
- In the second half of the 1990s, the economic situation of the country improved as the federal government eliminated its budget deficit and began renewing its commitment to research.
- The decline of the information and communications sector in 2001 led to two years of stagnation in R&D investments, particularly those of the private sector.
- Since 2003, overall growth has resumed, but at an average rate of 2.1 percent annually, four times lower than the rate that characterized the period from 1996 to 2001.

Over the last 15 years, research activities in the private sector and universities contributed most significantly to the increase in Canada's overall research performance.

- In 2007, private sector research accounted for an estimated 54 percent of all research activities performed in the country, valued at \$15.8 billion.
- Canada's private sector performs a smaller share (54 percent) of the country's overall research activities than is the case in key comparator countries.

- Private sector R&D activities are highly concentrated, with only 100 firms accounting for more than 50 percent of activities across the country. As a consequence, these activities are also more concentrated geographically than in the other major research-performing sectors.
- The university sector is the second largest performer of research in Canada. In 2007, Canadian universities performed an estimated 36 percent of R&D activities in the country, worth \$10.4 billion. This share is significantly larger than the OECD average (17 percent) or than that of key comparator countries such as the U.S. (14 percent) or the U.K. (26 percent).
- A key feature that distinguishes Canadian universities' R&D effort is that they perform most of the country's basic research. University research is also widely dispersed geographically, with significant research activities in all 10 provinces.
- In 2007, federal government departments and agencies conducted an estimated \$2.3 billion worth of research, amounting to eight percent of overall research activities in the country.

In 2007, an estimated \$10.4 billion was invested in university research.

- In 2007, external sources provided almost \$5.7 billion for university research, accounting for 54.4 percent of overall funding. The balance, which Statistics Canada estimated to be almost \$4.8 billion, was allocated internally by universities themselves.
- The federal government is the primary external funder of university research and an important catalyst for investments by several other sectors. In 2007, the federal government accounted for approximately 49 percent of universities' external research funding, or \$2.8 billion.
- Provinces were the second largest external funders of university research in 2007, providing close to \$1.1 billion (19 percent) of external funding.
- In 2007, the private sector contributed \$881 million to university research. At 6.4 percent of its total research investments, the private sector invests a higher proportion of its R&D expenditures in universities than is the case in all other G7 countries and all but three OECD countries.
- The not-for-profit sector invested \$813 million in university research in 2007.
- In 2007, Canadian universities attracted \$127 million in funding from foreign organizations.

Public investments in university research over the past decade have been designed to create an internationally competitive and sustainable research effort.

- Federal investments have focused on four interrelated, foundational elements:
 - Developing, attracting and retaining highly qualified talent (**people**);
 - Putting in place and operating cutting-edge research infrastructure and facilities (**infrastructure and facilities**);
 - Producing new ideas (**direct costs of research**);
 - Providing institutional support for the research effort (**institutional costs of research**).
- These foundational elements of university research do not exist in isolation from other complementary investments in funding for the teaching and community service missions of universities or for the funding of other sectors of the Canada research system.
- Even the "right" mix and level of funding of the four foundational elements of the university research enterprise do not guarantee that benefits will be maximized if other aspects of the university funding system or the national R&D funding system are in disequilibrium.
- To define the appropriate mix and level of funding for university research in Canada, policy makers, funders and performers of university research must consider:
 - What is the inter-relationship among the four foundational elements of university research funding and what impacts do changes to one or more components of this research ecology have on the university research environment as a whole?

- How can funders of university research best contribute to achieving and maintaining the appropriate mix and level of support for all four foundational elements, both for existing research initiatives and for emerging ones?
- What is the appropriate balance to be struck between support for broad-based, discovery-oriented research across a wide variety of disciplines, and investments in specific and targeted “strategic priorities”?

