SCIENCE AND TECHNOLOGY:

COMING OF AGE IN CANADA

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INTRODUCTION

This paper has been prepared at the request of Dr. A.E. Collin, Secretary and Chief Science Advisor, Ministry of State for Science and Technology. The purpose of the paper is to serve as a source document for information and ideas relevant to the preparation of speeches and other communications by the ministry.

The first two sections of this paper, The Current Perpsective and Looking Around Us, are statistical summaries with little analysis. Regular revision of this data by Statistics Canada makes it imperative that the Communications Branch work in close cooperation with departmental statisticians in order to maintain the best quality of statistical references.

The second and third sections, Looking Back and Looking Ahead, are more narrative presentations. Both Appendices A and B of this paper contain expansion and full referencing of the statistical highlights presented in the main body of text. They also contain additional information of value to MSST communications but which was not included in the main text for ease of presentation and reading. The reader is encouraged to familiarize her/himself with the entire paper.

The references made within this paper to other documents and publications will be of additional use to the Communications Branch of MSST.

It is important to note at the onset of this paper that the terms research and development, innovation, technological advancement and scientific advancement are not synonyms! These activities are synergistic yet independent.

Increasing the level of investment in research and development in Canada will not, on its own, provide an adequate solution to the international technological challenges facing us today. The impacts of capital and labour markets, regulatory policies, industrial standardization and the educational system on industrial innovation must also be addressed.

The author would like to thank those people within MSST who contributed to this paper; especially H. Whitehead, C. Barton, V. Kohse, P. Dufour and D. Low. The author relied heavily upon Statistics Canada publications and is grateful for the assistance of B. Plaus.

In evaluating some of the subjective statements made in this paper, knowledge of the author's background as a chemical engineer, her experience in the private sector (both with Syncrude Canada Ltd. and her own engineering consulting firm) and her limited exposure to the public sector may be relevant to some readers.

THE CURRENT PERSPECTIVE: SCIENCE AND TECHNOLOGY IN CANADA

The following statistical highlights reflect the current state of Canada's scientific and technological environment. An expansion of each of these points, and others on the topic, is presented in Appendix A of this paper. The corresponding appendix page number is given at the end of each of the following statistical highlights. The reader is encouraged to read the entire appendix.

1. The Canadian Gross Expenditure on Research and Development (GERD) for 1985 is estimated as $5.80 billion. Expressed as a percentage of GNP, the GERD was 1.30 in 1985. (A3)

2. Figure 1.

DISTRIBUTION OF THE 1985 GERD

(As estimated by Statistics Canada in Summer 1985)

FUNDING SECTOR	PERFORMING SECTOR					TOTAL
	Federal Govt.	Provincial Govts.	Business Enter.	Higher Educ.	Private Non-Profit	
	(millions of dollars)					
Federal Govt.	1,419	8	303	406	21	2,157
Provincial Govts.	--	163	39	119	15	337
Business Enter.	--	15	2,446	28	3	2,492
Higher Educ.	--	--	--	382	-	382
Private Non-Profit	--	--	--	127	32	159
Foreign	--	1	256	12	-	269
TOTAL	1,419	188	3,044	1,074	71	5,796
			(BERD)	(HERD)		

Source: Statistics Canada, (A4)
Note: Foregone Revenue not included.

THE CURRENT PERSPECTIVE (cont.)

For comparative purposes, the 1984 GERD distribution is also presented:

Figure 2.

DISTRIBUTION OF THE 1984 GERD

(As revised by Statistics Canada in Summer 1985)

FUNDING SECTOR	PERFORMING SECTOR					TOTAL
	Federal Govt.	Provincial Govts.	Business Enter.	Higher Educ.	Private Non-Profit	
			(millions of dollars)			
Federal Govt.	1,404	7	279	446	19	2,155
Provincial Govts.	--	157	36	113	14	319
Business Enter.	--	14	2,245	26	3	2,288
Higher Educ.	--	--	--	305	-	305
Private Non-Profit	--	--	--	121	29	150
Foreign	--	1	235	12	-	248
TOTAL	1,404	180	2,795	1,023	65	5,466
			(BERD)	(HERD)		

Source: Statistics Canada, (A5)
Note: Foregone Revenue not included.

3. Federal science and technology expenditures totalled $4.1 billion in 1984/85. (A9)

4. Recently signed Economic and Regional Development Agreements (ERDAs) between federal and provincial governments should increase this figure substantially in future years. (A9)

THE CURRENT PERSPECTIVE (cont.)

5. Figure 4. FEDERAL SCIENCE AND TECHNOLOGY EXPENDITURES
(1984/85)
(Treasury Board - millions of dollars)

Total S&T
$4,104

Foregone Revenue
(Finance Canada Estimate)
$875+

NSE S&T 3,363	SSH S&T 741	R&D and RSA
2,034	577	Intramural
1,329	164	Extramural (Total)
629	18	Industry
495	80	University
38	19	Private Non-Profit
38	9	Provinces, Municipalities, and PROs
97	23	Foreign
32	15	Other

Source: Statistics Canada, (A10)

Note that the $ 875+ million foregone revenue figure is an estimate obtained from P. Dick, Corporate Tax, Finance Canada. The estimate may be broken down as follows:

Regular R&D related incentives as of 1983 = $ 225 million
Scientific Research Tax Credit annual estimate for 1983, 1984 and 1985 = $ 650 million
New refunds for Small Business introduced in 1984/85 budget = represented as + in above figure.

More information regarding Finance Canada foregone revenue estimates for S&T-related incentives may be found in the Public Accounts Committee Records, Testimony by the DM of Finance Canada, May 31, 1985.

