SCIENCE AND TECHNOLOGY

RESOURCE ALLOCATION STATISTICS

1987/88

MINISTRY OF STATE FOR SCIENCE AND TECHNOLOGY

S&T DATA INTELLIGENCE BRANCH

JULY 1987

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Science and Technology Resource Allocation Statistics
(STRAS)

Introduction

This booklet, "S&T Resource Allocation Statistics" has been prepared to provide S&T policy analysts and managers with a source-book for S&T statistics for quantitative and qualitative analysis. The bulk of the material reviews the S&T and R&D resource allocations of the federal government, but national and international data are provided as well to place the federal figures in context and to provide comparisons.

No summary of the data has been prepared. The index provides an overview of the layout of the statistics. A small card, providing a few selected statistics will be published soon, for use as a compact reference.

This booklet has been compiled by the staff of the S&T Data Intelligence Branch using material that has been collected and processed by the S&T Statistics Unit of Statistics Canada. It could not have been prepared without their assistance, both in compiling the original statistics and in reviewing the material. The international comparisons section relies heavily upon material collected and processed by the Science, Technology and Industry Information Division of the OECD.

A publication of this type is a snapshot, freezing information at a particular point in time. New data are constantly becoming available. Analysts are encouraged to refer to the sources appended to each table to determine if more recent data have been published.

As with any compendium of numbers, errors inevitably creep into the text and tables. Readers are encouraged to make the S&T Data Intelligence Branch aware of any inconsistencies or errors.

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LIST OF ABBREVIATIONS

ABRC - Advisory Board for the Research Councils
AECL - Atomic Energy of Canada Limited
AGR - Agriculture Canada
B - billion(s)
CBC - Canadian Broadcasting Corporation
CC - Canada Council
CIDA - Canadian International Development Agency
CMHC - Canada Mortgage and Housing Corporation
COMM - Communications
E&RD - economic and regional development
EMR - Energy, Mines and Resources
ENV - Environment Canada
F&O - Fisheries and Oceans
FRG - Federal Republic of Germany (West Germany)
GDP - gross domestic product
GERD - gross expenditures on research and development
HQP - highly qualified personnel
IDRC - International Development Research Centre
M - million(s)
MESA - Main Estimates Science Addendum
MOSST - Ministry of State for Science and Technology
MRC - Medical Research Council
NCR - National Capital Region
NDEF - National Defence
NHW - National Health and Welfare
NLC - National Library of Canada
NRC - National Research Council
NSE - natural sciences and engineering
NSERC - Natural Sciences and Humanities Research Council
OECD - Organisation for Economic and Co-operative Development
PRO - provincial research organizations
PY - person-year
R&D - research and development
RIE - Regional Industrial Expansion
RSA - related scientific activities
RSE - research scientists and engineers
S&T - science and technology
SRTC - Scientific Research Tax Credit
SSC - Supply and Services Canada
SSH - social sciences and humanities
SSHRC - Social Sciences and Humanities Research Council
STC - Statistics Canada
STIID - Science, Technology and Industry Information Division
TRANS - Transport Canada

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A. HOW THE FEDERAL GOVERNMENT SPENDS ITS S&T BUDGET

The federal government is the largest single funder of science and technology (S&T) in Canada. Its expenditure decisions influence the whole pattern of R&D spending in Canada. Although S&T expenditures are not managed as an envelope in the Cabinet committee system, the decision framework process is designed to ensure that they are considered as a co-ordinated whole rather than as a series of unrelated decisions. The aggregate expenditures on S&T are larger than either of the external affairs and aid envelope or the services to government envelope in the 1987/88 Main Estimates.

1. Federal S&T Expenditures

Federal S&T expenditures in 1987/88 will total $4.14 billion, more than double their level in 1979/80. Table A-1 shows the growth of federal S&T expenditures since 1979/80, in actual dollars as well as in constant 1981 dollars. Federal S&T expenditures have grown at an average real rate of about 3.5% per annum from 1979/80 to 1987/88.

S&T expenditures are about 4% of total federal expenditures or about 11% of the non-statutory portion of the Estimates which is that part of federal expenditures not set by legislation, and which therefore has often been the subject of review and restraint.

TABLE A-1
FEDERAL S&T EXPENDITURES

	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88
	(billions of dollars)								
Actual $	1.99	2.27	2.75	3.08	3.49	3.89	3.94	4.19	4.14
1981 $	2.44	2.51	2.75	2.83	3.05	3.29	3.22	3.33	3.17
% Real growth from previous year	-7.6	2.9	9.6	2.9	7.8	7.9	-2.1	3.4	-4.8
% of Total Federal Expenditures	3.96	3.89	3.96	3.85	3.92	4.09	3.80	3.90	3.76
% of non-statutory expenditures	9.8	10.6	9.8	10.1	10.2	10.5	10.7	11.2	11.0

Sources: Statistics Canada, Federal Scientific Activities 1985/86, Cat. #88-204.
Main Estimates, Part I.
Statistics Canada, Federal Science Expenditures and Personnel, 1987/88.

2. Federal S&T Expenditures: R&D and RSA

Federal S&T expenditures can be divided into two major areas: research and development (R&D) and related scientific activities (RSA). R&D is defined by Statistics Canada as "creative work undertaken on a systematic basis to increase the stock of knowledge including the knowledge of man, culture and society and the use of the stock of knowledge to devise new applications." RSA are defined as those activities which complement and extend R&D by contributing to the generation, dissemination and application of S&T knowledge (e.g. surveys and mapping, weather forecasting, census, etc.). RSA, in the federal government context, comprises several governmental S&T support services, such as museums, collection of statistics, testing and standardization, S&T information services and policy studies.

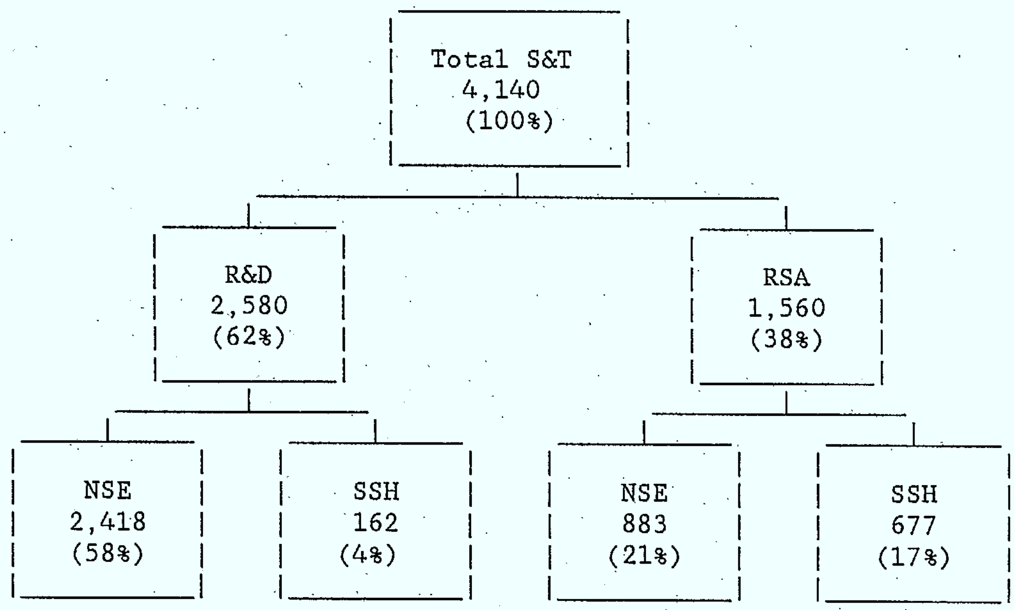
Federal expenditures on R&D will total $2.58 billion in 1987/88 or account for 62% of the federal S&T budget. Federal R&D expenditures represent a major instrument for the implementation of S&T policy.

The $1.6 billion in RSA expenditures account for 38% of the total S&T budget. The policy issues in RSA are usually quite specific to the type of service and often reflect strong client perceptions of the level of government involvement in that economic or social activity.

S&T expenditures can also be divided by subject area into the natural sciences and engineering (NSE) and the social sciences and humanities (SSH). Activity in the NSE tends to be tied to economic development objectives, while SSH activity is more evenly divided between economic and social development. R&D can also be divided into NSE and SSH activities. NSE accounts for 79% of all R&D expenditures.

Figure A-1 shows the division of federal S&T expenditures for 1987/88 into these categories.

FIGURE A-1
FEDERAL S&T EXPENDITURES, 1987/88
(MILLIONS OF DOLLARS)



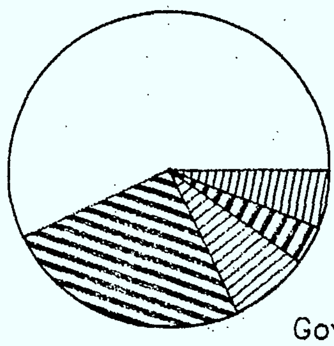
Source: Statistics Canada, Federal Science Expenditures and Personnel, 1987/88.

In addition to the direct expenditures on R&D, it is estimated that the federal government effectively funds another $400 million of R&D through tax expenditures. This issue is discussed further in Section A-9.

3. S&T Expenditures by Policy Envelope

Figure A-2 shows the distribution of S&T expenditures by envelope. R&D expenditures tend to fall in the economic development envelope, while RSA tends to be more evenly distributed between economic and social development envelopes. S&T expenditures account for 20% of all expenditures in the economic development envelope (excluding subsidies). R&D in the economic and regional development envelope accounts for 72% of federal R&D expenditures and 45% of all federal S&T expenditures, highlighting the connection between economic development and S&T expenditures. The S&T in the government services envelope is almost entirely attributed to the presence of Statistics Canada in that envelope.

FIGURE A-2
FEDERAL S&T EXPENDITURES BY ENVELOPE, 1987/88



$4.14 BILLION FEDERAL S&T EXPENDITURES
(DOES NOT INCLUDE $400 MILLION IN TAX EXPENDITURES)

Source: Statistics Canada, Federal Science Expenditures and Personnel, 1987/88.

4. S&T Expenditures by Department

The federal S&T effort is highly fragmented among 77 programs and 53 organizations that report to 25 Ministers. The fourteen departments shown in Table A-2 and Figure A-3 each have S&T expenditures greater than $50 million/year and account for about 82% of the total S&T budget. Six major spenders, AGR, EMR, ENV, NRC, NSERC and STC, all with S&T expenditures greater than $250 million in 1987/88, account for over half of the total S&T budget.

The six departments and agencies with the greatest average annual real growth from 1980/81 to 1987/88 are AGR, EMR, NDEF, RIE, NSERC and MRC, each with growth rates of 5% or more. By contrast, SSHRC showed very little growth. COMM, ENV and F&O are showing negative growth rates.

Although CIDA and NDEF are big S&T spenders, their S&T expenditures are a small proportion of their total program expenditures. As might be expected, research organizations such as NRC, the Granting Councils, and IDRC have a large percentage of S&T expenditures. STC also has a high percentage of its total expenditures allocated to S&T expenditures, since it is a major RSA performer.