CHAPTER 2: Drivers of change

Driver 1: Recognition of the link between university R&D and national prosperity/quality of life

- In today’s global economy, there is a heightened recognition that a strong domestic R&D system contributes not only to long-term economic growth and national prosperity, but also to education, health, the environment, culture and civil society.
- Both in Canada and internationally, R&D has gone from being a component of countries’ national competitiveness strategies to a central driver.
- Most national R&D strategies follow a common pattern reflecting an international consensus on the key elements needed to compete and prosper, which includes a focus on enhancing private sector innovation and recognizing the critical role universities play in national innovation systems, both as performers of basic and applied research and as providers of highly qualified personnel for all sectors.
- While national innovation strategies provide a broad overview of S&T priorities and intentions, gross expenditures on R&D (GERD) as a percentage of gross domestic product (GDP) is a measure of a country’s actual research intensity.
- Several countries have set national GERD to GDP targets as part of their innovation strategies and use this indicator to measure the impact of their collective efforts.
- With a GERD to GDP ratio of 1.94 percent in 2006 (the last year of internationally comparable data) Canada ranked 12th among OECD nations and was significantly below the OECD average of 2.25 percent.

Driver 2: Global race for research talent

- While Canada now has the largest and most diverse faculty complement in its history, with almost 41,000 full-time members, Canadian institutions face a significant challenge in retaining and recruiting faculty given the worldwide competition for talent and the current age distribution of Canadian faculty.
- The combination of faculty retirements and attrition, as well as enrolment growth, will translate into a need to replace more than 20,000 faculty members by 2016, and to hire some 10,000 to 15,000 additional faculty over the same period.
- This challenge is compounded by the fact that many more advanced degree-holders across all sectors of the economy are approaching retirement age than was the case two decades ago.
- Moreover, between 1990 and 2006, the Canadian economy generated an additional 560,000 jobs for people with postgraduate degrees (primarily master’s and doctoral graduates) an increase of more than 90 percent over this 15-year period.
- To meet this rising demand for highly educated employees, Canada has relied increasingly on immigrants who earned their doctorates abroad, as well as on foreign students. Yet while Canadian universities are attracting more foreign students to doctoral programs than ever before, fewer of these graduates are choosing to remain in Canada.

- To ensure that Canada has the requisite number of highly qualified personnel for all sectors of the workforce, universities will need both to increase the size of the domestic talent pool and to attract more students from abroad.
- However, relative to the size of its population, Canada currently awards only half as many master's degrees and one-third fewer PhDs annually than the U.S.

Driver 3: Growing complexity and costs of research

- Technological advances have created expectations that an increasingly wide range of problems can be researched and addressed in a more holistic fashion and at an accelerated pace.
- Consequently, the research enterprise is becoming larger and more complex, with a stronger focus on knowledge mobilization and applications, all of which add to the costs of research.
- Journal prices alone increased by 39 percent between 2000 and 2006. Also, requirements for computer processing power have escalated rapidly as researchers are now tackling problems that were previously inaccessible or which could not be solved in a reasonable time frame.
- Universities' costs are increasing more rapidly than the general rate of inflation. Between 1980 and 2006, the Consumer Price Index in Canada increased at an average rate of 3.6 percent annually while the Canadian Higher Education Price Index increased by a full percentage point more than CPI, at an average rate of 4.6 percent annually.
- Internationally, there are substantial differences in funding and support for the research environment. The U.S. has long set the pace in support for the institutional costs of research. In Canada, the federal government currently reimburses institutional costs at an overall rate of 25 percent of the total direct costs of research funded by the three federal granting agencies, excluding the salaries of principal investigators.

Driver 4: Increased emphasis on measuring R&D impact

- In recent years, there has been heightened interest in shifting from solely measuring research outputs, such as scientific publications, citations, patents and licenses, to also assessing research outcomes and impact, the effects of research on society and the economy, in order to demonstrate the value of these investments to the public.
- In Canada, the federal government's 2007 S&T strategy emphasized the importance of measuring the return on R&D investments to assess their contributions to economic and social objectives.
- The federal funding agencies are also developing impact assessment tools that relate to their respective mandates and research disciplines.
- In addition to these initiatives, the federal government has mandated the Science, Technology and Innovation Council (STIC) to benchmark Canada's S&T performance against international standards of excellence.
- Despite the challenge of measuring this impact, a number of scholars have undertaken micro- and macro-economic assessments and have concluded that the rate of return on publicly funded research is likely in the range of 28 to at least 50 percent.

