Environmental Scan
Final Report

For the Evaluation of the Research Grants Program

Prepared for:

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Natural Sciences and Engineering Research Council

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Executive Summary

For decades, the Research Grants Program of the Natural Sciences and Engineering Research Council (NSERC) has been the largest single source of funding for university research and training in the natural sciences and engineering. This paper analyses the environment in which this program finds itself at the beginning of the 21st century, at a time when the federal government announced its intention of bringing Canada in the top five countries in terms of investment in research and development (R&D).

This is a clear recognition by the federal government that R&D is key to success in the knowledge-based economy. Such an ambitious objective cannot be met unless all actors in the innovation system increase their investments: the private sector (including industry and the philanthropic sector), the provinces, and the federal government. There is also recognition that increased R&D investment will require large increases in the number of R&D workers in all sectors. A logical conclusion is that our higher education system must be in a position to train increasing numbers of highly qualified personnel through research.

The Changing Environment

The first section of the paper presents an overview of university research funding in Canada, including current and planned or proposed activities. This is followed by analysis of statistical data and projections into the future of planned increases in research funding. After a brief review of the recent evolution of the research environment, the paper discusses the implications of recent changes for NSERC and for the Research Grants Program. It raises many questions, but provides few answers. In fact, in most cases, the answer probably lies in NSERC finding an adequate balance in responding to competing priorities.

The paper shows that the research funding environment has changed in recent years with more funding sources available to institutions and researchers:

- increased recognition of the importance of research to the new economy by both levels of government and industry;
- increased funding from industry;
- increased funding for infrastructure (Canada Foundation for Innovation, or CFI), including recent expansion into international area;
- increased funding for senior fellowships (Canada Research Chairs) to help institutions attract and retain the best researchers;
- increased funding from some provincial governments (but not all provincial governments and not necessarily all disciplines); and, more recently

- increased incentives to manage intellectual property and commercialize research results;
- increased emphasis on health research (as opposed to strictly "disease-oriented" medical research), in universities and affiliated hospitals.

The way research is conducted has also evolved in the last two decades:

- the complexity of many research questions calls for multidisciplinary teams, as well as inter-institutional and inter-sectoral collaboration;
- these multidisciplinary teams often need to include individuals from the NSE, the SSH and the health sector, including people with training in two of the sectors;
- the time from idea to application is much shorter, and more and more knowledge is produced in the context of application (a clean environment, more efficient energy sources or better engineering processes) rather than from discipline-based research.

Universities themselves are changing:

- Universities had to make choices in the 1990's as their budgets were curtailed and governments had to control deficits. Faculty positions were cut.
- With deficits under control, student enrolment increasing and faculty members retiring, massive recruitment is expected in the next decade. Attracting and retaining faculty members in key areas of the NSE is and will continue to be difficult for research institutions.
- CFI and the Canada Research Chairs Program require that institutions engage in strategic planning for research (this had not been done in some of the institutions).
- Universities are increasingly taking up a third mission, that of contributing to the economy and to society; as a result, they are increasingly engaged in the transfer of research results to the user sector and in commercialization.
- University administrators are very concerned at the fact that NSERC and its sister agencies do not cover the indirect costs of the research they fund.

Analysis of trends in university research funding and projections of these data in the future show that:

- Research in health is increasing faster than research in other areas and this trend will continue;
- Within the natural sciences and engineering sector, the Research Grants Program accounts for a decreasing share of the pie; this share will continue to decrease without additional investment.
- In the past four years, the availability of budgetary surpluses has enabled the government to invest for the future by creating foundations that can spend "one-shot" allocations over a number of years. Whether the federal government will continue to create new entities to support research and research infrastructure is impossible to predict and much depends on the fiscal situation in years to come.
- In the other sectors performing research, government and industry, the share of the natural sciences and engineering is and will remain high, exceeding 85% in both sectors.

Implications and questions

Before discussing the implications of this changing environment for NSERC in general and for the Research Grants Program in particular, it may be useful to review the objective of this Program:

The objectives of the Research Grants Program are:

- promoting and maintaining a diversified base of high-quality research capability in the natural sciences and engineering in Canadian universities;
- fostering research excellence; and
- providing a stimulating environment for research training.

Over the years, NSERC has strived to meet an adequate balance between these objectives, in particular to ensure that highly qualified people were trained through research in all disciplines and across the country. Does the changing environment has implications for this balance?

The changing environment already has and will have major implications on:

- the need for highly qualified personnel in all sectors (HQP objective of the Research Grants Program, and, in fact, of all NSERC programs);
- the research capability across the country (Diversified base objective of the Research Grants Program);
- the need for Canada's research to be among the best in the world (Excellence objective of the Research Grants Program);
- whether NSERC continues to focus on individuals and disciplines, instead of teams and themes, and whether it continues to focus on programs rather than on projects (changes in the way research is done);
- the expectations that Canadian research will generate benefits to Canada (increased accountability).

It is obvious that newly launched and planned initiatives will succeed only if there are enough highly qualified researchers around to conduct excellent research. The goal to make Canada one of the most research-intensive countries in the world will not be met unless we attract the right people in sufficient numbers. Doubling R&D means major increases in the number of people involved.

The role of NSERC, via its grants and scholarships programs, and particularly via the Research Grants Program, is evident. The Canada Research Chairs Program and the Canada Foundation for Innovation are playing a major role in helping our universities attract outstanding people and offer them a stimulating environment. But these individuals will stay only if they have access to flexible and adequate research funding that enables them to exploit new ideas and become internationally competitive.

Despite the proliferation of new programs and new agencies, in many fields, the Research Grants Program is still the "only game in town". In others, researchers can use the Program as "seed money" that helps them tap other, larger sources of funds. As a result,

- Should NSERC offer a different program mix to different disciplines or areas?
- Should NSERC fund research by broad field rather than by program (for example, using NSF model of directorates by discipline or field), tailoring its programs to the needs of various communities?
- If it does not believe it is desirable to go that far, should it increase the flexibility given to the various disciplines in the Research Grants Program?

There has been, and will continue to be a massive infusion of infrastructure support via CFI and matching funding from provincial governments and other partners. To date, CFI funding distribution has been similar to that of the federal agencies. The Canada Research Chairs Program will also inject $300 million per annum. Except for 5% reserved for smaller institutions, the regional distribution will mirror that of the agencies. A number of provinces have also increased their research support programs. Other provinces (generally the less wealthy) count on the federal government to support a diversified base of high quality research and training. There is concern across the country at the increasing difficulties experienced by some smaller institutions and some regions in attracting and retaining excellent researchers, and with their relatively low success with granting agencies.

Given these pressures from various sectors, and its responsibility to support and assist research, NSERC faces difficult questions in adjusting the balance between the objectives of the Research Grants Program. What is best for the country, given NSERC mandate:

- Should the Research Grants Program put the emphasis on a diversified base to ensure that all regions and institutions have the opportunity to contribute to the knowledge-based society and to train the knowledge workers needed for that economy?
- Or is this best left to other programs (of NSERC or others)?
- If the Program chooses to focus on a diversified base, are there other programs, in NSERC or elsewhere that can support internationally competitive research at a high level?

These questions are far from easy to answer as the Research Grants Program is used extensively as a benchmark across the country. Making it past its highly regarded peer review system can have a major influence on tenure and promotion and on success in other granting programs. There is prestige to this Program.

The Research Grants Program, while encouraging collaboration and multidisciplinary research, essentially funds individual researchers in the various disciplines of science and engineering. The Program funds research programs, not specific projects, and is very flexible: if a researcher has a new idea, he or she is free to use grant funds to pursue this new avenue. Researchers can tackle many projects within the funded program, some alone, some with colleagues, some with students, some with industry, etc. This unique flexibility of the program has earned it an excellent reputation among researchers around the world.

- Does the Program with its focus on individuals and assessment of individual achievements encourage enough collaboration?
- Are grant selection committees too traditional in focusing on individual achievements and on contributions to the discipline?

The forthcoming program evaluation should help NSERC assess whether the Program strikes the right balance in fostering individual creativity while at the same time encouraging collaboration and multidisciplinary research.

The fact that researchers are free to change the direction of their research and the flexibility in the use of funds are features of the Program that enable researchers to respond quickly to new ways of doing research. This is important in times when everything changes so quickly. Reducing flexibility would certainly weaken the Program.

The relationship between universities and governments is also changing, in Canada and elsewhere. The question no longer is: what should governments be doing in support of research but, what research should be doing in support of society:

- How is research contributing to making the world better, safer and richer?
- Does this affect the Research Grants Program? Should it affect it?
- Should grantees be asked to report on results (outside the grant renewal process)?
- Should more focus be put in celebrating its results and its impacts?
- Should performance measurement be strengthened?

Environmental Scan for the Evaluation of the Research Grants Program Natural Sciences and Engineering Research Council

1 Introduction

The federal government is publicly committed to bringing Canada in the top five countries in terms of investment in research and development (R&D). This is a clear recognition that R&D is key to success in the knowledge-based economy.

As a result, there is a mood of optimism among decision-makers in the research community. All agree that such an ambitious objective cannot be met unless all actors in the innovation system increase their investments: the private sector (including industry and the philanthropic sector), the provinces, and the federal government. There is also recognition that increased R&D investment will require large increases in the number of R&D workers in all sectors. A logical conclusion is that our higher education system must be in a position to train increasing numbers of highly qualified personnel through research.

Since the bulk of private and public sector R&D is conducted in the natural sciences and engineering, this means that action is required on many fronts:

- young people have to be attracted to science and engineering (in universities and community colleges), and a larger proportion of those who graduate must choose to continue to graduate schools;
- more faculty members need to be recruited;
- both faculty members and graduate students will need research and infrastructure support.

For decades, NSERC's Research Grants Program has been the largest single source of funding for university research and training in the natural sciences and engineering. This paper analyses the environment in which this program finds itself at the beginning of the 21st century.

1.1 Objective

The objective of this paper, commissioned by NSERC for evaluation and planning purposes, is to provide information on the position of the Research Grants Program within the national research and innovation context. Indeed, it is important for NSERC to fully understand the Canadian context for the funding of university research by governments, including the changes that have occurred over the past several years, those that will likely occur and those that need to occur as Canada moves to increase its R&D capacity.

1.2 Study Questions and Methodology

In summary, NSERC formulated the following questions for study (detailed terms of references are found in Appendix 1):

- What is NSERC's current operating environment?
    - What other organizations/agencies (provincial, federal, industry) are funding research, training and infrastructure in the natural sciences and engineering (NSE) in Canada?
    - What new organizations/agencies are being planned or proposed? What are the objectives of these organizations/agencies?
    - What is the scale of investment in the NSE in Canada?
    - What is NSERC's position in this environment (i.e., what niche does NSERC and its programs occupy)?
    - To what extent are the activities of the organizations/agencies complementary? Is there overlap?
- How has the funding environment changed in the past 5 years? How has the way research is conducted changed? What is the implication of the changing environment for NSERC and the community it serves?
- What is the implication of the Federal Science and Technology (S&T) Policy, as well as current and planned federal activities, for NSERC's operating environment? for NSERC? for university researchers in the NSE?

This paper is organized as follows:

- description of the funding environment (federal and provincial research support programs), including proposed new or expanded activities;
- a broad brush picture of R&D trends in Canada, including projections into the future;
- a brief description of the changing research environment;
- discussion of the implications for NSERC and the Research Grants Program.

The main approach for this study consisted of secondary data collection – finding and updating existing information. Data collection involved searching relevant websites and contacting key individuals to ensure up-to-date information. Analysis of funding amounts was based on Statistics Canada S&T statistics and on data provided by the universities to the Canadian Association of University Business Officers (CAUBO)[1].

The last step of the study consisted of a workshop convened by NSERC to discuss the finding of this report and the implications of the changing environment. The Workshop Report, including the list of participants, is found in Appendix 2.
In parallel to this study, NSERC is conducting a survey of the research community. The results of this survey will help NSERC understand the changing environment from a university

[1] Canadian Association of University Business Officers (CAUBO). Financial Statistics of University Colleges, 1977-78 to 1998-99 (published annually by CAUBO).

perspective. In particular, it should help provide more in-depth answers on the following questions:

- How has the way research is conducted changed?
- What is the implication of the changing environment for the community served by NSERC?

2 Description of the Funding Environment

This section presents an overview of university research funding in Canada, including current and planned or proposed activities[2]. The first part summarizes federal support. The second one focuses on provincial programs.

Major sponsors of university research include:

- the federal government;
- provincial governments, through grants programs, matching funds for the Canada Foundation for Innovation (CFI) and others, as well as research contracts;
- business, through research contracts and joint support programs with the granting agencies and CFI;
- the non-profit sector, mainly through grants and awards in the biomedical fields.

Federal and provincial sources are the only ones discussed in detail in this report for the following reasons. Because the business sector provides support project by project, there are no official programs of support. Data are available only in aggregate form, as provided by universities to CAUBO. In the specific case of NSERC, there are data on amounts pledged by companies participating in research partnerships programs. The non-profit sector is a minor player in the NSE, most of the funding being directed to health research.

General research support is provided by:

- the universities themselves (mainly through provincial operating grants, in turn funded in part by the federal government via Canada Health and Social Transfers);
- provincial governments (through specific indirect cost reimbursement programs in a number of instances).

2.1 Federal Government

The federal government funds university research in several ways:

- through formal sponsored research programs, such as those of NSERC;
- through contributions and contracts from various departments and agencies;
- indirectly through transfer payments to the provinces.

[2] Much of the information presented in this document is an update from a recent unpublished report on indirect costs of research by Mireille Brochu and Nicole Bégin-Heick for the Advisory Council on Science and Technology. It also includes updates of information contained in 1) a background document prepared by Brochu for the Canada Foundation for Innovation; 2) a report on target areas for the Strategic Project Program conducted for NSERC by Brochu, Bégin-Heick and Monique Pelland; and 3) a similar report conducted for SSHRC by Brochu and Bégin-Heick.

The federal government also supports industrial R&D and performs in-house research.

2.1.1 Formal University Research Support Programs

The major instruments of federal research support are the three granting agencies, the Natural Sciences and Engineering Research Council (NSERC), the Canadian Institutes for Health Research (CIHR)[3] and the Social Sciences and Humanities Research Council (SSHRC). They contribute towards the direct costs of research projects or programs through:

- grants programs and the Networks of Centres of Excellence Program (NCEs);
- the direct remuneration of postdoctoral fellows and research students at all levels[4], through training awards;
- the salary of a relatively small number of principal investigators (via Industrial Research Chairs, for example);
- the salary and research costs of 2000 faculty members, via the Canada Research Chairs Program.

NSERC's budget for 2000-01 was $488 million, excluding Chairs and NCEs. Excluding the same programs, CIHR's budget was $360 million, and SSHRC's $130 million.

CIHR's budget is slated to increase significantly over the next few years. SSHRC's budget will increase by $20 million for an initiative on the new economy ($100 million over five years).

The share of Networks of Centres of Excellence (average from 1997-98 to 1999-2000) administered by NSERC is 57.5%.

The NSE share of Canada Research Chairs is 45% of the total, or 846 of the 1880 pre-allocated chairs.

When the Canada Research Chairs Program reaches maturity in 2004, the federal government will invest $300 million per annum in 2000 chairs. There will be two types of Chairs:

- seven-year renewable Chairs (at $200,000 per annum) targeted at experienced researchers who are acknowledged by their peers as world leaders in their own fields;
- five-year chairs, renewable once (at $100,000 per annum), targeted at researchers who are acknowledged by their peers as having the potential to lead in their fields.