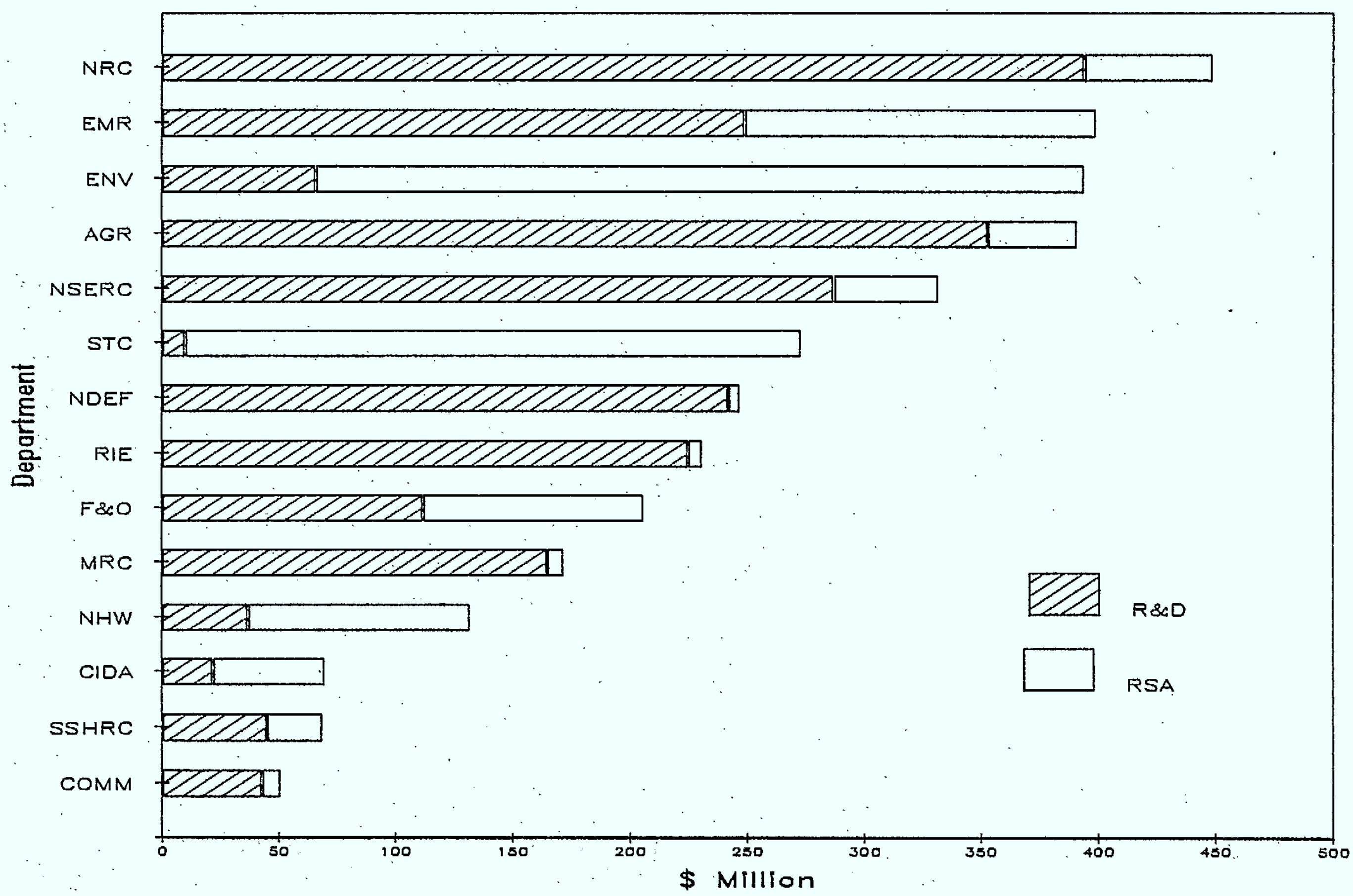
TABLE A-2
FEDERAL EXPENDITURES ON S&T BY DEPARTMENT, 1987/88*

Dept	R&D	RSA	Total S&T	Real Average Annual Growth Rates 1980/81 to 1987/88
	(millions of dollars)			(percentage)
AGR	353	38	391	5.7
CIDA	22	48	71	4.1
COMM	43	8	51	- 9.0
EMR	249	150	399	5.1
ENV	66	328	394	- 0.1
F&O	112	94	205	- 0.1
NDEF	242	5	247	7.4
NHW	37	95	132	3.3
NRC	394	55	449	4.4
RIE	225	6	230	6.8
STC	10	263	272	2.6
NSERC	287	45	332	5.0
MRC	165	7	172	5.4
SSHRC	45	24	69	1.5
OTHERS	330	394	726	
TOTALS	2,580	1,560	4,140	3.4

* Columns may not add due to rounding.

Sources: Statistics Canada, Federal Science Expenditures and Personnel, 1987/88.

FIGURE A-3
FEDERAL S&T EXPENDITURES BY DEPARTMENT, 1987/88



Source: Statistics Canada, Federal Science Expenditures and Personnel, 1987/88.

5. S&T Expenditures by Areas of Application

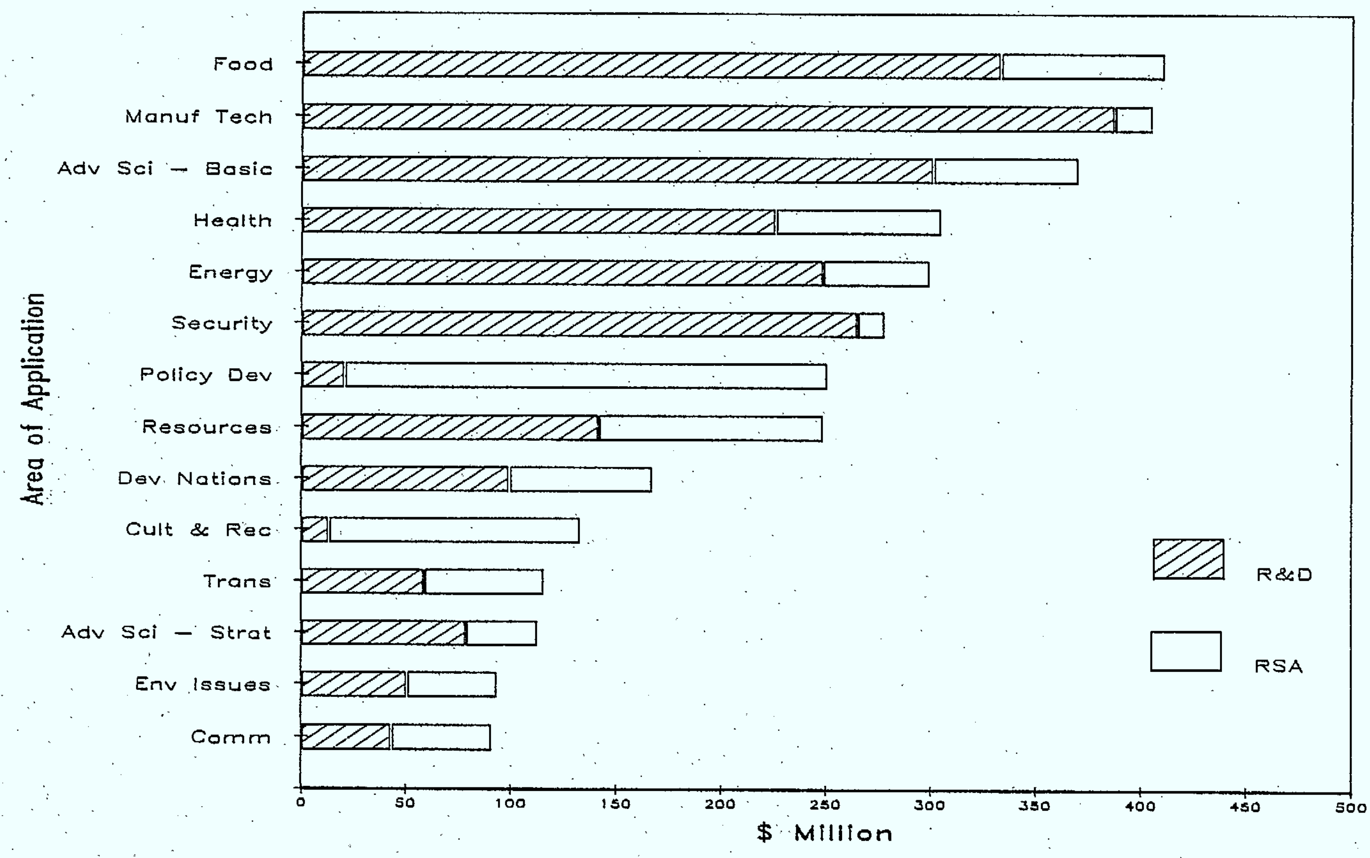
Departmental and agency missions cover a wide range of objectives. These are broadly divided by the S&T Decision Framework into economic and regional development, mission-oriented and basic research. Table A-3 shows how federal S&T expenditures are divided by the major framework areas. Table A-4 lists the components of each of these three main areas of the framework. Figure A-4 and Table A-5 show these areas of application, in more detail, by department.

TABLE A-3
S&T EXPENDITURES BY PURPOSE
1987/88

Performer	Area Basic	Area Mission	Area E&RD	Total
	(millions of dollars)			
Federal	20	1,170	1,190	2,380
Industry	--	470	520	990
University (and other)	350	110	20	480
Total	370	1,750	1,730	3,850*

* Does not include unallocated overheads of $290 million.
Source: Based on data from Statistics Canada, Main Estimates Science Addendum, 1987/88.

FIGURE A-4
FEDERAL S&T EXPENDITURES BY AREA OF APPLICATION, 1987/88



Source: Based on data from Statistics Canada, Main Estimates Science Addendum, 1987/88.

TABLE A-4
AREA OF APPLICATION (MESA) DATA, 1987/88

Application		Departmental Allocations	
	(millions of dollars)		
Advancement of Knowledge			
- advancement of science - basic	370	NSERC	296
(NSE and SSH)		SSHRC	68
		EMR	2
		COMM	2
		MOSST	2
		ENV	1
Total	370		370
Economic and Regional Development			
NSE components of:			
- advancement of science - strategic	113	NRC	392
- communications	47	AGR	332
- energy	299	EMR	243
- food - agriculture	299	RIE	224
- fisheries	89	F&O	176
- housing	41	AECL	134
- manufacturing technology	401	ENV	83
- northern development	8	COMM	45
- oceans	72	TRANS	36
- resources - forestry	69	NSERC	16
- mineral	90	MOSST	14
- water	25	SSC	10
- other	31	Others	26
- space	39		
- transportation	107		
Total	1,730		1,730
Mission-oriented			
The SSH components of the items listed above:	137		
plus the NSE and SSH of the below:			
- culture & recreation	133	ENV	277
- developing nations	168	NDEF	245
- environment (all)	94	STC	237
- health	305	MRC	172
- policy development	251	NHW	113
- security - domestic	30	COMM	106
- national defence	248	NMC	100
- social development	58	IDRC	98
- other	328	CIDA	70
		NLC	36
		NRC	30
		F&O	21
		NSERC	19
		MOSST	11
		Others	218
Total	1,752		1,752
Non-program Costs (Overhead)	288		288
Total S&T Spending	4,140		4,140

Source: Based on data from Statistics Canada, 1987/88.