Driver 5: Strong impetus and desire to partner across boundaries

- Policy makers, research administrators and research practitioners recognize that countries must heighten collaborative R&D activities across institutional, sectoral and geographic boundaries if they are to compete and contribute internationally.
- Governments increasingly view enhanced R&D collaboration as a necessary means to achieve economies of scale, address productivity gaps, strengthen knowledge mobilization and commercialization, and improve the overall well-being of their citizenry.

- Collaboration and partnerships have become features in nearly all national R&D strategies. This trend is equally prevalent both in key competitor countries and emerging economies.
- Many of the federal programs in support of university R&D introduced in the last 10 years included a collaborative dimension or objective and a culture of fostering such partnerships has clearly evolved.

CHAPTER 3: Universities' R&D partnerships

- Universities create and mobilize knowledge in collaboration with and often with support from governments, communities, the not-for-profit and private sectors and international partners. The application of university research across sectors and geography can provide any country with a significant competitive advantage.
- Chapter 3 explains the rationale for these partnerships, the breadth and depth of these relationships and the mechanisms which facilitate these collaborations.

University-private sector research collaboration

- Together, while respecting each partner's mission and culture, universities and the private sector can often transfer and implement new ideas and knowledge more efficiently and effectively.
- Through these partnerships, businesses and universities can pool their resources to reduce the financial risks to each partner and better leverage their respective investments.
- These collaborations also provide invaluable research and learning opportunities for faculty and students, as well as exposure to the business world.
- Businesses benefit from opportunities that universities create through basic research, which can transform traditional industries and lead to revolutionary new products and services.
- Cumulatively, the private sector invested \$6.5 billion in university research over the last 10 years.
- In 2006, universities undertook 6,000 research contracts with Canadian and foreign businesses valued at \$370 million.
- Twenty-five university research and science parks in Canada are home to more than 750 hi-tech companies and research centres, employing more than 39,000 people and contributing over \$3.8 billion annually to the national economy.
- In 2005, 934 Canadian scientific articles in the natural and health sciences and in engineering involved authors from both universities and the private sector, an increase of more than 80 percent over the previous 15 years.
- The federal research granting agencies fund close to 1,000 students per year to pursue internships with private sector companies.
- The Industrial R&D Internships program, which began in spring 2008, will support 1,200 interns in its first two years of existence.

University-government research collaboration

- University and government researchers share a number of complementary objectives that lead naturally to collaboration, including developing Canada's long-term discovery-oriented knowledge base, ensuring Canadians are aware and informed of current research developments, stewarding major national research facilities and contributing to public policy with regard to such priorities as the health and safety of Canadians, the environment and regional and national economic development.
- Strengthened government-university research linkages can lead to a number of mutual benefits, notably increased access to and leveraging of human, physical and financial resources, greater scope for research portfolios and reduced duplication of research efforts.

- Increased government-university linkages fuel economic development through the establishment and growth of R&D clusters, particularly when research collaborations are located in proximity to key industrial partners.
- According to an exploratory survey completed by AUCC in 2006, there are nearly 80 federal research facilities or joint federal-university research facilities located on or near 33 university campuses where research collaboration is taking place. These facilities employ approximately 3,375 federal researchers. Several hundred government researchers also teach or supervise university students as adjunct professors across Canada.
- Co-authored publications have increased between universities and the federal government over the last 10 years. In environmental research, for example, 51 percent of Environment Canada's scientific output was co-authored with Canadian university researchers in 2004.