As mentioned above, researchers in the NSE will receive 45% of these chairs. Researchers in the health and social sciences will receive 35% and 20%, respectively. The Canada Foundation for Innovation will provide infrastructure to chair holders. The CFI investment will amount to $250 million, which means that a total of $625 million will be invested in research infrastructure associated with chair research programs (see below for CFI matching requirements). Chair

[3] The Canadian Institutes for Health Research, created in 2000, replaced the Medical Research Council.
[4] Stipends to students and postdoctoral fellows are also eligible expenditures under grants.

awards are made to institutions, not to chair holders. Funds may be used to contribute to the salary of the chair holders, their research programs and administrative expenses related to the chairs.

Through recently created foundations or programs, the federal government funds research infrastructure and research. A summary of these new programs in Table 1 given below. More details are found in Appendix 3.

Table 1—Federal Programs in Support of University Research

Program/Agency	Date	Mandate	NSE %	Details
Canada Foundation for Innovation	1997	Infrastructure	~50	$3.15 B to 2010
Genome Canada	2000	Genomics	~30?	$300 M to 2005
Canadian Foundation for Climate and Atmospheric Studies (CFCAS)	2000		~100	$60 M to 2006
Climate Change Action Fund	1998		high	$150 M, $15 M for research to date
Sustainable Development Technology Fund	2000	Env. Tech.	~100	$100 M, mainly to industry, little R&D
Atlantic Innovation Fund	2000	Mainly economic development	?	Planning stages

In the NSE, NSERC, with its long-standing grants and scholarships programs, the NCEs and the Canada Research Chairs Program, remains the major player in the federal support of the operating costs of research and the training of highly qualified personnel. CFI has become the major agency supporting research infrastructure. In targeted areas, some of the life sciences and earth sciences communities also have access to new (short-term) funding, as outlined above.

2.1.2 Contributions and Contracts

Through other department and agencies, the federal government funds specific research contracts in support of departmental missions (on some of these contracts, the government pays indirect costs or part thereof[5]). Some of these awards are specifically for university research, others are in support of industry, but with some university involvement. Appendix 3 provides examples.

The direct investments of these agencies in university research pale when compared to those of the three granting agencies and CFI, which account for 92% of federal investments in university R&D[6]. The largest spenders are NRC ($29 million), the Canadian International Development

[5] CAURA. Indirect Costs of Federal Contracts to Universities, Mireille Brochu, 1996.

[6] Source: Statistics Canada, 2001. Federal Scientific Activities 2000-01 (Cat. No. 88-204-X1B). Table 4.5, Federal Extramural Expenditures for R&D by Department or Agency and Sector of Performance, 2000-2001.

Agency ($19 million), the Canadian Space Agency ($10 million) and Environment ($9 million). The bulk of these investments are in the natural sciences and engineering.

In-kind support provided by federal departments to the university research community is not captured by statistical data on university R&D. However, there is a consensus that support from line departments (e.g., ship time, logistic support for Northern Research), has decreased with the decrease in funding of internal federal research.

2.1.3 Indirect Support through Transfer Payments

Through Canada Health and Social Transfers (CHST), the federal government contributes to the costs of university education and research. Since 1996, transfers for health, social programs and post-secondary education have been merged. In 1996, the last year before the amalgamation, cash payments for post-secondary education (which includes community colleges) totalled $2.4 billion. How much of this finds its way to universities, and how much to research is impossible to say. However, through CHST and through historical transfer of tax points to provincial governments, the federal government indirectly contributes a fraction of the operating grants universities receive from provincial governments. Whether this is 20%, 30% or 40% is lost in history. Each level of government has its own interpretation.

There is a consensus among stakeholders that universities are under great pressures because the federal government does not pay for the indirect costs of the research it funds via the granting agencies (and because provincial operating grants have been insufficient to cover these costs).

2.1.4 Federal Support of Industry Research

In 2000-01, the federal government invested $865 million in industry R&D[7]. The Canadian Space Agency and National Defence are the largest spenders in terms of R&D contracts in 2000-2001 ($217 million and $109 million respectively). In terms of grants and contributions, Industry Canada ($332 million) and NRC ($108 million) are the largest spenders, mainly through the Technology Partnership Program and the Industrial Research Assistance Program (IRAP), respectively. Federal support of industry research is mainly in the NSE.

Of course, NSERC itself indirectly supports industrial research, thanks to its Industrial Research Fellowships and Research Partnerships programs, but also thanks to the fact that many of the discoveries supported by other grants programs are eventually transferred to Canadian industry.

2.1.5 Initiatives at the Planning or Proposal Stage

As mentioned in the introduction to this report, the federal government is publicly committed to bringing Canada in the top five countries in terms of investment in research and development

[7] Statistics Canada, 2001. op. cit. (Cat. No. 88-204-X1B)

and will be developing policies and programs to this end. An interdepartmental task force led by the Deputy Minister of Industry Canada is working on a White Paper on Innovation that would set the directions for the federal government innovation strategy. Current plans are for a presentation to Cabinet in June 2001. It is not known at this time whether the paper will focus on a broad vision or will propose concrete measures, and if so, whether these will be targeted at specific sectors or not.

Even before the announcement of the government's intention to increase R&D, the research community and the business sectors were planning various projects and programs for which they are or will be seeking financial support from the federal government. The government's announced intention and the forthcoming White Paper are already generating a flurry of other proposals from various sources. This section highlights some of those that are on the table at this time or are likely to come to the table shortly.

The *Advisory Council on Science and Technology* (ACST) has conducted four studies in the past few years:

- Commercialization of University Research;
- International S&T;
- Skills;
- Indirect Costs of University Research.

The first three reports are public documents; the fourth is confidential advice to ministers. The government is currently reviewing the recommendations of these reports. The following table highlights some of the proposals from ACST and other federal entities. The likelihood of any of these obtaining the go ahead is unknown at this time. More details are found in Appendix 3.

Table 2—Planned or Proposed Federal Initiatives

Program/Agency	Summary
ACST Commercialization	• Devote 5% of granting agency funds to commercialization; • many policy recommendations.
ACST International	• $150 million to enhance international R&D activities; • partly approved via CFI International Funds.
ACST Skills	• Does not focus directly on research; • skill challenges in aerospace, automotive, biotechnology, environmental technology and information and communications technology;
ACST Indirect costs	• Report confidential; universities asking for 40% of granting agency funding.
Astronomy community	• Proposed new facilities (estimated at $150 million); • additional $17 million in NSERC support; • Proposal that Canadian Space Agency invest $100 million in space-based research programs.

Program/Agency	Summary
EMPOWR	• More than $100 million per year to triple the number of faculty members in Canadian universities and colleges in the areas of microelectronics and ICT
Perimeter Institute	• Privately funded theoretical physics institute being planned in Waterloo is likely to seek matching federal dollars.
Neutron Facility	• $298 million for facility; • $90 million for beams for research, not counting operating costs.
Biodiversity Network Initiative	• A national strategy for establishing a biodiversity network in Canada is under development.
InnoCentre[8]	• Seeking federal support to expand its commercialization activities across the country.
Life sciences commercialization[8]	• An industry-led research organization, modelled on PRECARN, is being proposed to promote commercialization in the life sciences; • likely to seek federal support.
"Building capacity"	• AUCC and others developing proposals to help smaller universities build their research capacity.
NRC Initiatives	• Numerous strategic initiatives, some approved, some proposed, including E-Commerce Institute in New Brunswick, Fuel Cells in BC, Nanotechnologies in Alberta, Photonics in Ottawa.
Other federal agencies	• Virtually all other federal government departments and agencies are seeking major infrastructure renewal or planning new major initiatives totalling billions of dollars.
"Academy"	• A Task Force is preparing advice to the federal government on the creation of a "national science academy or organization" or other advisory and evaluation body.

2.2 Provincial Research Support Programs

This review focuses on five provincial governments (from West to East: British Columbia, Alberta, Ontario, Québec and Nova Scotia) and provides general information on five others.

As provincial governments balance their budget, there are signs that funds assigned to higher education and research are given more attention. At least five provincial governments now either allocate part of the university operating grants on the basis of research excellence (Alberta,) or to contribute to the indirect costs of research (Nova Scotia, Ontario, Québec and, for 2001, British Columbia). In Alberta, the formula for the "Research Performance Envelope" is based upon success with federal granting agency programs. In Nova Scotia and Ontario, the indirect cost envelope is also proportional to granting agency programs. Starting in 2001, Ontario is also paying for the indirect costs of provincially funded research (about 40% of direct costs). In

[8] Source: Research Money.

Québec, the indirect cost envelope is based on grants made by all funding agencies using a peer review system.

- Table 3 highlights provincial investments in university research, as reported by universities.

Table 3—University Research Funding from Provincial Sources
(in millions of dollars)

	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
CANADA	298.4	310.7	312.2	294.7	346.1	374.4
NFLD	2.0	1.8	3.4	0.6	0.4	1.2
PEI	0.0	0.2	0.3	0.2	0.4	0.4
NS	3.1	2.7	2.9	2.7	4.7	4.4
NB	3.1	3.2	3.5	3.5	2.3	3.8
QC	110.6	113.0	117.2	103.2	116.4	117.1
ON	115.7	127.4	117.7	111.0	125.5	122.6
MB	6.0	4.8	5.1	5.2	6.8	10.8
SK	11.1	10.5	11.5	11.8	16.5	16.9
AB	29.8	30.7	35.3	36.1	49.5	74.8
BC	17.1	16.3	15.4	20.3	23.5	20.5

Source: CAUBO

Unfortunately, the table is badly dated since the last year for which data are available is 1998-99. Since then, most provincial governments have increased support for research, to match funding provided by CFI but also, in several instances, through the creation of new direct funding programs and the expansion of existing ones. Ontario, Alberta and Québec, in particular, are expanding direct support to university research. BC, Manitoba and Nova Scotia have also announced new initiatives in the last few years. Investments in Saskatchewan will also be increasing, given commitments to the Canadian Light Source. For example:

- Québec's 2001 *Science and Innovation Policy* (Savoir changer le monde) proposes major increases to R&D and identifies a number of priority areas. The 2001 budget identifies an additional $250 million over three years for implementation of the policy, in addition to a $50 million reserve.
- In Alberta, provincial support reached $90 million in 1998-99 and has continued to increase since.

Most provincial governments are more and more conscious of the importance of university research for economic development and for the creation of the knowledge society and in support of the new economy. Key features of provincial programs are outlined below. More details are found in Appendix 3.

Table 4—Provincial Programs in Support of University Research

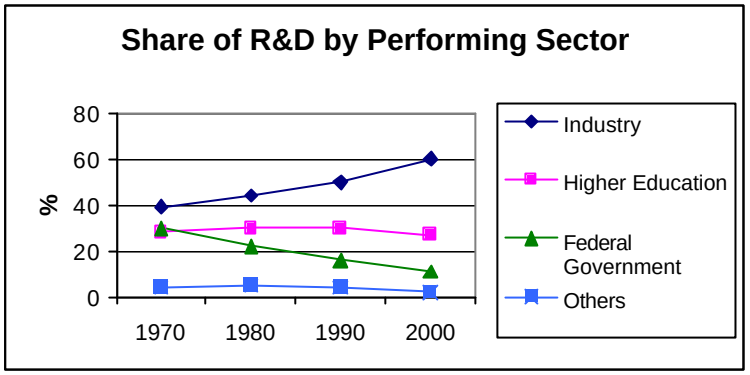
Prov	Program	%NSE	Details
BC	BC Knowledge Development Fund (BCKDF)	~40	CFI matching; $217 M to 2007.
	Michael Smith Foundation for Medical Research (MSFHR)	low	Created in 2000 to support health research; $110 M over five years.
	Science Council of BC/Forest Renewal BC/Applied Systems Institute	high	Various applied research programs; support for university-industry liaison offices; Approx. $15 M per annum.
AB	Department of Innovation and Science	high	Research Investments Program, including CFI matching, Research Excellence Envelope for new researchers, Strategic Research Initiatives, etc.; ~$30 M per year.
	Alberta Heritage Foundation for Science and Engineering Research (AHFSER)	high	New Foundation endowed with $500 million; launching its first programs in 2001.
	Alberta Heritage Foundation for Medical Research (AHFMR)	low	Since 1980; supports health research; above NSE Foundation modelled on this one; ~ $40 M per annum.
	Informatics Circle of Excellence	100	Fosters university research in information and communications technology; $10 M per annum.
	Agricultural Research Institute	high	Funds agriculture research. Total funding not clear
SK	Agriculture, CFI matching	high	Long tradition of funding agriculture research; investments in university research set to increase given commitments to the Canadian Light Source; Total provincial investment of about $17 M per annum.
MB	Agri-Food Research and Development Initiative	high	Long tradition of funding agriculture research; $6.5 M.
	Manitoba Innovation Foundation	50	CFI matching; totalling $7 M (duration not clear).
	Manitoba Science and Technology Fund	high	New initiative ($5 M, duration not clear).
ON	Research Overhead	~50?	Small contribution to indirect costs of federal grants; $28 million per annum.
	Research Performance Fund	~50?	Created in 2000; 40% indirect costs on provincial grants; ~$30 M per annum.
	Ontario Health Research Program	low	$44 M per year for a variety of health research projects and subprograms, with most of the latter administered by foundations.
	R&D Challenge Fund	~40	Funds human resources for university research; $318 M since 1997.

Prov	Program	%NSE	Details
	Ontario Investment Trust	~50	Mainly CFI matching; $300 M since 1998.
	Ontario Centres of Excellence	100	Four centres; $32.3 M per annum.
	Premier's Research Excellence Awards	~50	Help researchers attract talented people to their team; $85 M over ten years to 2008.
	Agriculture	high	Long standing agreement with the University of Guelph; some participation from other universities; $54 M per annum.
	Several targeted programs		Biotechnology, digital media, etc. Mainly for industry, but some university involvement; annual budget not clear.
QC	Fonds pour la formation des chercheurs et l'aide à la recherche (FCAR)		Granting agency in the social sciences, humanities and NSE. Will soon be NSE only. $55 M per annum.
	Fonds de recherche en santé du Québec (FRSQ)	low	$53 M per year; granting agency in the health sector.
	Conseil québécois de la recherche sociale (CQRS)	low	$12 M per year; granting agency in social research; will soon take over the SSH responsibilities of FCAR.
	Centres de liaison et de transfert		Six organizations to promote university-industry collaboration; 4 are mainly in the NSE; $10 M per annum.
	Agriculture		University research in agriculture is funded by the Conseil des recherches en pêche et en agroalimentaire du Québec; $3.7 M per annum.
	Research infrastructures	~50	CFI matching; $125 M, duration not clear.
	Valorisation Recherche Québec		Foundation created in 1999; 4 new technology transfer companies; short term funding of major projects; $220 M over 6 years.
NB	No specific program		CFI matching (often within federal-provincial agreements); Total provincial funding of $3.8 M per annum.
NS	CFI matching		Through federal-provincial agreement; $8.72 M since 1998.
	Indirect costs		Since 1998, 38% of federal agency funding; $7.3 M per annum.
	Technology Science Secretariat		Promotes industry development
PEI	No specific program		Total provincial investment of $350,000 per annum.
NF	No specific program		Support provided through federal-provincial agreements; Total provincial investment of about $1.5 M per annum.

3 Overview of R&D Trends in Canada

There are three major performers of R&D in Canada, industry, universities (including affiliated hospitals and institutes) and the federal government. The relative share has changed dramatically in the past thirty years, as shown in Figure 1 and Table 5.

