

The Role of the Federal Government in the Development of the Public Research Base in the Toronto Region



A Pro Bono Report to
The Toronto Region Research Alliance
By The Boston Consulting Group

December 15, 2005

The future prosperity of Canada will rest increasingly on the strength of the science and research-based industry clusters in our largest city regions. The Toronto region (embracing Hamilton, Guelph, the Waterloo region and the Greater Toronto Area or GTA), is home to a larger number of world scale clusters than any other region in Canada. In sectors as diverse as financial services, automotive, biotechnology and pharmaceutical, information technology, communications, advanced manufacturing, and media and cultural industries, the Toronto region ranks among the leading regions in North America and in some cases the world.

Moreover, these Toronto region clusters are in many cases linked to important industries in other regions. The information technology sector in the Toronto area, for example, is intimately linked through direct investments and supplier and customer relationships with the information technology clusters in the rest of the country. For example, Research in Motion (the Waterloo-based creator of the Blackberry) has recently announced a large customer service and technology centre in Halifax which will generate over 400 jobs in Nova Scotia.

A critical support to these clusters is the public research and technology base in the region. Our universities, colleges, teaching hospitals, and other public research facilities and programs play an important role in training and developing the skilled talent needed in these industries and in fuelling the fundamental discoveries in science and technology which lead to new products, processes, companies and jobs.

The Toronto Region Research Alliance (TRRA) was created to help develop and promote the vision and actions necessary to make this region a world-leading centre for research and research-driven industry. One of the critical elements in that vision is the region's partnership with the federal government. This report analyzes the support provided to the region's public research infrastructure by the federal government and makes recommendations as to how and where the federal government should invest going forward.

THE TORONTO REGION'S POTENTIAL

The Toronto region today accounts for 20 percent of Canada's gross domestic product and performs over 35 percent of all the research and development (public and private) carried out in Canada (BCG Analysis of Statistics Canada data). The research infrastructure in the region today puts it among a select number of premier research regions in the world.

With eight universities and 10 colleges, the Toronto region has the highest concentration of post-secondary institutions in the country and attracts top academics and students from across Canada and around the world. It is difficult to measure the output of scientists, but one accepted measure is the number of times a researcher's work is cited by other researchers.

Using the citation analysis performed by ISI (bibliometric database for scientific journals) which examined the locations of the 5,800 most highly cited researchers across the major scientific fields around the world, The Boston Consulting Group identified 53 Toronto region academics and researchers among this eminent group of scientists, including 34 in the GTA alone. (See Exhibit 1). These 53 represent a third of all the most highly cited scientists in Canada and, at 8.4 researchers per million residents, represent a much higher proportion of the population than the most highly cited scientists represent in countries such as Sweden, UK, Australia, Germany, France, Japan, and many others. In fact Sweden, which has roughly the same population as the Toronto region, has only 6.1 per million of the most highly cited scientists in the world vs. the Toronto region's 8.4. Australia, with more than three times the population, has only 4.8 per million. (See Exhibit 2).

The fields represented by this research excellence are quite diverse. They include the basic disciplines of biology, chemistry, physics, medicine, and engineering but also materials science, space sciences, environmental sciences, plant and animal sciences, the social sciences, and others. The very diversity of our research base is a key strength, especially in those areas where interdisciplinary work is becoming more critical. For example, computing and medicine are converging in areas such as mapping the human genome and delivering health services more effectively through information technology. In such areas of scientific convergence the Toronto region has a compelling position.