University-community research collaboration

- Universities work with communities of place – defined by their geography, with cultural communities, and with communities of purpose, such as national and provincial not-for-profits, particularly health charities and organizations concerned with social issues and services.
- Community partnerships help universities to define and scope the research questions and provide access to research participants and sources of local expertise, as well as additional funding and in-kind contributions.
- In turn, universities provide communities with access to wide-ranging and in-depth knowledge and national and international expertise that informs and addresses community challenges and opportunities in a meaningful way.
- There are no mechanisms in place to capture comprehensively, through national data, the breath and depth of university-community partnerships and the wide range of ways in which universities engage with communities to further common interests.
- Canadian universities are physically located in 80 cities and towns across Canada and have ample opportunities to engage with their surrounding areas on research programs and projects in a number of areas, including policies and planning, physical services and social services.
- Universities have established a wide variety of programs (including chairs, centres, and institutes) relating to specific cultural communities – focusing on history and traditions, languages and literature, other facets of their culture, and their contributions and adaptations to Canada.
- Canadian universities perform research for not-for-profit organizations, particularly the health charities and foundations. While many of these funders are national organizations, they have strong roots in communities across Canada and do much of their fundraising on a local or regional basis. They work closely with many community organizations and universities to fulfill their mandates.

Universities' international research collaboration

- The proportion of universities that include an international dimension, including international research collaboration, in their strategic planning processes grew from 84 percent in 2000 to 95 percent in 2006.
- Canadian universities partner with other industrialized parts of the world, most notably the U.S., the U.K., the E.U. and Japan, as well as with emerging and developing countries.
- Universities' engagement with international partners strengthens Canada's research presence on the world stage and provides opportunities to demonstrate greater leadership in international research projects, all of which serve to heighten Canada's international contributions and competitiveness. Canadian participation in international partnerships also increase the likelihood

that Canadian expertise and perspectives will be brought to bear on global issues and that research capacity will be strengthened at home and abroad.

- In Canada, the level of international co-authorship is double that of the world average, with more than 40 percent of academic publications having co-authors from other countries.
- In 2005, the U.S. accounted for more than half (52.1 percent) of Canada's co-authored articles.
- In recent years, Canadian researchers have significantly increased co-publication rates with emerging and developing countries (from 3.4 percent in 1992 to 6.4 percent in 2003).
- In 2006, Canadian universities completed 2,092 international research contracts worth \$199 million. Of this, 1,614 contracts and approximately \$150 million came from foreign businesses.
- In 2006-07, more than 6,200 international researchers used CFI-supported infrastructure at Canadian universities, colleges and research hospitals. Approximately half of these international researchers were from the U.S., with the balance coming from 76 different countries.

Toward better collaboration with all sectors

- Given the potential that these collaborations hold for Canada's competitiveness and contributions on the world stage, more can and should be done to share lessons learned from both mature and promising new partnerships and to find innovative ways to move beyond traditional impasses to successful engagement across sectors and countries.
 - Universities and their research collaborators must understand and respect each other's mission and culture if the two are to succeed in working together over the long term.
 - For research partnerships to be successful, partners must clearly understand their respective roles and responsibilities, as well as the shared objectives and desired outcomes that motivate the proposed collaboration.
 - Governance and management models should accommodate differences and be tailored to the particular objectives and circumstances of the ongoing collaboration.
 - Research partners must acknowledge their role in contributing to the institutional costs of research from which they benefit, to ensure universities can fulfill other critical aspects of their mandate such as educating students who in turn contribute to Canada's talent pool.
 - Partnerships with other sectors also challenge some traditional university approaches to evaluating and rewarding faculty contributions.

CHAPTER 4: Benefits from university research and knowledge mobilization

Of all the forms of knowledge mobilization that result from universities' research activities, the training of highly qualified graduates in a research-rich environment has the most pronounced impact and importance.

- University graduates contribute their analytical skills, their knowledge and an understanding of how to deploy, apply and grow that knowledge for society's benefit.
- The research skills that graduates bring to their careers in other sectors also create an important receptor capacity for new ideas and innovations.
- Between 1997 and 2007, approximately 1.53 million bachelor's and first professional degrees, 306,600 master's degrees and 44,300 doctoral degrees were awarded in Canada.
- During this period, master's degrees grew most significantly, by 68 percent, followed by bachelor's and first professional degrees, which grew by 31 percent, and doctoral degrees, which increased by 18 percent.