Figure 1



Source: Statistics Canada

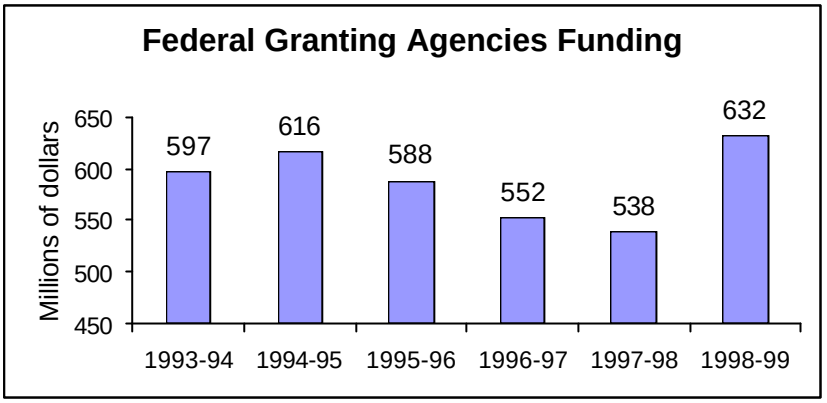
Table 5—R&D by Performing Sector (in millions of dollars)

Sector	1970	1980	1990	2000
Industry	408	1571	5169	9900
Higher education	295	1055	3033	4461
Federal	327	779	1654	1782
Provincial	30	140	303	211
Non-profit	9	30	102	200

Source: Statistics Canada

As shown in Figure 1, the last decade has been characterized by an increase in industrial R&D (from 50% in 1991 to an estimated 60% in 2000) and a significant decrease in federal government in-house R&D (from 16% in 1991 to an estimated 11% in 2000). In the last decade, the proportion of the national R&D effort performed by universities has fluctuated from a peak of 31% in 1991 to a floor of 26% in 1998. Estimates for 2000 and 2001 are at 27%. Cuts to the three funding agencies in the second half of the 1990's have contributed to the temporary decline. Restoration of this funding has reversed the trends, as shown in Figure 2. Funding for subsequent years will show further increases, given increases to the budget of CIHR, SSHRC and the Networks of Centres of Excellence.

Figure 2



Source: CAUBO[9]

R&D in the health field is increasing, with a corresponding decrease in the NSE and the social sciences and humanities (SSH). The health field has grown from 14% of total R&D in 1988 to an estimated 20% in 2000.

The bulk of industrial and government R&D is in the natural sciences and engineering. In health, most research is conducted in the higher education sector (which includes affiliated institutes and hospitals).

A snapshot of industry and government R&D expenditures by field for 1998-99 is found in Table 6 and Table 7 respectively. The evolution of university R&D expenditures in the three major fields is shown in Figure 3.

Table 6— Federal Expenditures on R&D (1998-99)
(in millions of dollars)

	Total R&D	In-house	Extramural
Total R&D	3412	1613	1799
Health	399	84	315
SSH*	200	100	100
NSE	2813	1429	1384
NSE share	82.4%	88.6%	76.9%

*Rough estimates, using SSHRC for extramural and Social structures for intramural

Source: Statistics Canada

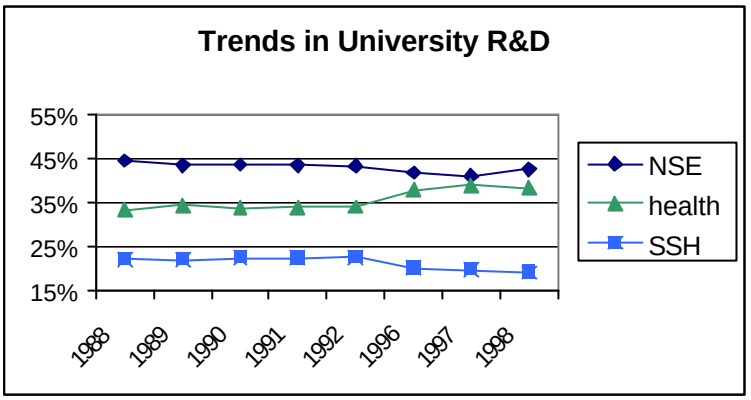
[9] CAUBO data excludes scholarships and fellowships programs.

Table 7— Industrial In-House Expenditures on R&D (2000)
(in millions of dollars)

Field	Amount
Total R&D	9900
Health	1284
SSH	Negligible?
NSE	8616
NSE share	87.0%

Source: Statistics Canada

Figure 3



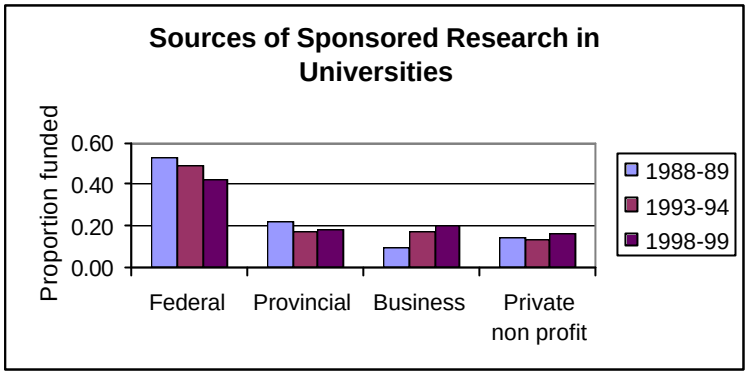
Source: Statistics Canada[10]

The sources of university R&D funding are both levels of government, industry and the private non-profit sector (sponsored research) and the institutions themselves (indirect costs, faculty salaries attributed to research, other contributions to research from internal sources). Sponsored research accounts for about 50% of total R&D. Figure 4 presents data on sponsored research only, showing trends in the contributions of each of the funding sectors. Breakdown between the NSE and other fields is available only for 1998-99. This is shown in Table 8[11].

[10] Statistics Canada data include all costs of research, i.e. sponsored research funding and expenditures borne by the institutions themselves.

[11] The share of R&D in the NSE, health and SSH is estimated by Statistics Canada because the universities do not collect this type of information. Industrial contributions by field are not known with precision: they are estimated from old data collected over a decade ago. Given the increase in pharmaceutical R&D, clinical trials and biotechnology research in recent years, industry funding of health university research may be underestimated.

Figure 4[12]



Source: Statistics Canada

Industry share grew from 10% to 20% between 1988 and 1998. Federal share shrank from 53% to 43%.

Table 8— Share of University Sponsored R&D, 1998-99

Sector	R&D (In million of dollars)				Share		
	NSE	SSH	Health	Total	NSE	SSH	Health
Federal	474	112	275	861	0.55	0.13	0.32
Provincial	185	74	111	370	0.50	0.20	0.30
Industry	246	17	145	408	0.60	0.04	0.36
Private non-profit	65	57	213	335	0.19	0.17	0.64
Foreign	30		20	50	0.60	0.00	0.40
Total sponsored	1000	260	764	2024	0.49	0.13	0.38

Source: Statistics Canada

In 1998-99, one billion dollars was invested in sponsored research in the NSE. NSERC Research Grants Program, at $212 million, accounted for 21% of that investment, slightly less than industrial investment and somewhat more than provincial investment. Has this proportion changed over time? In 1989-90, this share was 27%. In 1982-83, it was 30%[13]. What will it be in the future? To project into the future, a very conservative methodology has been used. Only announced increases have been taken into account: CFI and CFI matching, Canada Research Chairs, NCEs, projected increases to SSHRC and CIHR, new provincial programs. Table 9 presents these data.

[12] Absolute values are given in the first three column of Table 9 (next page).
[13] Source: NSERC Facts and Figures 1991-92.

Table 9— Estimates of R&D Expenditures in the Higher Education Sector, by Source of Funds (in millions of dollars)

Sector	Year						
	1988-89	1993-94	1998-99	1999-00	2000-01	2001-02	Beyond
Federal	625	873	861	1000	1200	1500	1800
Provincial	261	312	370	500	600	800	800
Business	115	314	408	400	400	400	400
Private non-profit	173	248	335	330	330	330	330
Foreign	13	20	50	40	40	40	40
Total sponsored	1187	1767	2024	2270	2570	3070	3370
Institutional	1482	1866	1940	2000	2200	?	?
Grand total	2669	3633	3964	4270	4770	?	?

Sources: Statistics Canada to 1998-99; author's projections for subsequent years.

Projected planned federal increases amount to a whopping $900 million (in the "steady state", i.e. by 2004 or 2005). This includes: Genome Canada (~$40 million per annum), CFI (~$300 million per annum), Chairs ($300 million at maturity) planned increases to CIHR (~$200 million per annum at maturity), SSHRC (~$20 million per annum), and various other announced increases estimated at about $40 million per annum in total. Projected increases in provincial funding amount to about $400 million, including CFI matching (~$250 million per annum[14]), as well as projected additional annual increases of $150 million per annum (new planned programs in the four largest provinces).

Estimating the NSE share is difficult. Of the planned increases, we assume that CFI share will be about 50% in the NSE and Genome about 30%. The planned NSE share of Chairs is 45%. The provincial share has been arbitrarily set at 45% (Alberta announced new funding for NSE, BC for health, etc.). Table 10 shows, roughly, how the projected increases will be divided between the major fields, in the "steady state", i.e. around the middle of this decade.

[14] This assumes that some of the CFI matching will not be reported as R&D (in-kind institutional expenses, for example)

Table 10— Projected increases in University R&D Funding
(in millions of dollars)

Program	Total	NSE	Health	SSH
Chairs	300	135	105	60
CFI	300	150	135	15
Genome	40	12	24	4
CIHR	200	0	200	0
SSHRC	20	0	0	20
Other federal	40	30	5	5
Prov. CFI matching	250	125	112.5	12.5
Other provincial	150	67.5	67.5	15
Total	1300	519.5	649	131.5
Share		0.40	0.50	0.10

Source: authors' estimates, based on government announcements

In summary, 40% of the increases would go to the NSE, half to health, and only about 10% to the SSH. Assuming that the Research Grants Program would remain constant at about $230 million, it would then represent less than 15% of total sponsored research of close to $1.6 billion in the NSE by the time all the announced increases take effect, in 2004 or 2005.

4 The Changing Research Environment

As we saw in earlier sections, the research funding environment has changed in recent years with more funding sources available to institutions and researchers:

- increased recognition of the importance of research to the new economy by both levels of government and industry;
- increased funding from industry (thanks in large part to the creation and expansion of programs such as NSERC's Research Partnerships Programs[15] and NCEs);
- increased funding for infrastructure (CFI), including recent expansion into international area;
- increased funding for senior fellowships (Canada Research Chairs) to help institutions attract and retain the best researchers;
- increased funding from some provincial governments (but not all provincial governments and not necessarily all disciplines); and, more recently
- increased incentives to manage intellectual property and commercialize research results;
- increased emphasis on health research (as opposed to strictly "disease-oriented" medical research), in universities and affiliated hospitals;

Since the creation of NSERC, grants programs in support of "project research" (including the NCEs) have grown faster than the Research Grants Program (or the longstanding postgraduate scholarship program). In the last decade, the difference has been relatively small: between 1989-90 and 1998-99, research grants programs increased by 25% and partnerships programs (excluding NCE which were just starting in 1989) grew by 32%[16].

The way research is conducted has also evolved in the last two decades:

- the complexity of many research questions calls for multidisciplinary teams, as well as inter-institutional and inter-sectoral collaboration;
- these multidisciplinary teams often need to include individuals from the NSE, the SSH and the health sector, including people with training in two of the sectors;
- there is increased recognition that some problems cannot be solved by technology alone, but require contributions from research in the SSH;
- expensive and sophisticated equipment and facilities are needed to answer these questions; these must be shared by a number of researchers to be cost-effective;
- developments in information and communications technologies have enabled real time collaboration between researchers from across the world;
- the time from idea to application is much shorter, and more and more knowledge is produced in the context of application[17] (a clean environment, more efficient energy sources or better engineering processes) rather than from discipline-based research.

[15] Source: NSERC Departmental Performance Report 1998-99, page 22.

[16] Source: NSERC Facts and Figures.

[17] These two ways of doing research are often called Mode 1 and Mode 2 research. Mode 1 refers to traditional investigator-driven discipline research. Mode 2 is research driven by problem or application. See, for example: Gibbons, M. Limoges, C. Nowotny, H. Schwartzman, S. Scott, P. and Trow, M. *The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies.* Sage Publications, 1994, 179

There is, of course, no magic recipe to tell a country or a granting agency what should be the proper balance between these two types of research (which in fact represent two extreme points in a continuum). The planned survey of the NSERC community being conducted by NSERC will enable it to assess the extent of the move towards multidisciplinary research and "mode 2" research.

Universities themselves are changing:

- Universities had to make choices in the 1990's as their budgets were curtailed and governments had to control deficits. Faculty positions were cut.
- With deficits under control, student enrolment increasing and faculty members retiring, massive recruitment is expected in the next decade. Attracting and retaining faculty members in key areas of the NSE is and will continue to be difficult for research institutions.
- CFI and the Canada Research Chairs Program require that institutions engage in strategic planning for research (this had not been done in some of the institutions).
- University research plans clearly indicate a move towards multidisciplinary approaches. Research is often conducted in multidisciplinary centres that span several departments and faculties. As a result, faculty members teach in one department and do research in another unit. Graduate programs also span several departments and faculties. Such transformation is costly, requiring massive investment in new space in research infrastructure. The advent of CFI has probably accelerated this transformation.
- Universities are increasingly taking up a third mission, that of contributing to the economy and to society[18]; as a result, they are increasingly engaged in the transfer of research results to the user sector and in commercialization.
- University administrators are very concerned at the fact that NSERC and its sister agencies do not provide the indirect costs of the research they fund.

In a recent paper on the evolution of universities, Martin and Etzkowitz[19] discuss three models to describe the recent evolution of universities. The first model is the shift from "Mode 1" to "Mode 2", as described by Gibbons et al. The second model is the "triple helix" model, where the links between universities, government and industry bring about the "socio-economic" mission mentioned above.

The third model is couched in terms of a changing "social contract" between the university and society. The changed social contract includes a clear expectation that, in return for public funds, scientists and universities must address the needs of "users". There are greater requirements for accountability. The social contract is no longer driven by what governments can do or should do for research and researchers. This is turned around completely: What can universities and researchers do for society? This model is also characterized by the disappearance of the linear model of innovation, where basic research is followed by applied research, and then by innovation and benefits to society (generally unpredictable at the start of the research).

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pp.

[18] For example, this is being strongly promoted in the 1999 Report of the Expert Panel on Commercialization.

[19] Martin, B.R. and Etzkowitz, H. 2000. The Origin and Evolution of the University Species. SPRU Science and Technology Policy Research. Electronic Working Paper Series no. 59.

5 NSERC in the Changing Environment

In this document we have seen that the outlook for research is positive:

- The federal government is publicly committed to bringing Canada in the top five countries in terms of investment in research and development (this means at least a doubling of R&D expenditures as a percentage of GDP).
- The federal government and the provinces recognize that R&D is key to success in the knowledge-based economy.

We have seen an increase in the number of research funding sources and in the number of federal and provincial funding programs. When they reach steady state, announced programs will translate, at a minimum, into an increase of 50% in sponsored research expenditures in universities and hospitals.

In the academic world, we have seen that research in health is increasing faster than research in other areas, a trend that will continue. Within the natural sciences and engineering sector, we have seen that the Research Grants Program accounts for a decreasing share of the pie. This share will continue to decrease without additional investment. In the past four years, the availability of budgetary surpluses has enabled the government to invest for the future by creating foundations that can spend "one-shot" allocations over a number of years. Whether the federal government will continue to create new entities to support research and research infrastructure is impossible to predict and depends a lot on the fiscal situation in years to come.

In the other sectors performing research, government and industry, we have seen that the share of the NSE is and will remain high, exceeding 85% in both sectors.

Finally, we have seen that the way research is conducted in our universities is evolving, with greater requirements for collaboration and multidisciplinary research and more expectations in terms of accountability for the research investment. We saw the need for increased collaboration between the NSE and the social sciences and humanities.

All this has major implications for universities and for the need for highly qualified personnel, for NSERC and its programs, particularly the Research Grants Program. For example, increasing the country's R&D efforts will require not only increased investments by all sectors, but major increases in the number of research workers (and workers in related professions), and therefore, an increased research training capability in our universities and colleges.

Before discussing the implications of this changing environment for NSERC in general and for the Research Grants Program in particular, it may be useful to review the main characteristics of this Program.