THE CURRENT PERSPECTIVE (cont.)

6. Canadian defence research and development expenditures accounted for about 5.7% of total government research and development funding in 1983. In 1984, the Department of National Defence experienced a 30% increase in its S&T budget, of which 98% is devoted to NSE R&D. The 1983/84, 1984/85 and 1985/86 defence S&T expenditures were $ 162, 209, and 234 (estimate) million, respectively. (A6)

   Note: Refer to items 10 and 11 on page 13 of this paper for international comparisons of defence R&D expenditures.

7. The proposed $500,000 capital gains exemption, about to be passed by Parliament, may actually deter private investors from higher risk research and development ventures.(A21)

8. The same piece of draft tax legislation contains urgently needed provisions aimed at increasing the amount of venture capital available to small and medium firms, including those performing significant research and development activities. (A21,A22)

9. The findings of Mansfield and Switzer regarding tax-incentive-induced business research and development are being challenged by other studies. (A22)

10. In 1983, 25 of Canada's 1,435 R&D performing companies accounted for over 50% of all industrial research and development performed in Canada. (A23)

11. A single European-based company has more people on its research and development payroll than does our entire country.
    (quote from B. Mulroney prior to September 1984). (A23)

12. In 1984, about 20% of Canada's total investment in research and development was controlled by non-Canadian interests (mainly American-controlled firms). (A7)

    Note: These funds still fall under the "domestic source" category, as opposed to "foreign source funding".

13. The approximate 400 foreign-controlled industrial R&D performers operating in Canada account for 40% of industrial R&D investment in our country. The remaining 60% is invested by roughly 1,000 Canadian-owned R&D performing firms. (A7,24)

THE CURRENT PERSPECTIVE (cont.)

14. In 1983, three major industries - communications equipment, wells and petroleum products and aircrafts and parts (a total of 151 firms) accounted for 45% of all private sector intramural research and development expenditures. (A24)

15. The aircraft and parts, communications equipment and engineering and scientific services industries received about 56% of all direct federal funding to industry. (A24)

16. The dependency of the Canadian economy on the resource-based industries is reflected in the fact that 50% of the total machinery and equipment for all industries is accounted for by the agriculture, mines and wells, and paper and primary metals sub-sectors. (A53)

17. All economic trends seem to indicate a maintenance of the status quo. Even the apparent improvement in balance of trade figures for manufactured goods is mainly attributable to an increase in export of resource-related products (wood and paper, fertilizers, iron and steel and non-ferrous metals). (A61)

18. A recent study by the OECD identified Canada as one of the few countries where its space industries sell more than the government itself spends on space programs and activities. (A62)

19. A 1985 discussion paper by MSST presented the following trends in Canadian high technology trade:

    - Canada's trade deficit in high technology is the worst among the Economic Summit countries. It stood at about $12 billion in 1984 and continues to grow.

    - Canada is the only major industrialised country with trade deficits in <u>all high-technology commodity groups.</u>

    - Canada ranks 8th in terms of market shares of OECD exports of high-technology products. Moreover, Canada is losing its market share over time, from 4.4% in 1970 to 3.5% in 1983.

    - Canada ranks 8th in terms of national expenditures on R&D as a percentage of GNP.

    - A recent OECD study confirms that the higher a country's R&D expenditures relative to total value-added, the higher is its high-technology share in manufactured exports. (A61)

THE CURRENT PERSPECTIVE (cont.)

20. Industrial laboratories account for just 2% of all Canadian-authored scientific papers. The corresponding American figure is 9%. (A30)

21. According to Statistics Canada, bibliometric analyses suggest that Canada's scientific strengths are most evident in the fields of medical biochemistry, applied physics and electronics. Main mathematics, physics, computer science, chemical analysis and ecological studies are also areas of relative Canadian expertise. (A31)

22. In 1978, Canadian scientists co-authored papers with counterparts in 19 foreign countries. The corresponding American figure was 42. (A33)

23. According to Statistics Canada, Canadian patent statistics indicate that the rate of invention in Canada is stable, that we are not as active in newer technologies as our international competitors and our relative rate of invention is lower than that of the U.S.A.. (A33)

24. According to the 1981 census, scientific, engineering and technical personnel accounted for less than 5% of the total labour force, which at that time was 12.27 million. (A34)

25. In 1983, the 72,470 persons engaged in research and development activities represented about 0.6% of the total work force. Scientists and engineers accounted for almost half of all research and development personnel. (A34)

26. Figure 5. DISTRIBUTION OF RESEARCH AND DEVELOPMENT PERSONNEL (1983)

Sector	Number of R&D Personnel
Federal Govt.	17,170
Provincial Govts.	4,550
Business Enterprise	35,400
Higher Education	13,630
Private Non-Profit	1,720
Total	**72,470**

Source: Statistics Canada, (A34)

THE CURRENT PERSPECTIVE (cont.)