TABLE A-5

S&T Expenditures by Area of Application, 1987/88 (NSE & SSH)

	Adv Sci Basic	Adv Sci Strategic	Comm	Culture & Rec	Dev. Nations	Energy	Env	Food	Health	Hous & Urb Dev	Manuf Tech	North Dev	Oceans	Policy Dev	Resources	Security	Soc Dev & Welfare	Space	Trans	Other	Total
(millions of dollars)																					
AGR						1.5	2.5	265.0							67.4						336.5
AECL						133.6			8.3												141.9
CIDA					70.2																70.2
COMM	1.5	0.9	37.4	0.5							3.1			0.5				4.1			48.1
EMR	2.4		1.0			125.2	6.5	0.3	4.2	2.6	2.6	4.3	4.9	0.3	133.7	2.8				60.4	351.1
ENV	0.8	0.8		7.4		5.9	58.9	0.7		5.9			27.7		43.5			7.0		202.0	360.6
F&O						5.9	14.0	95.3					35.2						46.3		196.7
IDRC					97.6																97.6
MRC									171.7												171.7
NHW									96.6					5.2			11.4				113.3
NRC		105.5				9.8	4.7	30.5	18.5	24.1	165.3					9.4		24.5	29.7		421.8
NSERC	295.7		6.1			4.0	2.9	5.4					3.0							13.3	330.5
NDEF																244.9					244.9
NLIB			35.6																		35.6
NMUS				100.0																	100.0
RIE											228.1										228.1
MOSST	1.5	5.6									5.6			11.3				3.1			27.1
SSHRC	68.0																				68.0
STC			0.2	2.3		0.8		12.5	5.8	3.1				190.3			17.8		4.2		237.0
TRANS						6.3								0.2					30.9		37.4
OTHERS	0.0	0.0	10.4	22.6	0.0	7.1	4.1	1.4	0.0	27.1	0.0	4.1	1.4	43.5	4.8	20.9	29.1	0.1	4.5	51.7	232.9
TOTAL	369.9	112.7	90.8	132.8	167.8	300.1	93.6	411.0	305.0	62.8	404.7	8.3	72.1	251.3	249.4	278.0	58.3	38.9	115.6	327.5	3,850.6

Note: This table does not include non-program costs.

Source: Statistics Canada Main Estimates Science Addendum, 1987/88

6. Public Service Personnel in Federal S&T Activities

The largest Public Service S&T employers with controlled PYs are AGR, ENV, NRC and STC. Their distribution, by department, is shown in Table A-6. AGR is by far the largest R&D employer, followed by NRC and EMR. STC is the largest RSA employer followed by ENV and NHW. Of the 16,510 employees in the RSA and Administration categories, 1,455 are engaged in the administration of external programs. Although RSA accounts for only 38% of S&T expenditures, it consumes 54% of S&T PYs.

TABLE A-6
PUBLIC SERVANTS ENGAGED IN S&T BY DEPARTMENT, 1987/88

Department/ Agency	R&D	RSA and Admin.	Total S&T
	(person-years)		
AGR	4,423	596	5,019
COMM	344	73	417
EMR	1,666	1,060	2,726
ENV	865	3,105	3,970
F&O	1,244	1,023	2,267
NHW	192	1,265	1,457
NDEF	1,640	81	1,721
NMC	135	1,006	1,141
NRC	2,867	580	3,447
STC	103	4,185	4,288
University Granting Councils - Total	--	289	289
All Others	318	3,248	3,566
Total Public Servants (1)	13,797	16,511	30,308
S&T Public Servants as % of total PYs	5.9	7.1	13.0

(1) Does not include Non-Public Servants (PYs of AECL, IDRC, CC, CMHC, CBC, or military personnel.)

Source: Statistics Canada, Federal Science Expenditures and Personnel, 1987/88.

The total number of S&T person-years in the Public Service, and excluding military personnel, in 1987/88 is 30,308 PYs. Given the distribution of PYs by category, as reported by Statistics Canada, with average salaries as shown below in Table A-7, the average salary for an S&T person year is $38,033.

TABLE A-7
S&T WORKERS IN THE PUBLIC SERVICE, 1987/88

Salary Category	Number	Estimated Average
	(person-years)	(dollars)
Executive	771	69,272
Professional	9,642	49,343
Admin. and Foreign Service	3,391	41,607
Technical	7,870	34,149
Admin. Support	6,013	24,345
Operational	2,621	25,763
Total	30,308	38,033

Sources: Statistics Canada, Federal Science Expenditures and Personnel, 1987/88.
1987/88 Main Estimates, Part III.

7. Federal S&T by Performer

FIGURE A-5

S&T
$4,140 M

Intramural	Industry	Universities	Others
$2,659 M	$587 M	$614 M	$280 M
(64%)	(14%)	(15%)	(7%)

There are three major performers of federally funded S&T: federal laboratories, industry, and Canadian universities (Figure A-5). The federal scientific establishment is, by far, the largest performer and in 1987-88 will spend 64% of the total expenditures on activities conducted intramurally. The next largest share, 15%, will be spent in the university sector. Canadian industries will receive 14%.

The distribution of performance shares varies with the field of science (NSE or SSH), the type of activity (R&D or RSA), and the mission of the funding department or agency. As a general rule, the intramural share is greatest in the SSH and for related scientific activities such as data collection, scientific information, museum services, and operations and policy studies.

(a) Intramural Programs

During the last ten years, the overall trend has been towards a greater centralization of intramural S&T activities within a relatively small number of departments and agencies. The five largest intramural programs (AGR, ENV, NRC, EMR, STC) now account for 60% of the total expenditures as compared with 53% in 1976. The top ten will spend 85%, a four percent gain over the period.

Federal laboratories are important sources of Canadian inventions. Between 1978 and 1984, more than 480 Canadian patents were granted to federal laboratories. NDEF, NRC and AECL are the major patentees. NDEF was granted almost half of the federal inventions, NRC about one-fifth, and AECL nearly one-sixth. Between 1978 and 1984, the federal government received as many patents for Canadian inventions as Northern Telecom, and three times that of the next largest corporate patentee, Canadian General Electric.

(b) Spending in Industry

Support for R&D in industry is highly concentrated among four departments and agencies. In 1987-88, for example, RIE will provide approximately 38% of the funds, NRC 21%, NDEF 19% and EMR almost 5%.

Table A-8 shows federal extramural S&T expenditures by department for 1987/88. Spending on R&D contracts has increased at a faster rate than expenditures on intramural R&D. As a percentage of current intramural R&D expenditures, R&D contracts increased from 15% in 1976/77 to a high of 19% in 1984/85 and decreased slightly to 18% in 1987/88.

TABLE A-8
FEDERAL EXTRAMURAL S&T EXPENDITURES, 1987/88

Department	Total Federal Extramural S&T Expenditures	Total Federal Extramural R&D Expenditures	S&T Contracts Extramural	R&D Contracts
	(millions of dollars)			
AECL	16.9	9.8	17.1	9.9
AGR	20.5	19.4	6.3	5.2
CIDA	65.9	21.4	44.4	--
COMM	12.6	11.1	6.0	4.6
EMR	109.2	53.8	83.3	28.0
ENV	25.8	12.1	24.5	10.9
F&O	16.4	8.3	16.0	7.9
MOSST	14.8	11.8	3.0	--
MRC	167.9	161.1	6.7	--
NDEF	108.0	107.9	108.0	107.9
NHW	34.6	17.0	19.0	1.5
NMC	19.9	0.5	19.9	0.5
NRC	141.1	140.4	30.4	29.7
NSERC	318.7	275.7	43.1	--
RIE	197.3	192.2	5.1	--
SSHRC	62.3	41.8	20.5	--
Other	148.9	116.6	74.3	42.0
TOTAL	1,480.0	1,201.1	527.7	248.1

Source: Statistics Canada, Federal Science Expenditures and Personnel, 1987/88.

(c) Spending in Universities

Federal support for sponsored research is concentrated in the larger universities. The top five received 43% of the 1984 grants and the top ten 63%. Ontario had four universities in the top ten and Quebec three. Table A-9 shows the distribution of funding among the top fifteen universities.

TABLE A-9
TOTAL FUNDING TO CANADIAN UNIVERSITIES, 1984/85

Universities	Grants	Total Funding
	(millions of dollars)	(percentage)
Toronto	67.3	14.7
McGill	40.2	8.9
British Columbia	38.5	8.4
Alberta	24.6	5.4
Montreal	24.5	5.4
McMaster	21.5	4.7
Manitoba	19.7	4.3
Western	19.0	4.2
Waterloo	18.2	4.0
Laval	15.9	3.5
Queen's	15.9	3.5
Calgary	14.5	3.2
Saskatchewan	13.9	3.0
Dalhousie	13.5	3.0
Ottawa	12.2	2.7
Total Funding to All Canadian Universities	457.2	100.0

Source: NRC, Canada Institute for Scientific and Technical Information, Directory of Federally Supported Research in Universities, Volume 1, 1984/1985.

8. Regional Distribution of Federal S&T

In 1985/86, the latest year for which regional data are available, the federal government spent $2.6 billion on R&D and $3.9 billion on S&T in total. Because of the way the statistics are collected, in a separate survey of regional institutions, the total of federal expenditures for 1985/86, by region, does not add up to the total $3.9 billion. The difference lies mainly in unallocated overhead costs and foreign R&D expenditures.

Tables A-10, A-11, A-12 and A-13 show the regional distribution of federal S&T financial and personnel resources, with the NCR shown as a separate region. In 1985, the last year for which regional distribution data is available, more funds were spent in the National Capital Region (25%) than elsewhere. Ontario had the second highest level of expenditures (22%), and Quebec the third (19%). Federal S&T expenditures tend to be as unevenly distributed regionally as the overall pattern of R&D expenditures. (See Section B-4.)

Over the 1981 to 1985 period, the proportion of funds spent in the National Capital Region decreased (from 32% to 25%), while in Quebec the proportion increased (from 13% to 19%). Expenditures remained constant in the other regions.

TABLE A-10
FEDERAL S&T EXPENDITURES BY REGION AS A PERCENTAGE OF TOTAL S&T (NSE)

Region	81/82	82/83	83/84	84/85	85/86
	(percentage)				
Yukon and N.W.T.	0.1	0.1	0.1	0.1	0.8
British Columbia	8.1	9.2	9.2	8.7	9.5
Alberta	6.3	5.0	5.1	5.6	5.7
Saskatchewan	2.5	2.5	2.7	2.6	2.8
Manitoba	5.8	5.8	6.0	5.9	4.7
Ontario (excludes NCR)	22.9	22.2	21.5	21.7	22.3
National Capital Region	31.5	31.2	29.7	28.8	25.1
Quebec (excludes NCR)	13.4	14.1	14.7	16.6	18.6
Atlantic Provinces	9.4	9.9	11.9	10.0	10.5
Canada	100.0	100.0	100.0	100.0	100.0

Source: Statistics Canada Data Bank.

As a result of their dominance in extramural S&T, Ontario and Quebec were the only two regions in which half or less of federal expenditures were for intramural performers. The NCR, P.E.I., Manitoba and Nova Scotia, on the other hand, were very dependent on federal intramural activities and received more than three-quarters of federal expenditures from these sources. The university program is also an important source of federal extramural funds and provided more than a quarter of the share in British Columbia, Ontario and Alberta.