5.1 Overview of the Research Grants Program

The objectives of the Research Grants Program are:

- promoting and maintaining a diversified base of high-quality research capability in the natural sciences and engineering in Canadian universities;
- fostering research excellence; and
- providing a stimulating environment for research training."

The selection criteria are:

- scientific or engineering excellence of the researcher(s);
- merit of the proposal;
- contribution to the training of highly qualified personnel; and
- need for funds.

Characteristics of the Program include:

- one person can hold only one grant at a time;
- the Program funds research programs as opposed to specific projects, and the use of funds is very flexible;
- group proposals are invited, but the Program is dominated by individual grants;
- proposals are reviewed by discipline committees and past and future contributions to the discipline are major considerations under the first two criteria;
- interdisciplinary research proposals are reviewed either by an interdisciplinary committee or by the most appropriate discipline committee, with advice from others as required;
- allocation by discipline is reviewed every four years by NSERC, based on a thorough planning and assessment process that takes a close look at what disciplines have accomplished and where research is going (discipline priorities); training needs and, of course, financial needs related to identified priorities are also scrutinized;
- the Program budget approaches $250 million per annum;
- over the past decade, competition success rate has fluctuated between 68% and 76%;
- average grant is around $32,000 per year;
- the number of grantees exceeds 7500, or about 75% of the eligible research community (this is a very rough estimate, as the eligible community cannot be easily circumscribed).

The two objectives can be seen as contradictory:

- Promoting and maintaining a diversified research capability can be interpreted to mean that the program ensures that there is a minimum of high quality research and training carried out not only in all disciplines (the major intent of the objective), but also in all regions of the country (this suggests that the program should support as many people as possible, provided they meet the minimum acceptable standards for each criterion).

- Fostering research excellence, on the other hand, can be interpreted to mean that the program should be very selective and fund only proposals that will meet the highest international standards and will build "pinnacles of excellence".

As a result, over the years, NSERC has strived to meet an adequate balance between these objectives, in particular to ensure that highly qualified people were trained through research in all disciplines and across the country. Does the changing environment has implications for this balance?

5.2 Implications of the Changing Environment

The changing environment already has and will have major implications for:

- the need for highly qualified personnel in all sectors (HQP objective of the Research Grants Program, and, in fact, of all NSERC programs);
- the research capability across the country (Diversified base objective of the Research Grants Program);
- the need for Canada's research to be among the best in the world (Excellence objective of the Research Grants Program);
- whether NSERC continues to focus on individuals and disciplines, instead of teams and themes, and whether it continues to focus on programs rather than on projects (changes in the way research is done);
- the expectations that Canadian research will generate benefits to Canada (increased accountability).

Each of these factors is discussed in turn in the following subsections.

5.2.1 Need for Highly Qualified Personnel

It is obvious that newly launched and planned initiatives will succeed only if there are highly qualified researchers around to conduct excellent research. The goal to make Canada one of the most research-intensive countries in the world will not be met unless we attract the right people in sufficient numbers. Doubling R&D means major increases in the number of people involved.

This study did not analyze supply and demand of highly qualified personnel, since NSERC is collecting and analyzing such data, including forecast for faculty members, as part of the allocation exercise and as part of its broad planning exercise. Nevertheless, our findings reveal that:

- Industry is the major performer of R&D (Figure 1, page 17). Over 85% of industrial R&D is conducted in the natural sciences and engineering (Table 7, page 19).
- Government R&D has been severely cut in the last decade (Figure 1). This sector has been streamlined and its R&D mission redefined. The share of R&D performed by government

should stabilize shortly. Departments are hiring again, and this will accelerate in the coming decade as current researchers retire in large numbers. Again, more than 85% of research is in the natural sciences and engineering (Table 6, page 18).

- Based on announced programs, R&D done by the academic sector will increase by about 50% in the next few years (Table 9, page 21). It could increase much more.
- There has been, and there will continue to be a significant increase in health research (Table 8, page 20, and Table 10, page 22), especially in universities and hospitals. It is important to remember that a significant number of health research workers (on the biomedical and clinical side of health research) get their first, second or third degree in the natural sciences and engineering, and get their first exposure to research in an undergraduate biology laboratory.

Whereas 85% of industrial R&D is the NSE, it is not clear what the percentage will be in the future, and it does not necessarily mean that 85% of the new research or research-related workforce will be in the NSE. In its plea for universities to train skilled people, the high technology industry stresses the need for social sciences and humanities graduates who understand technology and the need for NSE graduates with managerial, business, marketing, writing and communications skills. Nevertheless, the fact remains that more highly qualified personnel will be needed, and that a significant fraction will be in the NSE. There are implications:

- Young people have to be attracted to science and engineering (in universities and community colleges).
- A larger proportion of those who graduate must choose to continue to graduate schools. In many fields, especially information and communications technologies (at least until the recent downturn), industry snatches up graduates as soon as they graduate with a first degree, thus depleting the pool of potential faculty members and government research workers.
- More faculty members need to be recruited.
- Both faculty members and graduate students will need research and infrastructure support.
- In order to attract the best faculty members and students, a stimulating research environment is essential.

The role of NSERC, via its grants and scholarships programs, and particularly via the Research Grants Program, is evident. The Canada Research Chairs Program and the Canada Foundation for Innovation are playing a major role in helping our universities attract outstanding people and offer them a stimulating environment. But these individuals will stay only if they have access to flexible and adequate research funding that enables them to exploit new ideas and become internationally competitive.

5.2.2 Research Capability

Both levels of government have launched new initiatives in the last few years, and many more are on the drawing board.

A. What are the implications for the research capability in various fields of research?

Other federal programs promote basic and applied research targeted to specific areas, or research targeted towards socio-economic applications.

Examples include:

- NSERC partnership programs (about 10% of NSERC grantees are involved in these) and NCEs (also involving about 10% of NSERC population);
- Genome Canada;
- Climate Change Action Fund;
- Canadian Foundation for Climate and Atmospheric Studies (CFCAS);
- Sustainable Development Technology Fund;
- Biotechnology Strategy.

In the provinces, information and communication technology, biotechnology and agriculture receive more support than other areas.

Industrial R&D is dominated by information and communications technologies, aerospace and the pharmaceutical sector.

Outside of the Research Grants Program, what are the other sources of funding for researchers in other fields such as astronomy, civil engineering, chemistry, geology, mathematics, or zoology? The fact remains that, in some fields, the Research Grants Program is still the "only game in town".

In others, researchers can use the Program as "seed money" that helps them tap other, larger sources of funds.

NSERC must answer difficult questions and balance various issues in reviewing the discipline allocation within the Research Grants Program. For example:

- The availability of other sources of funding in a given field is an indication that it is relevant and important to society, and generally, that there is demand for highly qualified people.
- On the other hand, the absence of interest on the part of industry does not mean that the field will not generate tomorrow's major discoveries. Examples of this abound in the history of science, from the transistor to superconductivity. Industrial sectors also go through booms and busts, as exemplified by the current boom in the energy industry and the bust in the information and communications technology sector.

The re-allocation exercise, with its in-depth studies of research developments and research needs every four years, appears to be a good mechanism to help the program properly recognize the potential contributions of all fields.

Is this enough? Should NSERC offer a different program mix to different disciplines or areas? Should NSERC fund research by broad field rather than by program (for example, using the US

National Science Foundation (NSF) model of directorates by discipline or field), tailoring its programs to the needs of various communities?

If it does not believe it is desirable to go that far, should it increase the flexibility given to the various disciplines in the Research Grants Program?

B. What are the implications for the research capability across the country?

There has been, and will continue to be a massive infusion of infrastructure support via CFI and matching funding from provincial governments and other partners. To date, CFI funding distribution has been similar to that of the federal agencies.

The Canada Research Chairs Program will also inject $300 million per annum. Except for 5% reserved for smaller institutions, the regional distribution will mirror that of the agencies.

For the past twenty years, researchers in Québec have had access to a parallel stream of funding designed in part to make them more competitive in federal programs. This has worked, as exemplified by the increased success of Québec researchers in programs of NSERC and other federal agencies. The early emphasis on team work by FCAR has paid off, making Québec researchers competitive in national programs promoting collaboration, such as the NCEs and NSERC strategic grants.

Researchers in Alberta had a similar success in the biomedical area, thanks to the Alberta Heritage Foundation for Medical Research, which has helped the two medical schools in Alberta increase their competitiveness with the Medical Research Council (now CIHR). Last year, Alberta launched a similar Foundation in the NSE. Since 1996, Alberta has also been providing starter grants to selected new faculty members, enabling them to submit better proposals to national granting agencies.

In the past three years, Ontario has moved on several fronts to support research teams and young researchers in addition to infrastructure.

In other provinces, support is more targeted and amounts are often small. For example:

- forestry, fisheries and information technology and health in BC;
- agriculture and health in Manitoba and Saskatchewan;
- in Atlantic Canada, the new Atlantic Innovation Fund is under development; the proportion that will go to universities is not clear; commercialization is a major objective.

One can only conclude that some provinces have taken responsibility to develop research capability in science and engineering and look to the federal government to reward excellence by supporting the cream of the crop.

Other provinces (generally the less wealthy) count on the federal government to support a diversified base of high quality research and training. The AUCC and other organizations are concerned at the increasing difficulties experienced by some smaller institutions and some

regions in attracting and retaining excellent researchers, and with their relatively low success with granting agencies. Industry Canada itself has commissioned a study of the barriers the smaller institutions face in developing their research capability.

Given these pressures from various sectors, and its responsibility to support and assist research, NSERC faces difficult questions in adjusting the balance between the objectives of the Research Grants Program. What is best for the country, given NSERC mandate?

- Should the Research Grants Program put the emphasis on the diversified base to ensure that all regions and institutions have the opportunity to contribute to the knowledge-based society and to train the knowledge workers needed for that economy? Or is this best left to other programs (of NSERC or others)?
- If the Program chooses to focus on a diversified base, are there other programs, in NSERC or elsewhere, that can support internationally competitive research at a high level?

These questions are far from easy to answer as the Research Grants Program is used extensively as a benchmark across the country. Making it past its highly regarded peer review system can have a major influence on tenure and promotion and on success in other granting programs. There is prestige to this Program.

This brings us to the question of excellence.

5.2.3 Excellence

Both levels of government have stressed the importance of world-class competitive research in announcing new investments in university research in recent years. Expectations are high that Canada's research will be internationally competitive and will enable Canada to increase its contributions to the global economy in major ways.

After decades of focussing new investments in targeted research, recent federal investments have promoted excellence. For example:

- The Canada Research Chairs Program is intended to attract and retain the best brains to Canada.
- The Canada Foundation for Innovation accelerates research and enables researchers to exploit new ideas with new facilities.
- Excellence has been a strong selling point in the planning of the Canadian Institutes of Health Research.
- Ontario, Alberta, Québec and BC new grants programs also focus on excellence.

In the past year, NSERC has clearly demonstrated that our best researchers are poised to increase their contributions to the knowledge-based economy and shown how this will increase the pressures on the Research Grants Program:

- Chair holders will expect levels of funding commensurate with their expected contributions to their fields; without this funding, the high expectations of the federal government in terms of results will be difficult to meet.
- Although CFI will now contribute to operations and maintenance of infrastructure, this applies to infrastructure approved after mid-2001 and is not intended to cover all operating and maintenance costs.
- The availability of new infrastructure enables researchers to tackle new research ideas, to work faster, and thus to increase research productivity; this, in turn, requires more research personnel, more research expenses, and raises expectations. The inability of NSERC to provide adequate funding for excellent research conducted with CFI-funded infrastructure could seriously impact on the success of this major federal investment.
- Provincial grants programs raise expectations of researchers with respect to increased research grants funding for the best. Many of these programs are aimed at improving success in NSERC's programs, particularly the Research Grants Program, given its rigorous peer review system.
- There are criticisms that this program is not selective enough and spreads resources too thinly compared to other granting agencies, especially the Canadian Institutes for Health Research and the US NSF.

These trends increase pressures on the RG program to become more selective. This brings us back to the issue of balance between the objectives of the Research Grants Program. What is best for the country, given NSERC mandate to support and assist research in the NSE?

- Should the Program focus on supporting the best, encouraging regions and institutions to take responsibility for developing their research capability to the point where research becomes internationally competitive, and more likely to have major impacts on society?
- Or should the Program essentially provide seed money as discussed above, given that , in many fields and regions, the best researchers have access to other sources of funding?

These questions are really a different way of posing those asked at the end of section 5.2.2 on research capability. In both cases, the real questions really are: where is the proper balance between these two extremes? Or: given the environment, can one Program continue to do both? At the Workshop held to discuss the findings of this report, participants definitely believed that the program should continue to do both, with merit remaining the criterion for awarding research grants (see Appendix 2).

5.2.4 The Way Research is Done

The Research Grants Program, while encouraging collaboration and multidisciplinary research, essentially funds individual researchers in the various disciplines of science and engineering.

The Program funds research programs, not specific projects, and is very flexible: if a researcher has a new idea, he or she is free to use grant funds to pursue this new avenue. Researchers can tackle many projects within the funded program, some alone, some with colleagues, some with

students, some with industry, etc. This unique flexibility of the program has earned it an excellent reputation among researchers around the world.

We have seen in section 4 that more and more research is done outside academic departments, in centres or multidisciplinary departments, with sharing of ideas and equipment. The information technology revolution has accelerated international collaboration. Bibliometric analyses show that Canadian researchers in the NSE collaborate extensively[20].

Does the Program with its focus on individuals and assessment of individual achievements encourage enough collaboration? Are grant selection committees too traditional in focusing on individual achievements and on contributions to the discipline? The forthcoming program evaluation should help NSERC assess whether the Program strikes the right balance in fostering individual creativity while at the same time encouraging collaboration and multidisciplinary research.

The needs of various communities are different. This has been recognized by NSERC. The most striking example is subatomic physics which has adopted a "project" approach to research grants. Earlier, in the context of the discussion of the balance between the objectives of the Research Grants Program, it was suggested that NSERC explore greater discipline differentiation. Such a differentiation could involve not only the balance between supporting a diversified base and focusing on the very best, but also increased recognition of the different ways of doing research (throughout all NSERC programs).

The fact that researchers are free to change the direction of their research and the flexibility in the use of funds are features of the Program that enable researchers to respond quickly to new ways of doing research. This is important in times when everything changes so quickly. Reducing flexibility would certainly weaken the Program.

5.2.5 Measurable Impacts

We saw in section 4 that the social contract between universities and governments is changing, in Canada and elsewhere. The question no longer is: what should governments be doing in support of research? But, what research should be doing in support of society? What are its contributions to making the world better, safer and richer?

Does this affect the Research Grants Program? Should it affect it? Should grantees be asked to report on results (outside the grant renewal process)? Should more focus be put in celebrating its results and its impacts? Should performance measurement be strengthened?

[20] As reported in NSERC Departmental Performance Report 1998-99, citing studies from the Observatoire des Sciences et des Technologies.

Appendix 1–Terms of Reference

As part of the Evaluation of the Research Grants Program, NSERC is commissioning a National Context Study.

Background

The Planning Study for the Evaluation of the Research Grants Program was completed in November 1999. KPMG Consulting was commissioned by NSERC in January, 2000 to conduct Phase I (the design) of the Evaluation. A draft report was submitted to NSERC's Program Evaluation Committee (PEC) in April 2000. The conduct of Phase II (the execution) was delayed until 2001. One component of Phase II is the National Context Study.

Objectives of the Study

The National Context Study is intended to address an issue raised during the 17th meeting of the Program Evaluation Committee: what is the position of the Research Grants Program within the national S&T context. It was felt that there was a need to fully understand the Canadian context for the funding of university research by governments, including the changes that have occurred over the past several years. It was thought important to understand the context in order to properly position the program to meet the challenges of the future for Canada. As well, there was a need to demonstrate whether there is an ongoing requirement for the Research Grants Program as it currently exists, or whether change is required, and this issue could only be tackled with a full understanding of government S&T policy and direction.

