Resource Book for Science and Technology Consultations

Volume I

Government of Canada	Gouvernement du Canada

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Preface

Together with the accompanying discussion paper, this document is intended to provide a starting point for a national dialogue on science and technology (S&T). The Government of Canada promised in its February 1994 Budget to launch such a dialogue as a means of reviewing federal S&T priorities and developing a new S&T strategy for Canada.

In the following pages, the Secretariat for Science and Technology Review has assembled facts, figures and a glossary of technical terms relevant to the questions posed in the companion paper. There are statistics on S&T expenditures and a summary of federally commissioned S&T reports, along with other information. The material is strictly factual and is presented without editorial comment.

The raw data were provided by governments, business and other respondents according to precise definitions and classifications as set by the Organisation for Economic Co-operation and Development's *Frascati Manual* [*The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development* (Paris: OECD, 1981)], some of which are given in the glossary. Caution should be exercised in interpreting and drawing additional inferences from the statistics presented.

Thanks go to Statistics Canada, the OECD and other individuals and organizations whose material has formed the basis of the document.

1 The Economic Context

Econometric studies show that research and development (R&D) has a significant positive impact on both the level and growth of corporate productivity. Science-based technological change is creating new industries and transforming old ones. For example, biotechnology is creating new comparative advantages for industries such as agricultural crops, animal production and food, waste treatment, human health diagnostics and forestry renewal. Similarly, science and technology (S&T) investments in risk management, health and social development yield social benefits through both improvements in the quality of life of Canadians and the increased competitiveness of the Canadian economy.

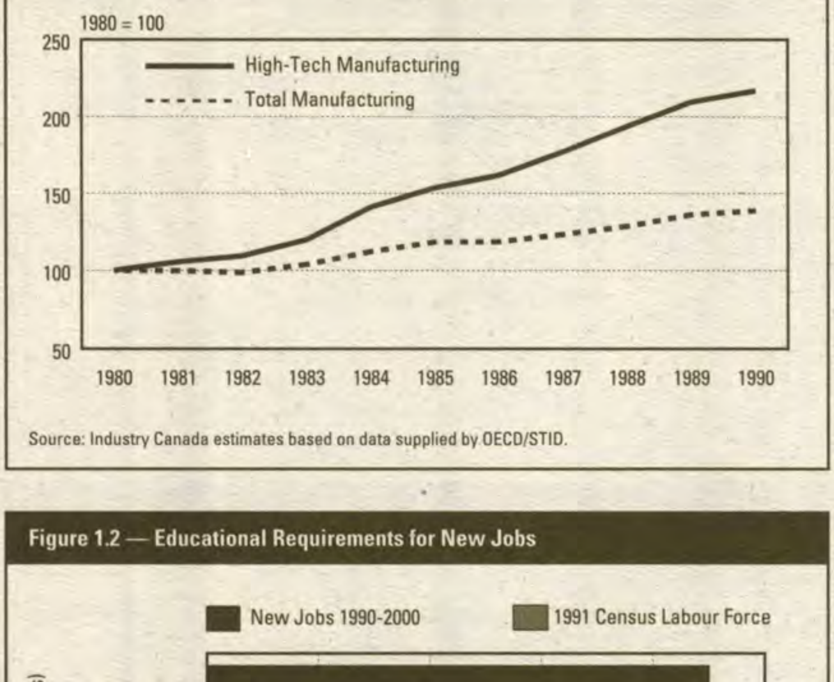
S&T is opening new ways of creating value and transforming ways companies do business. We are currently living through changes in the innovation system — the systemic relationship between outputs, production methods, methods of organization and institutions.

Noted Canadian economist Richard Lipsey, speaking on "Globalization, Technological Change and Economic Growth" at a Sir Charles Carter Lecture delivered at Queen's University in Belfast (Belfast: Northern Ireland Economic Development Office, 1993), said:

Technical change is the dominant vehicle of economic growth. ... In the new industrial paradigm, product and process innovation are becoming increasingly science based.

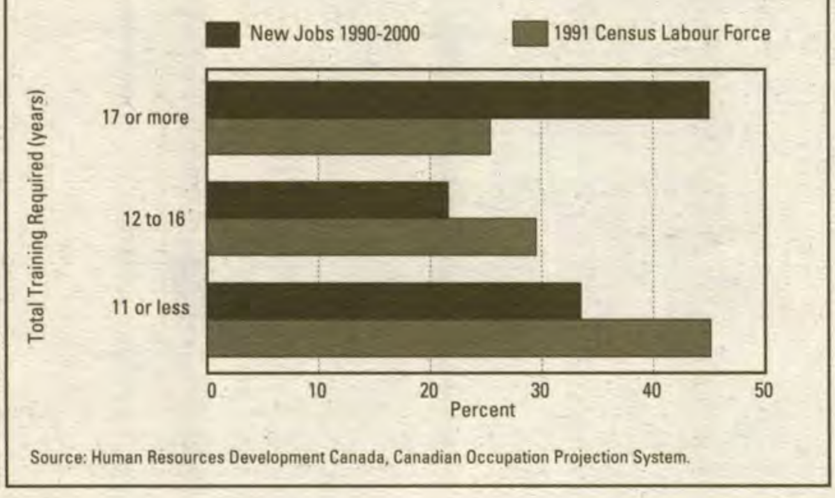
The global economy is progressively more driven by high technology. In constant-dollar terms, global production by high-technology industries has more than doubled between 1980 and 1990 (Figure 1.1), compared with production in other manufacturing industries of 23 percent. According to the Organisation for Economic Co-operation Development (OECD) data, output by high-technology industries, as a share of all OECD manufacturing, grew from 17 percent to 26 percent. The share of high-technology exports from OECD countries grew by 50 percent, from 14 percent to 21 percent of all exports in manufactured goods in the period 1980 to 1990. Canadian exports of high technology, as a share of all OECD high-tech exports, rose by 27 percent, from 2 percent to 2.6 percent of all exports in the same period.

Figure 1.1 — Growth in Production of Manufactured Goods for OECD Countries, 1980–1990



Source: Industry Canada estimates based on data supplied by OECD/STID.

Figure 1.2 — Educational Requirements for New Jobs



Source: Human Resources Development Canada, Canadian Occupation Projection System.

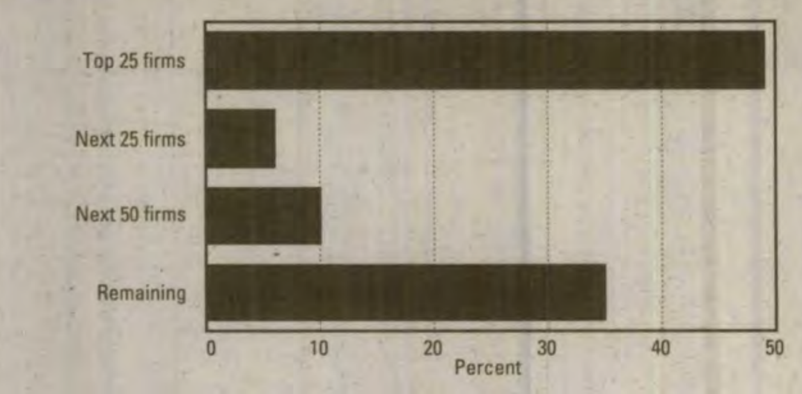
S&T is having a major impact on skill needs. In the past three decades, employment in knowledge-intensive industries in Canada grew almost four times as fast as in other industries. Close to half of all new jobs created between 1990 and 2000 in Canada will require at least an undergraduate degree (Figure 1.2). By comparison, only about 22 percent of new jobs in 1991 required this education level.

Statistical evidence suggests that Canada is not a nation of innovators. High gross domestic expenditures on research and development as a proportion of gross domestic product (GERD/GDP) appear to be characteristic of larger economies. For example, in 1991 the U.S. spent 20 times (US$154 billion) more than Canada (US$7.6 billion), even though its GDP and population are only 10 times our size. While Canada has the seventh largest economy, its GERD/GDP ratio is lower than those of much smaller economies such as Finland, Denmark and Norway.

The Canadian R&D effort tends to lean toward less commercial R&D projects. In 1992, Canada spent approximately 3 percent of estimated world expenditures on R&D but, according to the Institute for Scientific Information, Canadians publish about 4 percent of the world's academic literature in the sciences and engineering. Canada has an extremely narrow business base doing R&D; in 1992, 25 firms accounted for fully 49 percent of all industrial R&D in Canada (Figure 1.3).

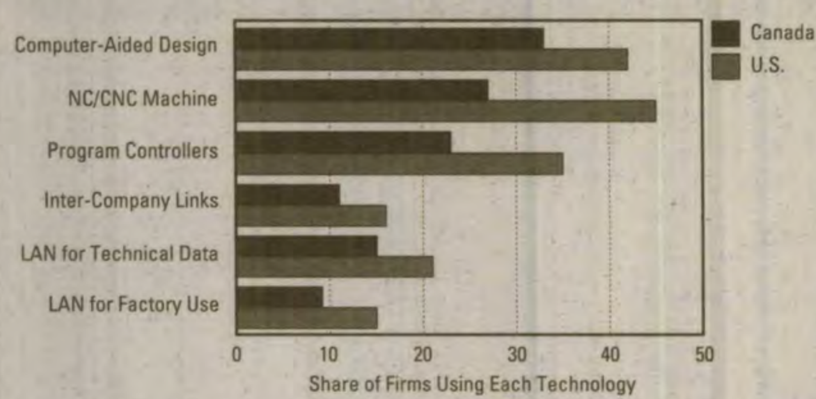
Diffusion of advanced manufacturing technologies is also low. Canadian firms lag their U.S. counterparts in technology usage (Figures 1.4 and 1.5).

Figure 1.3 — Industrial R&D in Canada, 1992



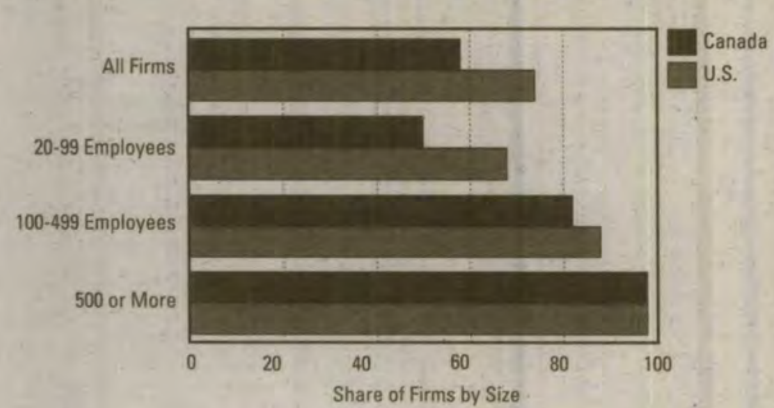
Source: Statistics Canada, *Industrial Research and Development Statistics (with Forecasts)*, Catalogue No. 88-202, Table 1.5.

Figure 1.4 — Use of Selected Technologies by Canadian and U.S. Industries, 1989



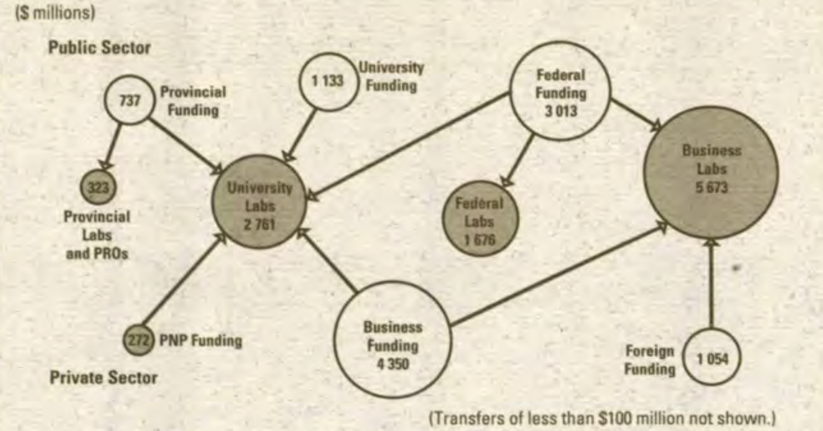
Source: Statistics Canada, *Indicators of Science and Technology*, Catalogue No. 88-002, Vol. 1, No. 4, Table 17.

Figure 1.5 — Use of at Least One Advanced Technology, by Size of Firm, 1989



Source: Statistics Canada, *Indicators of Science and Technology*, Catalogue No. 88-002, Vol. 1, No. 4, Chart 3.

Figure 1.6 — Canadian R&D Spending Flows, 1993



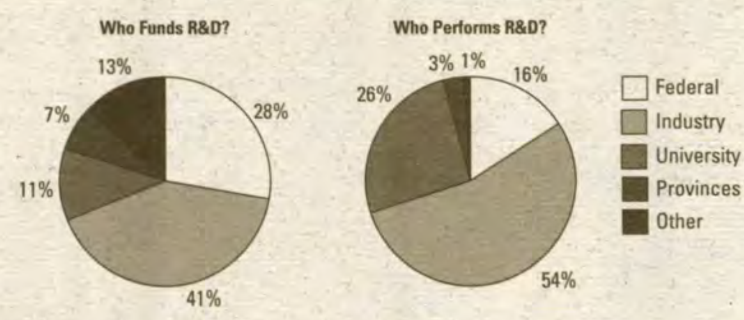
Source: Industry Canada estimates based on data supplied by Statistics Canada.

Table 1.1 — Expenditures on R&D, by Performing and Funding Sectors, 1993

Funder	Federal	Provincial	PRO	BE	University	PNP	Total	Distribution
	Performer							
	($ millions)							(%)
Federal	1 676	–	7	437	868	25	3 013	28
Provincial	–	227	54	108	330	18	737	7
PRO	–	–	1	–	–	–	1	–
BE	–	–	28	4 101	206	15	4 350	41
University	–	–	–	–	1 133	–	1 133	11
PNP	–	–	–	–	213	59	272	3
Foreign	–	–	6	1 027	11	10	1 054	10
Total	**1 676**	**227**	**96**	**5 673**	**2 761**	**127**	**10 560**	**100**
Share of Total (%)	16	2	1	54	26	1	100	

Source: Statistics Canada, *Science Statistics*, Catalogue No. 88-001, Vol. 17, No. 5.