TRRA has put a special focus on developing world leading capacity in the Toronto region in three areas where the region already has a critical mass of public and university research as well as research-based industry. Those three areas are:

- Biotech and life sciences
- Materials science and advanced manufacturing
- Information and communication technology

Biotech and life sciences is a growing strength. The Toronto region hosts the third-largest medical-hospital complex in North America, comprising more than 60 hospitals, 37 medical institutions, 8,200 physicians and 54,000 health professionals. The 12 research hospitals affiliated with the University of Toronto and McMaster University are a special resource boasting numerous world-recognized researchers in many fields. As a sign of strength, the University of Toronto's medical school faculty is ranked third among all medical schools in the number of times its faculty's papers are cited by other researchers. In addition there are key assets at York University such as its Centre for Research in Mass Spectrometry and its Centre for Vision Research and at Guelph with its leading veterinary college. Because of this biomedical capacity, the Toronto region is home to the fourth largest pharmaceutical and biotechnology industry cluster in North America, comprised of 700 firms, 140,000 jobs and \$4 billion in revenue.

The advanced manufacturing sector draws its strength from the large base of basic and applied research in engineering, materials science, nanotechnology, photonics, and related sciences in the core research universities. The colleges in the region also provide significant support to training and applied research in the materials and manufacturing sectors. The industrial clusters in automotive, steel, aerospace, metals forming, plastics, and related fields are both users of the skilled graduates in these fields and also partners for applied research and development. The Ryerson Institute for Aerospace Design and Innovation is just one example of how our educational institutions are partnering with industry for both skills training and applied research.

Of special note, the Toronto region boasts the second largest automotive cluster in North America and while the industry has recently moved into a period of consolidation, there remain significant opportunities for Toronto to continue to gain share in this sector – especially in the more research and development intensive parts of the business. The General Motors Beacon research project with its university and college investments at locations like the Ontario Institute of Technology illustrates the growing commitment to research and development in Ontario coming from the industry.

Information and communication technology is one of the region's most globally acknowledged strengths.

Home grown companies like Nortel, RIM, Open Text, Alias, Algorithmics, Gennum, and many others are known around the world for their very special products and technologies. The publicly funded research system has been critical to the success of these companies and others in this cluster. The University of Waterloo and University of Toronto graduates in software are prized around the world for their skills and innovative solutions. In addition the colleges and other universities in the region contribute significant numbers of high quality graduates to the industry. The region also has a collection of very successful private sector labs that are anchors in the global research and development systems of major multinationals such as IBM (with over 2,500 staff at its Markham software lab) and Xerox's Research Centre of Canada which generates over 10 percent of all Xerox's worldwide patents.

All of these strengths are enhanced by the high levels of skilled immigrants coming to the Toronto region. Currently over 100,000 immigrants a year come to the region and almost three quarters of those over age 15 have a post-secondary certificate or degree. The skills of these immigrants blend with the skills of our own graduates to create one of the most highly skilled workforces in the world. Healthy, publicly funded research institutions are a critical element of the training and development of this workforce. If students are to be able to work at the leading edge of industry, they need to be trained in state-of-the-art facilities working with world class faculty.

To maintain research excellence in the region, a partnership is needed between the research institutions, the provincial government, and the federal government. Industry must also be a partner, but the vast majority of public research will need to be funded by the provincial and federal governments. The federal role in that partnership will be critical and as we shall see below, there are several areas where federal support has lagged what the region needs and deserves.

THE FEDERAL RESEARCH ROLE IN THE REGION

The federal government funds public research in the Toronto region in two basic ways: through federal grants from research granting councils to individual researchers and universities, research hospitals, and other public research institutions and through direct investments in federal research facilities such as the Public Health Agency of Canada's Laboratory for Foodborne Zoonoses in Guelph. The federal government also participates in funding public-private applied research through programs such as the Canada Networks of Centres of Excellence.

Both the Ontario and federal governments have significantly increased research funding over the past decade. Federal research funding has increased by more than 50 percent since 1996 to \$7.5 billion annually across Canada.

Ontario has significantly increased its support for research and development, announcing \$730 million for the Ontario Research Fund through 2007-08 and an additional \$142 million for cancer research through 2007-08. This is on top of funding for the Ontario Centres of Excellence, MaRS, and Regional Innovation Networks as well as the \$6.2 billion in funding for post-secondary education (through 2009-10) following on the Rae Report. Both the federal and Ontario governments also support research and development in the private sector through tax credits, loans, and grants.