In addition to providing evidence for the evaluation, the National Context Study will also provide information for a strategic planning study.

Study Questions

The National Context Study will provide responses for the following questions:

- What is NSERC's current operating environment?
  - what other organizations/agencies (provincial, federal, industry) are funding research, training and infrastructure in the Natural Sciences and Engineering (NSE) in Canada?
  - what new organizations/agencies are being planned or proposed?
  - what are the objectives of these organizations/agencies?
  - describe the operations of these organizations/agencies (e.g., how is this support delivered, what funding criteria are applied, is peer review employed?).

- What is the scale of investment in the Natural Sciences and Engineering (NSE) in Canada (breakdowns of estimates of investment in university community vs. industry and government are required)? For each of the organizations/agencies identified:
  - what is the overall level of funding? Approximately what fraction is going to the NSE?
  - what types of individuals/organizations are supported (e.g., university researchers, universities, industry)?
  - approximately how many individuals/organizations are supported? roughly what proportion of the relevant target population is supported?
  - what type of funding is provided (e.g., infrastructure, funding for project research, program research, education, training);
  - how are the funds targeted (e.g., which industrial sectors, disciplines, strategic areas are funded)?
  - for approximately what proportion of NSERC grantees is this organization/agency relevant?
- What is NSERC's position in this environment (i.e., what niche does NSERC and its programs occupy)? To what extent are the activities of the organizations/agencies complementary or is there overlap?
- How has the funding environment changed in the past 5 years? How has the way research is conducted changed? What is the implication of the changing environment for NSERC and the community it serves?
- What is the implication of the Federal S&T Policy, as well as current and planned federal activities, for NSERC's operating environment? for NSERC? for university researchers in the NSE?

Methodology and Approach

The main approach for this study will involve secondary data collection – finding and updating existing information. Analysis of funding amounts will be based on Statistics Canada and CAUBO data. It is recognized that estimates of NSE share will be approximate, given that CAUBO data is not subdivided by field and Stats Can subdivisions may not provide the desired level of precision. Analysis of funding sources will involve documenting the characteristics of programs. Data collection will involve searching relevant Websites and telephoning contacts to ensure up-to-date information.

In addition to secondary data collection, a focus group/workshop will be conducted to obtain additional input regarding the last two issues: the implication for NSERC of federal activities and the changing environment.

Appendix 2—Report of Workshop on NSERC Strategy

June 21, 2001, 9:00 – 12:00

List of Participants

- Richard Botham – Department of Finance
- Mireille Brochu – Independent Consultant (Workshop Facilitator)
- Carmen Charette – Canada Foundation for Innovation
- Gilbert Drouin – Valorisation Recherche Québec
- Paul Dufour – Industry Canada
- Kevin Fitzgibbons – National Research Council
- Michelle Gauthier – Association of Universities and Colleges of Canada
- Feridun Hamdullahpur – Carleton University
- France Landriault – Social Sciences and Humanities Research Council
- Nigel Lloyd – NSERC
- Marshall Moffat – Industry Canada
- Susan Morris – NSERC
- Robert Mundie – Privy Council Office
- Robbyn Plumb – NSERC
- Christian Roy – Laval University
- Susannah Scott – University of Ottawa
- Steve Shugar – NSERC
- Janet Walden – NSERC
- Doug Williams – KPMG Consulting

Workshop Objectives

- Review and discuss the changing research environment described in the recent *Environmental Scan* carried out for NSERC[21].
- Discuss the implications of the changing environment for NSERC.
- Discuss the strategies NSERC should develop, given the changing context.

Workshop Discussion

Following welcoming remarks by Steve Shugar of NSERC and the introductions of participants, Mireille Brochu presented an overview of the study findings. This was followed by discussions of the major issues, which are summarized below.

[21] *Environmental Scan for the Research Grants Program of the Natural Sciences and Engineering Research Council,* Mireille Brochu and Douglas Williams, June, 2001.

Need for Highly Qualified Personnel

There was agreement with the conclusion of the study that there is an urgent need for many more highly qualified personnel in the natural sciences and engineering, particularly in the university sector, where the amount of research carried out is projected to increase significantly within the next few years.

It was noted that, in addition to the underlying factors noted in the study (large announced increases in university research spending, steadily increasing industrial R&D spending, likely increases in in-house government R&D), the urgent need for more HQP will also be affected by faculty renewal – the need to replace the large number of faculty members who will retire over the next 5-10 years.

One participant mentioned that Canada is projected to recruit as many as 30,000 university faculty members (in all fields) by 2010 to replace retiring individuals and fill new positions.

Additional comments made regarding this issue and the implications for NSERC included the following:

- The key to the government's goal of increased Canadian participation in R&D is people. Canada needs to do everything it can to attract and retain experienced researchers and train new researchers, particularly in multi-disciplinary research.
- Faculty renewal is a problem in all countries. Competition for senior people is increasingly difficult.
- The current expectations for the percentage of faculty members who are active in research may not be sustainable. It is anticipated that new faculty are increasingly going to focus on research (compared to those retiring) so that there will likely be even more competition for research grants. With the increasing need for more faculty members, it is likely that universities will be hiring some faculty members mainly for teaching purposes.
- Special efforts should be made to support young researchers – developing and retaining them is one of the keys to faculty renewal. NSERC should be targeting young researchers.
- There is significant pressure in Québec to attract more graduate students, since universities get more basic operating money for graduate students than for undergraduate students. Yet, it is difficult to attract foreign students, given the very high tuition fees for visa students in Québec. This creates problem in engineering, where Canadians do not continue on to graduate studies in large numbers.
- With the better infrastructure that is now available (mainly as a result of CFI and provincial matching funds) there are more and better opportunities for training in Canadian universities.
- The current stipends for graduate students are inadequate, especially compared with the US and in light of higher tuition fees that students often have to pay in Canada. NSERC should consider increasing the amount of funding available for scholarships (perhaps by reallocating from other programs).

In summary, there were two specific suggestions for NSERC:

(1) Review the support available for young researchers and target them in NSERC programming.

(2) Consider increasing the amount of funding available for scholarships.

Research Capability

The Research Grants program is currently focused on the development and maintenance of a broad base of research capability through supporting a high percentage (probably approximately between two third and three quarters) of the active university researchers in science and engineering. In view of the changing environment described in the study, arguments could be made that this should change, either through

- a greater focus on truly outstanding researchers – e.g., because a number of the provinces now provide support for the development of research capability and look to the federal government to reward excellence by supporting the cream of the crop, or
- a greater focus on supporting a broad research base – e.g., because there are now a large number of funding sources for "star" researchers and, in addition, the smaller provinces and smaller institutions are facing increasing difficulties in competing for research funding.

There are also questions about whether NSERC should consider a different program mix for different disciplines in view of the increasingly uneven access to research funding between disciplines.

Many workshop participants were of the opinion that the Research Grants program should continue to support a broad base of research capability. The following comments (which were made by different participants) are representative:

- Most programs are aimed at the top researchers. It is very important to support and strengthen the base. The role of NSERC is to develop and maintain research capability.
- NSERC should have a research enabling role.
- There is increasing disparity between the "haves" and "have nots" in the research community. The environment is getting more competitive. In view of this, NSERC needs to continue to provide support for the whole spectrum of capable researchers.
- Given the trend toward multidisciplinary research, it is even more important now than it was previously for Canada to develop and maintain a broad base of research capability. Otherwise, it won't be possible to support new initiatives. This is NSERC's role. In multidisciplinary research, each participant brings the strength of his or her core discipline.
- This program (Research Grants) needs to continue to have a delicate balance between supporting excellence and supporting a diversified base of research capability.
- NSERC should continue to support a broad base of research capability. Increasing attention should be focused on the current disparity between rich and poor regions of Canada and between large and small universities, but not at the expense funding excellence.
- There is alot of support for specific types of research (e.g., certain types of applied research) – including the SR&ED Tax Credit program -- and for the top performers. NSERC needs to continue its focus on the research base.

In summary, most of the comments made were supportive of NSERC continuing to fund a broad base of research capability. Merit should remain the primary criterion. There were no

suggestions regarding offering a different program mix for different disciplines or areas. However, the comment was made that the program should not try to be everything to everyone and should focus on a key role.

Other Comments

Participants were asked if, in view of the changing environment documented in the study, they had any advice for NSERC – e.g., regarding different programs or policies, or a different mix of programs. The following comments were made:

- Several people commented on the observation made in the report that the Research Grants program (in particular, a researcher's grant level) tends to be used as a yardstick for evaluating researchers, but there were mixed opinions regarding this. One person felt that NSERC should do what it can to discourage this practice, while another commented that this is one of the strengths of the program, since it facilitates the evaluation of researchers by the universities.
- One person suggested that NSERC should review the practice of awarding mostly individual grants in the Research Grants program in view of the trend toward an increasing amount of collaborative research.
- One person commented that NSERC needs to do a better job of communicating its role and impact. Politicians love new things (new programs, new organizations, new delivery models), and they tend to be less enthusiastic about building on existing programs and institutions. In addition, the role of NSERC is not well understood. Politicians need to better understand the system of how university research works. Should NSERC build a more dynamic structure over its traditional discipline structure (horizontal research, by themes or areas), on the model of the Canadian Institutes of Health Research?
- The role of industry in R&D continues to grow, and industry is under increasing pressure to be more innovative. It is also important to recognize that training does not only occur in the university milieu. This has implications for NSERC and the future of the Research Grants program. One person indicated that NSERC should not limit itself to providing a broad base, it must continue to offer other programs in addition to Research Grants and must be proactive. Its program structure must be dynamic.
- The key issue for the Research Grants evaluation is the role played by the program in the Canadian university research support system – e.g., what gaps are filled by this program, how is this program linked to other programs?
- There is a need in Canada for more problem-oriented research funding (although not more targeted research funding).
- The improved research infrastructure at Canadian universities may be having an impact on the type of research that is proposed – e.g., possibly higher risk or more ambitious. NSERC should be aware of this possibility.
- The research community needs to be involved in discussions of any potential major changes as a result of the changing environment.

In summary, there were no major changes recommended to current NSERC programs and policies. In particular, the workshop participants felt that the RG program should probably not be changed significantly.

Appendix 3–Federal and Provincial Support of University Research

Federal Government (excluding the three granting agencies)

Research Support Programs

Through recently created foundations or programs, the federal government funds research infrastructure and research. Table 1 from the body of the report is reproduced below, followed by more details on the various programs.

Table 1—Federal Programs in Support of University Research

Program/Agency	Date	Mandate	NSE %	Details
Canada Foundation for Innovation	1997	Infrastructure	~50	$3.15 B to 2010
Genome Canada	2000	Genomics	~30?	$300 M to 2005
Canadian Foundation for Climate and Atmospheric Studies (CFCAS)	2000		~100	$60 M to 2006
Climate Change Action Fund	1998		high	$150 M, $15 M for research to date
Sustainable Development Technology Fund	2000	Env. Tech.	~100	$100 M, mainly to industry, little R&D
Atlantic Innovation Fund	2000	Mainly economic development	?	Planning stages

Canada Foundation for Innovation www.innovation.ca

Budget: created with a $800 million fund in the 1997 budget. Initially, CFI was to exist until 2002. The mandate of CFI has now been extended to 2010 and the budget has grown from the original $800 million in 1997 to $3.15 billion. CFI funds only 40% of infrastructure projects. To date, CFI has approved over 1000 projects for a total of more than $850 million.

Type of agency: independent foundation.

Responsibility: research infrastructure in universities, hospitals, colleges and non-profit research institutes.

Activities: CFI contributes towards:

- the capital costs of research infrastructure, including both research equipment and facilities;
- the provision and modernization of research space;
- the operating costs of the equipment and facilities to be funded after June 2001;
- the capital costs of international facilities built in Canada (starting in 2001); and
- the provision of access to international facilities and programs (starting in mid-2001).

Review mechanism: merit-based review.

Criteria: Quality of the research and need for infrastructure; Building capacity for innovation; Benefits to Canada.

Fraction in the NSE: Difficult to say, given the large number of rather large multidisciplinary projects (such as Canadian Light Source, Digital Library, campus networks, genome facilities, etc.). Also, CFI mandate covers both disciplines and areas of application (science, engineering, environment, health) making it difficult to split along the mandates of the three federal funding agencies. The total of science, engineering and environment is about 55%, the balance being in health. However, the 55% includes some social sciences, and health includes some biomedical engineering. Nevertheless, 55% is a reasonable approximation. It is difficult to say how many researchers benefit from CFI, as some are involved in many of the 1000 projects and some projects (such as digital libraries or campus networks) indirectly affect all researchers.

Genome Canada (created in 2000) www.genomecanada.ca

Budget: $300 million over 5 years (funded from year-end money, $160 million in budget 2000 and $140 million in March 2001).

Type of agency: independent foundation.

Responsibility: coordination of genome research across Canada.

Activities: seven types of activities, including:

- Supporting large-scale genomics projects that draw on existing Canadian strengths and expertise, and whose scale and scope are such that they cannot currently be funded at internationally competitive levels, through existing mechanisms.
- Putting in place research infrastructure to support the major science and technology platforms that are essential for large-scale projects including, but not limited to functional genomics and proteomics, genomics sequencing, genotyping, bioinformatics and new technology development.
- Providing leading-edge technologies to researchers and cross-disciplinary training of the necessary workforce in all genomics-related fields through support for five Genome Centres across Canada: one each in British Columbia, the Prairies, Ontario, Québec and the Atlantic.

Review mechanism: peer review.

Criteria: There are 34 criteria, 13 scientific (excellence of research and researchers, training, benefits to Canada, etc.), the others are managerial and financial.

Fraction in the NSE: the first awards, totalling $136 million, were announced in April 2001. They include health, social and natural sciences. The split between the three is difficult to estimate because of the multidisciplinary nature of most of the centres (30% in NSE?). Funded projects involve 2000 researchers and technicians and will provide training opportunities for over 700 students and postdocs.

Canadian Foundation for Climate and Atmospheric Studies (CFCAS)
http://www.cfcas.org/

Budget: $60 million over six years (funded from year-end money in budget 2000). The first awards, totalling more than $3.9 million, were announced in February 2001.

Type of agency: CFCAS was incorporated with letters patent as a non-profit organization. It was established through a formal agreement amongst the Canadian Government (Environment Canada as lead), the Canadian Meteorological and Oceanographic Society (CMOS) and the Canadian Foundation for Climate and Atmospheric Sciences. The secretariat will have three staff members.

Responsibility: The Foundation objectives are to foster scientific research on the climate system, climate change, extreme weather, air quality and marine environmental prediction. This research will strengthen Canada's scientific capacity, improve scientific understanding of processes and predictions, provide relevant science to policy makers, improve understanding of how these challenges affect human health and the natural environment, foster collaboration and interdisciplinary approaches and encourage participation and support of others, including the private sector.

Activities: Research networks and projects. The Board takes a proactive role in funding university-led research in climate and atmospheric science, while also fostering collaborations that promote and support output-oriented science. All approved projects have set objectives over a definite period of time, and will deliver results in ways that are valuable to governments and to Canadians.

Criteria: Proposals must:

- be scientifically sound;
- justify the need for Foundation funds;
- indicate the source and amount of additional or levered financial support;
- identify partners and collaborators and their respective roles in the proposal;
- clearly identify one or more areas of the Foundation's objectives;
- address issues of national / regional concerns and their connections.

Review mechanism: peer review.

Fraction in the NSE: almost 100%. The eligible community spans the purview of several NSERC grant selection committees, particularly environmental earth and space and astronomy. Eligible research projects that address one or more of the following areas:

- understanding key climate system processes, including greenhouse gas sources and sinks;
- understanding key meteorological and atmospheric processes that impact on air quality;
- improving knowledge of oceanic and atmospheric processes leading to improved marine environmental predictions;
- understanding the probability of occurrence and/or improving the prediction of extreme and hazardous weather;
- developing and improving weather, air quality and climate system models for Canada.