27. In 1981, 45% of 33,600 full-time Canadian university teaching staff worked in the fields of Natural Science and Engineering (NSE). (A38)

28. Following the trend of Canada's overall population, the median age of NSE university teachers is increasing. The academic hierarchy is becoming top heavy and there is some concern over the stagnating effect this trend might have on future NSE academic research and instruction.(A39)

29. Foreign student enrollment provides a buffer to changing patterns in Canadian student enrollment at Canadian universities. This is especially the case at postgraduate levels. The security of this buffer may be dwindling due to escalating foreign student tuition fees; a direct result of the current university financial squeeze. (A40)

30. Education and research have always been dual responsibilities of universities. The impact of changes in the national economy on both of these responsibilities must be considered in the new PSE financing agreement to be struck between the two levels of government. Such an agreement is imperative to the continued success of Canadian universities and is therefore an urgent national priority.(A45)

31. The main argument of support for university funding may not be to satisfy projected demands for highly qualified manpower. Rather, the logic might better be adjusted to reflect the greatly enhanced "employability" of university graduates over those who do not pursue postsecondary education. At 81%, the ratio of employment to population for university graduates is almost 10% higher than that of the next most employable group - non-university PSE graduates. Futher research is needed in this area to confirm the reasons for this increased "employability". (A41,A42)

32. As of November 1985, the seasonnally adjusted unemployment rate for Canadians between the ages of 15 and 24 years of age was 16.2%. (A63)

33. In the 1984/85 fiscal year, Federal PostSecondary Education (PSE) contributions via Established Program Financing (EPF) transfer payments accounted for 80% of the total national PSE operating grants issued by the provinces. In fact, federal contributions to five of the provinces exceeded their PSE operating budgets. Just seven years ago, federal PSE contributions comprised only 65% of the total PSE operating

THE CURRENT PERSPECTIVE (cont.)

34. The 1984/85 federal science and technology budget allocated $500 million for data collection and information services. (A49)

35. The Canadian operations of foreign-owned multi-national enterprises greatly enhance Canada's scientific and technological infrastructure. Not only do these companies fund 40% of total industrial research and development investment in Canada, their international technical information network is an invisible yet potent source of expertise and advice. Government policy must strive to expand the scope and magnitude of MNE R&D in Canada. (A51,A52)

36. An acceleration in the rate of scientific and technological advancement in Canada will be signified by an increase in some or all of the following indicators:

    a) The extent of Canadian participation in international:

    - industrial licensing agreements
    - cooperative private sector research and development programs (and those involving the academic and public sectors)
    - coauthored scientific and technological publications
    - joint patents.

    b) The GERD

    c) The BERD
    Note: The 1983, 1984 and 1985 values for this indicator are probably inflated due to the effects of the Scientific Research Tax Credit (but not by the value of the credits themselves). The amount of bona fide scientific research and development induced by this Credit is highly questionable.

    d) The HERD

    e) Net Fixed Capital Formation

    f) Export Shares of High Technology, and other, manufactured products

    g) Trade Balance in Technology-Intensive Manufactured Goods

    h) Levels of Employment

    i) Amount of Science and Technology-Related Discussion During Question Period.

THE CURRENT PERSPECTIVE (cont.)

Some recommended references for further details regarding the current Canadian scientific and technological environment are:

- Appendix A of this paper
- "The Federal Source Book", MSST
- "The Provincial Source Books", MSST
- "Federal S&T Expenditures", MSST
- "Canadian Trade in High-Technology", MSST
- "Science and Technology Indicators 1984", Cat. NO. 88-201, Statistics Canada and the entire 88- series
- "A Practical Perspective The NRC Plan 1986-1990", National Research Council

LOOKING AROUND US: THE INTERNATIONAL ENVIRONMENT

Some statistical highlights comparing Canada's scientific and technological environment to that of other industrialised nations are presented below. Note that this data is based on OECD documentation and so may differ slightly from previously presented Statistics Canada data. As in the previous section, the corresponding appendix page number is indicated at the end of each statistical highlight.

1. In 1983, Austria and Italy were the only OECD nations reporting lower GERD values, as a percentage of GDP, than Canada. (B3)

2. In 1983, the Canadian public sector GERD contribution, at 53.5%, ranked among the highest of any OECD nation. (B4)

3. In 1983, Canadian private sector R&D investment, at 37.7%, was the lowest of all reporting OECD nations. Canadian private sector funding of R&D increased in 1984 and 1985, primarily due to the SRTC, but the scientific relevance of this increased activity is questionable. (B5)

4. From 1981 to 1983, the private sectors of Finland, France, Japan and Switzerland made measureable increases in their levels of R&D investment. Other reporting economies maintained their positions. Only Canada and Italy showed significant decreases in industrial R&D investments. (B6)

5. The 66,260 Canadian personnel engaged in R&D in 1981 accounted for 0.55% of our total labour force. Spain, Ireland and Italy had lower poportions of R&D personnel in their work forces. Austria's fraction was similar to Canada's. All other OECD nations had larger R&D contingents, relative to their labour force. In fact, Sweden, Japan, France and Germany had roughly double the per capita human resources devoted to research and development. (B29)

LOOKING AROUND US (cont.)

6. International comparisons of Gross Expenditure on R&D in the Business Enterprise Sector (BERD) illustrate that Canadian industry is falling behind the international pace in this regard:

   - In 1981, Canada had the highest BERD average annual rate of growth of any OECD nation. In 1983, the Canadian BERD growth rate was the lowest of the same group of nations.B13

   - The Canadian BERD, expressed as a percentage of DPI, has consistently been among the lowest in the OECD community; roughly half that of many other nations. (B14)

   - While the fraction of the BERD financed by industry was increasing in many countries, Canada's private sector was unable to even maintain its funding level during the early eighties. (B15)

   - At 11.2%, the portion of the BERD financed by the Canadian public sector in 1983 was lower than that of several other nations. With the exception of Italy, the higher public sector BERD financing of other nations such as the U.S.A., the U.K. and France can be explained by their much higher public sector investments in defence R&D. (B16)

   - In 1983, the percentages of BERD financed by foreign sources for Canada, the U.K., France, Germany and Japan were 8.5, 6.8, 4.6, 1.4 (1981), and 0.2%, respectively. B17

7. International comparison of Canadian expenditure on Research and Development in the Higher Education Sector (HERD) depends greatly upon how the expenditure is expressed:

   - As a percentage of GERD, Canada's HERD investment appears to be greater than the OECD average. (B21)

   - Expressed as a percentage of GDP, Canada's HERD investment is below the OECD average. (B22)

8. The proportion of the Canadian R&D effort that is performed in the public sector is similar to that of France, Italy and the U.K.. The relatively lower value of the corresponding American statistic might be explained, in part, due to the comparative strength of American university-based R&D programs and the assignment of "industrial" defence contracts to firms whose only customer is the American government. (B7)

LOOKING AROUND US (cont.)