The largest share of federal research funding to the region is delivered through the main federal research granting agencies including the Canada Foundation for Innovation (CFI), the Natural Sciences and Engineering Research Council of Canada (NSERC), Canadian Institutes of Health Research (CIHR), and the Social Sciences and Humanities Research Council of Canada (SSHRC). Across the region as a whole (including the GTA, Hamilton, Guelph, and the Waterloo region), federal grants from these agencies totalled \$438 million in the most recent reporting year, including \$285 million in the GTA alone. This \$438 million represents 21.1 percent of the total \$2,071 million distributed by those agencies across Canada.

This figure is surprising given that the Toronto region performs over 35 percent of all the research and development in the country and accounts for 33 percent of our most highly cited scientists.

One would expect that with the region's high level of research excellence and large R&D industry clusters, a higher proportion of federal research funding would be invested in the region.

In fact, while Toronto region institutions have received the largest amount of funding given to any city region, the Toronto region is receiving the lowest funding per capita of any major Canadian urban centre. The GTA received only \$51 per capita (and the region as whole \$69 per capita) versus \$95 per capita in Vancouver, \$85 per capita in Ottawa, \$77 per capita in Montreal, and \$73 per capita in Calgary. (See Exhibit 3). This significant difference in research funding needs to be studied.

FEDERAL RESEARCH FACILITIES

The federal government supports public research through direct funding of federal research labs. The Laboratory for Foodborne Zoonoses (LFZ) of the Public Health Agency of Canada in Guelph is a good example of such a lab. The LFZ is a world recognized research leader in the study of illnesses arising from the interface among humans, animals, and the environment. Located adjacent to Guelph University, the LFZ leverages Guelph's outstanding veterinary school.

Recently, the federal government announced that it is investing \$20 million in new equipment and moving the CANMET Materials Technology Laboratory from Ottawa to McMaster University's new Innovation Park.

With a staff of over 100 scientists and technicians, this move will bring significant new critical mass to the emerging cluster of advanced materials and manufacturing expertise at McMaster University, its Brockhouse Institute of Materials Research, and elsewhere in the region such as at the University of Toronto's Nanotechnology Program, Ontario's Centre of Excellence in Materials and Manufacturing, and regional members of the Canadian Institute of Advanced Research's program in Quantum Materials.

THE NATIONAL RESEARCH COUNCIL

Historically, the National Research Council of Canada (NRC) has played a key role in boosting regional research investment and commercialization through the establishment of regional R&D anchors focused on targeted research with industrial applications. NRC facilities catalyze commercialization by bringing regional research and industry partners together to accelerate the pace of bringing new products to market.

The largest federal government direct research agency, the NRC had a total budget of \$725 million last year. It operates research programs across the country in 22 institutes, 17 research centres, and 3 major labs. (See Exhibit 4) None of these 42 facilities is in the Toronto region. The complete lack of any NRC facility in the region is hard to explain.

The time has come for the NRC to establish a major presence in the Toronto region. Such a presence is important both to ensure adequate federal support to the growing clusters and to link the important research in the region to the rest of Canada. There are in fact three major new projects in the region which all should command federal support.

There are currently two major proposals for a direct NRC investment in the region. Together, they would represent a substantial commitment to applied research in biomedical sciences and related technologies that could be of significant benefit to all Canadians. The two proposals, which have complementary strengths, are:

- A proposal from the University of Toronto and the renowned Battelle Institute (in the United States) for a National Centre for Biomedical Innovation that would speed biomedical discoveries into health care applications and attract new R&D investment. Supported by MaRS and leading research hospitals including the Hospital for Sick Children, University Health Network, Sunnybrook & Women's, Mount Sinai, and St. Michael's, this centre would be staffed by up to 250 scientists, technicians and other employees. This facility would leverage the massive network of research activity within the Toronto region and beyond, creating a national resource to accelerate the translation of innovations into novel products. The result will be positive impacts on quality of life for Canadians, the creation of jobs and an increase in national wealth both directly and indirectly.