TABLE A-11
FEDERAL S&T EXPENDITURES BY REGION, 1985/86

	Total Expenditures	Expenditures per Capita	Extramural Expenditures	Extramural Per Capita	SSC S&T Contracts
	(millions of dollars)	(dollars)	(millions of dollars)	(dollars)	(millions of dollars)
Nfld	66	114	14	24	6
P.E.I.	11	86	4	32	1
N.S.	158	180	37	42	11
N.B.	80	111	37	51	4
Que.	569	86	290	44	24
Ont.	684	75	320	35	105
NCR	1,199	n.a.*	98	n.a.	n.a.
Man.	144	135	33	31	6
Sask.	83	82	31	30	11
Alta.	171	73	61	26	18
B.C.	283	98	126	44	39
Yukon & N.W.T.	23	310	0	0	1
Total	3,473		1,051		226

* Not calculated; if expenditures are assigned to Quebec and Ontario, their per capita expenditure rise to $113 and $187 respectively.

Source: MOSST analysis.

TABLE A-12
FEDERAL S&T EXPENDITURES BY REGION AND BY PERFORMER, 1985/86

		Extramural			
	Federal Government	Canadian Industry	Canadian Universities	Other Canadian Performers	Total
	(millions of dollars)				
Yukon and N.W.T.	23	--	--	--	23
B.C.	150	42	84	9	285
Alta.	106	18	43	4	171
Sask.	49	9	18	7	83
Man.	106	10	23	5	144
Ont. (ex. NCR)	326	125	207	26	684
NRC	1,085	78	22	14	1,199
Que. (ex. NCR)	251	163	138	17	569
N.B.	40	25	7	8	80
N.S.	118	16	21	3	158
P.E.I.	7	3	1	--	119
Nfld.	50	4	9	3	66
Canada	2,311	493	573	96	3,473

Source: Statistics Canada, Science Statistics, Vol. 11, No. 7.

TABLE A-13
PERSONNEL ENGAGED IN SCIENTIFIC ACTIVITIES,
BY REGION AND BY SELECTED DEPARTMENTS, 1985/86

Region	AGR	AECL	EMR	ENV	F&O	NRC	STC	Other	Total
	(person-years)								
Yukon & N.W.T.	--	--	5	115	--	--	--	27	147
B.C.	425	--	74	361	558	93	64	168	1,743
Alta.	607	--	212	446	--	2	56	193	1,516
Sask.	400	--	7	192	--	115	--	10	724
Man.	361	922	3	287	146	9	57	17	1,802
Ont. (ex. NCR)	745	1,640	31	1,314	204	39	119	570	4,662
NCR	519	--	2,305	161	324	2,811	3,948	7,146*	18,214
Que. (ex. NCR)	487	--	1	590	172	182	80	841	2,353
N.B.	294	--	2	115	2,096	3	--	13	633
N.S.	159	--	142	238	836	86	56	226	1,743
P.E.I.	113	--	--	14	--	1	--	7	135
Nfld.	102	--	1	83	260	59	31	19	555
Canada	5,212	2,562	2,783	3,916	2,706	3,400	4,411	9,236	34,227

* includes 1,446 person-years for National Health and Welfare, 549 person-years for the National Library of Canada and 1,043 person-years for National Museums of Canada.

Source: Statistics Canada.

9. Industrial R&D and Tax Incentives

In addition to direct intramural and extramural investments in R&D, the federal government grants tax incentives to assist the industrial sector to undertake R&D. Tax incentives are often viewed as the preferred means of industrial support, rather than grants, because they are viewed as less interventionist and involve lower administrative costs. In Canada, there are two forms of tax incentives: the write-off of R&D expenditures as operating costs and the refundable R&D tax credit.

(a) Write-off of R&D Expenditures

The Income Tax Act allows corporations who spend money on R&D to treat such expenditures, whether they are operating or capital, as current costs of doing business, and thus to exclude them entirely from taxable income. Such a procedure is sometimes called "the 100% write-off". For companies paying corporate income tax of approximately 50%, this means that the federal government is providing 50 cents of every R&D dollar spent. This tax credit can be deferred for up to seven years.

Tax credits (whether for R&D, or other items) are only useful to those corporations which have taxable income. (The greatest value of these tax credits is claimed by the larger, and generally foreign-controlled, corporations.) Thus, the use of this tax incentive, like the "100% write-off" incentive, may not be representative of firms doing R&D and in particular is not representative of the smaller and newer firms, since they have little or no taxable income.

(b) The Refundable R&D Tax Credit

A firm with no taxable income or a firm that chooses to defer the R&D tax credit can claim a tax refund of 35 cents for every dollar spent on R&D. This refund, which is paid regardless of whether the company paid taxes in the year in question, is intended primarily to support small businesses, particularly those starting up, by giving them an immediate cash reimbursement. There are, in addition, regional incentives and an upper income limit defining "small business."

The Scientific Research Tax Credit

The Scientific Research Tax Credit (SRTC) scheme was first introduced in a paper "R&D Tax Policies" in April 1983 and the enabling legislation was tabled in October 1983. This program was established to allow companies that had no taxable income, and hence could not qualify for R&D investment tax credits, to sell their tax credits to investors who, in return for investing in the company, could benefit from the otherwise unusable tax write-offs. In the approximately twelve months in which the program operated, some $7.0 billion in R&D expenditures were designated for the SRTC (according to Revenue Canada).

Given that the level of self-funded industrial R&D in 1984 was approximately $2.2 billion, this designation of $7.0 billion in R&D expenditures represented a major increase in R&D funding, which probably could not be supported by the R&D performers. Recent figures issued by Revenue Canada indicated that of the original $7.0 billion designated, at least $1.8 billion will not be spent on R&D, resulting in tax revenue losses of some $900 million. It is also thought, that as 1984 and 1985 corporate returns are processed and audited that this tax revenue loss will rise still further. At the same time, there is no evidence, based on preliminary GERD figures, that the SRTC generated any large increase in R&D expenditures during the period.

B. THE NATIONAL R&D ENVIRONMENT

Preceding sections of this paper have focussed on the S&T and R&D expenditures of the federal government. These expenditures must also be viewed in the context of the national levels of R&D spending. As stated before, the federal government is the largest single funder and performer of R&D in Canada, so that its expenditure decisions act as signals to the R&D community as a whole. It is not possible to demonstrate that federal R&D expenditures lead national R&D expenditures, in that large percentage increases in federal spending in one year are not followed by increases in national spending. However, the fact that the federal government funds about 12% of all industrial R&D (see Table B-3), provides it with a policy tool to increase industrial R&D performance at the margin.

1. Gross Expenditure on R&D

The Gross Expenditure on R&D (GERD) is a measure of the level of the national effort on R&D. Statistics Canada collects statistics on R&D expenditures by all performers: governments, industries, universities and non-profit institutions. Table B-1 shows the GERD from 1979 to 1987.

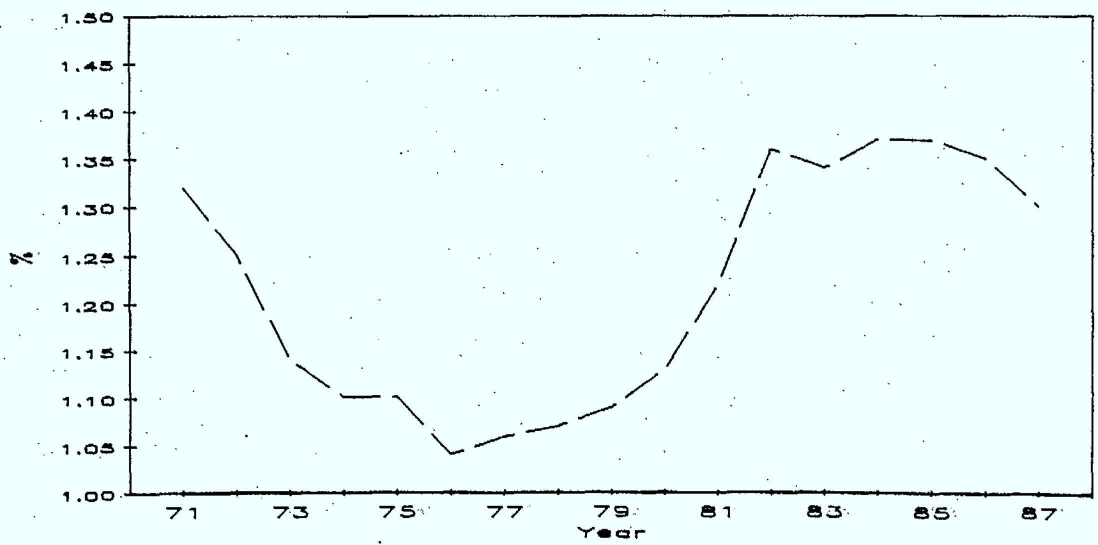
TABLE B-1
NATIONAL GERD

	1979	1980	1981	1982	1983	1984	1985	1986	1987
Actual $ M	2,995	3,494	4,334	5,090	5,416	6,091	6,530	6,801	7,072
Deflated (1981 $ M)	3,670	3,869	4,334	4,674	4,738	5,144	5,335	5,406	5,407
% Real Growth	6.0	5.4	12.0	7.8	1.4	8.6	3.7	1.3	0.0
GERD/GDP (%)	1.08	1.13	1.22	1.36	1.34	1.37	1.37	1.35	1.30e

(e) estimated.
Sources: Statistics Canada, Science Statistics, Vol. 11, no. 6.
Bank of Canada Monthly Report.

In order to remove the effects of inflation and to take into account the effects of real growth in the economy, the GERD/GDP is often used. Figure B-1 shows that in Canada the GERD/GDP has varied widely over the past sixteen years from a low of 1.04% in 1976 to a high of 1.37% in 1984 and 1985. It is interesting to note that the anomalous peak in 1982 is more likely due to a less-than-average growth in GDP than a faster-than-average growth in GERD.

FIGURE B-1
GROSS EXPENDITURES ON R&D AS PERCENT OF GDP



Source: Statistics Canada, Science Statistics, Vol. 11, No. 1.

The ratio of Gross Expenditure on R&D (GERD) to the Gross Domestic Product (GDP) is the most commonly used basis for international comparison of relative technological capacity. While not an entirely reliable gauge, it is one of the most readily available standard international indicators. However, in reality, a comparison of technological competence should not be based solely on GERD/GDP but should be done in conjunction with other factors and indicators such as the absolute size of the economy, degree of foreign ownership, etc. Furthermore, it is the trend in the ratio that is more meaningful and important.

2. Funders and Performers

The relative shares of funders and performers among the federal, industrial, university and provincial sectors of the national R&D effort are not the same. The federal and provincial governments fund more R&D than they perform, while the reverse is true for industry and universities.

Over the past decade, industry has steadily increased its share both as a funder and as a performer. Since 1979, industry has been both the largest funder and performer. In 1984, the top 25 firms that performed R&D spent $1.47 billion on sales of $68.7 billion. They represented 52% of all industrial R&D expenditures. The federal government's shares both as a funder and a performer have remained roughly constant since 1979.

Although provincial and university funding shares have dropped over the past seven years, these changes have not affected the relative positions of the federal government and industry as funders, because both the provinces and the universities are relatively small funders.

Table B-2 below shows the relative percentages of the national GERD in the NSE and SSH both by funder and performer.

TABLE B-2
GROSS EXPENDITURE ON R&D BY FUNDER AND PERFORMER BY PERCENTAGE (NSE+SSH)

Year	Federal Government	Provincial Government	Business	University	Other
Funder Shares, % of GERD					
1981	34	7	42	11	6
1983	37	7	39	10	7
1985	35	7	42	9	7
1987	34	7	43	10	7
Performer Shares, % of GERD					
1981	21	3	49	25	2
1983	23	3	48	25	1
1985	21	3	51	23	2
1987	20	2	51	25	2

Source: Statistics Canada, Science Statistics, Vol. 11, No. 1, 1987.