9. Canadian government funding as a percentage of GDP, is similar to that of Australia, Finland, Italy, Japan, New Zealand and Norway. Japan's much larger economy sets that nation apart from the others. Canadian public sector R&D funding, as a percentage of GDP, is less than two-thirds that of France, Germany, the Netherlands, Sweden, the U.K., and the U.S.A.. (B8)

10. It is interesting to note that once the defence R&D component is eliminated, Canadian government civil R&D funding as a percentage of GDP, is lower only than that of France, Germany, the Netherlands and Sweden. (B9)

11. In 1983, the Canadian Federal government devoted 5.7% of its total R&D budget to defence R&D. This figure was similar to previous annual allocations. It was similar to the corresponding values for Spain and Italy, but roughly half that for Australia, Germany and Norway and far lower than the defence R&D budgets of France, Sweden, the U.K. and the U.S.A.. (B10)

Some recommended references for further details regarding Canada's standing in the international fields of science and technology are:

- Appendix B of this paper
- "Science and Technology Indicators 1984", Cat. No. 88-201, Statistics Canada, and the entire 88- series.
- "Selected S&T Indicators 1981-1986", OECD, October 1985, DSTI 7601S
- "1985 Report on International Competitiveness", EMF, January 1985
- Global Competition The New Reality, Report of the President's Commission on Industrial Competitiveness, Vol. II, January 1985, U.S.A.
- Periodicals:
  highTechnology, U.S.A.
  The Futurists, U.S.A.
  Science 85, AAAS, U.S.A.
  Access, AASC, Canada
  ISSUES IN SCIENCE AND TECHNOLOGY, NAS, U.S.

LOOKING BACK: THE HISTORY OF SCIENCE POLICY IN CANADA

Since World War II, Canada has languished in the bounty of its natural resources. Governments maintained responsibility for industrial development and innovation. But in fact, no federal government has ever had a peacetime economic-industrial strategy which accurately reflected the impact of science and technology. As a result, the Canadian private sector has grown soft. Canada has been experiencing the consequences of its own inertia for the past decade.

This mistake of failing to plan for Canada's technological future is now recognized. For over twenty years numerous government-appointed committees warned of the perils of continued neglect of Canada's technological development. The Glassco Commission (1963), the OECD Review of Canadian Science and Technology Policy (1969), the Gendron Task Force (1971), the Lamontagne Senate Committee (1970-1977), the Wright Task Force (1984), the Doody Senate Report (1984) and the Winegard Task Force (1984) all urged the governments of the day to provide strong, visionary leadership in the management of technological change.

In August 1971, the Ministry of State for Science and Technology (MSST) was established by Order-in-Council (P.C. 1971-1695). In brief, MSST was intended to:

- o develop S&T policies
- o co-ordinate all government S&T activities
- o provide liaison with industry, the general public, provincial and foreign governments
- o cooperate with other departments and agencies to optimize government monetary and manpower investment in S&T activities
- o advise on the best organization of federal S&T activities
- o undertake studies on the social impact of S&T issues.

But at the time of its establishment, MSST was not granted the statutory and budgetary authority necessary to excercise its mandate.

In 1971, the New Democratic Party strongly opposed the formation of MSST and other Ministries of State on the grounds that without executive powers, the new Ministries of State would be ineffective. (See Hansard pp. 7172-3).

LOOKING BACK (cont.)

In fact, MSST was established along the recommendations of the OECD review:

> "The report did, however, recommend that a senior member of the cabinet be appointed a minister for science policy, but without being in charge of any activity. This would be, like the chancellor of a university, a position of dignity without responsibility. At the confrontation meeting, Mr. Drury (C.M. Drury - then President of the Treasury Board) pointed out in rebuttal that it was unlikely the prime minister would delegate just science policy but no other portfolio to a senior colleague. If the function were assigned to a junior member of the cabinet, it would be unlikely that his views would strongly influence departmental policies of more senior ministers."
>
> "The Chaining of Prometheus", F. Ronald Hayes, 1973, p. 50.

In February 1974, The Honourable Jeanne Sauvé, then Minister of MSST, announced that the government had decided to implement a number of important proposals made by the Lamontagne Special Committee of the Senate on Science Policy:

> The Ministry of State for Science and Technology was to have a stronger role in the formulation of new science-oriented policies.
>
> A special budgetary procedure would be developed for examining and approving departmental and agency science expenditure proposals, leading to the separate publication of a science budget.
>
> MSST would be given the additional responsibility of reviewing and assessing science expenditure proposals before their final approval.

Tragically,these promises were never adopted into actual government operation.

In April, 1983 the Liberal government introduced the Scientific Research Tax Credit. The disastrous effect of this incentive has been to reduce federal tax revenue by millions of dollars, with very little of those funds supporting bona fide research and development. This fiasco revealed a serious lack of knowledge within the federal government and politicians regarding the nature of scientific and technological advancement.

LOOKING BACK (cont.)