Figure 1.7 — R&D in Canada, 1993



Source: Statistics Canada, *Science Statistics*, Catalogue No. 88-001, Vol. 17, No. 5.

Funders and Performers

The federal government is the largest, single funder and performer of R&D in Canada (Figure 1.6), and its R&D expenditure decisions can act as signals to the R&D community as a whole. Federal R&D expenditures do not necessarily lead national R&D spending, in that large percentage increases in federal spending in one year are not necessarily followed by increases in national spending; the federal government directly funds about 8 percent of all industrial R&D and subsidizes another 18 percent of the total through the tax system, which provides it with a major economic policy tool.

Over the past decade, industry has steadily increased its share of both the funding and performance side of Canada's R&D effort. For 1993, it is estimated that industry performed about 54 percent of GERD and funded 41 percent, a substantial increase over the 1979 values of 43 and 38 percent, respectively. Concurrently, federal performance and funding shares have declined to 16 percent and 28 percent, down from 23 and 35 percent, respectively. Table 1.1 and Figure 1.7 shows the estimated funder/performer matrix for 1993. The table shows that there are substantial transfers of funds from the two levels of government to industry and universities. The provincial governments transfer a much higher percentage of their R&D funding to extramural performers than does the federal government.

The Role of the Federal Government

In 1993–94, the federal government spent $3.5 billion on S&T activities within 150 labs and other establishments located across the country, staffed by over 35 000 people. Of these, 11 800 were scientific and professional staff and 8 600 were technicians. Extramural expenditures consisted of $977 million to Canadian industry, $971 million to the university sector, $287 million to foreign performers, $105 million to PNPs, and $105 million to provincial and municipal governments, and other performers (Tables 1.2 and 1.3).

The federal S&T portfolio is more than just economic; it includes risk management and the advancement of Canadian science. It has been estimated by Industry Canada that wealth creation accounts for an estimated 49 percent of all S&T expenditures. Key departments include the National Research Council Canada (NRC), Natural Resources Canada and Industry Canada. Risk management and quality of life activities account for 31 percent, including expenditures by Environment Canada, National Defence, Health Canada and the Medical Research Council of Canada (MRC). Activities that support the advancement of Canadian science account for 20 percent of the total. This includes the Natural Sciences and Engineering Research Council Canada (NSERC), Social Sciences and Humanities Research Council of Canada (SSHRC), Statistics Canada and the Canadian Space Agency.

Federal investment in S&T is spread over almost 60 distinct organizations, but over 90 percent of S&T resources is spent by 17 departments and agencies. The total $6 billion federal S&T expenditures do not include federal R&D tax credits. In 1991, according to Revenue Canada, the value of these tax credits exceeded $1 billion, for a total federal S&T program commitment in that year of about $7 billion.

Table 1.2 — Federal S&T Expenditures, 1993–94

	Total	Intramural	Extramural
		($ millions)	
R&D	3 541	1 676	1 865
RSA	2 390	1 811	579
Total S&T	**5 931**	**3 487**	**2 444**

Source: Statistics Canada, *Science Statistics*, Catalogue No. 88-001, Vol. 17, No. 7.

Table 1.3 — Federal S&T Expenditures, 1986–87 to 1993–94

	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993[p]	1993-1994[p]
					($ millions)			
S&T Actual $	4 454	4 512	4 823	5 067	5 471	5 776	5 896	5 931
of which:								
Intramural	2 790	2 721	2 833	3 026	3 311	3 435	3 399	3 487
Industry	640	708	799	781	750	932	1 028	977
University	662	697	761	807	926	938	976	971
Other	362	386	430	453	483	471	493	496
S&T 1986 $	4 454	4 309	4 400	4 410	4 606	4 738	4 790	4 783[e]
R&D Actual $	2 552	2 586	2 802	2 984	3 174	3 345	3 543	3 541

[p] Preliminary data.
[e] Estimate.
Source: Industry Canada estimates based on data supplied by Statistics Canada and the Bank of Canada.

R&D in the Universities

Universities perform 26 percent of all Canadian R&D and perform most of the basic research in Canada. They employ more than one third of our doctoral degree-holders. Universities train virtually all new highly qualified personnel; research is an important part of that training. Canada can no longer count on immigration to increase highly qualified personnel.

Almost all of the $2.7 billion spent annually by Canadian universities on R&D is provided by the public sector. The federal government provides 32 percent directly and much of the remainder indirectly, through Established Program Financing transfers to the provinces for post-secondary education.

Canadians place a high value on education, but a relatively low value on scientific and engineering qualifications, as measured by salary levels for engineers and scientists relative to those of other professions that require post-graduate training. This is reflected in low participation rates in natural sciences and engineering enrolments, as well as a much smaller proportion of Canadian university graduates holding engineering degrees relative to our major competitors.

Indicators of S&T Performance

While the simplest method of measuring an S&T activity is to measure the human and financial resources devoted to it, such a measurement suffers from the fact that it does not reflect the quality of the work done, nor does it allow for weighted comparisons between different entities.

It is usually necessary to modify S&T statistics to take into account the wide variation in sizes of economic units, populations, etc. Thus, "indicators" are variables that are usually expressed as a ratio of two statistics: the numerator is the specialized statistic, such as R&D spending, and the denominator is a general statistic, such as GDP or population.

Indicators provide indirect information on the phenomena or events to which they are applied. An indicator is a measure of one item used to provide information about another, immeasurable item. For example, statistics on the number of scientists and engineers, and on their levels of training, are indicators of the quality and quantity of S&T knowledge available. Expenditures on R&D are indicators of the levels and sites of the indigenous generation of S&T knowledge. Patent statistics are indicators of the intensity, direction and location of inventive activity. [H. Stead, "Science and Technology Indicators in Canada and the United States of America," Working Paper (Ottawa: Statistics Canada, 1985)]

Consequently, different series of indicators must be developed and used in order to gain the fullest understanding of the S&T "enterprise."

This volume focuses on indicators of inputs to S&T simply because they are usually the easiest to measure. Output measures do exist and some (citation analysis, for example) are mentioned. The OECD's *Frascati Manual* provides an internationally agreed upon standard set of definitions for S&T statistics. *Science and Public Policy*, the journal of the International Science Policy Foundation based in Guildford, U.K., recently published a set of papers reviewing S&T indicators in current use.

The use of S&T indicators and the choice of which indicators to use are important policy issues in their own right, and should be included in any major S&T policy initiative. The use of the rate of return on industrial R&D expenditures as the indicator of performance leads to a significant policy consequence which would not have been apparent if only the absolute levels of industrial expenditures were examined. S&T policy analysis at a bare minimum requires the development of systematic data to form the foundation for policy deliberation.

Trying to follow a science policy, to choose objectives and to count the cost of alternative objectives, without such statistics, is equivalent to trying to follow a full employment in the economy without statistics on investment or employment. It is an almost impossible undertaking. The chances of getting rational decision making are very low without such statistics.

C. Freeman, "Science and Economy at the National Level," *Problems of Science Policy* (Paris: OECD, 1968), p. 58.

2 The National S&T Environment

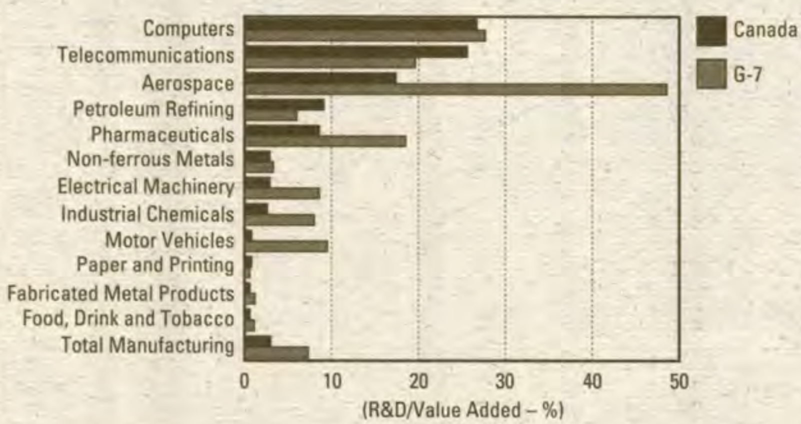
In the context of technological performance, the most widely used comparative indicator is the ratio of GERD to GDP. Few other technology indicators have influenced policy discussions as much as comparisons of this single R&D measure. However, expenditure on R&D is not the only technological input; the acquisition of intellectual property, the use of technology-intensive equipment and the level of highly trained personnel are also important as measures of resources allocated to improve the level of technology in a country.

Table 2.1 — National GERD, 1986 to 1993

	1986	1987	1988	1989	1990	1991	1992p	1993p
				($ millions)				
Actual $	7 347	7 745	8 254	8 786	9 621	10 024	10 289	10 560
1986 $	7 347	7 397	7 531	7 647	8 112	8 223	8 358	8 516e
				(percent)				
Real growth	8.2	0.7	1.8	1.5	6.1	1.4	1.6	1.9
GERD/GDP	1.45	1.40	1.36	1.35	1.44	1.49	1.50	1.49e

p Preliminary data.
e Industry Canada estimate.
Source: Statistics Canada, *Science Statistics*, Catalogue No. 88-001, Vol. 17, No. 5, and Bank of Canada.

Figure 2.1 — Comparisons of Industrial R&D Spending, Canada versus G-7, 1989



Source: Industry Canada estimates based on data supplied by OECD/STID.

Gross Expenditure on R&D

Canadian R&D spending has increased every year since the mid-1980s, in actual as well as in constant dollars (Table 2.1).

Canada's spending in the public sector on civilian R&D (as a percentage of GDP) is comparable with that of the other major OECD nations (see Chapter 4). Federal government R&D spending has grown by 6 percent in real dollar terms since 1984–85, while its share of "discretionary" expenditures has remained approximately constant at about 5 percent of all federal program spending (excluding public debt charges) in a time of expenditure reductions (see Chapter 3). The government also supports industrial R&D through tax expenditures, with tax credits of approximately $1 billion in 1991. The Canadian tax credit system has been recognized in a report by the Conference Board of Canada, titled *Canadian R&D Tax Treatment*, Report 125-94 (Ottawa: Conference Board, 1994), as being the most generous system among those of the industrialized nations.

While industrial R&D spending has risen significantly in inflation-adjusted terms over the past two decades and now is the largest single component of Canadian R&D spending (56 percent), Canadian industry does not invest nearly as much as does the private sector in the other Group of Seven (G-7) most developed nations (Figure 2.1), neither in absolute terms nor expressed as a percentage of GDP (see Chapter 4). However, this can be explained, in part, by the resource-based structure of the Canadian economy, since resource extraction industries typically spend a lower percentage of their sales on R&D than do manufacturing industries (less than 1 percent of sales compared with the Canadian manufacturing average of 1.5 percent of sales, according to Statistics Canada), and possibly by the level of foreign ownership in the Canadian manufacturing sector.

Industrial R&D in Canada

In Canada, as elsewhere, R&D spending is heavily concentrated within a very few industrial sectors (Figure 2.2). These R&D-intensive industries (their expenditures amount to at least 3 percent of sales) depend on a continuous supply of new technologies to maintain their competitive edge. Resource-based industries perform relatively little R&D — they often acquire their new technologies through the acquisition of state-of-the-art production machinery developed and manufactured in other sectors. Current expenditures (i.e. not including capital expenditure) as a percentage of sales is shown in Table 2.2.

Use of Advanced Manufacturing Technologies

Statistics Canada in 1989 carried out a survey of the use of advanced manufacturing technologies in Canada's manufacturing sector. The survey found that 48 percent of plants use at least one of 22 advanced manufacturing technologies, listed in Figure 2.3, in their factory operations. These same plants accounted for about 90 percent of the total value of manufacturing shipments.

Ranked by the percentage of establishments using them, programmable controllers, computer-controlled manufacturing, computer-aided design (CAD) and materials requirement planning were the leading technologies.

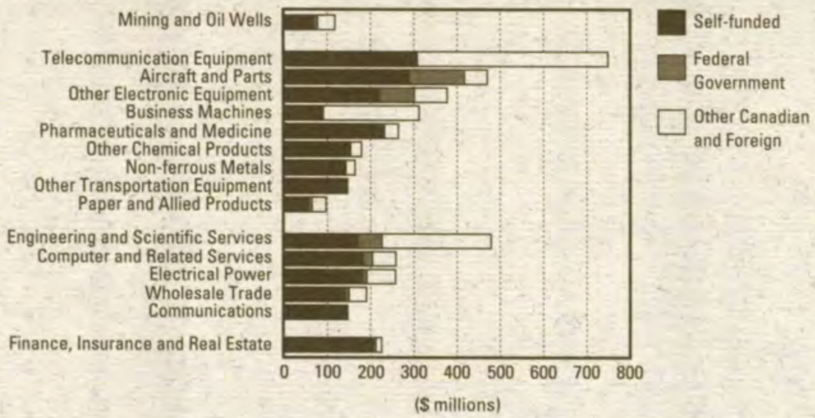
Three industries (ranked either by value of shipments or by percentage of establishments) led in the use of technology: transportation equipment, primary metals, and electrical and electronic products. Of all manufacturing industries, transportation equipment was the principal user of robots.