Table B-3 is the matrix of funders and performers for the year 1987; it demonstrates that there are substantial shifts of funds from the two levels of government to industry and universities. Indeed, on a percentage basis, the provincial governments transfer a much higher percentage of their R&D funding to extramural performers than does the federal government.

TABLE B-3
TOTAL EXPENDITURES ON R&D (NSE AND SSH), 1987

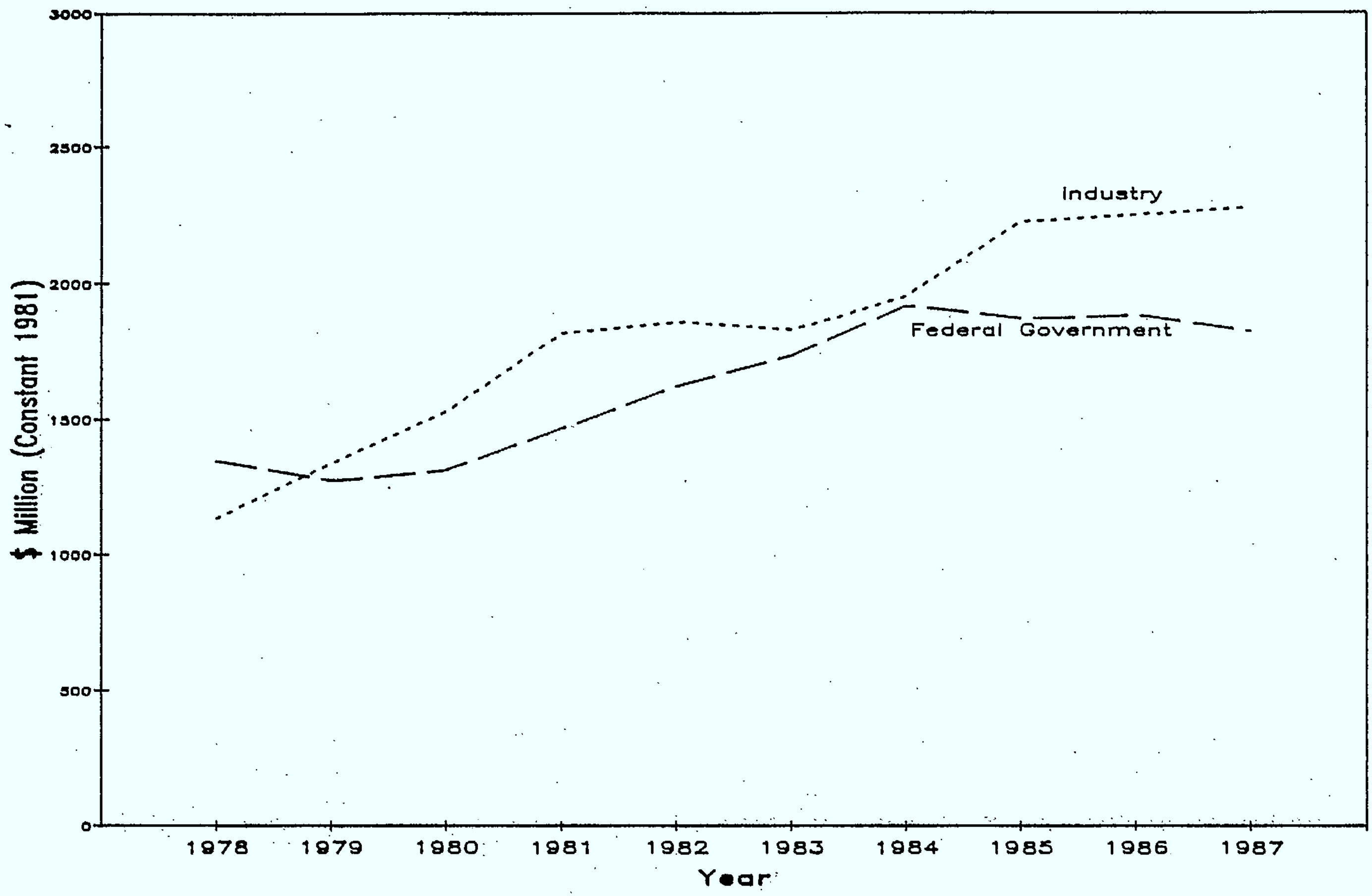
FUNDER	PERFORMER FED	PROV	PRO	BE	UNIV	PNP	TOTAL	
	(millions of dollars)							
FED	1,380	--	10	375	592	28	2,385	(34%)
PROV	--	138	44	57	205	25	469	(7%)
PRO	--	--	6	--	--	--	6	--
BE	--	--	16	2,888	70	6	2,980	(42%)
UNIV	--	--	--	--	680	--	680	(10%)
PNP	--	--	--	--	186	38	224	(3%)
FOREIGN	--	--	2	316	10	--	328	(5%)
TOTAL	1,380 (20%)	138 (2%)	78 (1%)	3,636 (51%)	1,743 (25%)	97 (1%)	7,072	

PRO = Provincial Research Organization
BE = Business Enterprise
PNP = Private Non-Profit Organization
Source: Statistics Canada, Science, Technology and Capital Stock Division.

The amount of real funding of R&D by the federal government and by industry is illustrated in Figure B-2. These two sectors account for approximately 75% of the total GERD. As can be seen, these monies have remained essentially constant or declined over the past three years. Table B-4 compares growth in GDP to the growth in R&D funding by the federal government and by industry.

Federal funding of industrial R&D is relatively small. R&D expenditures for which industry gets tax relief are included in the figures which show the industrially-funded component of the industrial R&D effort. In general, industry has increased its funding at a higher rate than the government has increased its support for industrial R&D.

FIGURE B-2
TOTAL R&D EXPENDITURES BY CANADIAN INDUSTRY AND FEDERAL GOVERNMENT



Source: Statistics Canada and MOSST estimates.

TABLE B-4
YEAR-OVER-YEAR CHANGE IN FEDERAL FUNDING AND INDUSTRIAL FUNDING OF INDUSTRIAL R&D

	Federal Funding		Industrial Funding		GDP	
	M $1981	Percent Year-over-year change	M $1981	Percent Year-over-year change	B $1981	Percent Year-over-year change
1979	132	- 2.2	1,297	18.2	338	3.7
1980	132	0.0	1,482	14.3	343	1.5
1981	190	43.9	1,774	19.7	356	3.8
1982	244	28.4	1,820	2.6	344	- 3.4
1983	245	0.4	1,790	- 1.6	354	2.9
1984	278	13.5	1,902	6.3	374	5.6
1985	297	6.8	2,157	13.4	389	4.0
1986	289	- 2.7	2,184	1.3	401	3.1
1987	287	- 0.7	2,208	1.1	417	4.0

Source: Statistics Canada, Science, Technology and Capital Stock Division. MOSST Estimates.

3. Industrial R&D in Canada

R&D spending in Canada, as elsewhere, is concentrated in a few industries. These R&D-intensive industries depend on innovation to maintain their competitiveness and market share. Resource-based industries, whose products compete mainly on price and availability, perform relatively little R&D, as shown in Table B-5.

TABLE B-5
CURRENT R&D EXPENDITURES AND SALES BY INDUSTRY, 1985

Industries	R&D	Sales by R&D Performers	R&D/Sales
	(millions of dollars)	(billions of dollars)	(percentage)
MINING AND OIL WELLS			
Mining	48	5.3	0.8
Crude petroleum and natural gas	51	7.1	0.7
TOTAL MINING AND OIL WELLS	99	12.4	0.8
MANUFACTURING			
Food, beverages and tobacco	69	18.4	0.4
Rubber and plastic products	15	2.2	0.8
Textiles	13	1.1	1.2
Wood	18	0.1	1.4
Pulp and paper	63	12.8	0.3
Primary metals (ferrous)	23	6.9	0.3
Primary metals (non-ferrous)	89	6.8	1.3
Metal fabricating	23	2.1	1.0
Machinery	53	2.5	2.0
Aircraft and parts	312	2.0	15.8
Other transportation equipment	82	29.5	0.3
Telecommunication equipment	504	3.5	14.3
Electronic parts and components	63	0.7	8.3
Other electronic equipment	153	1.1	14.3
Business machines	157	5.3	3.0
Other electrical products	66	4.3	1.6
Non-metallic mineral products	14	2.7	0.5
Refined petroleum and coal products	136	30.4	0.4
Drugs and medicines	62	1.5	3.9
Other chemical products	148	11.5	1.2
Scientific and professional equipment	33	1.2	2.8
Other manufacturing industries	18	1.1	1.5
TOTAL MANUFACTURING	2,114	147.9	1.4
SERVICES			
Transportation and other utilities	109	24.3	0.4
Electrical power	143	13.5	1.1
Computer services	94	1.1	8.5
Engineering and scientific services	178	1.0	17.6
Other non-manufacturing industries	64	5.7	1.1
TOTAL SERVICES	588	45.5	1.2
TOTAL ALL INDUSTRIES	2,802	205.8	1.3

Source: Statistics Canada, Industrial Research and Development Statistics, 1985, Catalogue No. 88-202.

Foreign-controlled companies perform less R&D in Canada than Canadian-controlled ones as a percentage of sales as shown in Table B-6. R&D is a staff function that is usually allocated to corporate headquarters. Since multi-national corporations can transfer technology much more easily than products, they tend to distribute their technologies to their branch plants, often free-of-charge, where the technologies are then applied to the manufacturing process.

TABLE B-6
R&D AS A PERCENT OF SALES BY INDUSTRY AND COUNTRY OF CONTROL, 1985

Industry	Canadian	Foreign	Total
	(percentage of sales)		
Mining and oil wells	0.94	0.56	0.77
Chemical-based	0.54	0.75	0.67
Wood-based	0.36	0.28	0.35
Metals	0.85	0.72	0.83
Machinery & transport equipment	5.23	0.80	1.30
Electrical & electronic products	14.22	3.25	6.08
Other manfuacturing	0.95	0.66	0.81
Services	1.34	0.68	1.25
Total	1.59	1.04	1.32

Source: Statistics Canada, Science, Technology and Capital Stock Division.

4. Highly Qualified Personnel

Expenditures are, of course, not the only measure of activity. The workforce required to maintain this level of effort is significant. Training and maintaining this workforce is a major concern of both federal and provincial governments.

TABLE B-7
1971/1981 CENSUS
EXPERIENCED LABOUR FORCE 15 YEARS AND OVER BY HIGHEST DEGREE OBTAINED

Occupation	Total All Education 1971	Total All Education 1981	Master's & Doctorate Degrees 1971	Master's & Doctorate Degrees 1981	Percent of Total 1971	Percent of Total 1981
	(thousands)				(percentage)	
Managers & Admin. & Related Occs.	372.2	814.0	23.5	53.3	6.3	6.5
Physical Sciences	34.3	40.5	5.3	6.9	15.3	17.1
Life Sciences	19.1	28.3	3.1	5.2	16.4	18.2
Architects & Engineers	154.5	266.4	7.9	20.7	5.1	7.8
Mathematics & Systems Analysts	26.2	67.7	2.0	5.2	7.7	7.7
Soc. Sci, Soc. Work, Law & Religion	102.6	220.9	16.6	35.7	16.2	16.1
University Teachers	23.5	33.6	19.6	27.6	83.7	82.1
Other Teaching Occupations	325.8	455.6	20.6	43.4	6.3	9.5
Medicine & Health**	326.6	519.2	50.0	64.9	12.3	12.5
All Other Occupations	7,428.5	9,820.8	22.3	40.4	0.3	0.4
All Occupations	8,813.3	12,267.1	161.0	303.4	1.8	2.5

** Includes first professional degrees (M.D.s, D.D.S.s, D.V.M.s, etc.) with masters's and doctorates.

Source: Statistics Canada, 1971/1981 Census (Special Run).