The governmental structure that Canada has been left saddled with is described quite vividly in THE CANADIAN ENCYCLOPEDIA, by Hurtig Publishers:

> "This option (Ministry of State for Science and Technology) has proved to be weak, given the political realities of the Canadian Cabinet and bureaucratic system, and there has been a succession of short-lived incumbents ..., none of whom has been particularly effective."

J.W. Grove, p.1660.

The Conservative Party recognized the role of science and technology in economic-industrial development during the election campaign.

"In our view, Canada has a number of fundamental obstacles to overcome if we are to reduce unemployment and achieve economic growth:

1. The high level of real interest rates,
2. The undercapitalization of Canadian industry,
3. The uncompetitive structure of many firms located in Canada,
4. Our deplorable record in research and development and technological innovation, and;
5. The lack of markets for our goods and services."

Notes for an address by Brian Mulroney, M.P., Leader of the Opposition to the Canadian Daily Newspaper Publishers Association, Toronto, April 18, 1984.

In fact, all of these obstacles exist as a result of our past inertia with regard to technical innovation and scientific advancement.

LOOKING BACK (cont.)

The Conservative Party also recognized the most important factor needed to overcome these obstacles:

"Canada needs a national government with a vision to match the grandeur of our physical resources and the limitless capabilities of our people.

Canada needs a government with the courage to define great national goals, and the will to mobilize our resources to achieve them.

Canada needs a government with the committment to ... recapture our national dream."

Notes for an address by Brian Mulroney, M.P. to a Toronto PC fundraising dinner, November 24, 1983.

"If we are going to manage economic change properly, we have to remember that over ninety percent of the labour intensive industries which exist today will require that (new) technology to remain competitive and viable in the decades ahead."

Notes for an address by Brian Mulroney, M.P. to the Rotary Club "Adventure in Citizenship" Dinner, Ottawa, May 14, 1984.

The period from 1965 to 1975 marked a decade of debate regarding science policy in Canada. We have reached the end of another decade; one of self-doubt and introspection with regard to science and technology - an identity crisis. Canada, and particularly the federal government, is more likely to abate this indulgence by actions rather than words.

Government leaders must begin to wield the tools of science and technology with the same skill and confidence as used with the more traditional economic measures.

LOOKING AHEAD : THE POLITICAL CHALLENGE

"The fact of the matter is that the role of R&D and of science and technology has entered the political arena after decades of considerable neglect. Science and technology is now a matter of national concern. It has and will continue to have a significant impact on Canada's social, cultural, regional and economic development objectives."

"The fact that most industrialized nations have recognized that a concerted government approach to investment in innovation, in partnership with the private and academic sectors, <u>is necessary for economic survival</u>, <u>let alone industrial competitiveness</u>, is all the more reason for Canada's public sector to provide leadership in science and technology."

"The Organization for Economic Cooperation and Development (OECD) has identified three essential components in pursuing a course of economic renewal through science and technology.

1. Clear focal points must be created for a national technological effort.

2. There must be a solid basis (infrastructure) for accumulating and transmitting knowledge and know-how.

3. There must be an appropriate climate for innovation and entrepreneurship."

Quotations from a speech by Dr. D.I.R. Low to the Canadian Instiiute for Professional Development, November 14, 1985.

In his speech, Dr.Low goes on to define MSST as the focal point for federal government initiatives in science and technology. In fact, this is not always the case. Many other departments and agencies independently operate far greater S&T budgets than MSST.

Regardless, there is another connotation to the OECD use of the term "focal points for national technological effort". This other meaning can be described as strategic "critical mass" projects such as found under the American national security umbrella (ex. SDI), the European EUREKA alliance or the Japanese strategy of producing value-added goods from a very small resource base.

LOOKING AHEAD (cont.)

Canadian examples of large, mission-oriented projects include the Space Program, the Nuclear Energy Program, the commercial Tar Sands Plants, the James Bay Hydro-Electric Dam and the National Railway. These projects played a significant role in the evolution of Canadian economy and identity.

Future mega-projects will effect the course of future economic-industrial development. Canada has many opportunities available for strategic development. Some would require the development of new technology and skills; others would rely on existing knowledge and techniques. As the adage goes -

Nothing ventured, nothing gained.

A quick list of potential realities includes:

- Controlled Climate Environment Technology:
  The development of new skills based on existing strengths in the climatic, astrophysics, space, communications, materials, energy, applied physics, automation and control, environmental and earth sciences. These skills could be applicable to northern development and defence, agriculture, energy production, urban development and resource management.

- Intelligent Robotics:
  The integration of artifical intelligence and advanced robotics will catapult manufacturing, defence and resouce management practices into a new era. Canada has the expertise to undertake a major initiative in this field.

- Water Diversion:
  Several proposals for the collection and diversion of fresh water to the American market have been identified. It's the same old theme of exploiting raw resources for export; little scope for creativity or technological advancement.

- Import Substitution:
  The identification of strategic commodities, presently being imported, with significant potential for Canadian production could have a positive impact on our national balance of trade and therefore help to relieve the national deficit. This strategy could ease Canadian industry into modernisation and innovation but it also emphasizes following the pack, rather than running with it or challenging for the front line.

LOOKING AHEAD (cont.)

- Coordinated Multi-Level Government Procurement: Maximized buying power could give the governments additional leverage to promote Canadian-developed and produced goods and services. To be effective, this program would have to be very future-oriented. Potential purchases would have to be identified very early to allow the development of specific products and production techniques. This level of fiscal coordination and committment would be a difficult challenge to all governments.

The challenge to government is not a scientific or technological one. It is not a call for drastic economic or industrial intervention. The challenge is for effective, informed and wise leadership of the nation and administration of the government.