Table 2.2 — Current Intramural R&D Expenditures, by Industry, 1991

Industry	R&D ($ millions)	Average R&D/Sales (%)
Agriculture, fishing and logging	**19**	**4.4**
Mining and oil wells	**97**	**0.7**
Metal mines	51	0.9
Other mines	5	0.4
Services incidental to mining	4	2.2
Crude petroleum and natural gas	37	0.5
Manufacturing	**3 205**	**1.8**
Food	48	0.2
Beverages and tobacco	9	0.2
Rubber products	5	0.4
Plastic products	15	1.9
Textiles	45	1.7
Wood	18	0.3
Furniture and fixtures	3	1.3
Paper and allied products	89	0.3
Printing and publishing	10	2.5
Primary metals (ferrous)	20	0.4
Primary metals (non-ferrous)	155	1.4
Fabricated metal products	35	1.5
Machinery	90	3.4
Aircraft and parts	445	13.0
Motor vehicles, parts and accessories	70	0.2
Other transportation equipment	145	8.4
Telecommunication equipment	655	22.1
Electronic parts and components	38	8.1
Other electronic equipment	361	13.5
Business machines	284	3.1
Other electrical products	49	1.2
Non-metallic mineral products	15	0.6
Refined petroleum and coal products	128	0.6
Pharmaceutical and medicine	234	5.3
Other chemical products	156	1.5
Scientific and professional equipment	57	2.7
Other manufacturing industries	28	2.8
Construction	**10**	**1.2**
Utilities	**217**	**1.0**
Electrical power	212	1.2
Other utilities	5	0.1
Services	**1 304**	**1.6**
Transportation and storage	20	0.2
Communication	137	1.0
Wholesale trade	177	1.2
Retail trade	29	0.6
Finance, insurance and real estate	201	0.7
Computer and related services	234	17.9
Engineering and scientific services	423	18.7
Management consulting services	32	7.2
Other services	52	4.5
Total All Industries	**4 853**	**1.9**

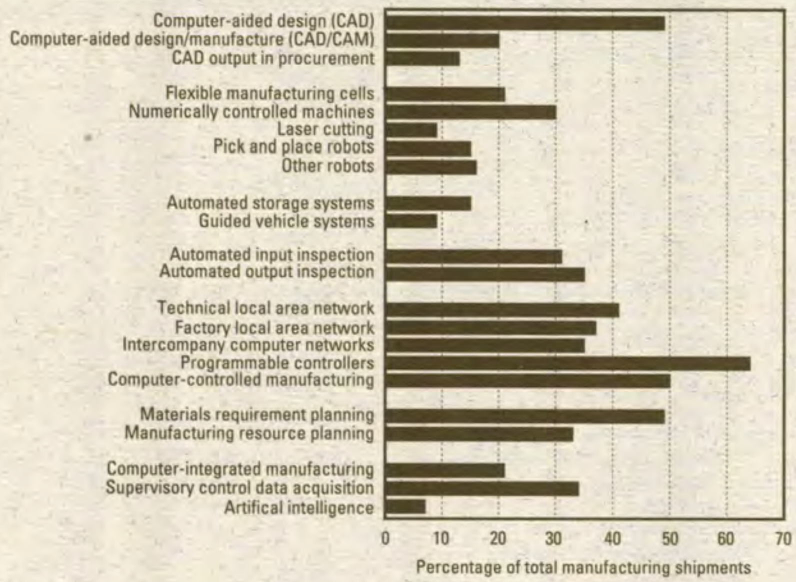
Note: Sales are for R&D-performing firms only.
Source: Statistics Canada, *Industrial Research and Development*, Catalogue No. 88-202.

Figure 2.2 — Industrial R&D, by Source of Funds, Selected Sectors, 1991



Source: Statistics Canada, *Science Statistics*, Catalogue No. 88-001, Vol. 17, No. 4.

Figure 2.3 — Use of Advanced Manufacturing Technologies in Manufacturing Establishments, by Technology, 1989



Source: Statistics Canada uncatalogued working paper.

Manufacturers in Quebec and Ontario made the widest use of the new technologies, followed by those in Newfoundland, Saskatchewan and British Columbia. Half or more of the plants in the first two provinces used at least one of the 22 technologies (Table 2.3).

In 32 percent of the manufacturing plants, accounting for 67 percent of shipments, companies had made modifications to the technologies so as to improve their output.

Although one industry may actually conduct a substantial amount of R&D, that R&D may be focused toward meeting the needs of a technology-consuming, or target, industry, often a primary industry such as mining. Thus R&D figures for the mining industry may not in fact represent all the R&D generated by the mining sector. Without the existence of the target industry, R&D in other industries might not have occurred or might be directed in other areas. For more information, see *Survey of Diffusion of Technology in the Mining Industry* (Ottawa: Statistics Canada in cooperation with (then) Energy, Mines and Resources Canada, Communications Canada and Industry, Science and Technology Canada, 1990).

Top 50 Companies

The accompanying table has been adapted from an exclusive report on Canada's Top 100 corporate R&D spenders published in the June 15, 1994 edition of *Re$earch Money*. The data were compiled by Evert Communications Limited of Ottawa, which maintains the *Canadian Corporate R&D Database*, an electronic directory of industrial R&D performers and funders in Canada.

The data are collected from annual surveys, direct inquiries and public documents and are verified by Evert Communications. The definition of R&D is that used by Revenue Canada in its assessment of scientific research and experimental development tax incentive claims.

R&D expenditure figures are composed of pre-tax R&D expenditures, including government assistance. They do not include contract R&D.

For Canadian-based multinationals, the numbers represent worldwide R&D expenditures. All figures originally stated in U.S. currency were converted to Canadian dollars. Unless otherwise noted, the expenditure period is the fiscal year ended December 1993.

Inquiries should be directed to Evert Communications Limited, 1296 Carling Avenue, Ottawa, Ont. K1Z 7K8; tel.: (613) 728-4621. A copy of a table showing the Top 100 corporate R&D spenders is available upon request.

Readers should note that the expenditures reported here may include sums spent overseas, which are not included in Statistics Canada surveys. At least one company (AECL) is normally considered to be part of the public sector; its activities are also reported under federal government expenditures by Statistics Canada.

Top 50 Companies, 1993

	Company	1993 R&D Spending	Change	R&D/ Revenue
		($ millions)	(%)	(%)
1	Northern Telecom Limited	1 190 485	14.03	11.33
2	IBM Canada Ltd.	258 000	4.03	3.82
3	AECL (Mar 31)	198 172	-8.22	58.89
4	CAE Industries Inc. (Mar 31)	191 000	0.00	19.07
5	Pratt & Whitney Canada Inc.	186 000	-7.46	12.95
6	Ontario Hydro	171 000	-6.56	2.04
7	Hydro-Québec	142 423	10.00	2.02
8	Bell Canada	128 000	1.11	1.61
9	Alcan Aluminium Limited	127 690	-16.54	1.35
10	Imperial Oil Limited	89 000	7.23	1.00
11	Merck Frosst Canada Inc.	79 000	4.08	15.31
12	Bombardier Inc. (Jan 31)	73 135	36.21	1.64
13	Ericsson Communications Inc.	62 273	137.85	36.14
14	Connaught Laboratories Limited	58 000	31.82	18.41
15	Noranda Inc.	54 000	3.85	1.03
16	INCO Limited	51 551	-6.71	1.71
17	NOVA Corporation of Alberta	48 000	17.07	1.47
18	Mitel Corporation (Mar 28)	45 200	-8.13	10.68
19	Digital Equipment of Canada Limited (Jul 1)	45 000	3.21	3.69
20	BC Telecom Inc.	42 500	-29.05	1.92
21	Canadian Marconi Company (Mar 31)	40 432	-4.60	13.26
22	Newbridge Networks Corporation (Apr 30)	38 936	32.17	12.66
23	Allied-Signal Canada Inc.	35 000	-7.05	9.57
24	Amoco Canada Petroleum Company Limited	35 000	0.00	0.80
25	Apotex Inc. (Mar 31)	34 500	25.84	14.44
26	Asea Brown Boveri Inc.	34 000	-10.53	4.36
27	Shell Canada Limited	32 000	-11.11	0.68
28	Spar Aerospace Limited	30 215	65.22	5.73
29	Glaxo Canada Inc. (Jun 30)	30 000	7.98	10.53
30	Siemens Group	29 600	-4.52	3.95
31	Du Pont Canada Inc.	29 248	16.31	1.83
32	Diversey Corporation (Mar 31)	28 900	11.15	2.23
33	Boehringer Ingelheim (Canada) Limited	28 879	2.76	39.44
34	Com Dev Ltd. (Jan 1)	28 750	74.24	43.56
35	Marion Merrell Dow (Canada) Inc.	28 700	18.11	10.84
36	Wyeth-Ayerst Canada Inc.	27 817	32.87	N/A
37	The Seagram Company Limited (Jan 31)	26 900	23.11	0.36
38	Unitel Communications Inc.	26 000	205.88	6.05
39	Syncrude Canada Inc.	26 000	0.00	1.84
40	AT&T Global Info Solutions Canada Ltd. (Nov 30)	25 858	-1.03	7.80
41	Gandalf Technologies Inc. (Mar 31)	25 035	17.87	12.74
42	General Motors of Canada Limited	25 000	-32.43	0.11
43	Ciba-Geigy Canada Ltd.	21 892	17.08	4.78
44	Teleglobe Inc.	21 300	55.47	3.92
45	Hoffmann-La Roche Limited	21 200	92.73	24.65
46	Amdahl Canada Limited	20 900	33.97	29.27
47	Motorola Canada Limited	20 800	1.46	3.43
48	Xerox Canada Inc.	20 800	-1.89	1.82
49	Cognos Incorporated (Feb 28)	20 121	12.28	13.63
50	Novopharm Limited	20 000	4.71	8.70

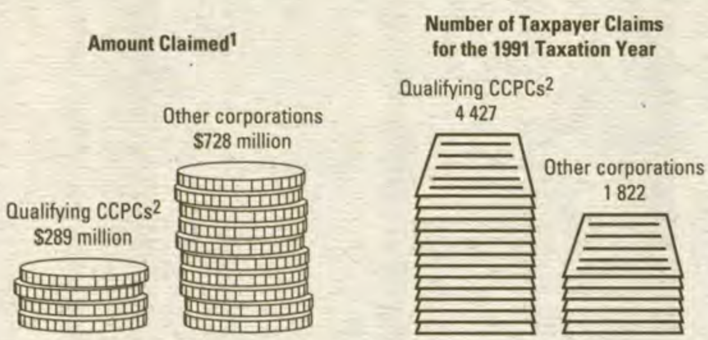
N/A: not available.

Table 2.3 — Advanced Manufacturing Technology Use, by Province, 1989

Province	Establishments Using at Least One AMT	Value of Shipments Involving at Least One AMT
	(percentage of total in province)	
Newfoundland	49	57
Prince Edward Island	31	71
Nova Scotia	32	85
New Brunswick	34	64
Quebec	54	88
Ontario	50	90
Manitoba	38	78
Saskatchewan	44	75
Alberta	37	86
British Columbia	43	86
Canada	**48**	**88**

Source: Industry Canada estimates based on data supplied by Statistics Canada.

Figure 2.4 — Investment Tax Credit for R&D, 1991



[1] The amount claimed is the amount requested by the taxpayer prior to an audit and/or assessment.
[2] A qualifying CCPC is a Canadian-controlled private corporation whose taxable income for the preceding year was $200 000 or less.
Source: Revenue Canada — Taxation.

R&D Tax Expenditures

Present Tax Structure

The Scientific Research and Experimental Development program, currently in effect, was first introduced in May 1985 to replace the Scientific Research Tax Credit program. R&D expenditures are defined in Revenue Canada's Information Circular No. 86-4R2; the Revenue Canada definition is similar to that used by the OECD in the *Frascati Manual.* In accord with the recommendations of the *Frascati Manual,* R&D tax benefits to industry are not considered as government expenditures and, hence, are not included in the statistics of federal R&D expenditures.

Figure 2.4 shows figures on R&D tax incentives for 1991 released by Revenue Canada — Taxation. It is estimated that, for 1991, tax credits of approximately $1 017 million were granted on $5.1 billion of industrial R&D funded by the private sector for that year. Since these tax credits are themselves taxable as income, the foregone revenue to the government is somewhat lower.

Expenditures on R&D, current and qualified capital, can be offset against taxable income. These expenditures are also eligible for investment tax credits (ITCs). ITCs must be declared as income. The magnitude of ITCs depends on the type of entity and the location. Canadian-controlled private corporations (CCPCs) with taxable income less than $200 000 can claim 35 percent of the first $2 million and 20 percent of the remainder of R&D expenditures. All other entities are eligible for 20 percent of the R&D expenditures everywhere except in the Atlantic provinces including the Gaspé Peninsula, where ITCs are at the rate of 30 percent.

CCPCs and individuals meeting certain conditions are eligible to receive a refund on unused ITCs. The amounts of refunds vary depending on the type of entity. CCPCs are refunded 100 percent of the first $2 million of current expenditures and 40 percent of the remainder. Individuals are eligible to receive 40 percent of current and capital expenditures.

R&D tax incentives are intended to promote and enhance R&D expenditure in Canada, particularly R&D of a commercial nature, and to improve the technological competitiveness of Canadian industry. Tax expenditures represent an important and efficient mechanism for stimulating industrial R&D in Canada. They have been an integral part of Canada's overall strategy to encourage a stronger industrial R&D base.

Regional Expenditures on R&D

Canada's R&D efforts are not spread evenly across the country, as R&D expenditures tend to be concentrated in Ontario and Quebec and to mirror the distribution of population and industry in the country.

Although Ontario has 37 percent of the nation's population and 40 percent of the GDP, it has 51 percent of the total GERD, as shown in Table 2.4. Quebec, an industrialized province like Ontario, with 25 percent of the nation's population and 23 percent of its GDP, has 26 percent of GERD.

Besides having the largest share of federal GERD, Ontario also has the highest ratio of R&D to provincial GDP (Figure 2.5). Ontario and Quebec were the two provinces where this proportion was higher than the national average of 1.49 percent; however, the Ontario figures include most of the federal R&D spending in the National Capital Region (see Chapter 3). Five provinces had GERD/GDP ratios of less than 1 percent — Newfoundland, Prince Edward Island, New Brunswick, Saskatchewan and British Columbia.