Table B-7 indicates a substantial growth in the numbers of higher-degree holders in all professional occupations between 1971 and 1981, but only a slight change in the proportion of HQP in each occupation. However, cumulatively, the proportion of HQP in all occupations increased from 1.8% to 2.5% during the same time period.

5. Regional Expenditures on R&D

The level of effort on R&D is usually measured as the ratio of Gross Expenditures on R&D (GERD) divided by the Gross Domestic Product (GDP) of the economic unit involved, in this case the province.

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

Although Ontario has 36% of the nation's population and 39% of the GDP, it has 52% of the total GERD as shown in Table B-8. Quebec, an industrialized province like Ontario, with 26% of the nation's population and 23% of its GDP, has 22% of its GERD.

Even greater disparities exist with the Atlantic and the Western provinces. Different levels and types of R&D are required for each region, to match the relative strengths of their industrial and resource sectors of the economy.

The GERD/GDP ratio (Table B-8 and Figure B-3 [page 23]) highlights the regional differences in the Atlantic region. Newfoundland and Nova Scotia are major recipients of federal R&D funds, so that they stand out against Prince Edward Island and New Brunswick which do not have major federal R&D institutions. Ontario and Quebec, the industrial centre of the nation, have a larger percentage of the nation's industrial R&D; Ontario has a much higher GERD/GDP than the national average.

TABLE B-8
TOTAL EXPENDITURES ON R&D, GDP AND POPULATION BY PROVINCE, 1985

Prov.	GERD (NSE + SSH)	GDP	Population	GERD(NSE+ SSH)/GDP	GDP/Population
	(millions of dollars)		(thousands)	(percentage)	(thousands of dollars per capita)
Nfld.	67	6,236	580	1.07	10.8
P.E.I.	9	1,317	127	0.68	10.4
N.S.	157	11,631	881	1.35	13.2
N.B.	89	8,823	720	1.01	12.3
Que.	1,444	108,625	6,600	1.33	16.5
Ont.	3,371	184,354	9,100	1.81	20.3
Man.	195	17,993	1,075	1.08	16.7
Sask.	152	17,297	1,020	0.88	17.0
Alta.	584	61,968	2,370	0.94	26.1
B.C.	450	54,103	2,995	0.83	18.1
Canada*	6,530	474,366	25,400	1.38	18.7

* including the Yukon and Northwest Territories.
Source: Statistics Canada, Estimates of Canadian Research and Development Expenditures by Region, 1979 to 1985.

Manitoba has a relatively high GERD, both from federal and industrial sources, compared to its GDP and therefore a relatively high GERD/GDP, compared to the neighbouring western provinces. Saskatchewan, Alberta and British Columbia have relatively high GDP per capita, as they are resource-exporting economies. In the case of Alberta, although the GERD is roughly proportional to the population, the GERD/GDP ratio is low, compared to the national average. Saskatchewan and B.C. have significantly lower than average GERD and consequently low GERD/GDP ratios.

The federal government and the business sector are the main funders of R&D in Canada. It is interesting to note the relatively small amounts of R&D funded and performed by provincial institutions. Table B-9 shows the regional distribution of R&D by major funder and performer. The industrial R&D effort is concentrated in Ontario and Quebec. This probably reflects differences in the type of industries in the two provinces as well as differences in overall industrial activity.

The federal government performed 24% of the total R&D in B.C. in 1985, 20% in Ontario and 15% in Quebec, compared to over 45% in Manitoba, Nova Scotia, P.E.I. and Newfoundland. Business enterprise performed about half of all R&D in the larger provinces; the levels were Ontario (58%), Quebec (55%), Alberta (43%) and B.C. (43%).

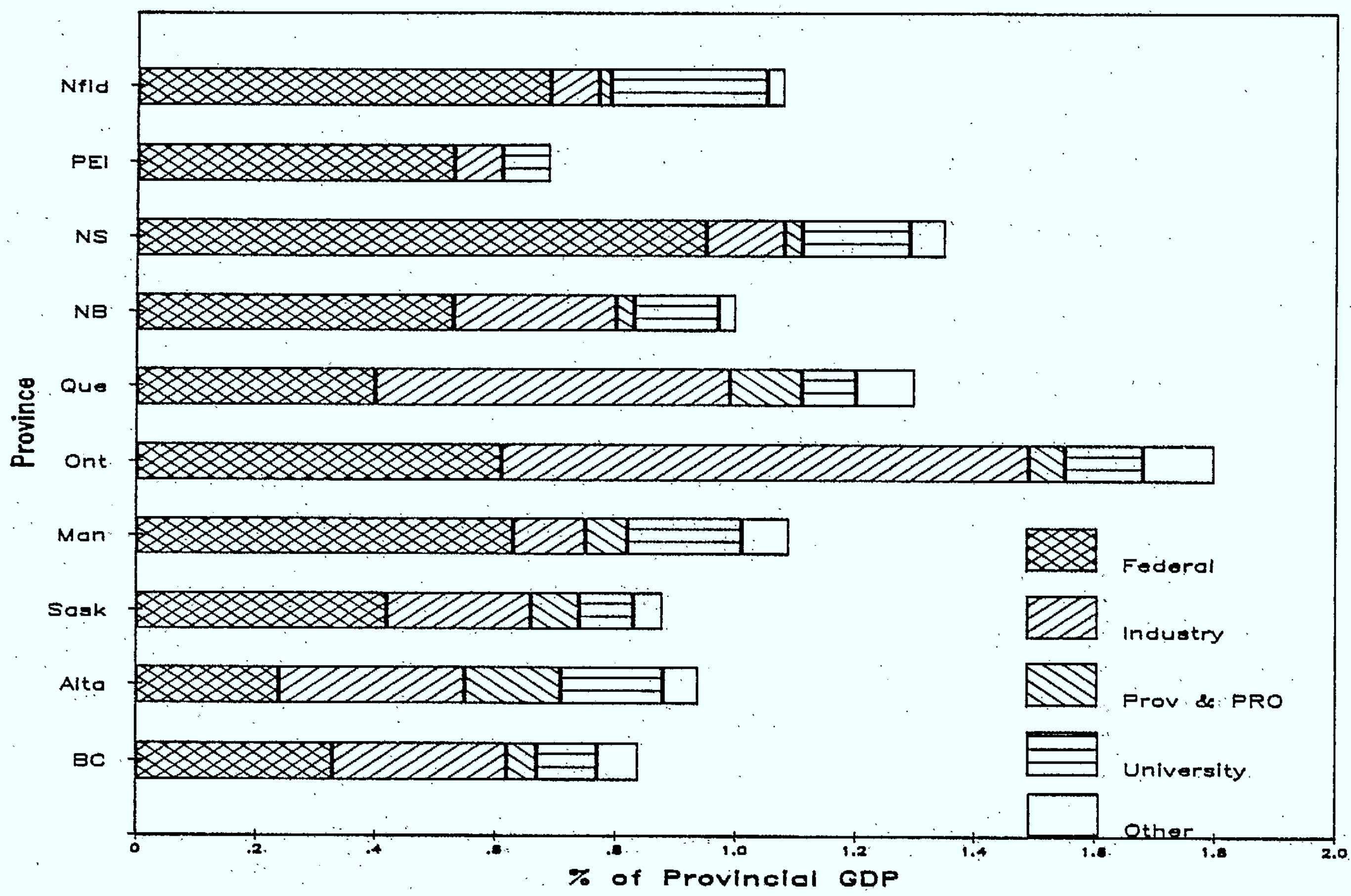
TABLE B-9
PROVINCIAL FUNDING AND PERFORMANCE OF R&D, 1985

Province & Region	Performer			Funder		
	Federal Govt.	Prov. Govt. & PRO*	Business Enterprise	Federal Govt.	Prov. Govt. & PRO*	Business Enterprise
	(millions of dollars)					
Nfld.	34	1	4	43	1	5
P.E.I.	7	--	1	7	--	1
N.S.	84	4	17	110	4	15
N.B.	32	4	28	47	3	24
Que.	212	60	793	433	159	646
Ont.	681	66	1,961	1,128	111	1,615
Man.	88	8	21	133	12	21
Sask.	45	8	50	73	13	42
Alta.	79	46	252	150	101	191
B.C.	109	15	195	180	27	155
Canada**	1,375	212	3,330	2,289	431	2,721

* PRO = Provincial Research Organizations
** includes the Yukon and the Northwest Territories.
Source: Statistics Canada, Estimates of Canadian Research and Development Expenditures by Region, 1979 to 1985.

The federal government is the major funder of R&D in the Maritimes, Manitoba, Saskatchewan and British Columbia. In spite of the concentration of research facilities in the National Capital Region, the federal government is not the largest funder in Ontario or Quebec. Indeed, in Quebec the federal presence is relatively low, resulting in a much higher percentage of R&D being funded by industry.

FIGURE B-3
FUNDING OF R&D (NSE+SSH) BY PROVINCE
AS A PERCENTAGE OF PROVINCIAL GDP, 1985



Source: Statistics Canada, Estimates of Canadian Research and Development Expenditures by Region, 1979 to 1985.

C. CANADIAN SCIENCE AND TECHNOLOGY: INTERNATIONAL COMPARISONS

The purpose of this section is to provide a comparison of Canada's performance in science and technology with that of other major industrialized nations. The indicators used for this comparison include: R&D expenditures, research scientists and engineers, trade in high-technology products, publications and patents. The last two are indicators of the "output" of the S&T production system and, as such, complement the information provided by the"impact" indicator (trade in technologically-intensive products) and the "input" of expenditures and HQP. These indicators are, however, all partial measures. Also, while each of these indicators has inherent weaknesses, as a group they provide a fair assessment of Canada's competence in S&T relative to that of its major international competitors.

1. R&D Expenditures

Canada ranks eleventh of the twenty-four nations in the OECD in terms of GERD/GDP and its ratio is considerably lower than that of most G-7 countries (Table C-1 and Figure C-1). Even when the defence-related R&D expenditures are subtracted, Canada's relative position does not change.