Climate Change Action Fund (CCAF)
http://www.climatechange.gc.ca/english/actions/action_fund/index.shtml: contributions to in-house and university research on climate change. Initial funding of $150 million over three years (1998 budget), of which $15 million was for research (called science component). The balance of the fund is for a consultation process, the development of a national strategy, public education and outreach, and for the development and deployment of emission reducing technologies. In Budget 2000, new funding totalling $210 million over three years was provided for the CCAF and other federal energy efficiency and renewable energy programs. (No information to date on how much will go to research and how much to other types of projects; relationship with above Foundation not clear).

Most projects funded to date are government-led, but university researchers are included as partners in virtually all of them. In most instances, the focus is in the NSE. The science component of the Fund is managed through an interdepartmental committee involving most science-based departments and agencies, including NSERC and SSHRC. The technical committee is mainly federal, but it can call on outside experts if required.

Sustainable Development Technology Fund: To help Canada remain a world leader in environmental technology, the government established a Sustainable Development Technology Fund at an initial level of $100 million in Budget 2000. This fund will stimulate the development and demonstration of new environmental technologies, particularly those aimed at reducing greenhouse gas emissions such as fuel cells, wind turbines and advanced materials. Project funding would be available to the private sector, research centres and other institutes (university involvement not clear). The Foundation will be managed by a Board of Directors with expertise in technologies that promote sustainable development. They will be chosen from the business community and not-for-profit organizations. The Foundation will operate at arm's length from the government and will be fully accountable to the public, presenting an annual report on its activities to Parliament.

Contributions and Contracts

Through other department and agencies, the federal government funds specific research contracts in support of departmental missions (on some of these contracts, the government pays indirect costs or part thereof[22]).

Examples:

- $20 million in 1999-2000 to support "Phase III" of ***PRECARN'***s program for research and development. Some university involvement.
- ***Connecting Canadians****:* there are many programs, few for research. CANARIE has a research component. Advanced Network Applications, Services and Technologies (ANAST). The total ANAST Program budget is $8 million. It will be allocated over the three fiscal years 1999-2000, 2000-01 and 2001-02. About a third is for research. Only a few projects have been approved to date, none in universities. Another program is Bell Wireless Alliance/Telus Mobility and Canarie Phase II of Wireless Telecommunications R&D Investment Program, but it is for small companies only.
- *NRC'*s contribution to the operating costs of ***TRIUMF*** (approx. $40 million per year).
- *NRC'*s contribution to ***telescopes and other national facilities***.
- ***NRC's IRAP,*** which funds industry, but where universities may be involved in subcontracts.
- Contributions of regional economic development agencies to university research, such as contributions of ***Western Diversification*** to the Canada Light Source, or ***ACOA***'s matching contributions for CFI infrastructure.
- Contributions of the ***Canadian Space Agency*** to space R&D.
- Contributions via agriculture federal-provincial agreements.
- Contributions via ***Natural Resources Canada***, in forestry, energy and other natural resources.
- Some contracts from the ***Canadian International Development Agency*** have a research component in addition to an international development component.
- Some international research funded by the ***International Development Research Centre*** involve Canadian universities.

The ***Canadian Biotechnology Strategy***, with $55 million over three years announced for biotechnology R&D and regulation in federal labs announced in 1998 and $90 million announced in 1999 (probably not much for university R&D); and the Canadian Biotechnology Advisory Committee.

The Atlantic Canada Opportunity Agency is developing terms of references for the $300 million ***Atlantic Innovation Fund***. This fund, part of the Atlantic Investment Partnership announced in the summer of 2000, intends to promote applied research and commercialization of university research across Atlantic Canada[23]. The proportion going to universities as opposed to industry or other entities is not determined at this time. The current version of the consultation document indicates that most of the funding will be in the natural sciences and engineering. Other parts of

[22] CAURA. Indirect Costs of Federal Contracts to Universities, Mireille Brochu, 1996.
[23] ACOA, March 2001. Atlantic Innovation Fund. Consultation Document.

the Atlantic Investment Partnership are geared at community economic development; trade and investment; and entrepreneurship and skills development.

Initiatives at the Planning or Proposal Stage

Table 2, reproduced from the body of the report, summarizes some of the proposed federal initiatives. More details of the various programs or projects follow the table.

Table 2—Planned or Proposed Federal Initiatives

Program/Agency	Summary
ACST Commercialization	• Devote 5% of granting agency funds to commercialization; • many policy recommendations.
ACST International	• $150 million to enhance international R&D activities; • partly approved via CFI International Funds.
ACST Skills	• Does not focus directly on research; • skill challenges in aerospace, automotive, biotechnology, environmental technology and information and communications technology;
ACST Indirect costs	• Report confidential; universities asking for 40% of granting agency funding.
Astronomy community	• Proposed new facilities (estimated at $150 million); • additional $17 million in NSERC support; • Proposal that Canadian Space Agency invest $100 million in space-based research programs.
EMPOWR	• More than $100 million per year to triple the number of faculty members in Canadian universities and colleges in the areas of microelectronics and ICT.
Perimeter Institute	• Privately funded theoretical physics institute being planned in Waterloo is likely to seek matching federal dollars.
Neutron Facility	• $298 million for facility; • $90 million for beams for research, not counting operating costs.
Biodiversity Network Initiative	• A national strategy for establishing a biodiversity network in Canada is under development.
InnoCentre[24]	• Seeking federal support to expand its commercialization activities across the country.
Life sciences commercialization[8]	• An industry-led research organization, modelled on PRECARN, is being proposed to promote commercialization in the life sciences; • likely to seek federal support.
"Building capacity"	• AUCC and others developing proposals to help smaller universities build their research capacity.

[24] Source: Research Money.

Program/Agency	Summary
Other federal agencies	• Virtually all other federal government departments and agencies are seeking major infrastructure renewal or planning new major initiatives totalling billions of dollars.
"Academy"	• A Task Force is preparing advice to the federal government on the creation of a "national science academy or organization" or other advisory and evaluation body.

The government is reviewing the recommendations of the ***Expert Panel on Commercialization of University Research*** of the Advisory Council on Science and Technology (ACST). One of the recommendations is that the federal government devote 5% of granting agency funding to commercialization of university research. Other groups including NSERC and its sister agencies are calling for the government to implement the Expert Panel Report and to promote an increase in commercialization activities. Examples include:

- ***InnoCentre***, based in Montréal, is currently seeking federal support to expand its activities across the country[25]. InnoCentre offers a variety of services to help commercialize university (or government) inventions.
- An industry-led research organization, modelled on PRECARN, is being proposed to promote ***commercialization in the life sciences***. It is supported by the life sciences Network of Centres of Excellences and is likely to seek federal support[26].

The ***Expert Panel on International S&T*** recommends the injection of an additional $150 million per annum (or 5% of federal S&T expenditures). The fund should provide additional support, when needed and on a competitive basis, for the following:

- international partnerships and collaborative research, including multi-sector partnerships;
- Canada's participation in international programs;
- Canada's access to international facilities;
- Canada's participation in international S&T organizations; and
- Canadian participation in activities under bilateral and multilateral government-to-government S&T agreements.

The government has partly responded to this recommendation through $200 million in additional funding to CFI. The response is partial because CFI funding can go only to universities, colleges, hospitals and non-profit institutions, not to government and industry. Also, CFI funds infrastructure costs (including international access fees in some cases), not research costs, student expenses, etc.

[25] Research Money, Volume 15, Number 1, January 15, 2001. InnoCentre seeking Finance Canada funding to replicate successful technology commercialization model across Canada.

[26] Research Money, volume 15, Number 6, April 4, 2001. Life sciences commercialization initiative seeks to capture benefits of Canada's growing research base.

The same panel also recommends that the government establish a mechanism for priority setting. This recommendation is intended to address the current lack of a mechanism for even limited coordination of the international S&T activities of different departments and agencies, including the following:

- a mechanism for developing priorities for the government's international S&T activities; and
- a mechanism for identifying ways in which the government's return on its investment in international S&T can be maximized.

The last recommendation of this panel concerns IRAP and assistance to small companies. Consultation is underway on the recommendations of this report.

The report of the ***Expert Panel on Skills*** focuses less directly on research and more on people. It addresses skill challenges in aerospace, automotive, biotechnology, environmental technology and information and communications technology. It recommends the creation of an agency led by the private sector and funded by the federal government. Consultations are underway, led by Human Resources Development Canada. Given NSERC's major role in the support of highly qualified personnel, any major initiative could have an impact on NSERC. It is, however, difficult to quantify at this time.

The ***Report of ACST on Indirect Costs of Research*** is confidential. However, it is no secret that universities are asking the federal government to fully fund the indirect costs of the research supported by the three granting agencies. Universities state that 40% of direct costs would represent a reasonable compensation. The funding of indirect costs is the first priority of the Association of Universities and Colleges of Canada (AUCC).

Some sectors of the research community in the natural sciences and engineering are planning new initiatives:

- The ***astronomy and astrophysics community*** is looking at new facilities (estimated at $150 million) to be managed by NRC; it is also seeking an additional $17 million in NSERC support. Finally, it also suggests that the Canadian Space Agency invest $100 million in space-based research programs.
- The ***Task Force on Northern Research*** recommends investments of $24 million per annum from NSERC and SSHRC to support northern research and training. In partial response, NSERC recently announced the creation of Research Chairs and supplements to training awards, amounting to $1.25 million per annum.
- ***eMPOWR Canada*** is seeking more than $100 million per year to triple the number of faculty members in Canadian universities and colleges in the areas of microelectronics and ICT (with concomitant research funding) to ensure an adequate supply of highly qualified personnel. eMPOWR believes that NSERC and the Canada Research Chairs should be targeting more of their programs in areas of high demand[27].

[27] It is too early at this time to know whether the current global downturn of the high technology industry, the loss of jobs and the decreasing opportunities for graduating students will affect eMPOWER's estimated requirements for the longer term.

- The ***Perimeter Institute***, a privately funded theoretical physics institute being planned in Waterloo, is likely to seek matching federal dollars.
- The ***Canadian Neutron Facility*** would support the CANDU business of Atomic Energy of Canada (AECL) and support materials research. The facility itself would costs $298 million, and beam facilities for research would cost $90 million (not counting operating costs).
- A strategy is under development for the creation of a ***biodiversity network*** in Canada. No amounts are available at this time.

During the development of the Canada Research Chairs Program, the AUCC, the presidents of smaller universities and some members of Parliament expressed concern that new initiatives, such as Canada Research Chairs, CFI and potential contributions to indirect costs on federal grants would "make the rich richer". Such initiatives are not seen as effective in ***building the research capacity of smaller universities***. As a result, the AUCC has been developing a proposal to the federal government. Concurrently, Industry Canada has asked a consultant to look at the issue in a policy context. The Industry Committee of the House of Commons is also looking at the issue. The cost of any initiative is not known at this time.

With respect to in-house federal research, ***NRC*** is proposing several strategic initiatives, some of which have been approved or partially funded by the federal government. With funding of $110 million over five years, NRC is a key player in the government's ***Atlantic Innovation Fund***. This will include the creation of an E-Commerce Institute in New Brunswick as well as several other initiatives across Atlantic Canada. Other proposed initiatives include a nanotechnology facility in Alberta, an aerospace initiative in Montreal, a fuel cells initiative in BC (with NRCan, partially funded), and a prototyping facility for optoelectronics in Ottawa. NRC is developing innovation clusters in various regions of the country and regional universities will be involved in these. In particular, NSERC is developing a nanotechnology innovation platform in collaboration with NRC, as part of its proposal to create NSERC Innovation Platforms to accelerate research in the most important new areas of scientific discovery and transformative technological development.

After years of downsizing, virtually all other federal government departments and agencies are seeking major infrastructure renewal or planning new major initiatives totalling billions of dollars.

On the policy side, a Task Force is preparing advice to the federal government on the creation of a "national science academy or organization" or other advisory and evaluation body.

Provincial Governments

Major provincial programs in support of university research are summarized in Table 4, reproduced below from the body of the report. The table is followed by a province by province description of the various programs.

Table 4—Provincial Programs in Support of University Research

Prov.	Program	%NSE	Details
BC	BC Knowledge Development Fund (BCKDF)	~40	CFI matching; $217 M to 2007.
	Michael Smith Foundation for Medical Research (MSFHR)	low	Created in 2000 to support health research; $110 M over five years.
	Science Council of BC/Forest Renewal BC/Applied Systems Institute	high	Various applied research programs; support for university-industry liaison offices; Approx. $15 M per annum.
AB	Department of Innovation and Science	high	Research Investments Program, including CFI matching, Research Excellence Envelope for new researchers, Strategic Research Initiatives, etc.; ~$30 M per year.
	Alberta Heritage Foundation for Science and Engineering Research (AHFSER)	high	New Foundation endowed with $500 million; launching its first programs in 2001.
	Alberta Heritage Foundation for Medical Research (AHFMR)	low	Since 1980; supports health research; above NSE Foundation modelled on this one; ~ $40M per annum.
	Informatics Circle of Excellence	100	Fosters university research in information and communications technology; $10 M per annum.
	Agricultural Research Institute	high	Funds agriculture research. Total funding not clear
SK	Agriculture, CFI matching	high	Long tradition of funding agriculture research; investments in university research set to increase given commitments to the Canada Light Source; Total provincial investment of about $17 M per annum.
MB	Agri-Food Research and Development Initiative	high	Long tradition of funding agriculture research; $6.5 M.
	Manitoba Innovation Foundation	50	CFI matching; totalling $7 M (duration not clear).
	Manitoba Science and Technology Fund	high	New initiative ($5 M, duration not clear).
ON	Research Overhead	~50?	Small contribution to indirect costs of federal grants; $28 million per annum.
	Research Performance Fund	~50?	Created in 2000; 40% indirect costs on provincial grants; ~$30 M per annum.
	R&D Challenge Fund	~40	Funds human resources for university research; $318 M since 1997.
	Ontario Investment Trust	~50	Mainly CFI matching; $300 M since 1998.
	Ontario Centres of Excellence	100	Four centres; $32.3 M per annum.
	Premier's Research Excellence Awards	~50	Help researchers attract talented people to their team; $85 M over ten years to 2008.

Prov.	Program	%NSE	Details
	Agriculture	high	Long standing agreement with the University of Guelph; some participation from other universities; $54 M per annum.
	Several targeted programs		Biotechnology, digital media, etc. Mainly for industry, but some university involvement; annual budget not clear.
QC	Fonds pour la formation des chercheurs et l'aide à la recherche (FCAR)		Granting agency in the social sciences, humanities and NSE. Will soon be NSE only. $55 M per annum.
	Centres de liaison et de transfert		Six organizations to promote university-industry collaboration; 4 are mainly in the NSE; $10 M per annum.
	Agriculture		University research in agriculture is funded by the Conseil des recherches en pêche et en agroalimentaire du Québec; $3.7 M per annum.
	Research infrastructures	~50	CFI matching; $125 M, duration not clear.
	Valorisation Recherche Québec		Foundation created in 1999; 4 new technology transfer companies; short term funding of major projects; $220 M over 6 years.
NB	No specific program		CFI matching (often within federal-provincial agreements); Total provincial funding of $3.8M per annum.
NS	CFI matching		Through federal-provincial agreement; $8.72 M since 1998.
	Indirect costs		Since 1998, 38% of federal agency funding; $7.3 M per annum.
	Technology Science Secretariat		Promotes industry development.
PEI	No specific program		Total provincial investment of $350,000 per annum.
NF	No specific program		Support provided through federal-provincial agreements; Total provincial investment of about $1.5 M per annum.