Table 2.4 provides a comparison of the regional importance of the various funding sources. As expected, industry is the principal funding source in both Ontario and Quebec, where it supports about 41 percent of provincial R&D in Ontario and 52 percent in Quebec. In six of the 10 provinces, the federal government is the major contributor, its share varying between 41 percent in Saskatchewan to 88 percent in Prince Edward Island. Only in Alberta and Saskatchewan does the provincial government fund more than 10 percent of regional R&D.

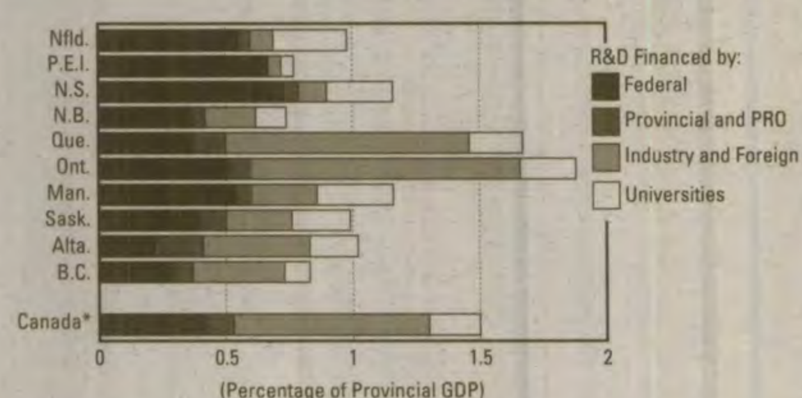
Provinces where the federal government bears the largest share of R&D expenditures generally have a relatively weak manufacturing base. In these provinces, most of the federal funds are directed toward management and exploitation of the resource sector. In Nova Scotia, for example, more than one half of the expenditures were provided for R&D related to agriculture, fishing, and offshore oil and gas exploration. Similarly, in British Columbia, at least one half of federal R&D spending was in support of agriculture, fishing and forestry.

Table 2.4 — GDP, Population and R&D Performance, by Province, 1991

	GDP	Population	Federal	Provincial and PRO	Industry	University and PNP	Total
	($ billions)	(thousands)			($ millions)		
Nfld.	9	576	32	4	9	46	91
P.E.I.	2	131	10	-	2	4	16
N.S.	18	901	74	5	26	99	204
N.B.	14	728	34	3	30	36	103
Que.	156	6 874	214	75	1 540	782	2 611
Ont.	270	9 971	897	127	2 983	1 098	5 105
Man.	23	1 094	89	3	64	113	269
Sask.	20	994	47	9	54	86	196
Alta.	72	2 522	71	71	335	258	735
B.C.	84	3 212	87	29	347	230	693
Canada*	**672**	**27 134**	**1 555**	**326**	**5 391**	**2 752**	**10 024**

*Includes Yukon and Northwest Territories.
Source: Industry Canada estimates based on data supplied by Statistics Canada.

Figure 2.5 — R&D Funding as a Percentage of Provincial GDP, 1991



*Includes Yukon and Northwest Territories.
Source: Industry Canada estimates based on data supplied by Statistics Canada.

Differences in the provincial treatment of industrial R&D credits exist as outlined in Table 2.5. According to the methodology used, the best location to perform R&D in Canada from a tax perspective for large companies is Manitoba followed by New Brunswick and Nova Scotia, and for small companies it is Quebec followed by Manitoba and Ontario.

Table 2.5 — Interprovincial R&D Tax Credit Comparison, 1993–94

Province	After-tax cost of $1 R&D expenditure Large Company	Small Company
British Columbia	0.514	0.522
Alberta[1]	0.528	0.548
Saskatchewan	0.509	0.530
Manitoba	0.439	0.452
Ontario	0.507	0.455
Quebec	0.479	0.394
Newfoundland	0.583	0.555
P.E.I.	0.583	0.539
New Brunswick	0.446	0.479
Nova Scotia	0.462	0.482

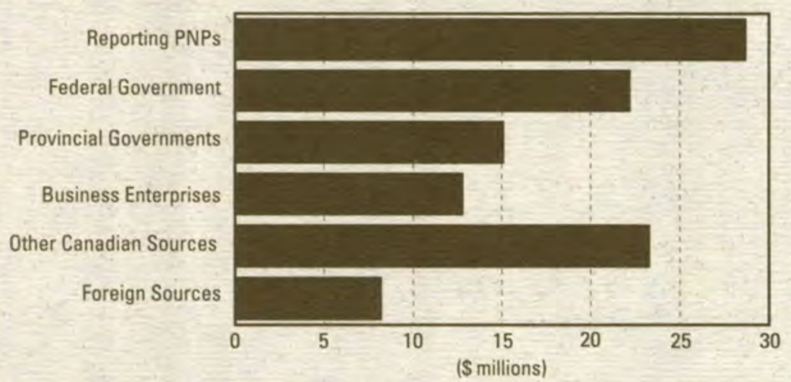
[1] Alberta applied a reduced (9 percent) corporate income tax rate for large manufacturing.
Source: Conference Board of Canada, *Canadian R&D Tax Treatment*, Report 125-94 (Ottawa: Conference Board, 1994).

Table 2.6 — Total Expenditures of Provincial Governments on Scientific Activities, by Sector of Performance, 1991–92

($ millions)	Intramural	Industry	Universities	Hospitals and Health Organizations	Provincial Research Organizations	Other	Total
Nfld.	19.9	2.6	1.7	0.02	–	1.9	26.2
N.S.	33.3	4.9	2.2	0.15	0.18	6.0	46.7
N.B.	19.6	4.9	2.2	0.22	0.29	2.8	29.9
Que.	348.3	34.4	72.6	36.9	0.52	104.4	597.1
Ont.	243.1	69.3	144.9	20.1	7.4	41.1	525.8
Man.	26.7	1.0	4.9	0.45	2.5	3.3	38.9
Sask.	14.9	12.8	12.1	0.31	5.3	5.3	50.8
Alta.	98.9	40.2	42.2	2.6	34.1	15.8	233.8
B.C.	118.1	52.3	25.1	1.8	2.7	16.9	216.9

Source: Statistics Canada, *Science Statistics*, Catalogue No. 88-001, Vol. 17, No. 12.

Figure 2.6 — Sources of Funds for PNP Intramural R&D, 1991



Source: Statistics Canada, *Science Statistics*, Catalogue No. 88-001, Vol. 17, No. 1.

S&T Spending by Provincial Governments

Provincial governments have significant S&T programs. Table 2.6 shows the distribution of their direct expenditures by sector of performance. There are no data collected from Prince Edward Island.

R&D Spending by Private Non-Profit Research Organizations

Private non-profit research organizations occupy an important niche in the national R&D effort. About 95 percent of their efforts are in the health sector, reflecting the importance of voluntary organizations in this field (Figure 2.6).

The University Sector

In every province, the university sector is an important element in the R&D system. In eight of the 10 provinces, it is the largest or second largest performer. About two fifths of total university R&D is self-funded from general university grants (which themselves are supported through the federal post-secondary education program) and one third is supported by the federal government directly (Table 2.7).

Table 2.7 — University R&D Funding, by Source, 1991

	Federal	Provincial	Business	Self-funded	Other	Total
			($ millions)			
Nfld.	16	1	2	22	5	46
P.E.I.	3	–	–	1	–	4
N.S.	46	7	1	43	1	98
N.B.	12	4	3	15	1	35
Que.	226	114	101	263	61	765
Ont.	298	115	57	466	85	1 021
Man.	29	5	3	52	16	105
Sask.	26	12	3	41	4	86
Alta.	70	36	13	117	22	258
B.C.	106	21	14	63	20	224
Canada	**832**	**315**	**197**	**1 083**	**215**	**2 642**

Source: Statistics Canada estimates.

Scientific, Technical and Engineering Personnel

Table 2.8 shows the distribution of the labour force by level of educational attainment based on the 1986 Census.

Table 2.8 — Experienced Labour Force 15 Years and Over, by Occupation and Highest Degree Obtained, 1986

Occupation	Total	Degree Holders: Bachelor's		Master's		Doctoral	
	(000)	(000)	(%)	(000)	(%)	(000)	(%)
Managers, Admin. and Related	1 047.8	208.4	19.9	68.2	6.5	8.6	0.8
Natural Scientists	469.3	135.0	28.8	34.8	7.4	10.6	2.3
Physical Scientists	42.9	12.4	28.8	3.6	8.5	3.6	8.3
Life Scientists	33.4	9.9	29.6	3.5	10.4	2.8	8.3
Architects and Engineers	279.3	77.1	27.6	20.8	7.4	3.2	1.2
Mathematicians, Statisticians and Systems Analysts	113.7	35.7	31.4	6.9	6.1	1.1	0.9
Social Scientists	260.8	80.5	30.9	33.5	12.8	4.0	1.5
Teachers	566.4	224.3	39.6	61.9	10.9	25.9	4.6
University Teachers	59.4	12.4	20.8	14.5	24.5	22.6	38.0
Medicine and Health[1]	635.8	66.0	10.4	10.7	1.7	4.2	0.7
Sales Occupations	1 371.5	92.0	10.9	10.0	7.3	0.8	0.6
Services Occupations	1 824.0	49.8	2.7	4.8	0.3	0.4	0.0
All Occupations	**19 634.1**	**1 254.3**	**6.4**	**293.3**	**0.1**	**67.0**	**0.3**

[1]Includes first professional degrees (M.D., D.D.S., D.V.M., etc.) with master's and doctoral degrees.
Source: Statistics Canada, 1986 Census data.

3 How the Government Spends Its S&T Budget

Trends during the 1980s

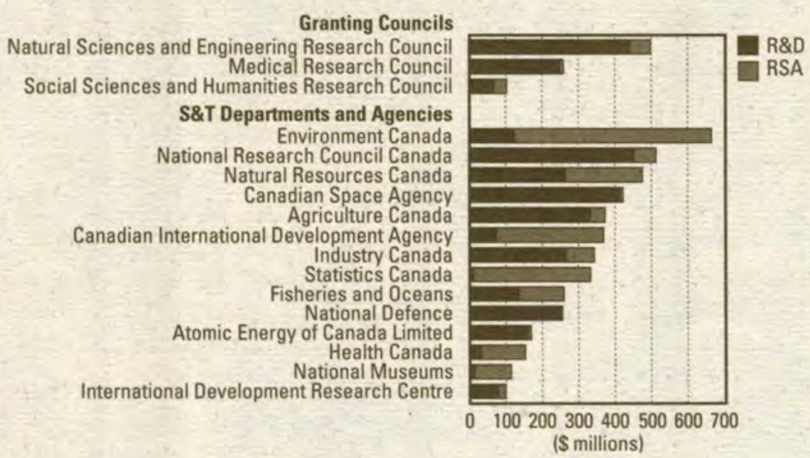
S&T expenditures for 1993–94 represent about 5 percent of total federal government program spending, as shown in Table 3.1 (program spending is the sum of all government spending excluding interest payments). Figure 3.1 shows S&T expenditures by department and agency in 1993–94.

Table 3.1 — Federal S&T Expenditures, 1986–87 to 1993–94

	1986–1987	1987–1988	1988–1989	1989–1990	1990–1991	1991–1992	1992–1993	1993–1994[p]
				($ millions)				
Actual $	4 454	4 512	4 823	5 067	5 471	5 776	5 896	5 931
1986 $	4 454	4 309	4 400	4 410	4 606	4 738	4 790	4 783[e]
Year-to-Year Change (Actual $)	7.5	1.3	6.9	5.1	8.0	5.6	2.1	0.6
Year-to-Year Change (1986 $)	5.0	-3.3	2.1	0.2	4.4	2.9	1.1	-0.1
				(percent)				
Non-Statutory Appropriations	11.9	11.9	11.8	11.8	12.3	12.3	12.1	12.1
Program Expenditures*	5.0	4.7	4.8	4.9	5.1	5.0	4.8	4.9

[p] Preliminary figures.
[e] Industry Canada estimate.
* Program expenditures = Total Estimates – Public Debt Charges.
Source: Treasury Board, *Main Estimates, Part I*, 1986–87 to 1993–94.

Figure 3.1 — Federal S&T Expenditures, by Department and Agency, 1993–94



Source: Statistics Canada, *Federal Scientific Activities*, Catalogue No. 88-204.

Federal spending on S&T increased from $3.7 billion in 1983–84 to an estimated $5.9 billion in 1993–94. Over the decade, expenditures compounded at an average rate of 6 percent per year.

In inflation-adjusted dollars, federal S&T expenditures grew, on average, by 2.3 percent per year, from $4.0 billion in 1983–84 to $4.8 billion in 1992–93. Real growth has decreased from annual rates of 5.2 percent in the first half of the decade to 2.2 percent in the last half.

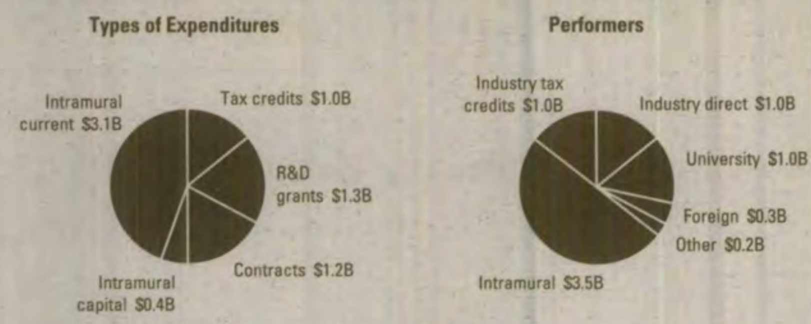
In addition to direct federal expenditures on S&T, the federal government foregoes approximately $1 billion per year in revenue through the tax credit system. Thus the total federal S&T effort totals approximately $7 billion per year (Figure 3.2)

Federal S&T by Performer

There are three major performers of federally funded S&T: federal laboratories (i.e. intramural), industry and Canadian universities. The federal scientific establishment is by far the largest performer and, in 1993–94, accounted for $3.5 billion or about 59 percent of the total. The next largest share, $977 million, or almost 17 percent, was spent in the industry sector. Canadian universities received $971 million (16 percent) of all federal funding. The remaining 8 percent was accounted for by PNPs, provincial and municipal governments, foreign performers and others.