TABLE C-1
SELECTED INTERNATIONAL COMPARISONS OF GERD, 1984,
IN ORDER OF DESCENDING GERD/GDP

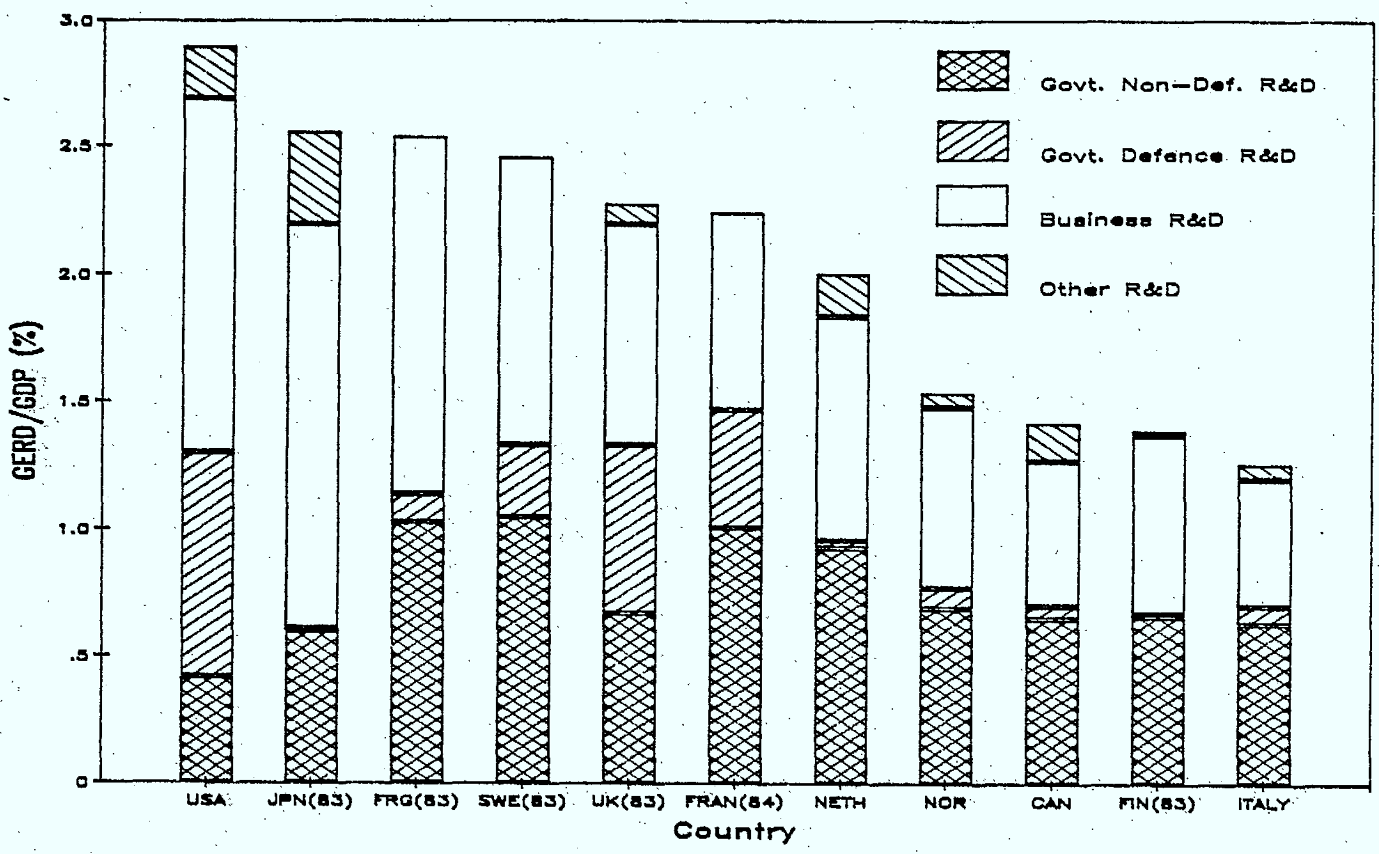
Country	GDP	GERD	GERD/GDP	GERD (Excl. Def.)/GDP	Population	GERD/ Capita
	(billions of US dollars)		(percentage)		(millions)	(US dollars)
U.S.	3,635	99.5	2.74	1.93	236.7	420
Japan*	1,469	38.9	2.65	2.55	120.0	324
FRG*	767	19.5	2.54	2.44	61.4	318
Sweden*	129	3.0	2.46	2.18	8.3	361
Switzerland*	99	2.1	2.28	n.a.	6.5	323
U.K.*	587	13.5	2.28	1.68	56.4	239
France	694	15.6	2.24	1.75	54.9	284
Netherlands	169	3.4	1.99	1.96	14.4	236
Norway	64	1.0	1.53	1.45	4.1	244
Finland	60	0.8	1.42	1.41	4.9	163
Canada	383	5.4	1.40	1.35	25.2	214
Austria	86	1.1	1.27	1.27	7.6	145
Italy	575	7.1	1.24	1.18	57.0	125

* 1983 data.

Note: OECD data for Canada may differ from that of Statistics Canada due to differences in definition of GDP and the use of earlier GERD figures.

Source: OECD, Recent Results, 1979-1986.
OECD, Main Economic Indicators, March 1986.

FIGURE C-1
GERD/GDP, 1985



Source: OECD, Recent Results, 1979-1986.

Table C-2 gives the percentage of GERD financed by industry. Over the 1974/84 period, the GERD funded by industry in Canada increased by 30%, substantially exceeding the growth in the proportion of industry-funded R&D in other G-7 nations. Canadian industry funds less R&D than its counterparts in the other nations shown. However, over the last few years, industry's contribution, in percentage terms, has remained essentially constant.

TABLE C-2
PERCENTAGE OF GERD FINANCED BY INDUSTRY

Year	U.S.	Japan	FRG	U.K.	France	Canada	Italy
	(percentage)						
1974	44	60	48		38	29	52
1975	43	58	50	41	39	30	51
1976	44	58	51		42	29	50
1977	44	59	53		41	30	47
1978	45	58	52	44		31	50
1979	46	59	55		43	37	55
1980	49	61			44	40	52
1981	49	62	58	41	41	42	50
1982	50	64	57		42	40	49
1983	49	65	59	42	42	39	45
1984	49	67			41	40	41
1985	49					42	41
1986	49					42e	

e estimate.

Source: OECD, Recent Results, 1979-1986.
OECD, S&T Statistical Indicators, GERD, 1969-1982.

As can be seen from Table C-3, the industrial sector in Canada also performs a smaller proportion of GERD relative to other G-7 nations. As was the case with industrial funding of R&D, industry-performed R&D in Canada has increased significantly since 1974, but has remained essentially constant since 1981.

TABLE C-3
INDUSTRY-PERFORMED R&D AS A PERCENTAGE OF GERD

Year	Canada	U.S.	Japan	France	FRG	Italy	U.K.
	(percentage)						
1974	36	67	59	59	61	55	
1975	37	66	57	60	63	56	62
1976	36	67	57	60	63	55	
1977	37	67	58	60	65	54	
1978	38	67	57	60	65	55	66
1979	42	68	58	60	69	58	
1980	45	69	60	60		59	
1981	49	70	61	59	70	56	62
1982	49	72	62	58	71	57	
1983	48	71	64	57	71	57	61
1984	49	72	65	57		54	
1985	51	72				53	
1986	51e	72					

e estimate.
Sources: OECD, Recent Results, 1979-1986.
OECD, S&T Statistical Indicators, GERD, 1969-1982.

In proportionate terms, governments in Canada account for more of the national R&D performance effort than they do in other major industrialized nations. As a funder, the governments in Canada are near the top (Tables C-4 and C-5).

TABLE C-4
GOVERNMENT-PERFORMED R&D AS A PERCENTAGE OF GERD*

Year	Canada	U.S.	Japan	France	FRG	Italy	U.K.
	(percentage)						
1974	33	15	12	24	18	21	
1975	31	16	12	23	17	22	26
1976	31	15	12	22	17	23	
1977	30	15	12	23	16	25	
1978	30	15	12	23	17	24	22
1979	27	14	12	24	15	24	
1980	26	13	12	23		25	
1981	25	12	11	24	14	26	22
1982	25	12	10	25	13	25	
1983	27	12	10	26	13	24	22
1984	28	12	9	27		29	
1985	26	13					
1986	25e	12					

e estimate.
* For statistical reasons, the government sector includes private non-profit institutions. These represent only a small percentage of the sectoral expenditures.
Sources: OECD, Recent Results, 1979-1986.
OECD, S&T Statistical Indicators, GERD, 1969-1982.

TABLE C-5
GOVERNMENT-FUNDED R&D AS A PERCENTAGE OF GERD

Year	Canada	U.S.	Japan	France	FRG	Italy	U.K.
	(percentage)						
1974	63	54	29	56	50	42	
1975	62	55	30	54	47	43	52
1976	63	54	29	52	47	46	
1977	62	54	30	52	44	48	
1978	60	53	30		45	48	47
1979	56	52	29	50	43	44	
1980	54	50	28	51		45	
1981	49	49	27	53	41	47	49
1982	51	49	26	54	42	49	
1983	52	49	24	54	39	52	50
1984	53	49	23	54		56	
1985	51	49				56	
1986		49					

Sources: OECD, Recent Results, 1979-1986.
OECD, S&T Statistical Indicators, GERD, 1969-1982.

2. Research Scientists and Engineers (Highly Qualified Personnel)

Canada ranks below the median of OECD countries in both total R&D personnel and numbers of research scientists and engineers (RSE) per thousand persons of the labour force (Table C-6). The U.S. and Japan are substantially ahead of the other nations in the number of RSE.

TABLE C-6
TOTAL R&D PERSONNEL AND RESEARCH SCIENTISTS AND ENGINEERS (RSE)
PER THOUSAND LABOUR FORCE, 1983

Country	R&D Personnel	RSE	Change in RSE from 1979
	(per thousand)		(percentage)
FRG	13.5	4.8	7
Japan	12.1	7.4	14
Switzerland ('79)	11.8	3.4	--
France	11.0	3.9	26
Sweden	10.5	3.9	39
Netherlands	9.9	3.7	6
Norway	7.9	4.1	11
Finland	7.9	3.7	23
Canada	5.9	2.7	17
Austria ('81)	5.6	2.0	--
Italy	4.9	2.7	29
United States	--	6.4	21

Note: RSE in some countries consists of all university graduates in science and engineering.
Source: OECD, Recent Results, 1979-1986. The OECD notes that the Japanese data are likely over-estimated. No data are available for the U.K.

The growth in the number of research scientists and engineers in Canada from 1979 to 1983 was slightly higher than the median for other OECD countries.

3. Trade in High-technology Products

There is no standard definition of "high-technology" products. It is common practice among many countries to identify high-technology products based on the level of R&D expenditure associated with the product. In most such cases, the R&D expenditure is at least 4% of either the sales or value added.

A number of lists of products deemed to be "high-technology" have been developed by various countries and organizations. There are, however, certain core products which are common to all existing lists. The common products are aircraft, computers, electronic and telecommunications equipment and instruments, drugs and medicine. In addition to these, Statistics Canada includes scientific instruments, electrical and non-electrical machinery, and chemicals in the group of high-technology products.

Trade in high-technology products has been increasing over the last few years. In 1986, high-technology exports were 11% of total exports whereas high-technology imports were 18% of the total. Table C-7 shows the levels of imports and exports of high-technology trade from 1980 to 1986.

TABLE C-7
TRADE IN "HIGH-TECHNOLOGY" PRODUCTS, 1980-1986

Year	Imports	Exports	Deficit Current $	Deficit 1981 $
	(millions of dollars)			
1980	10,522	5,911	4,611	4,745
1981	12,888	7,441	5,447	5,447
1982	11,955	7,723	4,232	3,909
1983	13,512	8,415	5,097	4,654
1984	17,604	11,222	6,382	5,381
1985	18,427	12,059	6,368	4,960
1986	19,885	12,874	7,011	4,983

Source: Statistics Canada, International Trade in High-technology Products, July 1987.

Since 1980, in constant dollar terms, the high-technology trade deficit has varied by less than 10% around the average of $4.9 billion, except for 1982 at the height of the recession when business cut back on capital expenditures. The average compounded growth rate of the deficit since 1980 has been less than one percent compared to a real growth in the GDP of 2.6%. Table C-8 provides the deficit as a percentage of GDP for 1980-1986.