Such leadership must strive to reflect and anticipate the attitudes and values held by the majority of Canadians. The unique "psychographics" of our nation preclude the absolute mimicry of any other nation on earth. It is not only our national economic and infrastructural differences which must determine our unique path of advancement but also our particular dreams and moralities.

National deficit reduction is the first hurdle in the race. A reversal of spiralling national debt costs will provide the economic stability needed to encourage both domestic and foreign direct investment in Canada. Increased investment will accelerate the rate of technological diffusion and innovation throughout Canadian industry.

The financial stabilization of higher education institutions is the second hurdle. If Canada could only afford to exploit one resource we would have to choose our wealth of human intelligence. This is the one resource which will not lie dormant for years waiting to be mined. It is like an election campaign; the seeds are sown, the garden tended and the fruit ripened. If you do not harvest at the proper time, all efforts are lost. The fruit withers and much labour is needed to recover the seeds for replanting.

If the funding of post secondary educational institutions was regarded as "intellectual employment insurance" and given the same priority as other social support programs, then the remaining portion of government science and technology expenditures could come under the scrutiny of a scientific and industrial board which would accredit individual proposals prior to their submission to Treasury Board.

LOOKING AHEAD (cont.)

The route to stable and adequate university funding is yet unclear. Federal and provincial governments and industry each have responsibilities in this regard. Direct payments to the user might eliminate the "leakage" that is presently occurring between federal allocation and university receipt of funds. A new method of financing must address the need to support both the educational and research and development roles of universities equitably, with a view to the next generation of skilled, resourceful, educated and open minds.

A gradual and significant shift of some human, monetary and material resources from federal intramural R&D laboratories to university-based facilities could have many advantages.

The resultant increase in direct federal R&D grants and contracts to universities would create a larger, more flexible PSE operating budget. A well-managed transfer of R&D personnel could infuse universities with new ideas, expanded research capabilities and additional teaching skills.

A pragmatic and generous resolution of the R&D roles of universities and the federal government would relieve much of the tension within the Canadian S&T community. It could enable the federal government to concentrate more successfully on strategic initiatives and the short and long term intricacies of industrial-economic-scientific development.

The challenge of university funding will be facilitated by recently improved federal/provincial relations. A creative solution will be needed to satisfy all parties both now and in the future. It might be conceivable that such a solution be enshrined in "A Constitution of Education and Fundamental Research".

LOOKING AHEAD (cont.)

Measures taken towards a stabilized economy and revitalized university sector will provide a fertile climate for creative and promising approaches to other national goals such as the ones briefly outlined earlier.

The challenges now facing the government will never be resolved independently nor completely. Such is the nature of the beast. Federal policy-making must reflect the flexible nature of government leadership. The government must take action in those areas where leadership needs to be demonstrated but must be careful to minimize its interventions as much as possible. The roles of conciliator, coordinator, advisor and listener are equally important, as is the international projection of our national image and direction.

It is the responsibility of government to guide the public, private and academic sectors towards the type of society we want to achieve for future generations.

"... but until that society is spelled out by those who seek to build it, we remain destined to tilt at the windmills of our favourite myths, advocating policy after policy in frantic desperation, and bound, in the last analysis, to be dominated by the instrumentality which we were unable or unwilling to control."

Canada's Science Policy and The Economy, N.H. Lithwick, 1969, p. 120.

CONCLUSION

The brilliant history of science and technology in Canada has been tarnished by cynicism, skepticism and excessive introspection over the past two decades. Our's is yet a young country, in relative terms. Mistakes are made; lessons are learned. Even if we should want to follow the paths of other nations, we could not. We are a unique nation in unique times.

Science is an art and technology is a means to an end. The interdependence of these two separate fields has resulted in stupendous achievements. It is the social and economic success of these achievements that spurs governments to invest money and personnel in these areas.

Canada has many strengths on which to build. The promising and profitable developments that we are currently pursuing must receive continued support and direction. In addition, our natural resources, geographic challenges and existing scientific talent offer many opportunties for new achievements; new successes.

But like all endeavours, scientific and technological advancements require both capital and resolve. Specific activities must be scrutinized both for their scientific or technological integrity and for their economic justification. It is this last point that sparks much of the controversy and tension surrounding the topic.

The pursuit of creative scientific study is difficult to justify in economic terms and yet intrinsic to the nature of mankind. The long-term and uncontrollable nature of scientific discovery demands the patient support and vision of a patron and the discipline and integrity of a scientist.

Other, more tangible economic demands will always threaten the funding of basic research activities. Such is life. Patrons of science (governments, businesses and individuals) must shield the scientific community from fiscal oblivion by involving them in activities which are economically justifiable at the time. Scientists must reciprocate by applying their expertise to the problems at hand to the fullest extent possible.

It is the responsibility of government to coordinate the identification of "the problems at hand". Without proper leadership, a chaotic struggle for funding and direction ensues, wasting precious human resources.

The direction of this Federal government's leadership on scientific and technological matters will become more evident during the next months as Cabinet faces some major decisions regarding the funding of the university granting councils, the five year plan for the National Research Council, renewal of Canada's major defence pact with the United States and several major commitments that will steer the future course of Canada's Space Program. In addition, the government's posture during the upcoming "Free Trade" negotiations will have a tremendous impact on Canada's rate of scientific and technological advancement.

Statistics, such as the GERD and many others, provide information regarding the quality and quantity of existing scientific and technological resources. These statistics facilitate identification of strengths and weaknesses in our economic, scientific, educational, information, social and cultural infrastructures. Too narrow a focus on the statistics themselves rather than the environment they represent serves more to distort the issue than to elucidate the best future actions.