- A joint proposal developed by York University and the Town of Markham, in partnership with the University of Waterloo, the Town of Markham, IBM and sanofi pasteur on behalf of a strong consortium of industry and community hospital participants. The unique National Institute for Convergent Technologies would co-locate researchers and industry from the biomedical and information technology sectors to conduct research where these technologies converge and commercialize their discoveries into marketable products with an emphasis on new medical devices for health care. Positioned as a catalyst for convergence, the institute will support existing, enterprising small and mid-sized businesses to foster growth in productivity and global trade, ultimately to support their transformation into the next RIM or Boston Scientific Corporation.

In addition to these two proposals for NRC funding, a third major proposal has come forward for federal funding that could be delivered either through the NRC or directly via another mechanism. This third proposal is from the University of Waterloo, the Perimeter Institute and partners such as Mike Lazaridis, co-CEO of Research In Motion. Revolutionizing the way computers work, the Institute for Quantum Computing (IQC) conducts research into ways to increase computing power by harnessing quantum information processing and mechanics. This represents a multidisciplinary endeavour, in the hopes of creating a new dialogue between computer scientists, physicists, chemists and engineers.

The ultimate vision for IQC is to catapult Ontario into the future as a world leader in quantum computing research. Quantum computing is likely to provide the solution to what follows the end of productivity gains from Moore's law – which postulates a doubling of computing capacity every 18 months for a given level of cost. This proposal has the potential to make Canada one of the pre-eminent centres of what could be the most fundamental next generation computing technology.

THE FEDERAL OPPORTUNITY

The federal government is a critical partner for the Toronto region as it seeks to take the next big step in developing its research capacity. Investments like the CANMET-MTL labs at McMaster showcase the enormous potential when the federal government partners with a regional institution to build to critical mass.

The federal government has an opportunity to increase its strategic investment in the region. Working with TRRA, the federal government should:

- Partner to develop a long-term strategy to grow the region's research hubs;
- Invest in the three new research centre proposals in downtown Toronto, Markham and Waterloo to grow the region's biomedical and information technology capabilities;
- Review the level of per capita research funding in the region; and,
- Examine ways to improve the commercialization of publicly funded research in the region.

The federal government also plays an important role in supporting private sector research and development through tax credits, loans, and grants. While this support was not the subject of this paper, the federal role in this area is also critical to the region's and Canada's economic success. As part of developing a long-term strategy to grow the region's research hubs, the federal government, the province, and the regional partners should examine ways to enhance the private sector's research and development and commercialization efforts.

Together, the federal and provincial governments and the major regional research institutions and businesses can take the Toronto region's research capacity to the next level to benefit all Canadians.

Exhibit 1: Regional Breakdown of Top Cited Researchers

REGIONAL BREAKDOWN OF TOP CITED RESEARCHERS

Urban Region	Number of Top 5800 Cited Researchers (n) ⁽¹⁾	Number of Top Cited Researchers / 1M Population
Toronto region ⁽²⁾	53	8.4
GTA	34	6.1
Montreal	19	5.2
Vancouver	18	8.2
Ottawa	11	9.6
Calgary	2	1.9
Canada	160	4.9

(1) Based on 2005 Bibliometric data, 18 categories included: Agricultural sciences, Biology & Biochemistry, Chemistry, Clinical Medicine, Ecology & Environment, Economics / Business, Engineering, Immunology, Materials Science, Mathematics, Microbiology, Molecular Biology & Genetics, Neuroscience, Pharmacology, Physics, Plant & Animal Sciences, Psychology/Psychiatry, Social Sciences, Space Sciences
 (2) Includes GTA, Hamilton, Guelph and Waterloo region
 Source: BCG Analysis, ISI Bibliometric data, Statistics Canada

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Exhibit 2: The Toronto Region Has a Broad and Deep Research Base

THE TORONTO REGION HAS A BROAD AND DEEP RESEARCH BASE It Ranks Highly When Comparing Citations of Scientists In Other Countries

The Toronto Region has 53 of the World's Most Highly Cited Scientists⁽¹⁾ ...