The intramural share of total S&T expenditures has declined over the past eight years, from 63 to 59 percent. On the other hand, industry's share increased by 2 percentage points to nearly 17 percent, and universities' share has grown to 16 percent (Table 3.2). Spending on R&D contracts and grants represents about 30 percent of total S&T (Table 3.3).

Figure 3.2 — How the $7 Billion Is Spent, 1993–94



Source: Industry Canada estimates based on data supplied by Revenue Canada and Statistics Canada.

Table 3.2 — Federal Government S&T Expenditures, by Performing Sector, 1986–87 to 1993–94

	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992	1992-1993	1993-1994p
					($ millions)			
Intramural	2 790	2 721	2 833	3 026	3 311	3 435	3 399	3 487
Industry	640	708	799	781	750	932	1 028	977
University	662	697	761	807	926	938	976	971
PNP	53	77	82	87	86	85	105	105
Other Cdn	76	85	94	119	124	107	97	105
Foreign	232	224	253	246	274	279	291	286
Total	**4 454**	**4 512**	**4 823**	**5 067**	**5 471**	**5 776**	**5 896**	**5 931**

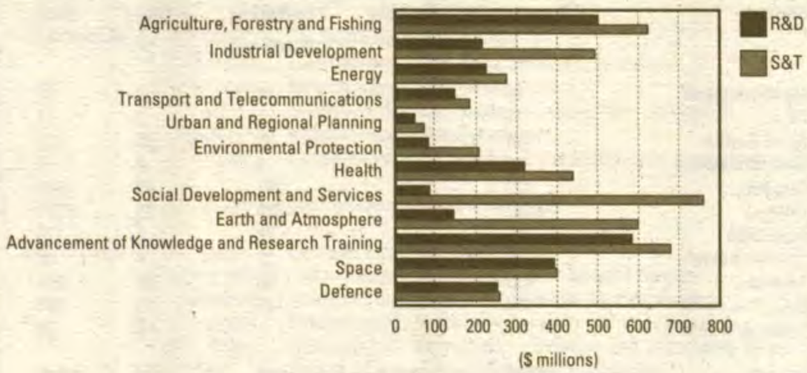
p = preliminary.
Source: Statistics Canada, *Federal Scientific Activities,* Catalogue No. 88-204.

Table 3.3 — Total Federal Expenditures on S&T, by Activity, 1991–92 to 1993–94

	1991–92	1992–93	1993–94
		($ millions)	
Extramural			
R&D Contracts	472	518	517
R&D Grants	1 250	1 332	1 277
R&D Fellowships	69	69	71
RSA	550	578	579
Total Extramural	**2 341**	**2 497**	**2 444**
Intramural			
Current Costs — R&D	1 370	1 412	1 428
Capital Costs — R&D	184	212	249
Current Costs — RSA	1 747	1 628	1 640
Capital Costs — RSA	133	147	171
Total Intramural	**3 435**	**3 399**	**3 487**
Total S&T	**5 776**	**5 896**	**5 931**

Source: Statistics Canada, *Federal Scientific Activities,* Catalogue No. 88-204.

Figure 3.3 — Federal R&D and S&T Expenditures, by Area of Application, 1992–93



Source: Statistics Canada, *Federal Scientific Activities*, Catalogue No. 88-204.

Table 3.4 — Federal Personnel Engaged in S&T Activities, by Major Department or Agency, 1991–92 to 1993–94

Department	1991–92	1992–93	1993–94
AgCan	3 689	4 050	4 053
AECL	2 600	2 762	2 717
CIDA	149	148	157
CSA	309	353	373
EnvCan	4 527	4 718	4 752
F&O	2 323	2 339	2 304
HWC	1 481	1 620	1 650
IDRC	260	248	248
IndCan	1 116	1 176	1 115
MRC	65	67	72
NDEF	1 858	1 846	1 821
NMC	1 171	1 221	1 245
NRCan	3 722	3 844	3 842
NRC	3 144	3 241	3 297
NSERC	181	181	183
SSHRC	104	104	107
StatCan	5 586	4 534	4 418
Other	3 140	2 875	2 895
Total	**35 425**	**35 327**	**35 249**

Source: Statistics Canada, *Federal Scientific Activities*, Catalogue No. 88-204.

Table 3.5 — Personnel Engaged in S&T Activities, by Category, 1991–92 to 1993–94

Category	1991–92	1992–93	1993–94
		(person-years)	
Executive	812	779	758
Scientific and Professional	11 073	11 792	11 821
Administration and Foreign Service	4 583	4 427	4 414
Technical	8 429	8 620	8 639
Administrative Support	7 271	6 349	6 297
Operational	3 052	3 157	3 116
Military	204	203	203
Total	**35 425**	**35 327**	**35 249**

Source: Statistics Canada, *Federal Scientific Activities*, Catalogue No. 88-204.

R&D and S&T Expenditures by Area of Application

Figure 3.3 shows the division of federal R&D and S&T expenditures by area of application as defined by the OECD. Social development and services receives about $800 million of S&T expenditures, advancement of knowledge and research training receives nearly $700 million and agriculture, forestry and fishing about $650 million.

As is to be expected, departments such as Agriculture and Agri-Food Canada, Natural Resources Canada, Environment Canada, Fisheries and Oceans, Industry Canada, the Canadian Space Agency and National Defence are the major funders in the area of application that falls within their primary areas of responsibility. In contrast, the NRC supports a broad spectrum of work by area of application. Virtually all of Statistics Canada's program expenditures fall under the heading of "social development" RSA.

Public Service Personnel in Federal S&T Activities

Table 3.4 shows the distribution of federal S&T personnel by department and agency. Table 3.5 presents a distribution by category for the last three years. Over 30 percent of total S&T personnel are in the scientific and professional category.

Province	Dept	Lab Name	City	FTEs
Ontario	AECL	Chalk River Laboratories	Chalk River	2 227
	AgCan	Centre for Land and Biological Resource Research	Ottawa	290
	AgCan	Plant Research Centre	Ottawa	217
	AgCan	Centre for Food and Animal Research	Ottawa	300
	AgCan	Harrow Research Centre	Harrow	102
	AgCan	Pest Management Research Centre	London	173
	CSA	Canadian Space Agency/David Florida Laboratory	Ottawa	60
	EnvCan	Canadian Wildlife Service-Water and Wetlands Branch	Ottawa	40
	EnvCan	Atmospheric Environment Service: Ontario Region	Toronto	204
	EnvCan	Environmental Conservation Service: Ontario Region	Nepean	30
	EnvCan	National Water Research Institute	Burlington	265
	EnvCan	National Laboratory for Environmental Testing	Burlington	42
	EnvCan	Wastewater Technology Centre	Burlington	116
	EnvCan	Dry Deposition Research Centre	Downsview	4
	EnvCan	King Radar Research Facility	King City	10
	EnvCan	Centre for Atmospheric Research Experiments	Egbert	20
	EnvCan	Atmospheric Environment Service: Downsview	Downsview	723
	EnvCan	Environmental Technology Centre	Gloucester	90
	EnvCan	Great Lakes — St. Lawrence Regulation Office	Cornwall	5
	EnvCan	Monitoring and Systems Branch — Ontario Region	Toronto	41
	F&O	Canadian Hydrographic Service	Ottawa	90
	F&O	Marine Environmental Data Services	Ottawa	32
	F&O	Bayfield Institute	Burlington	110
	HC	Food Directorate	Ottawa	296
	HC	Laboratory Centre for Disease Control	Ottawa	213
	HC	Health Protection Branch — Ontario Region	Scarborough	205
	HC	Drugs Directorate	Ottawa	511
	HC	Radiation Protection Bureau	Ottawa	6
	HC	Environmental Health Centre	Ottawa	380
	IndCan	Communications Research Centre	Ottawa	396
	NDEF	Defence Research Establishment/Ottawa	Ottawa	197
	NDEF	Defence and Civil Institute of Environmental Medicine	Downsview	147
	NRC	Institute for Information Technology	Ottawa	104
	NRC	Institute for Engineering in the Canadian Environment	Ottawa	104
	NRC	Institute for Environmental Chemistry	Ottawa	109
	NRC	Herzberg Institute of Astrophysics	Ottawa	113
	NRC	Institute for Aerospace Research	Ottawa	237
	NRC	Institute for Biological Sciences	Ottawa	136
	NRC	Centre for Surface Transportation Technology	Ottawa	37
	NRC	Institute for Research in Construction	Ottawa	236
	NRC	Steacie Institute for Molecular Sciences	Ottawa	77
	NRC	Institute for Microstructural Sciences	Ottawa	130
	NRC	Institute for National Measurement Standards	Ottawa	106
	NRC	Institute of Advanced Manufacturing Technology	Ottawa	66
	NRCan	Canmet/Sudbury Backfill Laboratory	Sudbury	10
	NRCan	Surveys, Mapping and Remote Sensing Sector	Ottawa	400
	NRCan	Geological Survey of Canada	Ottawa	600
	NRCan	Canmet/Efficiency and Alternative Energy Technology Branch	Ottawa	38
	NRCan	Canmet/Mineral Sciences Laboratories	Ottawa	94
	NRCan	Canmet/Metals Technology Laboratories	Ottawa	62
	NRCan	Canmet/Energy Research Laboratories	Ottawa	100
	NRCan	Canmet/Mining Research Laboratories	Ottawa	32
	NRCan	Petawawa National Forestry Institute	Chalk River	133
	NRCan	Explosives Branch and Explosives Regulatory Division	Ottawa	13
	NRCan	Canada Centre for Remote Sensing	Ottawa	128
	NRCan	Forest Pest Management Institute	Sault Ste. Marie	85
	NRCan	Canmet/Elliot Lake Laboratory	Elliot Lake	16
	NRCan	Canadian Forestry Service — Ontario Region	Sault Ste. Marie	173
	RCMP	RCMP/Science and Technology Branch	Ottawa	6
	TC	Technical Systems Centre	Ottawa	21
	TC	Navigational Aids Test Establishment	Cardinal	3
	TC	Air Traffic Services Research & Experimentation (R&E Centre)	Gloucester	43

Province	Dept	Lab Name	City	FTEs
Manitoba	AECL	Whiteshell Laboratories	Pinawa	925
	AgCan	Winnipeg Research Centre	Winnipeg	102
	AgCan	Agri-Food Diversification Research Centre	Morden	51
	AgCan	Brandon Research Centre — Agriculture and Agri-Food Canada	Brandon	75
	EnvCan	Atmospheric Environment Service	Winnipeg	254
	F&O	Freshwater Institute	Winnipeg	255
	HC	Health Protection Branch — Central Region	Winnipeg	60
	NRC	Institute for Biodiagnostics	Winnipeg	68
Saskatchewan	AgCan	Swift Current Research Station — Agriculture and Agri-Food Canada	Swift Current	128
	AgCan	Saskatoon Research Station — Agriculture and Agri-Food Canada	Saskatoon	192
	EnvCan	National Hydrology Research Institute	Saskatoon	74
	EnvCan	Western and Northern Region	Regina	195
	NRC	Plant Biotechnology Institute	Saskatoon	117
Alberta	AgCan	Lacombe Research Station	Lacombe	82
	AgCan	The Research Centre — Agriculture and Agri-Food Canada	Lethbridge	298
	AgCan	Northern Agriculture Research Centre	Beaverlodge	50
	EnvCan	Prairie and Northern Region Environmental Protection	Edmonton	12
	EnvCan	Environmental Conservation Service — Prairies and N.W.t.	Edmonton	75
	EnvCan	Atmospheric Environment Service Prairies and Northern Region	Edmonton	240
	NDEF	Defence Research Establishment/Suffield	Medicine Hat	166
	NRCan	Canmet/Western Research Centre	Devon	55
	NRCan	Canadian Forestry Service — Northwest Region	Edmonton	151
	NRCan	Institute of Sedimentary and Petroleum Geology	Calgary	153
British Columbia	AgCan	Agriculture and Agri-Food Canada Research Station	Agassiz	58
	AgCan	Pacific Agriculture Research Centre	Vancouver	53
	AgCan	Summerland Research Centre	Summerland	83
	EnvCan	Environmental Protection: Pacific and Yukon Region	Vancouver	92
	EnvCan	Atmospheric Environment Service: Pacific and Yukon Region	Vancouver	231
	EnvCan	Canadian Wildlife Service: Pacific and Yukon Region	Delta	32
	EnvCan	Environmental Conservation Service: Conservation Laboratories	Vancouver	22
	EnvCan	Environmental Conservation Directorate: Pacific and Yukon	Vancouver	127
	F&O	West Vancouver Laboratory	Vancouver	35
	F&O	Pacific Biological Station	Nanaimo	206
	F&O	Institute of Ocean Sciences	Sidney	424
	HC	Health Protection Branch — Western Region	Burnaby	115
	NDEF	Defence Research Establishment/Pacific	Victoria	128
	NRC	Institute for Machinery Research	Vancouver	46
	NRC	Dominion Astrophysical Observatory	Victoria	42
	NRC	Dominion Radio Astrophysical Observatory	Penticton	29
	NRCan	Canadian Forestry Service — Pacific and Yukon Region	Victoria	183
	NRCan	Pacific Geoscience Centre	Sidney	40
	NRCan	Cordilleran Division/Geological Survey of Canada	Vancouver	32
N.W.t.	EnvCan	Background Air Pollution Monitoring Laboratory	Alert	2
	EnvCan	Arctic Stratospheric Ozone Observatory (ASTRO)	Eureka	5
Yukon	EnvCan	Canadian Wildlife Service — Whitehorse District Office	Whitehorse	4

N/A: not available.
Source: Industry Canada, Canadian S&T Information System, based on data supplied by the named departments.