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ERRORS AND OMISSIONS

APPENDIX A:

Page A3 - Replacement first paragraph

"The differences between these two sources of information are substantial. In particular, Treasury Board's Main Estimates for Federal extramural R&D funding to industry are inflated due to ... programs."

Page A6 - Replacement second paragraph

"The oft quoted figure of an 8 or 9% defence component of R&D spending refers to Federal expenditures only."

(ie. omit "intramural")

Page A50 - Omission

This discussion should include mention of the role of The Science Council of Canada.

* * *

APPENDIX A

THE CURRENT PERSPECTIVE: Science and Technology in Canada

A.1 Research and Development Expenditures

A.1.1 The GERD

FORMULATION OF THE GERD

Research and development is creative and novel work undertaken in a systematic fashion in order to advance knowledge.

The amount of monies spent by a nation on R&D activities is referred to as Gross Expenditures on Research and Development (GERD). The definitions, classifications and methodology used to develop a national GERD figure were established by the United Nation's Educational, Scientific and Cultural Organisation (UNESCO) and the Organisation for Economic Co-operation and Development (OECD).

While the OECD GERD figures reflect both natural science and engineering (NSE) and social science and humanities (SSH) research and development, the GERD figures published by Statistics Canada reflect only the NSE portion of national R&D expenditures. Statistics Canada chooses to report their information in this way as they have no measure of the SSH-related R&D performed in the business enterprise sector. Throughout this paper, GERD figures will refer only to NSE expenditures unless otherwise specified.

The national GERD value is an aggregate figure based on performer-reported funding of research and development in the government, private, higher education and foreign sectors. The distribution of R&D funds is examined both from the funder and performers' perspectives.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

APPLICATION OF THE GERD

The GERD indicator is used internationally in the formulation, evaluation and modification of national science policies. It's value as an indicator is strengthened by its wide acceptance and usage. There are other indicators, including economic and labour force variables, that are also valuable in determining Canada's current research and development resources and potential needs. These indicators are presented and discussed within this paper.

In Canada, the GERD is most commonly expressed as a percentage of Gross National Product (GNP). This normalization minimizes variations due to differing currencies, labour rates and inflation rates over time and between nations under comparison.

Gross National Product is a measure, at market prices, of the total value of production of goods and services of Canadian residents.

The Gross Domestic Product (GDP) is that part of the GNP that is produced within the boundaries of Canada. In some references, the GERD is normalized against GDP rather than GNP.

The OECD use the ratio of GERD to GDP for their studies. However the GDP used by the OECD is at purchasers' values rather than the Canadian-used index of GDP at market prices. Although the ratio is not materially affected by the choice of denominators, it is important to be aware that there are distinctions in the formulation of each indicator.

It is also important to remember that the GERD represents R&D expenditures as reported by the performer. GERD-based values will not be exactly the same as funder-based R&D expenditures such as those reported in Treasury Board "Main Estimates".

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

The differences between these two sources of information are substantial. These differences are, in part, due to the following factors:

- o The GERD, performer-based figures do not include the related direct overhead costs incurred by the funders such as salaries, administration etc...
- o Treasury Board's "Main Estimates" for Federal extramural R&D funding to industry are inflated due to the inclusion of industrial contracts that are really attributable to the operation of Federal intramural R&D programs.

Statistics Canada refers to the unaccountable discrepancies between funder and performer-reported investments in R&D as **"leakage"**. They take steps to try to account for the unidentified dollars.

Both sources of information are used in this paper in order to present statistics in sufficient detail and of use in international comparisons.

Finally, it must be stressed that the GERD is a rough input indicator of research and development performed by a nation. It accounts for neither basic economic differences between nations nor for different distributions of funds between the many possible areas of activity. These differences, and others, greatly affect the influence of R&D on the general economy of a nation.

THE CANADIAN GERD

The estimated Canadian GERD value for 1985, in current dollars and for natural sciences and engineering only, is $ 5.80 billion. The GNP figure was $ 446 billion. Thus the 1985 GERD/GNP ratio is 1.30.

This GERD figure does not include tax revenues the federal government foregoes in support of industrial R&D. These tax initiatives add up to about $875+ million per annum, as presented further on in this section. This R&D contribution could be viewed as the average Canadian's contribution to national research and development.
(Statistics Canada: E. Bradley, S&T Division)

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

Figure A.1.

DISTRIBUTION OF THE 1985 GERD
(As estimated by Statistics Canada in Summer 1985)

FUNDING SECTOR	PERFORMING SECTOR					TOTAL
	Federal Govt.	Provincial Govts.	Business Enter.	Higher Educ.	Private Non-Profit	
	(millions of dollars)					
Federal Govt.	1,419	8	303	406	21	2,157
Provincial Govts.	--	163	39	119	15	337
Business Enter.	--	15	2,446	28	3	2,492
Higher Educ.	--	--	--	382	-	382
Private Non-Profit	--	--	--	127	32	159
Foreign	--	1	256	12	-	269
TOTAL	1,419	188	3,044	1,074	71	5,796
			(BERD)	(HERD)		

Source: Statistics Canada,
Note: Foregone Revenue not included.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

Figure A.2.