- In 2006, employment of doctoral graduates aged 25 to 64 rose to record levels. PhD graduates were employed in more than 122,000 full- and part-time positions in Canada, a 30 percent increase since 2001.
- Overall employment growth for university graduates is outpacing the growth in the number of graduates awarded degrees by Canadian universities. As a result, Canada is growing increasingly reliant on immigration to meet labour market demand for university graduates.

University graduates generate significant individual and societal returns.

- Over the longer-term, Canada benefits from many of the attributes of university graduates, such as their entrepreneurship, their responsiveness and adaptability, and their propensity to engage in life-long learning.
- Over the course of their careers, individuals with bachelor's degrees from Canadian universities earn, on average, \$1 million more than those with only a high school education.
- University graduates are more likely to live longer, make fewer visits to medical professionals and generally enjoy better health. They are also less likely to require many of the social services provided by governments.
- In Canada, while university graduates made up about 22 percent of the population aged 25 to 64 in 2006, they accounted for 34 percent of earnings, contributed 40 percent of the income tax base and received only 13 percent of the direct government transfers to individuals.

University research creates benefits for Canada and the world by generating new ideas and discoveries – a reservoir of knowledge which governments, communities, businesses and the not-for-profit sector can use to understand and address problems and issues.

- Universities create and house collections and databases that play crucial roles as platforms for research and dissemination of knowledge of cultural and scientific value.
- Canadian researchers contribute to internationally acclaimed research breakthroughs and are publishing their findings at proportionately higher levels than many other countries.
- While Canada accounts for only one half of one percent of the world's population, its publications accounted for 4.7 percent of the world total in 2005, resulting in an eighth place ranking in the world.
- Canada ranks well in terms of its citations. For the period 1997-2007, Canada ranked sixth internationally for its cumulative number of citations, and third among G7 countries for the number of citations per paper.
- Over the past decade, Canada has worked to turn its "brain drain" into a "brain gain" and has successfully attracted a number of high profile and leading researchers to Canadian institutions. More than 650 researchers have been recruited internationally and awarded Canada Research Chairs since the program was launched in 2000.
- Recent international awards won by Canadian researchers as well as their appointment to prestigious foreign bodies provide some evidence of more frequent and more prominent recognition on the world stage.

People and knowledge that emanate from a research-rich university environment are key to fuelling innovations in products, processes and services as well as new policies and ways of thinking and behaving.

- Traditionally, measures of the degree to which university research is commercialized have been the principal quantitative indicators of the application of knowledge.

- The 2006 data on total income derived from the commercialization of university IP indicate that overall income increased by 131 percent since 1999, to \$54 million. These figures suggest universities collectively remain on track to meet the tripling target of \$70.2 million by 2010.
- Canadian universities are also making significant progress on a number of contextual commercialization indicators including new patent applications, number of spin-offs, new licenses and value of industrial research contracts.
- However, while these remain useful measures of research outcomes, they provide only a limited summary of universities' contributions. Consequently, this edition of *Momentum* provides more than 50 institutional examples of partnerships and innovations that have resulted or will result in benefit for Canadians and the world.
- These examples demonstrate that universities across the country are contributing concretely to innovation in the private and not-for-profit sectors, in government and in communities, both locally and globally and that universities' research efforts can result in new and cost-effective ways of doing business and performing everyday tasks, whether they be in a manufacturing plant, a small business, a major resource sector or in the home. The outcomes of university research partnerships have also led to improvements and efficiencies in the provision of services, and to new policies and applications in both the private and public sectors.
- Fernand Martin, a professor at the Université de Montréal, has developed a model that estimates the cumulative dynamic impact of university research on the Canadian GDP. While Dr. Martin's model cannot provide a comprehensive account of the impact that university research and educational activities have on the country, his work does suggest the extent to which these activities play a seminal role in fuelling the Canadian economy and contributing to Canadians' quality of life.
- The most recent update of Dr. Martin's model, for the year 2007, estimates the dynamic impact of universities' contributions to the economy through R&D to be at least \$60 billion.
- Given this cumulative economic impact and the wider non-economic impact on Canadian society and culture, university research is a critical driver of prosperity and quality of life in Canada.