4 International Comparisons

International Comparisons of S&T Activities

In order to make meaningful international comparisons of S&T activities, the OECD created the *Frascati Manual,* which sets out various definitions and gives detailed examples. Canada has been an active participant in the formulation and updating of the definitions. As part of its overall statistical database, the OECD uses the U.S. dollar as the common currency, adjusted for the differing costs of living in each of the OECD countries, or purchasing power parity (PPP) adjusted. PPP rates are established annually by the OECD using estimates of the overall cost of living in each of the member nations; PPP values are not specific to S&T expenditures. In theory, there could be a difference between the general PPP and a PPP prepared on a "basket" of S&T expenditures. However, work done for Statistics Canada by Jeffrey I. Bernstein, "Price Indexes for Canadian Industrial Research and Development Expenditures," Working Paper (Ottawa: Statistics Canada, 1992), suggests that the price index for S&T expenditures in Canada moves in a fashion similar to that for the general GDP deflator. PPP-adjusted prices are probably a good approximation of the relative expenditures on S&T from country to country.

Nevertheless, differences among nations remain, probably related more to productivity and indirect costs than to direct costs. Studies carried out by Investment Canada (now Industry Canada) measured relative intensity of self-funded research and relative concentration of research personnel as indicators of the relative cost-effectiveness for R&D activities in six North American cities. The results suggest that it may be more cost-effective to carry out R&D in Canadian cities than in equivalent U.S. cities. In general, industrial R&D operating costs in Canada per person-year, by sector, are probably lower than in other G-7 countries.

Science Policy

R&D statistics are ... used as a management tool in Government and as indicators of national investment. During the 1980s, science and technology have moved from the periphery of Government policy to a more central position.

In the public sector, overall policy on R&D spending is settled to a large degree by comparisons — historical comparisons with the spending levels of past years or contemporary comparisons with the spending levels of other countries. Although some quantitative tests about the "health" of research can be employed, such as the flow of manpower and successful performance (assessed with hindsight), decisions about policy depend primarily on subjective judgement. The goals of science policy can rarely be assessed in absolute terms.

"The most useful indicator of all is international comparison, even with its admitted imperfections. This is the key. Ultimately, the goal is the United Kingdom's survival as a leading industrial nation in world competition. The United Kingdom must therefore spend sufficient to improve (or at least to maintain) its industrial and cultural base relative to those countries which are judged to be its natural competitors, making allowances for differences in size and resources." A look at the *Debates [Hansard]* of the House of Commons confirms that such comparisons are often used in political debate.

Extract from *Definitions of R&D*, Third Report by the House of Lords Select Committee on S&T, Session 1989–90.

R&D spending is concentrated in the developed countries, with the seven largest economies in the OECD accounting for over three quarters of all R&D (Figure 4.1). As a percentage of GDP, Canada's R&D expenditure ranks fourteenth among the 24 nations of the OECD and is considerably lower than that of most of the G-7 countries (Table 4.1).

Public Sector Spending

Canada ranks in the middle range of OECD countries in terms of direct government support for civilian R&D (Table 4.2).

In terms of direct government support to industry, international comparisons are very hard to make for a number of reasons, not the least of which is the transparency (or otherwise) of the measures used and the source of the support. Direct government spending on R&D in industry is made up of grants and contracts to the industrial sector, including defence (Figure 4.2). While these data have not been separated into defence and civilian industries, it is probably no accident that the larger governmental funders of industrial R&D are also those nations with large defence programs.

Industrial R&D

R&D expenditures by Canadian industry are at the low end as a share of GERD (Table 4.2), as measured by business enterprise expenditures on R&D (BERD).

The ratio of industry-financed R&D to GDP can be used as an indicator of the industrial sector's participation in R&D. The OECD nations have generally shown increasing levels of industrial participation from 1981 through 1986. Japan, Sweden, Germany and the U.S. have much higher industry-financed BERD/GDP ratios than other countries.

Table 4.1 — International R&D Spending, 1991

	GERD	GERD/GDP	GERD/capita
	$M (PPP)	%	$ (PPP)
Australia*	3 671	1.34	215
Austria	2 043	1.51	261
Belgium*	2 752	1.69	276
Canada	7 783	1.50	288
Denmark	1 535	1.69	298
Finland	1 617	2.02	322
France	25 033	2.42	439
Germany	35 563	2.66	446
Greece	369	0.46	36
Iceland	420	1.04	176
Ireland	420	1.04	119
Italy	12 899	1.32	226
Japan	67 349	2.87	544
Netherlands	4 750	1.91	315
New Zealand*	399	0.88	119
Norway	1 315	1.84	308
Portugal	502	0.61	51
Spain	4 337	0.87	111
Sweden	4 186	2.90	485
Switzerland**	3 828	2.86	576
Turkey*	884	0.47	16
United Kingdom	18 735	2.08	325
United States	154 348	2.75	611
* = 1990			
** = 1989			
Selected Non-OECD Countries (1992)			
Chile	282*	0.74	21
China	2 965*	0.71	2.5
Indonesia	307	0.25	1.6
Korea (South)	5 327*	2.02	122
Mexico	750*	0.3	9.0
Russia	9 570	0.78	64
Singapore	577*	1.27	205
Taiwan	4 028	1.70	193
Thailand	147*	0.17	2.5

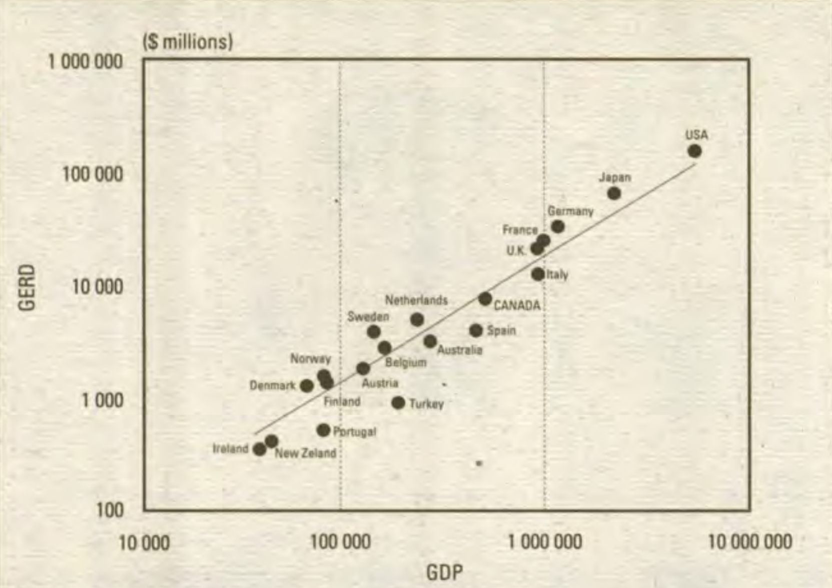
* Based on average exchange rates.
Source: OECD/STID and the Pacific Economic Cooperation Conference.

Table 4.2 — National Expenditures on R&D (GERD), 1991

			R&D Funding by Source			
Country	GERD	GERD/GDP	All Gov't	Gov't (civil)[1]	Domestic Industry	Other Private Sector and Foreign
	(US$ billion)				(% GDP)	
U.S.	154.3	2.75	1.29	0.51	1.40	0.06
Japan[2]	67.3	2.87	0.46	0.43	2.22	0.19
Germany	35.6	2.66	0.97	0.86	1.61	0.08
France	25.0	2.42	1.18	0.74	1.03	0.21
U.K.	18.7	2.08	0.71	0.39	1.04	0.33
Italy	12.9	1.32	0.61	0.56	0.63	0.08
Canada[3]	7.8	1.50	0.66	0.61	0.61	0.23
Netherlands	4.8	1.91	0.78	0.75	0.98	0.15
Sweden	4.2	2.90	1.10	0.80	1.74	0.06

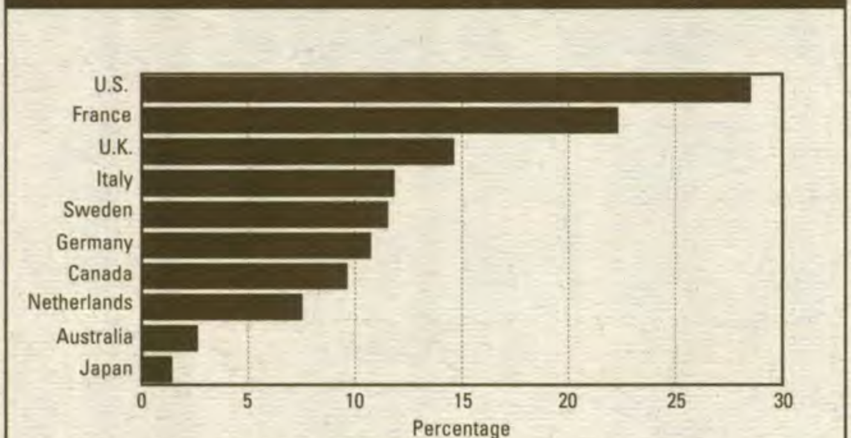
[1] ISTC estimate based on government appropriations.
[2] Japanese data adjusted by OECD secretariat.
[3] The GERD/GDP ratio was adjusted by the OECD and therefore is slightly different from the one published by Statistics Canada.
Source: OECD, *Main Science and Technology Indicators*, May 1992.

Figure 4.1 — GERD and GDP, 1990



Source: Industry Canada estimates based on data supplied by OECD/STID.

Figure 4.2 — Government-funded Industrial R&D, Selected Countries, 1991



Source: Industry Canada estimates based on data supplied by OECD/STID.

Patents

According to the Canadian Intellectual Property Office (CIPO), 26 865 patent applications were filed in Canada in 1992–93, and 17 247 were granted. Of these, Canadian inventors applied for 3 154 patents, accounting for 12 percent of all applications filed (Figure 4.3), and 7 percent (or 1 227 patents) were granted. Although these shares are high for Canada, they are nevertheless still low by international standards. American inventors account for almost one half of these applications but their share has been rapidly declining, with Japan emerging as an increasingly important source. Applications filed on Japanese inventions have almost doubled since 1978.

Ontario has consistently outperformed all other provinces in terms of the number of patents granted to its residents. In 1992–93, for example, Ontarians received 619 (50 percent) of the total. This is more than twice the number granted to Quebec inventors and five times that issued to Albertans or British Columbians. This is understandable, as Ontario is also the leader in R&D performance.

Perhaps because of the size of the market to be gained or protected and the close proximity of the two countries, Canadian residents normally file for more patents in the U.S. than at home. Since at least 1970, they have accounted for an almost steady 2 percent of all U.S. patents. Having overtaken Switzerland in 1984, Canada now ranks sixth among OECD nations, as measured by its annual share of U.S. patents. As is to be expected, U.S. inventors claim the most patents but, in recent years, the dominance has been seriously eroded by the large increase in Japanese applications. Patents granted on Japanese inventions have increased by 668 percent since 1970, compared with a 7 percent increase in those taken out by U.S. residents. As a result, Japan's share of all U.S. patents has grown from about 4 percent to 21 percent and its share of foreign-origin U.S. patents has increased from 15 percent to 44 percent.

With the almost 900 patents that have been assigned to its various departments and agencies between 1974 and 1987, the federal government is the largest Canadian holder of U.S. patents. Bell Canada Enterprises is a close second with about 850 patents. However, after Bell Canada, there is no other Canadian-controlled firm that has accumulated more than 200 U.S. patents.

Trade in Advanced Technology Products

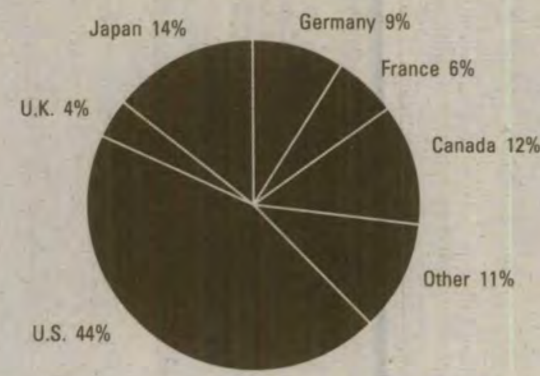
In January 1989, monthly trade statistics produced by the Census Bureau of the U.S. Department of Commerce began to include an advanced technology trade balance. The advanced technology products category comprised about one sixth of total U.S. exports and imports in 1989 according to the Census Bureau. The trade balance in this category was $25.5 billion.

About 500 of some 22 000 commodity classification codes used in reporting U.S. merchandise trade are identified as "advanced technology," meaning manufactured or processed goods containing leading-edge technologies. To be included in this category, a product must contain leading-edge technology from a recognized advanced technology field. The products selected also must constitute a significant part of all items covered in the selected classification code. The methodology adopted by the Americans permits frequent revision of the list of high-tech products, making the statistics more relevant in rapidly changing technology fields.

Applying a simplified version of the American advanced technology products classification methodology to Canadian data showed a Canadian high-tech trade deficit of $9.6 billion in 1988, declining to $8.2 billion (from 1.59 percent to 1.21 percent of GDP) in 1991. As the method used to produce these figures was not as detailed as that used in the U.S., these results should be taken as indicative rather than definitive.

The aerospace and nuclear technologies had positive trade balances in 1991 (Table 4.3). Chief export markets for the products of these technologies were the U.S. and non-developed countries. Computers and telecommunications showed a substantial deficit; Canadian strength in telecommunications is masked by the inclusion of telecommunications with computers in the American system.

Figure 4.3 — Patent Applications Filed in Canada, by Residence of Inventor, 1992–93



Source: Canadian Intellectual Property Office.