British Columbia

The ***British Columbia Knowledge Development Fund (BCKDF)***, http://www.aett.gov.bc.ca/bckdf/, was created in 1998/99 with a budget of $100 million to permit public post-secondary institutions, teaching hospitals, and affiliated non-profit research

agencies to invest in research infrastructure. It is administered through the Ministry of Advanced Education, Training and Technology and is the major provincial mechanism to provide matching funding for CFI infrastructure. The 2000-01 provincial budget increased the Fund by $117 million for a total of $217 million over the term of the Fund (to 2006-07).

Review and criteria: similar to CFI, but with a "benefit to BC" clause and the opportunity to fund 40% of non-CFI projects.

Proportion in the NSE: approx 38% (as per CFI in BC).

The British Columbia government also offers a relatively large number of programs in support of university research.

In March 2001, the British Columbia government announced the creation of the ***Michael Smith Foundation for Health Research (MSFHR)***, http://www.msfhr.org/ to which it allocated a budget of $110 million to be used over the next five years for a range of programs. The full range of health-related research will be supported, aligned with the four CIHR pillars (biomedical, clinical, population and services).

The ***Science Council of British Columbia (SCBC)***, http://www.scbc.org/ operates several programs, some of which support university research to some extent:

- ***Technology BC***, http://www.scbc.org/programs/techno/default.asp, is the province's most significant source of financial support for applied research and development projects. It is administered by the Science Council on behalf of the Ministry of Employment and Investment and supports the development of new products, processes and systems which will have a positive economic impact on BC. Its budget is $5.8 million. Of this amount, $1.4 million or 23% was for university research in 1999-2000. Support is mainly in the NSE, and research is very applied.
- The ***Graduate Research Engineering and Technology Scholarship Program (GREAT)***. This program is funded ($1.5 million) by the Information, Science and Technology Agency (see below). It assists graduate students in science and engineering working in projects involving industry cooperation. This program is entirely allocated to the universities. All NSE.
- ***Forest Renewal BC***, http://www.forestrenewal.bc.ca, is a Crown corporation, established in 1994. Part of its mandate covers research to expand knowledge of all aspects of the forest sector by supporting research and extension in forestry. It also provides bursaries to help young British Columbians pursue forestry-related studies at B.C. post-secondary institutions. Universities received $5.6 million in 1999-2000 (35% of a total of $16.2 million). There is a strong management component, therefore it is difficult to estimate the NSE share. These programs are operated on behalf of Forest Renewal BC by the Science Council. Proposals are peer reviewed (using a ProGrid tool).
- ***Fisheries Renewal BC***, http://www.scbc.org/programs/fisheries/default.asp, is a Crown corporation created to lead the renewal of British Columbia's fish resource and the communities that depend on it. The corporation works with partners to make strategic

investments in program. About $30,000 (approx. 10% of a total budget of $282,000) was allocated to the universities in 1999-2000.

The ***BC Advanced Systems Institute (ASI)***, http://www.asi.bc.ca/asi/, encourages technology development projects involving BC's industry by sponsoring industry-specific programs and seminars. Universities are involved in some of these programs:

- The ***Industrial Fellowship Program*** provides matching salary support for companies hosting university researchers in advanced systems (less than 12 months duration). The review process is modelled on NSERC's.
- The ***New Faculty Awards Program*** supports newly hired (i.e. for a period of less than two years) university faculty who are conducting research in advanced systems (Intelligent Systems, Robotics, Computer Science, Microelectronics, and Telecommunications) and are interested in working with local advanced systems technology companies.
- The ***Research Fellowship Program*** is designed to "restock" BC's universities in the advanced systems faculties. It will provide funds of $40,000 a year for up to four years, to supplement their non-teaching salary.
- The ***Visiting Fellowship Program*** supports the visits of researchers in advanced systems (Robotics, Computer Science, Microelectronics, and Telecommunications) to SFU, UBC, UNBC and UVIC.

For 2000-01, ASI has budgeted $2.4 million to support university research activities. As all this funding supports BC industry-relevant research undertaken at the University, ASI funding will require matching funds of approx. $0.9 million from industry; therefore, in total $3.3 million will support activity at the universities.

The Science and Technology Division of the ***Information, Science and Technology Agency***, http://www.scitech.gov.bc.ca/, works with post-secondary institutions; provincial, national and international research facilities; and business and industry to develop, promote and support science and technology-based research and industry in British Columbia. It focuses on improving access for British Columbians to telecommunications services as well as fostering the development of BC's information technology sector.

The BC government funds university-industry liaison offices. In 2000-2001, this funding amounts to $1 million distributed among five universities.

From the inception of the NCE program by the federal government, the BC government has provided infrastructure and administrative support for NCEs, amounting to $1.5 million annually to the 26 or so participating groups in British Columbia. In the first round of the Program, the province provided $0.50 for each federal dollar; this has since decreased to about $0.16 since.

According to CAUBO data, provincial support for university research has been around $20 million in the 1990's. The amount of research funding contributed by the provincial government should increase as the BCKDF and MSFHR investments (see above) come into play. Total research funding from the federal government declined from a high of almost $120 million in 1994-95 to approximately $90 million in 1997-98. It increased to $102 million in 1998-99. By

contrast, non-government funding has doubled during the decade to stabilize at around $60 million in 1996-97 (decreasing to $56 million in 1998-99).

In the 2001-02 budget, the BC government introduced a one-time allocation of $23 million to the universities in recognition of the indirect costs of research.

The research environment in British Columbia universities was considered to have declined since the mid 1990's, due to significant decreases in provincial support programs and unstable policies.[28] However, recent investments described above have reversed that trend.

Alberta

A policy framework for Alberta's University Research System was adopted in the spring of 1996. Implementation of the Framework also started in 1996, with the introduction of the Research Excellence Envelope (created to facilitate the recruitment and retention of new faculty members).

All Alberta research and technology support programs have recently been consolidated under the newly created Department of Innovation and Science. Alberta science and research agencies are also under the purview of the department. These include the Alberta Science and Research Authority (ASRA), the Alberta Heritage Foundation for Medical Research (AHFMR), the Alberta Research Council (ARC), the Alberta Oil Sands Technology and Research Authority (AOSTRA), the Alberta Agricultural Research Institute (AARI) and the newly created Alberta Heritage Foundation for Science and Engineering Research (AHFSER).

The University Research Branch of Innovation and Science, http://www.gov.ab.ca/is/research/rsrch-2.cfm, administers the ***Innovation and Science Research Investments Program (ISRIP)***, a new competitive funding program that supports selected science and research initiatives of strategic importance to Alberta. ISRIP combines the former Intellectual Infrastructure Partnership Program (IIPP) and the Science and Research Fund (created in 1995) into a single program with three distinct funding streams, two of which support university research. The first stream corresponds to IIPP (see below) and the second one is in support of research application and technology transfer. The third stream is public awareness of science. All three streams share the overall objectives of promoting quality, innovation, and supporting initiatives that will be of strategic value to Alberta.

- ISRIP committed $18.7 million in 2000-01. The major component, the former IIPP, is intended to modernize research infrastructure in strategic areas of institutional and provincial competitive priority. This fund was created in part to help Alberta institutions compete for funding from the CFI. Criteria are similar to those of CFI, but with a "benefits to Alberta" clause. NSE share of CFI in Alberta is approximately 40%.

[28] Munroe-Blum, Heather, Growing Ontario's Innovation System: The Strategic Role of University Research- Case Studies, December 1999, p. 38.

- The ***Research Excellence Envelope (REE)*** helps universities attract talented researchers and graduate students in areas of identified strengths. It is intended to stimulate financial contributions from the universities and their partners towards the total cost of the recruitment of new faculty. Allocation of the envelope is as follows: 50% of the allocation is based on each university's share of granting agency awards and the other 50% reflects the ratio of granting agency grants as a percentage of operating grants. A three-year average is used. Eligible expenditures must be made in relation to the research program of an identified faculty member or research team. Only faculty members hired in the previous three years are eligible and their research must be in a priority area, as identified by the university. Annual commitments are approximately $3.5 million.
- ***Equipment Grants*** in support of Canada Research Chairs amounted to $5 million (also formula-based).

Commitments extend over several years. Total annual funding to universities from the Department of Innovation and Science probably exceeds $30 million per annum. In addition to the support provided through the main research granting programs, the province supports a number of strategic research initiatives. Examples include:

- $10 million commitment to the Alberta Network of Proteomics Innovation;
- $2 million investment in the Genome Prairie Projects (conditional upon approval by Genome Canada);
- commitment of $9.8 million over five years to the Canadian Light Source and the Alberta Synchrotron Institute.

The ***Department of Economic Development*** has been funding the industry liaison offices at the universities for a number of years. Responsibility for this has also been moved to Innovation and Science (Research and Technology Commercialization Division). Ongoing funding for these offices is currently under discussion.

The Alberta government has set aside $500 million in Budget 2000 for the creation of ***Alberta Heritage Foundation for Science and Engineering Research (AHFSER)***, http://www.ahfser.ab.ca, to provide stable, long term funding for research and development in a variety of science and engineering fields. If provincial finances permit, an additional $100 million will be added to the fund each year for the next five years, meaning the endowment fund could be worth $1 billion by the province's centennial in 2005. AHFSER is launching its first competitions in 2001, scholarships for graduate students ($20,000 per annum) and Establishment Grants (start-up grants for new faculty members). The goal is to fund 10 awards at $200,000 in the first year, i.e. a budget of $2 million. At this time, it is not possible to predict the proportion of the research community that will benefit from this fund when it is totally operational. For the time being, graduate students and new faculty members from all NSE fields have access to AHFSER programs.

ICORE, http://www.icore.ca, is a $10 million per year program launched in October 1999 to foster university-based research in information and communications technology (ICT). iCORE's mandate is to develop and support excellent university-based research teams around fundamental and applied problems in information and communications technology. Its goal is to build a

critical mass of leading researchers in the fields of computer science, computer engineering, physics, mathematics and other ICT disciplines. ICORE programs include chairs, research grants, establishment grants and supplements to NSERC scholarships

The ***Alberta Agricultural Research Institute (AARI)***, http://www.aari.ab.ca/index.html, is a provincial Crown corporation. Its mission is to enhance the economic contributions of a sustainable agriculture and food industry through research and technology transfer. AARI coordinates agriculture and food research conducted in government, university and private sector organizations. Through its research funding programs, AARI also expands and complements research done within the Government of Alberta. It accomplishes the latter task by supporting research in private sector organizations, universities and government research centres.

The ***Alberta Heritage Foundation for Medical Research (AHFMR)***, http://www.ahfmr.ab.ca, was established in 1980. The $300 million health research fund – worth over $1 billion by March 31, 2000 – was established to generate an annual source of research funding. In 2000, the AHFMR generated about $40 million in direct funding for health research in Alberta.

Alberta has a strong research policy and research programs in support of that policy. Overall, provincial funding for research increased significantly every year since 1995 (from $30 million in that year to more than $90 million in 1999-2000, according to data reported by the universities to Alberta Innovation and Science). This should continue to increase as the new programs and CFI matching expand in the next few years. Alberta universities continued to excel in attracting federally sponsored research grants through peer-reviewed competitions with their counterparts across Canada. In fact, federal research funding in Alberta grew slightly despite significant budget cuts to the granting agencies. In 1998-99, federal funding increased by 8% to reach $96 million (CAUBO data). Industry demonstrated a strong commitment to innovation and economic growth by increasing its investment in research by approximately 45% from 1995-96 to 1998-99. In total, universities reported $300 million in research funding in 1999-2000. The base funding of universities does not specifically include an indirect cost component but the provincial government estimates that universities use approximately $150 million from their annual provincial operating grants for research-related purposes.

Saskatchewan

The Saskatchewan government has a long tradition of funding agricultural research (partly through federal-provincial agreements) and public health research. In 1998-99, it invested about $17 million in university research (compared to federal investment of about $22 million). Both levels of government are slated to increase funding, given the committed contributions to the funding of the CFI-funded Canadian Light Source. The government also matches CFI investments. Excluding the CLS, the NSE share of CFI investment in Saskatchewan is about 55%.

In the natural sciences and engineering, funding is focused on agriculture. There are numerous programs. The University of Saskatchewan is the main beneficiary.

The ***Department of Agriculture and Food***, http://www.agr.gov.sk.ca/, supports R&D to promote the development and diversification of the agriculture and food sectors in Saskatchewan, add value to agricultural products, and develop improved and environmentally sustainable practices. The Department uses a number of mechanisms including proposal-based funding through the *Agriculture Development Fund*, support to industry through funds such as the Saskatchewan Beef Development Fund, Horned Cattle Trust Fund, and the Cattle Marketing Deductions Fund.

The Agriculture Development Fund supports research and development through a competitive and open proposal-based program known as ADF R&D Projects. The ADF Board of Directors selects proposals to be supported and proponents are then offered a contract to perform the research. All projects supported and most non-commercial research results are made public.

Funding to strategic programs is provided through the ***Canada-Saskatchewan Agri-Food Innovation Fund***. The Department also supports the Prairie Agriculture Machine Institute and Ag-West Biotech Inc. through operating grants. The ***AgriFood Innovation Fund*** (Canada-Sask. Agreement) http://www.agr.gov.sk.ca/afif/Homepage.htm, also supports agriculture.

The ***Strategic Research Program (SRP)*** is an umbrella agreement between Saskatchewan Agriculture and Food and the University of Saskatchewan. Under SRP, the Department provides funding to the University for defined research activity that is long-term and strategic in nature, maintains research capacity and provides industry support and services in those areas. This is not peer-reviewed in the classic sense, but there is a steering committee which includes industry representatives and there is a full review every five years.

All these programs support mainly the NSE (agriculture economics and management are also funded.) Except for the Agriculture Development Fund, where some projects are university-based, and the Strategic Research Program, most of the programs support industry.

Manitoba

In 1998-99, the Government of Manitoba invested more than $10 million in university research, mainly at the University of Manitoba, and mainly in health and agriculture research. This will increase in the future, as the government matches CFI investment via the Manitoba Innovation Foundation ($7 million, with the NSE share about 50%). In the 1999 budget, the Manitoba government also announced increases to the funding of health research ($2 million for a Health Research Initiative), created a Manitoba Science and Technology Fund ($5 million) and added $6.5 million for the Agri-Food Research and Development Initiative. Some of these new funds should have components for universities.

The $40 million ***Canada/Manitoba Economic Development Partnership Agreement***, http://www.gov.mb.ca/finance/edpa/strategic.html, is a collaborative partnership focusing on strategic priorities including:

- Business Development - Projects focus on initiatives which advance entrepreneurship potential, particularly among youth, Aboriginal people and immigrants, enhance expertise in the small business sector and promote products and services nationally and internationally.
- Economic Innovation - The agreement supports economic and technological innovation within Manitoba industry as well as increased collaboration with local research institutions to develop and commercialize leading edge products for global markets.

Ontario

Compared with Québec and Alberta, the Government of Ontario has not traditionally provided much direct support of university research by arm's length agencies. This has been changing in the past few years.

The ***Research Overheads/Infrastructure Envelope (ROIE)*** was established in 1987-88 at $25 million to help make up the shortfall in the funding of indirect costs of research, acknowledging that many universities had expanded their research activities with inadequate incremental base funding. The ROIE is distributed among the universities on the basis of their average share of peer-adjudicated research grants awarded by the three federal granting agencies. The ROIE's 2000 value, at $27.8 million, represents only 1.7% of the total provincial operating grants ($1.63 billion) to universities. In her report issued in December 1999, Heather Munroe-Blum[29] recommended that a Research Performance Fund be established, starting at $225 million annually, to be allocated to the universities on the basis of their success with the granting agencies and with Ontario's competitive research programs that do not include an overhead component.

The 2000 Ontario Budget provided $30 million for the Ontario Research Performance Fund, to support the indirect costs of research funded by the Province. The Ministry of Energy, Science and Technology, http://www.est.gov.on.ca/english/index.html, is administering the Fund. This amount corresponds roughly to 40% of direct costs.