TABLE C-8
DEFICIT IN HIGH-TECHNOLOGY TRADE AS A PERCENTAGE OF GDP

	1980	1981	1982	1983	1984	1985	1986
	(percentage)						
Deficit/GDP	1.38	1.53	1.14	1.31	1.44	1.27	1.24

Sources: Statistics Canada, International Trade in High-technology Products, July 1987.
Bank of Canada.

About 75% of the trade in high-technology products in 1986, exports as well as imports, was with the U.S. Over the last five years, exports to the U.S. increased from 68% to 75% while imports declined from 83% to 76%. In 1986, the deficit with the U.S. was 78% of the total deficit. A third of the total deficit occurred in computers and related equipment alone, while 80% occurred in just three areas: computers, scientific instruments and non-electrical machinery.

Table C-9 provides a comparison between the total high-technology trade deficit and that with the U.S. by product group for 1986.

TABLE C-9
HIGH-TECHNOLOGY TRADE DEFICIT BY PRODUCT GROUP, 1986

Product Group	Total		With the U.S.	
	(millions of dollars)	(percent)	(millions of dollars)	(percent)
Aerospace	- 288*	- 3	241	4
Computers and related equipment	2,381	34	2,128	39
Electronic equipment	863	12	722	13
Telecommunications equipment	67	1	- 177*	- 3
Scientific instruments	1,410	20	842	15
Electrical machinery	629	9	429	8
Non-electrical machinery	1,803	26	1,131	21
Chemicals (including drugs)	87	1	136	2
Total	7,011	100	5,452	100

* positive trade balance
Note: Totals may not add due to rounding
Source: Statistics Canada, International Trade in High-technology Products, July 1987.

4. Scientific Literature (Bibliometrics)

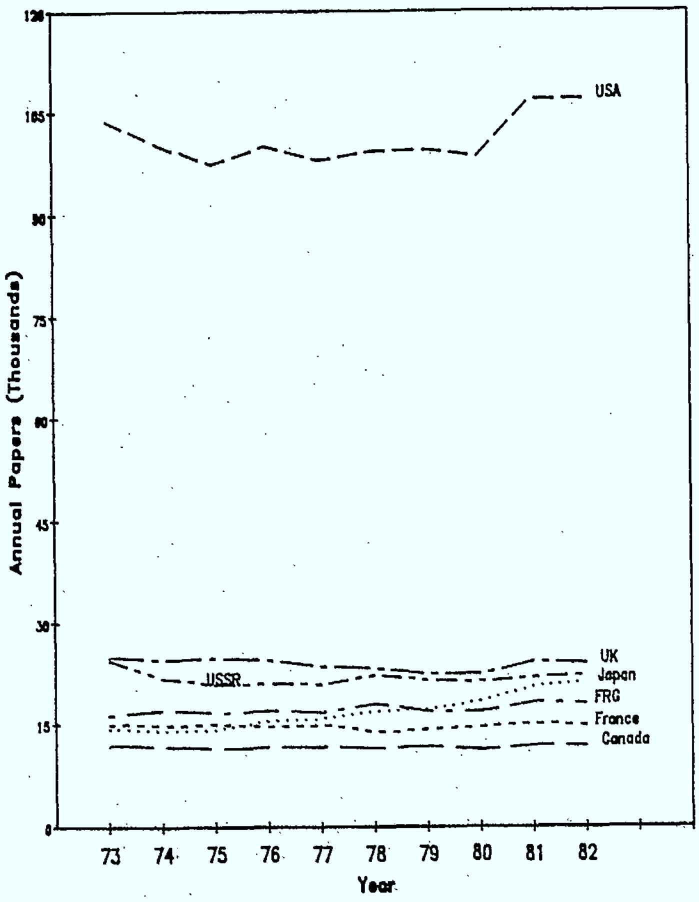
Scientific literature is one of the major direct outputs of research and can be considered as an intermediate as well as a final product of research. The indicators used in the following section are based on a set of over 2,100 highly cited and influential scientific and technical journals. Critical review prior to their publication in these influential journals helps to ensure a standard of quality and significance.

A recent study done by the Advisory Board for the Research Councils (ABRC) in Britain shows that Canada ranks well below the United States, but is more or less on par with Britain, Japan, the FRG and France, particularly if the relative populations are taken into account. These figures are national averages for outputs in basic science; they do not represent overall national outputs in R&D, nor are they indicative of outputs in any applied field of R&D. Publication counts are accepted as output indicators of the quantity of scientific activities, although these counts are not necessarily indicative of the quality of output.

The most accurate form of bibliometric indicators is the number of citations per paper published. This is the technique used by J. Irvine and B. Martin for the ABRC and which has been adopted by the Royal Society as its standard for measuring output in the basic sciences. This indicator is further modified by eliminating citations by the author (self-citations) and citations by other researchers at the same institute as the author of the original paper (co-worker citations).

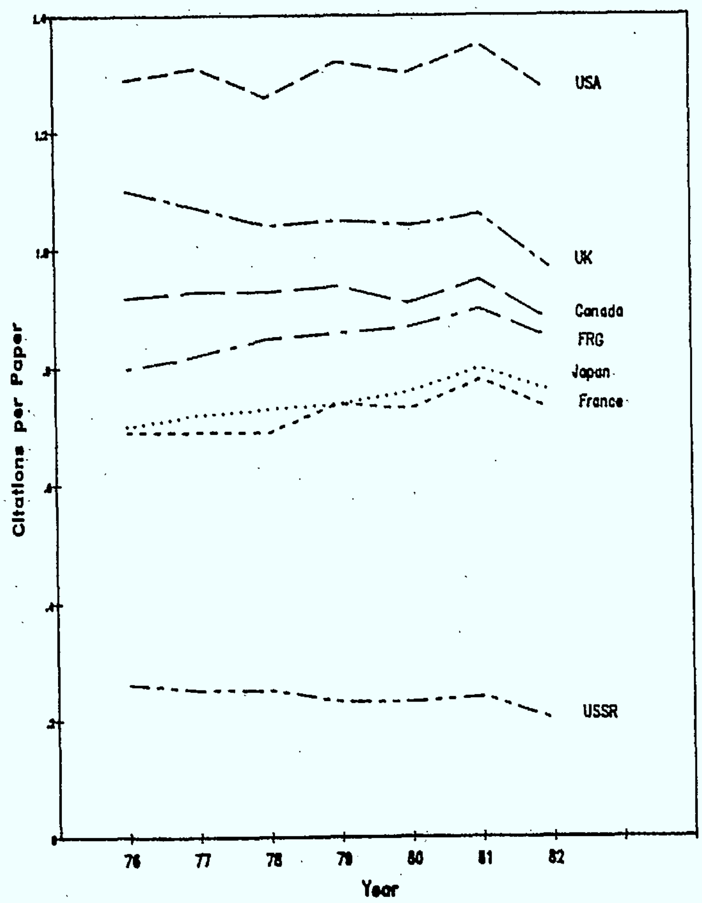
The results obtained by Martin and Irvine demonstrate that there are substantial differences in the quality of output amongst the major nations carrying out R&D. Figure C-3 shows the numbers of papers written by all researchers in the seven countries surveyed, for all fields of basic science. Figure C-4 shows the citations per paper.

FIGURE C-3
TOTAL ANNUAL PAPERS (ALL SCIENCES)



Source: ABRC Report, "Evaluation of national performance in basic research," 1986.

FIGURE C-4
CITATIONS PER PAPER PUBLISHED IN CURRENT YEAR OR PRECEDING THREE YEARS (ALL SCIENCES)



Source: ABRC Report, "Evaluation of national performance in basic research," 1986.

While the U.S. publishes many more papers, they are not of any noticeably greater quality in that they are not cited more often. On the other hand, Soviet papers may be cited less since most Soviet papers appear only in translated journals and the quality of the translations varies widely.

It should be noted that these techniques, while valid for basic R&D, should not be used for applied R&D. Engineering and applied science research frequently results in patents or in unpublished material rather than material published in the academic journals; thus, the numbers of papers published and cited in the scientific press do not represent a fair measure of the output of the individual or the institution.

5. Patents

Patent data can be used to gain some useful insights to the relative positions of the various countries as producers of technology. Moreover, patent statistics can give an indication of the contribution by a nation to the international dissemination of technology.

Table C-10 shows that, with the exception of the U.S., Canadian inventors do not actively protect their inventions overseas. There could be many reasons for this: the fact that many of the patents are secured by subsidiaries of U.S. multinationals, the cost of multiple filings, or a lack of technological competitiveness.

TABLE C-10
PATENT APPLICATIONS FILED BY CANADIANS
IN SELECTED OECD COUNTRIES, 1970-1984

Year	Canada	France	FRG	Japan	U.K.	U.S.	European patent[1]
	(units)						
1970	1,986	256	318	308	677	1,535	-
1971	1,970	228	274	277	525	2,025	-
1972	1,872	264	333	321	631	1,966	-
1973	1,906	310	392	359	648	2,095	-
1974	1,812	224	308	297	629	2,191	-
1975	1,853	250	322	301	629	2,126	-
1976	1,839	223	271	273	667	2,237	-
1977	1,832	198	260	259	695	2,192	-
1978	1,872	182	231	225	541	2,050	18
1979	1,602	164	203	238	397	2,061	73
1980	1,785	119	172	271	346	1,969	95
1981	1,951	102	119	270	291	2,202	167
1982	1,936	78	96	273	256	2,138	229
1983	2,017	73	97	323	272	1,995	308
1984	2,026	58	70	307	258	2,273	303

1 The "European" patent has affected the applications made in several countries which are signatories to the Munich Convention (EPC); by filing for this "European" patent, applicants need not file in countries such as France, the FRG and the U.K.

Source: Industrial Property Statistics, World Intellectual Property Organization, Geneva, various issues.

Canadian patenting activity is largely dominated by foreign nationals with American residents accounting for at least half of the patents filed in Canada, as shown is Table C-11. Canada's share increased from 6% to 8%, a proportion which is unusually small even for countries that are not industrially advanced. In Spain, for example, indigenous inventions account for about 16% of the total applications, in Denmark 19%, and in Belgium 24%.

TABLE G-11
PATENT APPLICATIONS FILED IN CANADA BY COUNTRY OF INVENTOR, 1975-1984

Year	Canada	France	FRG	Japan	U.K.	U.S.	Other	Total
	(units)							
1975	1,853	1,057	2,055	1,752	1,432	14,070	3,433	25,652
1976	1,839	1,108	1,949	1,832	1,438	14,696	3,301	26,163
1977	1,832	1,038	1,914	1,611	1,312	14,159	3,301	25,167
1978	1,872	1,142	1,814	1,601	1,315	13,597	3,340	24,681
1979	1,602	1,053	1,957	1,869	1,285	12,774	3,414	23,954
1980	1,785	1,203	2,148	2,018	1,194	13,125	3,501	24,974
1981	1,951	1,163	2,192	2,228	1,384	12,938	3,642	25,498
1982	1,936	1,332	2,209	2,446	1,375	12,427	3,568	25,293
1983	2,017	1,206	1,886	2,358	1,495	13,042	3,703	25,707
1984	2,026	1,379	2,208	2,655	1,524	13,028	3,915	26,735

Source: Industrial Property Statistics, World Intellectual Property Organization, Geneva, various issues.

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