Table 4.3 — High-Technology Imports and Exports (Canada-World Trade), 1991

	Imports	Exports	Balance*
		($ millions)	
Biotechnology	124	65	(60)
Life Science	2 338	476	(1 862)
Opto-electronics	264	73	(191)
Computers and Telecommunications	8 249	4 427	(3 823)
Electronics	4 470	3 000	(1 470)
Computer Integrated Manufacturing	2 077	814	(1 263)
Material Design	663	173	(489)
Aerospace	3 886	4 838	952
Weapons	344	65	(280)
Nuclear	55	307	252
Total	**22 471**	**14 238**	**(8 233)**

*Numbers in parentheses are negative.
Source: Industry Canada estimates based on data supplied by Statistics Canada.

Funding of Academic and Academically Related Research

For many years, the OECD has collected data on R&D expenditures in the higher education sector but, because of wide variations in the structure of national educational systems and data collection practices of the statistical agencies, data are often incompatible. Accordingly, in 1984, the Advisory Board for the Research Councils (ABRC) in the U.K. commissioned Professors B. R. Martin and John Irvine of the University of Sussex to carry out a comparative study of university research funding in six different countries: France, Germany, Japan, the Netherlands, the U.K. and the U.S.

The original studies have been updated, and Canada and Australia have contributed material to the group. A summary of the data can be found in a paper by Martin and Irvine, titled "Trends in Government Spending on Academic and Related Research: An International Comparison," *Science and Public Policy* 19(5) [October 1992].

The studies collected data on R&D expenditures by discipline in three categories: general university funding (GUF), separately budgeted research (SBR) and academically related research (ARR). GUF is research costs allocated to the general operating funds of the universities, SBR is research paid for by identifiable government research funding agencies, and ARR is research performed in public sector non-university institutions devoted to curiosity-driven research, usually funded directly by governments through budgetary processes separate from the university R&D funding process.

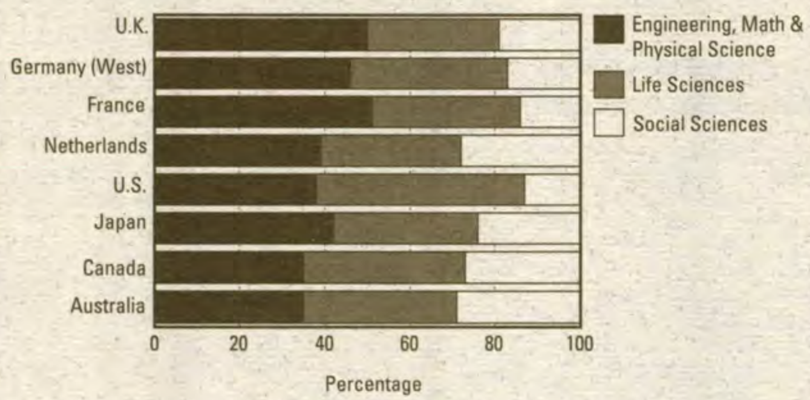
The data, which were initially government expenditure data in national Funding of Academic and Academically Related Research currencies, were transformed into constant 1987 U.S. dollars using deflators and purchasing power parities prepared by the OECD. Thus, the data give comparable expenditures that are in a common inflation-adjusted currency and which take into account the varying costs of living across the countries surveyed (see accompanying table and figure).

Academic and Academically Related Research, 1987

	$M (PPP)	$ per capita	as % GDP	Separately Budgeted (%)
U.K.	2 787	48.9	0.396	21
Germany (West)	4 037	66.0	0.496	18
France	3 212	57.7	0.453	31
Netherlands	958	65.3	0.532	20
U.S.	14 905	61.1	0.336	66
Japan	3 736	30.6	0.232	24
Canada	1 267	49.4	0.286	51
Australia	738	45.4	0.338	17

Source: B. R. Martin and J. Irvine, "Trends in Government Spending on Academic and Related Research," *Science and Public Policy* 19 (5).

Academic and Academically Related Research, 1987



Source: B. R. Martin and J. Irvine, "Trends in Government Spending on Academic and Related Research," *Science and Public Policy* 19 (5).

The U.S. dominates world trade in advanced technology products. It was the destination of 75 percent of these exports in 1991, while Canada sourced 61 percent of its imports in this category from the U.S. The European Community has declined in importance as an export destination over the four years (1988 to 1991) from 17 to 12 percent, while Canadian imports from this trading area have declined from 14 to 13 percent. Japan has held steady at 1 percent of high-tech exports and is the source of 10 percent of our imports of this category.

Scientific Literature

Relative publication and citation rates for academic papers are performance measures for academic R&D.

The Institute for Scientific Information publishes the *Science Literature Indicators Database*, which is based on approximately 3 500 journals widely recognized as being the most important journals in their respective fields. A recent British study by B. R. Martin et al. titled "Output Measures: Recent Trends in the Output and Impact of British Science," which appears in *Science and Public Policy* 17 [February 1990], shows that Canadian papers accounted for 4.35 percent of all papers in 1986, up from 3.92 percent in 1981, an increase of 11 percent. The U.S. registered a decline of 1 percent and the U.K. a decline of 2 percent (Table 4.4).

Citation rates measure the degree to which other researchers refer to the work done and are a good measure of the quality of the published work. Canadian papers accounted for 4.13 percent of all citations in 1986, up 6 percent from 1983. The next highest growth rate was 2 percent for Japan and the U.S. (Table 4.5).

The study also compared the performance of various fields of study. For Canada, while the average percentage of papers published was 4.3 percent of the total world's literature, clinical medicine was 1.24 times the national average, indicating a strong national presence in this field. Conversely, engineering accounted for only 0.53 times the national average.

Table 4.4 — National Shares of World Publication Output, Selected Countries, 1981 and 1986

Country	1981	1986	Change (%)
Canada	3.92	4.35	11
France	5.02	4.87	-3
Germany[1]	6.28	5.84	-7
Japan	6.79	7.69	12
Netherlands	1.61	1.84	14
U.K.	8.34	8.19	-2
U.S.	35.92	35.60	-1
USSR	8.01	7.56	-6
Other	24.10	24.08	0

[1] Data predate reunification.
Source: B. R. Martin et al., "Recent Trends in the Output and Impact of British Science," *Science and Public Policy* 17.

Table 4.5 — National Shares of Citations, Selected Countries, 1983 and 1986

Country	1983	1986	Change (%)
Canada	3.89	4.13	6
France	4.36	4.26	-2
Germany[1]	6.14	5.57	-9
Japan	5.76	5.89	2
Netherlands	1.90	1.91	1
U.K.	9.21	9.13	-1
U.S.	50.22	51.45	2
USSR	1.87	1.54	-18
Other	16.65	16.12	-3

[1] Data predate reunification.
Source: B. R. Martin et al., "Recent Trends in the Output and Impact of British Science," *Science and Public Policy* 17.

Table 4.6 — Canadian Output by Field (Ratio to National Average*), 1986

Field	Publications	Citations
Clinical Medicine	1.24	1.02
Biomedicine	1.07	0.85
Biology	1.05	2.04
Chemistry	0.74	1.05
Physics	0.88	0.71
Earth and Space Science	0.83	1.30
Engineering	0.53	0.98
Mathematics	1.05	1.09

* National average = 100.
Source: B. R. Martin et al., "Recent Trends in the Output and Impact of British Science," *Science and Public Policy* 17.

Citation analysis reveal Canadian strengths in the quality of publications in biology and earth and space science (2.04 and 1.30 times the national average). Physics was considerably weaker than other fields, with a citation rate of only 0.71 times the national average (Table 4.6).

International Competitiveness of Canadian R&D Tax Incentives

The Conference Board of Canada examined the relative attractiveness of the R&D tax systems in various countries in a study titled *Canadian R&D Tax Treatment*, Report 125-94 (Ottawa: Conference Board, 1994).

Specifically, the Conference Board used an index (the B-index) developed by D. McFetridge of Carleton University and J. Warda, now of the Conference Board. Their methodology is outlined in *Canadian Tax Incentives: Their Adequacy and Impact* (Toronto: Canadian Tax Foundation, 1983).

The B-index represents a minimum benefit-cost ratio at which, in a given tax jurisdiction, an R&D investment becomes profitable. The lower the B-index, the more attractive the tax benefits of undertaking R&D. The B-index is a more meaningful indicator of tax treatment than the after-tax cost of R&D, which can produce the erroneous result that a higher rate of taxation appears to benefit the firm.

The study provides a two-way comparison of R&D tax systems. Firstly, it compares B-index rankings among countries (see accompanying table). Secondly, it discusses changes in the attractiveness of R&D tax incentives over time by comparing the results of similar past Conference Board studies with the outcome of this one.

Canada's tax treatment of R&D remains the most favourable among the 11 countries.

B-indexes[1]: 1993–94

Country	B-index
Canada	0.69
Australia	0.77
Korea	0.89
U.S.	0.89
France	0.91
U.K.	1.00
Japan	1.00
Sweden	1.02
Mexico	1.03
Italy	1.03
Germany	1.06

[1] B-index = [after-tax cost / (1 – tax rate)].
Source: Conference Board of Canada, *Canadian R&D Tax Treatment*, Report 125-94 (Ottawa: Conference Board, 1994).

The competitive edge of Canada's R&D tax treatment is provided by the significant tax incentives that exist in some Canadian provinces.

There are some limitations to this study: certain timing aspects of R&D tax incentives, particularly the use of carry-forward/carry-back provisions and the like are omitted. Since the study deals only with the corporate income tax system, it excludes from analysis other elements of the tax environment such as personal income taxes, commodity taxes, property taxes and taxes on capital. The study also assumes that firms have sufficient taxable income to claim the full amount of R&D tax incentives in the current year. Thus, the analysis is limited to the tax treatment of intramural R&D expenditures of a large manufacturing corporation and may be incomplete, particularly with regard to small businesses.

Scientific, Technical and Engineering Personnel

The development or hiring of scientific, technical and engineering personnel (STEP) is a third measure of input of technology to the economy. As shown in Table 4.7, the level of R&D personnel in Canada is comparable with that of other nations, and estimates indicate that our level of scientific and engineering personnel is also comparable.

Since 1979, the growth in the number of Canadian research scientists and engineers has been slightly higher than the median for the OECD. In the OECD on average, the number of research scientists and engineers increased by 25 percent, compared with a 31 percent increase in Canada.

Table 4.7 — Selected International Comparisons, 1991

	Researchers per 1 000 Labour Force
Sweden	5.5
Japan	7.3
Switzerland	4.0*
U.S.	7.6
Germany	5.9
France	5.0
U.K.	4.6**
Netherlands	4.0
Canada	4.6
Italy	3.1

*1989 data.
**1988 data.
Source: OECD, Japanese data adjusted by the OECD.

5 A Selected Bibliography of Major Federal S&T Policy Reports

Introduction

The following annotated bibliography of major national reports on S&T policy and organization of S&T is designed to be an illustrative guide for those who may be interested in learning more about the history and legacy of policy reports in this field. It is not intended to be comprehensive, nor does it attempt to summarize the results of studies listed. However, the reader, by consulting some of these works, can receive a more informed overview of how the S&T and innovation policy debate in Canada has been shaped and how it has progressed over the past three decades.

Some of the recommendations from these reviews have led to significant institutional and other changes in the conduct of science policy. Examples include the creation of the Ministry of State for Science and Technology (later amalgamated into what is now Industry Canada, a shift to applied research and cost-recovery within a number of government laboratories, the creation of industry-based advisory boards for many departments, laboratories and research programs, and a general change in the corporate culture of how central agencies view S&T as engines of economic growth.

Annotated Bibliography of Selected Federal S&T Policy Reports

Royal Commission on Government Organization. *Volume 4: Special Areas of Administration.* Ottawa: Queen's Printer, 1963. Chairperson: J. Grant Glassco.

This report triggered much of what was to become the new machinery of science policy in the federal government. The 100-page chapter on "Scientific Research and Development" focused on the growth of government scientific activities, research in government departments and the place of industry in government science. The report made many recommendations designed to improve coordination of research among government departments and agencies, and also offered suggestions on improving the central machinery of science policy. Some of its recommendations were supplemented through a commissioned report from C. J. Mackenzie, the former president of the NRC.

Selected Conclusions and Recommendations:

- Promotion of industrial research by government departments, particularly the NRC, has been ineffective and needs to be strengthened
- Government research conducted for or in collaboration with a government department should be done by a research branch within that department

- The science policy advisory apparatus has been ineffective and has failed to function as intended. As a result, the Cabinet needs a single minister responsible for guiding them in the making of science policy to be housed in the role of President of Treasury Board, a science secretariat under the direction of the President of the Treasury Board, and a National Scientific Advisory Council to bring in the views of knowledgeable groups outside government. Its initial role was to review all government scientific programs. This council later came to be the Science Council of Canada.

Science Council of Canada. *Towards a National Science Policy for Canada.* Report 4. Ottawa: Queen's Printer, 1968.

The first report ever to issue a series of national objectives for S&T in Canada, it remains a classic. It was issued in the heyday of international examinations of how science can be better used to meet social and economic objectives.

Selected Conclusions and Recommendations:

- develop six national goals for science policy, including national prosperity, a high and rising standard of education, and physical and mental health and high life expectancy
- encourage the federal government to contract out its programs to increase the technological capacity of Canadian firms
- organize most new undertakings in Canadian science as large, multidisciplinary mission-oriented projects (major programs) to solve some important economic or social problem (e.g. space, water resources management, computer applications).

Senate. Special Committee on Science Policy. *A Science Policy for Canada.* 4 vols. Ottawa: Queen's Printer, 1971 to 1977. Chairperson: Maurice Lamontagne

Volume 1: A Critical Review: Past and Present. 1 recommendation.

Volume 2: Targets and Strategies for the Seventies. 45 recommendations.

Volume 3: A Government Organization for the Seventies. 27 recommendations.

Volume 4: Progress and Unfinished Business.

This remains the landmark assessment of Canada's national innovation system. Not only did the Senate committee generate volumes of hearings and open a national debate on the future of Canada's science policy, but also the exercise led to some impressive recommendations which are still topical today.