The ***Ontario Health Research Program (OHRP)*** is a long standing program operated by the Ministry of Health and Long-Term Care. It is divided into two research components: The Ontario Health Research Co-sponsorship Fund and the Health Research Development Fund. The Ministry's programs in aid of research total approximately $45 million per year.

The ***Ontario Research and Development Challenge Fund (ORDCF)***, http://www.ontariochallengefund.com, was established in 1997 with a budget of $500 million over 10 years. The ORDCF invests in research and development projects aimed at furthering innovation, keeping scientific talent in the province, and creating highly skilled jobs. One of its original objectives was to help Ontario researchers compete for funding from the Canada Foundation for Innovation. However, with the creation of the Ontario Innovation Trust (see below), the ORDCF focuses on investments in people rather than infrastructure. The May 2000 budget speech announced an additional investment of $50 million for cancer research,

[29] Munroe-Blum, H. Growing Ontario's Innovation System: The Strategic Role of University Research. Dec. 1999.

specifically for the development of the Ontario Cancer Research Network. ORDCF uses peer review. To date, the ORDCF has committed $318 million to 77 major projects. About 38%, or $120 million, was invested in the NSE. A further 40% was committed to Imaging, Genomics, and Proteomics proposals. About 30% of that investment, or an additional $38 million, can be attributed to the NSE. Biomedical research accounts for about 17% of the total ORDCF commitments to date, and Business and the Social Sciences account for about 5%.

The ***Ontario Innovation Trust (OIT)***, http://www.oit.on.ca, was announced by the Government of Ontario in the May 1999 Budget. It was created to help Ontario's universities, colleges, hospitals and research institutions enhance the infrastructure needed for scientific research and technology development. It focuses on capital expenditures, and is designed to complement the work of the ORDCF, which funds the human resources requirements of research. Matching grants are also provided by OIT for projects in Ontario supported by the Canada Foundation for Innovation. It was inaugurated with a fund of $250 million. In the 2000 Budget, the Minister of Finance announced an additional endowment of $500 million, bringing the total budget to $750 million. The OIT operates under a Trust Agreement at arm's length from the Government of Ontario. The OIT may use a peer review system to assess projects, unless they have already been reviewed by the Canada Foundation for Innovation or another granting agency, in which case, OIT will add their reviewers' comments to its review. To date, OIT has approved $300 million in CFI matching funding, encompassing 287 projects (NSE share of CFI is about 49%). It has also approved 6 other projects totalling $57 million. Of these, 2 are in the NSE, totalling $17 million.

Both OCRDF and OIT programs are managed by the ***Innovation Institute of Ontario (IIO)***, a service/administrative organization created by OIT and hired by the Ministry of Energy, Science and Technology to administer the ORDCF.

The ***Ontario Centres of Excellence Program (OCE)*** was established in 1987. The Province provides annual support of $32.3 million. Ontario's Centres of Excellence are not-for-profit corporations that support networks of Ontario university researchers working in advanced technology areas of interest to Ontario industry. The four Centres are: Materials and Manufacturing Ontario; Communications and Information Technology Ontario; Photonics Research Ontario; and the Centre for Research in Earth and Space Technology. All four centres are in NSE and all promote technology transfer.

The ***Premier's Research Excellence Award Program (PREA)*** was instituted in 1998. It was designed to help gifted researchers attract talented people to their research teams. At its inception, PREA represented an investment of $75 million over 10 years (with the government contributing $50 million and the universities contributing $25 million). In the May 2000 Budget, the Province's investment over 10 years was increased to $85 million, with $42.5 million contributed by the universities, for a total of $127.5 million. To date, a total of 305 researchers have been awarded approximately $30.4 million, of which about $16.2 million or 53% is in the NSE.

The provincial government announced in May 2000 that it will invest up to $57 million over five years to create the ***Ontario Research and Innovation Optical Network (ORION)***. ORION will

be a high speed, state-of-the-art network to be used by researchers, educators and scientists to conduct advanced research and to develop and test new technologies.

The ***Biotechnology Commercialization Centre Fund (BCCF)*** was established in 1999 with a budget of $20 million over four years to assist in the creation of regional commercialization centres and to house start-up biotechnology firms from Ontario's research institutions and private industry. NSE share is impossible to predict at this time.

The ***Interactive Digital Media Growth Fund*** is a five-year, $10 million initiative. Its purpose is to invest in strategic initiatives and activities that will spur the growth of, and increase the number of jobs in small IDM firms and the overall IDM industry in Ontario. Projects supported by the Fund must have commitments of resources from business partners and the support and involvement of small IDM firms, and must demonstrate they can deliver industry-wide benefits. This Fund is mainly NSE, but also includes social sciences and arts.

The ***Ontario Ministry of Agriculture, Food and Rural Affairs,*** http://www.gov.on.ca/OMAFRA/english/index.html. OMAFRA funds agricultural research, including social sciences aspects, mainly through an agreement with the University of Guelph. In 1999-2000, there was a total transfer payment from OMAFRA of $53.7 million of which $36 million provided direct support to 347 research projects. OMAFRA funding supports the natural sciences and engineering for the large part, but it also supports social sciences (economics, management, etc.).

Following the release by the Council of Ontario Universities in 1997 of a report showing that Ontario was lagging behind other jurisdictions in its ability to leverage funds from the national granting agencies[30], the Government of Ontario made a concerted effort to encourage research in the province. A recent report[31] asserts that despite this effort, there remains significant gaps in Ontario's research policy: first the "upgrading and operation of world-class infrastructure and, second, the absence of a Health Research Council." As noted above, the 2000 Ontario Budget[32] has proposed measures that will help fill the first gap.

Québec

Québec has well structured programs to support research and to ensure that researchers from the province's universities are competitive at the national (and international) level. The creation of granting agencies more than 20 years ago is reaping immense benefits as, in recent years, Québec researchers have been steadily increasing their share of federal research funds. There are three granting agencies:

- ***Fonds pour la formation des chercheurs et l'aide à la recherche***, http://www.fcar.qc.ca. At this time, FCAR covers the NSE and the social sciences and humanities. In 1999-2000,

[30] Brochu, Mireille. The Impact of Provincial Policies on University Research. A Comparative Study of Selected Canadian Provinces, Council of Ontario Universities, March 1996.
[31] Munroe-Blum, H. op. cit.
[32] http://www.gov.on.ca/FIN/bud00/index.htm

FCAR budget was $55 million. It is estimated that about 50% was in the NSE. Only 30% of scholarships are in the NSE, but the percentage is higher in the various grants programs.

- ***Fonds de recherche en santé du Québec (FRSQ)***, http://www.frsq.gouv.qc.ca, budget of $62 million in 1999-2000).
- ***Conseil québécois de la recherche sociale (CQRS)***, budget in 1999-2000, $12 million).

In 2001, the government announced its intention to limit the purview of FCAR to the NSE and to transfer its responsibilities for the social sciences and humanities to CQRS (changing the status from a "conseil" to a "fonds)". There will be a two-year transition period. A tri-agency committee (Conférence des présidents des fonds de recherche du Québec) is planning the transition and ensuring coordination between the three agencies.

None of these agencies support indirect costs. However, since, 1989-90, the funding formula for universities include an *envelope for the indirect cost of research*, based on peer reviewed grants from "accredited" government and philanthropic organizations. In 1995-96, the envelope was $37.6 million; it has grown to $41.2 million in 1999-2000. One feature of this envelope is that each institution receives a minimum amount of $40,000, which gives small institutions a base from which they can develop research.

In 1984, the Québec government created ***Centres de liaison et de transfert***, http://www.mrst.gouv.qc.ca/_fr/struct.html , to promote university-industry collaboration and to address priority research areas. In 1997, the budget was $10 million and six centres were funded; 4 are mainly in the NSE. The focus of the six centres are: information technologies, applied mathematics, biotechnology, aluminium; and, mainly in SSH: computerization of organizations and analysis of organizations.

Agriculture research is funded by the ***Conseil des recherches en pêche et en agroalimentaire du Québec (CORPAQ)***, http://www.agr.gouv.qc.ca/frdt/corpaq/index.htm. Research grants proposals are peer reviewed. Criteria include scientific quality and relevance. A total of $3.7 million was provided in 1999-2000, of which $2.8 million came from a federal-provincial agreement. Most of the funds go to universities.

The Québec government also funds 23 specialized research and technology transfer centres in community colleges (Cégeps). Most are in the natural sciences and engineering.

- In response to the creation of CFI, the Québec government created a special envelope (in three parts totalling about $125 million) called "***Research Infrastructures***," to assist universities in leveraging CFI contributions[33]. To date, NSE share of CFI is about 50%.

Valorisation Recherche Québec, http://www.vrq.qc.ca, was created in 1999 to forge closer links between university research and innovation. It was created as a non-profit, arm's length organization with a budgetary envelope of $100 million over 6 years (1999-2006). This Québec government initiative was designed to encourage innovation by helping to transform research results into patent applications, industry/business start-ups and social applications. This truly

[33]Gouvernement du Québec. Ministère de l'Éducation. Plan d'investissements universitaires pour la période du 1er juin 1998 au 31 mai 2003.

distinctive financial support program applies to all disciplines and funds activities that neither industry, line departments of government, nor the research funding agencies are able to fund. It addresses the need to finance the "gap" between basic research and its potential applications. There are two major axes: Valorisation and Research, each with an initial envelope of $50 million. The results of the first two competitions for research support have been announced. The proportion in the NSE is difficult to estimate, because amounts awarded to individual projects have not been published. Of the 22 projects funded so far, eight focus primarily on the NSE.

The Valorisation axis helped universities create technology transfer companies (four were created in 2000, regrouping all Québec universities). The funding amounts to $50 million over 5 years (with a requirement that a matching amount be found from other sources). After this initial period, the companies must be self-supporting. The companies are operational or will be in the very near future. These companies will play a strategic role in the optimization of the dissemination of university research results by:

- being proactive in the identification of promising ideas and the assessment of their commercialization potential;
- targeting research activities towards optimal commercialization by adding value to the research results;
- protecting intellectual property through patenting activities;
- mentoring and supporting researchers throughout the process;
- directing market studies on products and services to be commercialized;
- negotiating and managing royalties and other revenues from commercialization.

The companies will have to identify niche areas where they can make major contributions to commercialization. It is expected that, together, the four companies should cover the major areas of knowledge. There is also a requirement that each company adopt an intellectual property management policy and work out a reasonable division of responsibilities between university-industry liaison offices and the company. The expectations is that university-industry liaison offices will devote their energies to negotiations of agreements or contracts with the private sector, to linkages with researchers, thereby increasing their mentoring role.

In February 2000, VRQ received an additional $120 million to be used for the development of research, Part of it will be used for matching some of CFI's investments and the launching of Genome Québec. The balance will be used to fund major research projects

Québec's 2001 ***Science and Innovation Policy*** (Savoir changer le monde) reinforces the importance of adding value and commercialization, but goes beyond commercialization to include knowledge transfer to all types of users. It introduces the concept of "innovation sociale" to describe transfer of research results to society (governments, community groups, health and education systems) as opposed to transfer to the private sector. The Policy also proposes harmonization of IP policies among universities and affiliated hospitals/institutes (towards university-owned).

The Science and Innovation Policy proposes major increases to R&D and identifies a number of priority areas. The 2001 budget identifies an additional $250 million over three years for implementation of the policy, in addition to a $50 million reserve (no details at this time). There is no question that Québec continues to pay great attention to research and research policy. However, in recent years, there has been serious concern that the repeated cut-backs in the budgets of universities in the recent past threaten the quality of the teaching and research programs in the province. This concern is now alleviated by the fact that the Québec government is also committed to increasing university operating grants.

New Brunswick

The New Brunswick government invested $3.8 million in university research in 1998-99. CFI matching has generally come from federal-provincial agreements, with the Atlantic Canada Opportunity Agency (ACOA) being the major federal partner. CFI investments in New Brunswick are mainly in the NSE.

Nova Scotia

Since the implementation of the Canada Foundation for Innovation, Nova Scotia has been able to obtain approximately $8.72 million through the federal-provincial Economic Diversification Agreement (EDA) in support of the matching funding requirement of successful CFI applications. The Economic Diversification Agreement is co-administered by ACOA (Atlantic Canada Opportunities Agency) and the N.S. Department of Economic Development. About 90% of CFI investment to date are in the NSE.

Until 1998, an amount of $330,000 per year was available to universities to compensate partially for the ***indirect costs of research*** funded by the federal granting agencies (including the Canada Council for the Arts). In 1997-98, this represented less than 2% of the total received from these agencies. In 1998, this proportion increased to $7.3 million or 38% of the three-year average of federal granting agency grants obtained between 1994/95-1996-97.

Nova Scotia has one research support program: the ***Nova Scotia Health Research Foundation*** was created in 1998 with an annual budget of $5 million. The foundation supports worthy applicants in the fields of health outcome research and evaluation (15%), medical research (40%), health public policy research (15%) and health utilization research (15%), with the remaining 15% spent on administration and on stimulation of public awareness.

It is the role of the ***Technology and Science Secretariat*** **(TSS)**, http://www.gov.ns.ca/tss/, to help define a new framework for the development and application of all technology within the Province and government, with a particular emphasis on information technology. The TSS will actively promote industry development via the use of technology within the provincial economy and will promote the development and application of science and technology as enablers of economic growth and good jobs for Nova Scotians. One of the planned activities is: strengthening links with universities, private sector industries, federal/provincial research

facilities and institutions via the pursuit of joint science and technology development initiatives. This includes strategies for the development of technology and science as generators of economic opportunity through: private sector partnerships and the promotion of technology and science as keys to industry development.

The task of the ***Nova Scotia Innovation Corporation (InNovacorp)***, http://www.innovacorp.ns.ca/about/index.html, is to help entrepreneurs commercialize their technology-based products and services. Most of the funding comes from federal-provincial agreements and is geared to industry or commercialization.

Prince Edward Island

In 1998-99, out of a total of $3 million in sponsored research funding at the University of Prince Edward Island, the provincial government invested $350,000 and the federal government $1.5 million.

Newfoundland

Research activity at Memorial University of Newfoundland totalled $28 million in 1998-99, with the lion's share ($18 million) coming from the federal government through the granting agencies but also through other programs ($8.6 million), such as federal departments, federal-provincial agreements and ACOA. For its part, the province committed $1.5 million to university research, whereas the private sector invested $7 million.

The five-year ***Canada/Newfoundland Agreement on Economic Renewal***, http://www.edu.gov.nf.ca/division/fedpro/Fedspec2.htm, signed in 1996, aims to increase opportunities for economic development through investment in key growth industries, with the primary focus being on tourism, aquiculture, and advanced technology. The $100 million accord is based on a 80-20 cost-shared arrangement between the federal and provincial governments.

Totalling approximately $5 million, the ***Ocean Technology Fund*** and the ***Research Infrastructure Fund*** are initiatives of the advanced technology component of the Canada/Newfoundland Agreement on Economic Renewal.
Valued at $3 million, the three-year Ocean Technology Fund, provides investment in strategic areas of marine technology which have a local user industry and strong commercial growth potential. At Memorial University of Newfoundland, a $2 million Research Infrastructure Fund will enhance the institution's research and development capability. This fund focuses on four strategic areas: Medical Research ($500,000); Information Technologies and Informatics ($500,000); Biotechnology and Pharmaceuticals ($500,000); and Marine Sciences and Environmental Research ($500,000).

The ***Canada/Newfoundland Comprehensive Economic Development Agreement***, signed in 1998 and recently expanded, will enable the federal and provincial governments to implement measures that target strategic sectors offering the best opportunity for growth. Enhancing the

global competitiveness of industry, establishing linkages within the target sectors, and developing an export focus among key stakeholders are goals of this agreement. This agreement includes a research infrastructure fund (CFI matching).