By Institution	
26	University of Toronto
8	McMaster University
6	University of Waterloo
6	Toronto Hospitals
4	University of Guelph
3	Other Research Centers

By Field of Study	
23	Health & Life Sciences, Medicine ⁽²⁾
11	Engineering, Computer Sciences, Geosciences, Materials Science, Physics
10	Agriculture, Environment & Animal Sciences
7	Math, Physics, Space Science
1	Economics & Business
1	Social Sciences

...And Ranks Well When Compared With Other Countries

	Highly Cited Scientists Per 1M Population
Switzerland	12.1
U.S.	12.0
Canada	4.9
• Toronto region	8.4
U.K.	6.7
Sweden	6.1
Australia	4.8
Germany	2.7
France	2.2
Japan	1.7
Italy	1.1

(1) From pool of 5,800 top cited researchers, ISI Citation Data (December 2005)
 (2) Includes Biology & Biochemistry, Chemistry, Clinical Medicine, Immunology, Microbiology, Molecular Biology & Genetics, Neuroscience, Pharmacology, Psychology/Psychiatry
 Source: BCG Analysis, ISI Citation Data (December 2005)

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Exhibit 3: Regional Breakdown of Research Funding

REGIONAL BREAKDOWN OF RESEARCH FUNDING

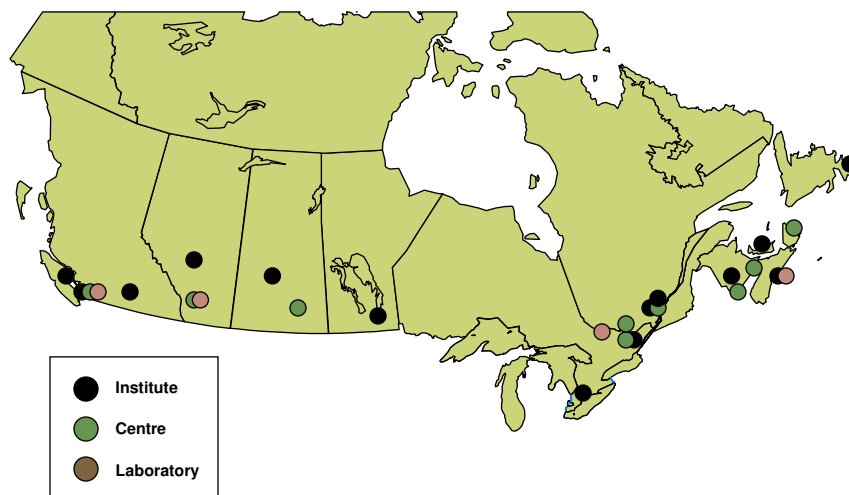
Urban Region	Selected Major Federal Funding (\$M) ⁽¹⁾	Federal Research Grants / Capita (\$)	Federal Research Grants / Regional GDP ⁽²⁾ (%)
Toronto region ⁽⁴⁾	438	69	0.19%
GTA	285	51	0.15%
Montreal	283	77	0.26%
Vancouver	207	95	0.30%
Ottawa	97	85	0.25%
Calgary	76	73	0.17%
Canada	2071	64	0.20%

(1) Includes 2004 CFI, 2004-05 CIHR, 2004-05 NSERC, 2004 SSHRC
 • 2004 GDP data based on Conference Board of Canada Metropolitan Data
 • Includes GTA, Hamilton, Guelph and Waterloo region
 Source: BCG Analysis, ISI Bibliometric data, CFI, CIHR, NSERC, SSHRC, Conference Board of Canada, Statistics Canada

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Exhibit 4: Locations of National Research Council Facilities (2005)

42 NRC INSTITUTES, CENTRES AND LABS ARE LOCATED ACROSS CANADA, BUT NONE IN THE TORONTO REGION



Source: BCG Analysis, NRC Annual Report, 2005

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