Selected Conclusions and Recommendations:

- a central coordinating body be created within the federal government (the Ministry of State for Science and Technology was created in June 1971)
- Canada aim to spend 2.5 percent of GDP on R&D by 1980 (subsequently revised to 1.5 percent by 1982)
- all existing specific grants designed to encourage R&D activities in industry be integrated into one multipurpose program
- a lending and investing institution called the Canadian Innovation Bank be created to support, in cooperation with private venture capital companies, the activities involved with the launching of technological innovations, especially in new or existing small and medium-sized firms, and provide managerial services to these enterprises
- the government institute a series of awards to be given to Canadian firms for meritorious technological innovation and invention

- the Ministry of State for Science and Technology be made responsible for keeping a national R&D inventory and be made responsible for developing a national audit of current R&D programs and projects supported by public funds
- NRC become a science academy and devote itself solely to basic research with the majority of in-house government research to be performed at NRC
- R&D grants to universities include indirect costs of projects.

Task Force on Federal Policies and Programs for Technology Development. *A Report to the Hon. Edward C. Lumley, Minister of State, Science and Technology.* Ottawa: Supply and Services Canada, 1984. Chairperson: Douglas Wright. 27 recommendations.

As the task force's name implies, the Wright report dealt mainly with technology, not science. But it was launched at the time when the federal government had issued a technology development policy, and sought guidance on how the government's industry support programs could be improved, how responsive universities were to the R&D needs of the private sector, and how relevant government labs were to industry's needs and to the government's economic and social objectives.

Selected Conclusions and Recommendations:

- the federal government's purchasing power should be effectively used to promote private sector innovation
- the federal government should pay the full costs of university research that it funds through its agencies
- public laboratories should operate in a business-like environment and should be awarded contracts within the framework of a multi-year planning system with clearly stated objectives and indicators for investment returns
- each laboratory should have a board of directors representing its major clients
- all federal laboratories should be evaluated for relevance and usefulness through peer reviews and evaluations.

National Advisory Board on Science and Technology. *Innovation and National Prosperity: The Need for Canada to Change Course.* Committee on National Science and Technology Priorities. Ottawa: Supply and Services Canada, 1991. Report chairperson: Peter Nicholson. 3 recommendations.

This report, issued at a time when competitiveness studies were the rage (with Michael Porter having been commissioned by the federal government and the Business Council on National Issues to assess Canada's competitiveness), attempted to position S&T as a prime engine of Canada's prosperity.

Selected Conclusions and Recommendations:

Policies that harness S&T to promote innovation must move forward on several fronts, including:

- framework policies that encourage the application of S&T, that promote national savings, competition and facilitate adjustment
- human resources policies that address the full spectrum of training and education
- policies that promote the development, acquisition and diffusion of technology.

National Advisory Board on Science and Technology. *Revitalizing Science and Technology in the Government of Canada: The Report of the Committee on Federal Science and Technology Expenditures.* Ottawa: Supply and Services Canada, 1990. Report chairperson: Pierre Lortie. 40 recommendations.

Inspired by the Wright report and other studies on how to improve the links between federal research laboratories and the private sector, the Lortie report focused on new experiments with "privatizing" public labs.

Selected Conclusions and Recommendations:

- creation of institutes — each department should consolidate its S&T activities in an institute with a clearly defined mission
- contractual agreements — the institutes should have contractual agreements with federal departments
- self-financing — the funds allocated to a department by Parliament should include the amount necessary to carry out the department's scientific and technological mandate and obtain necessary services on a contractual basis
- management structure — institutes should be relatively autonomous
- evaluation program — each institute should be subjected to peer evaluation.

Steering Group on Prosperity. *Inventing Our Future: An Action Plan for Canada's Prosperity.* Ottawa: Supply and Services Canada, 1992. Co-chairs: Marie-Josée Drouin and David R. McCamus. 10 recommendations.

This was a massive national consultation exercise designed to produce a plan of action to secure Canada's future economic and social well-being. Its S&T elements were significant and led to a separately published report called *Prosperity Through Innovation* by the Task Force on Challenges in Science, Technology and Related Skills under the Prosperity Initiative. In May 1993, the Government of Canada published a progress report on each and every recommendation issued by the Prosperity Steering Committee.

Selected Conclusions and Recommendations:

- concentrate more effort on adopting and diffusing technology as well as on creating new knowledge
- consolidate government technology support programs into coherent, readily accessible packages, responsive to customer needs and with a demonstrable value-added component
- strengthen intellectual property rights legislation and accelerate the approval process of patents
- build a national high-speed, broad-band electronic "information highway"
- establish a limited number of key institutions as champions of change and encourage the business, scientific and engineering communities to provide public leadership in this matter.

National Advisory Board on Science and Technology. *Spending Smarter.* Committee on Federal Science and Technology Priorities. Ottawa: Supply and Services Canada, 1993. Report chairperson: Peter S. Janson. 5 recommendations.

This report assessed the S&T spending of 12 federal departments or agencies. While the committee found unequivocal evidence of government priority for the allocation of funds to S&T, it could not confirm any explicit rationale for the allocation of S&T funds among federal departments or within the departments themselves, and called for high-level strategic planning for better management of S&T.

Selected Conclusions and Recommendations:

- the government should require that all departments and agencies manage their S&T activities as a distinct strategic asset, with central agencies monitoring the total S&T investment as an asset portfolio
- federal S&T should be catalogued according to consistent principles
- there should be two main objectives for the S&T programming of the federal government:
  - development of a knowledge-thirsty society
  - market-driven technology development
- the government should establish a system for priority setting for S&T within and among federal organizations

- Cabinet should review, and approve or modify, S&T activities of departments and agencies at least once every five years
- advice from groups external to government should be sought on S&T priorities.

Other S&T Policy Reports

A considerable number of reports and studies not listed in the annotated bibliography above have had significant impact on the S&T debate in Canada. Among these are:

provincial: *White Paper: Proposals for an Industrial and Science Strategy for Albertans 1985 to 1990* (July 1984); *A Collective Project: Statement of policy objectives and plan of action for the implementation of a scientific research policy for Québec* (1980); *White Paper: Towards a Science Policy for Newfoundland* (1981); *Competing in the New Global Economy*, Ontario Premier's Council (1988).

industry associations: The Canadian Chamber of Commerce, *Focus 2000: Report of the Task Force on Technology and Canadian Business* (1988); Information Technology Association of Canada, *A Knowledge-Based Canada: The New National Dream* (1993); Canadian Advanced Technology Association, *The Report of the National Technology Policy Roundtable* (1986).

Parliament: *Federal Government Support for Technological Advancement: An Overview*, a report of the Standing Senate Committee on National Finance (1984); *Canada Must Compete: Report of the Standing Committee on Industry, Science and Technology, Regional and Northern Development* (1990) and *Government Response to Canada Must Compete* (1991).

science advisory councils: National Forum of Science and Technology Advisory Councils, (a series of four reports of conferences in Halifax, Edmonton, Victoria and Hamilton (1989–1993); Conseil de la science et de la technologie, *Emergency: Technology — For a Bold, Competitive and Prosperous Québec* (1993).

national conferences on S&T policy: *Canada Tomorrow Conference* (1983); *Technology and Innovation in Canada: The Case for National Action — A Report Based on the National and Regional Conferences on Technology and Innovation* (1989); National Conference on Science and Technology Policy (1986).

national statements on S&T: *A National Science and Technology Action Plan;* Council of Science and Technology Ministers (1991); *The National Science and Technology Policy Forum* (1986); *Science, Technology and Economic Development: A Working Paper* (1985); *Discussion Paper on Canada's Research and Development Effort*, Annual Conference of First Ministers (1987); *Research and Development in Canada: Report of the Ad Hoc Advisory Committee to the Minister of State for Science and Technology* (1979); *Towards a National Science Policy for Canada*, Science Council of Canada (1968); *InnovAction: The Canadian Strategy for Science and Technology* (1987).

special commissions: *Royal Commission on the Economic Union and Development Prospects for Canada* (1985); Advisory Council on Adjustment, *Adjusting to Win*, A. Jean de Grandpré (1989).

international reviews of Canada's S&T policy: *OECD Review of National Science Policy — Canada: Its Relevance to NRC*, OECD (1970); *Innovation Policy: Western Provinces of Canada*, OECD (1988).

institutions examining the role of S&T: numerous reports from the Science Council of Canada (1966–1992), the Economic Council of Canada, federal departments and agencies, university-based institutes such as the Centre interuniversitaire de recherche sur la science et la technologie (UQAM), and scientific and academies including the Royal Society of Canada, and the Canadian Institute for Advanced Research.

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Glossary

Applied Research — original investigation undertaken in order to acquire new knowledge directed primarily toward a specific practical aim or objective (*Frascati Manual*/OECD).

Basic Research — experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view (*Frascati Manual*/OECD).

Diffusion — the way in which innovations spread, through market or non-market channels; without diffusion, innovation has no economic impact (*Oslo Manual*/OECD).

Experimental Development — systematic work, drawing on existing knowledge gained from research and practical experience, that is directed to producing new materials, products and devices, to installing new processes, systems and services, and to improving substantially those already produced or installed (*Frascati Manual*/OECD).

Extramural — pertaining to scientific activities for which funding and other services are provided to another agency to carry out, and may include grants, contributions or contracts.

Gross Domestic Product (GDP) — total flow of goods and services produced by an economy over a specified period of time, normally one year.

Gross National Product (GNP) — GDP plus the income accruing to domestic residents arising from investment abroad less income earned in the domestic market accruing to foreigners abroad.

High-Technology Industries — include aerospace, electronics, computers, scientific instruments, pharmaceutical and electrical machinery (OECD).

Industry — business and government enterprises including public utilities and government-owned firms as well as incorporated consultants providing scientific and engineering services.

Innovation System — players involved in the generation of innovation, such as the government, industry and universities, and the means through with information contributing to the development of innovation moves between them.

Intramural — pertaining to scientific activities carried out by the agency's in-house personnel of units assigned to the program; the related acquisition of land, buildings, machinery and equipment for scientific activities; the administration of scientific activities by program employees; and the purchase of goods and services to support in-house specific activities.

Natural Sciences — disciplines concerned with understanding, exploring, developing or utilizing the natural world, including engineering, mathematical, life and physical sciences.

Non-profit Institutions — charitable foundations, voluntary health organizations, scientific and professional societies, and other organizations not established to earn profits.

Process Innovation — a significant change in the technology of the production of an item, which may involve new equipment, new management and organization methods, or both (*Oslo Manual*/OECD).

Product Innovation — commercialization of a technologically changed product, whose design characteristics are changed in ways which deliver new or improved services to consumers of the product (*Oslo Manual/* OECD).

Research and Development (R&D) — creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of humans, culture and society, and the use of the stock of knowledge to devise new applications; composed of basic research, applied research and experimental development (*Frascati Manual/*OECD).

Related Scientific Activity (RSA) — activities that complement or extend R&D by contributing to the generation, dissemination and application of S&T knowledge; examples of extramural RSA include data collection, scientific information, museum services, operations and policy studies.

Risk Management/Quality of Life — the relationship between S&T and risk management/quality of life is best demonstrated in the fields of defence, security, safety, standards, regulations and the environment; in these areas, S&T becomes a tool which can help to deliver programs more efficiently and effectively.

Science and Technology (S&T) — systematic activities which are closely concerned with the generation, advancement, dissemination and application of scientific and technical knowledge in all fields of science and technology including such activities as R&D, scientific and technical education and training and the scientific and technological services (UNESCO).

Social Sciences: all disciplines involving the study of human actions and conditions and the social, economic and institutional mechanisms affecting humans, including anthropology, business administration and commerce, communications, criminology, etc.

Universities — affiliated institutes owned, administered or staffed by universities, including industrial research institutes located at universities.

Wealth Creation — within the context of S&T, the employment of S&T with the objective of adding to present and future flows of wealth.

List of Abbreviations

AECL	Atomic Energy of Canada Limited
AgCan	Agriculture and Agri-Food Canada
BE	business enterprise
BERD	business enterprise expenditures on research and development
CCPCs	Canadian-controlled private corporations
CIDA	Canadian International Development Agency
Com	Communications Canada (now Industry Canada)
CSA	Canadian Space Agency
EIC	Employment and Immigration Canada (now Human Resources Development Canada)
EMR	Energy, Mines and Resources Canada (now Natural Resources Canada)
EnvCan	Environment Canada
F&O	Fisheries and Oceans Canada
ForCan	Forestry Canada (now Natural Resources Canada)
G-7	Group of Seven most developed member countries of the OECD
GDP	gross domestic product
GERD	gross domestic expenditure on research and development
HC	Health Canada
HERD	higher education expenditures on research and development
HWC	Health and Welfare Canada (now Health Canada)
IDRC	International Development Research Centre
IndCan	Industry Canada
ISTC	Industry, Science and Technology Canada (now Industry Canada)
ITCs	investment tax credits
LAN	local area network
MRC	Medical Research Council of Canada
NCR	National Capital Region
NC/CNC	numerical control/ computer numerical control
NDEF	National Defence
NLC	National Library of Canada
NMC	National Museums of Canada
NRC	National Research Council Canada
NRCan	Natural Resources Canada
NSE	natural sciences and engineering
NSERC	Natural Sciences and Engineering Research Council Canada
OECD	Organisation for Economic Co-operation and Development
OECD/ STID	OECD Science, Technology and Industry Directorate
PNP	private non-profit organization
PPP	purchasing power parity
PRO	provincial research organizations
PYs	person years
R&D	research and development
RSA	related scientific activities
S&T	science and technology
SSH	social sciences and humanities
SSHRC	Social Sciences and Humanities Research Council of Canada
StatCan	Statistics Canada
STEP	scientific, technical and engineering personnel
TC	Transport Canada
UNESCO	United Nations Educational, Scientific, and Cultural Organization

Canada