DISTRIBUTION OF THE 1984 GERD
(As revised by Statistics Canada in Summer 1985)

FUNDING SECTOR	PERFORMING SECTOR: Federal Govt.	Provincial Govts.	Business Enter.	Higher Educ.	Private Non-Profit	TOTAL
	(millions of dollars)					
Federal Govt.	1,404	7	279	446	19	2,155
Provincial Govts.	--	157	36	113	14	319
Business Enter.	--	14	2,245	26	3	2,288
Higher Educ.	--	--	--	305	-	305
Private Non-Profit	--	--	--	121	29	150
Foreign	--	1	235	12	-	248
TOTAL	1,404	180	2,795	1,023	65	5,466
			(BERD)	(HERD)		

Source: Statistics Canada,
Note: Foregone Revenue not included.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

THE CANADIAN GERD EXCLUDING DEFENCE EXPENDITURES (1984)

About 2% of total Gross Expenditures on Research and Development in the Natural Sciences and Engineering are devoted to defence applications. Thus, the Canadian GERD value, excluding defence R&D expenditures, was 1.22 for 1984.
(Statistics Canada, Cat. No. 88-204E, p.63

The oft quoted figure of an 8 or 9% defence component of R&D spending refers to Federal intramural expenditures only.

The OECD, reporting figures received from Statistics Canada, lists Canadian defence R&D expenditures as 5.7% of total government R&D funding in 1983. This figure is compared to international statistics in Section 4.1 of this paper.
(Science and Technology Indicators, Basic Statistical Series, Recent results, Selected S&T Indicators, 1981 - 1986, OECD, 1985, DSTI 7601S)

Since 1979, the Department of National Defence has spent about 98% of its S&T budget on R&D (NSE). During this period, DND shifted 15% of its R&D funding to industry from its intramural laboratories. Current distribution of funds is 56% in-house, 40% industrial contracts and 4% university and other.

In 1984/85, DND experienced a 33% increase in its S&T budget; the largest such increase in several years. The total S&T budget for defence in 1984/84 was $204 million and 1,957 person years (32% of which fall in the scientific and professional category).
(Stats. Can., Cat. No. 88-204E, pp. 41,42.)

A parliamentary committee recently recommended that Canada renew its major defence pact with the United States for another five year term and that Canada increase the defence budget from 2.1% of GDP to 3.8%. The 1985-86 budget is about $9.7 billion. The proportion of the increased budget to be directed towards S&T was not identified in the article.
(The Citizen, A1, January 22, 1986)

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

THE CANADIAN GERD EXCLUDING FOREIGN-CONTROLLED R&D EXPENDITURES (1983)

The 1983 GERD was $ 4,876 million. In that year, $ 1,012 million of R&D expenditures were invested in Canada by firms under foreign control. Thus, just over 20% of Canada's total investment in scientific research and development (or 40% of industrial R&D investments) was controlled by non-Canadian interests (80% American).
(Stats. Can., Cat.No. 88-202, pp. 32,38,77,92,94)

This statistic seems to discredit the assertion that foreign ownership in Canadian industry inhibits Canadian-based R&D.

It is important to keep these statistics in the proper perspective. As will be presented further on in this section, ten firms account for over 40% of industrial R&D investment in Canada. So while the proportion of foreign-controlled R&D might seem high to some, it may reflect the operations of less than a half-dozen firms.

The Canadian offices of multi-national companies receive a great deal of information from the R&D performed by related offices/companies. The costs of acquiring this information are not included in the GERD. Without this corporate network of international activity, acquisition of this knowledge would require both a greater indigenous R&D effort and a more extensive national S&T information infrastructure. These measures would require a larger GERD investment.

Since the vast majority of multi-national enterprises operating in Canada are foreign owned, it follows that although non-Canadian interests account for roughly 20% of the Canadian GERD, the impact of these interests on the dynamism of nation-wide scientific and technological activity implies a substantially greater contribution.

Thus, because of the relatively large proportion of foreign-owned and multinational business enterprises operating in Canada, the Canadian GERD is not directly comparable to the GERDs of other nations and, in fact, may tend to understate the strength of the research and development infrastructure active in Canada.

The reader is referred to Section A.5 of this paper for more discussion on the diffusion of scientific and technical knowledge.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

USING THE GERD IN CONJUNCTION WITH OTHER INDICATORS

A statistical presentation and analysis of data concerning the GNP shares, export market shares, GERD shares and net fixed capital formation trends of various industries would be of benefit to MSST. The department should consider either preparing such an analysis itself or commissioning Statistics Canada to do so.

Some information of this type may be found in Statistics Canada publications 88-201 p. 196 and 88-202 p. 29.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT

It is important to underscore that the figures presented under federal government expenditures in this section are not GERD-related. To obtain the detail presented here, Statistics Canada uses information as provided in the Treasury Board's "Main Estimates".

The total federal S&T budget for 1984/85 is estimated as $4.10 billion.
(Stats. Can.)

A significant increase in this figure should be evident in 1985/86 and beyond due to the science and technology components of the newly established Economic and Regional Development Agreements (ERDAs). The reader is referred to the National Science and Technology Sector of MSST for details regarding ERDA S&T sub-agreements. The possibility of federally allocated S&T funds leaking to other provincial priority areas should be considered in light of recent experiences with the PSE portion of Federal EPF transfer payments.

According to the Main Estimates, the 1984/85 budget for federal R&D was $ 2.70 billion. About 95% of these funds were devoted to natural science and engineering related activities while the rest went to social science and humanities research.
(Stats. Can.)

In the 1984 GERD analysis presented in this paper, the comparable Federal R&D budget figure used is $2.16 billion. The discrepancy between these two numbers (2.70 and 2.16, billion) was explained earlier under the heading "Application of the GERD".

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT (cont.)

The following table roughly indicates the distribution of Federal science and technology funds.

Figure A.3. FEDERAL SCIENCE AND TECHNOLOGY EXPENDITURES (1984/85) (Treasury Board - millions of dollars)

Total S&T
$4,104

Foregone Revenue
(Finance Canada Estimate)
$875+

NSE S&T 3,363	SSH S&T 741	R&D and RSA
2,034	577	Intramural
1,329	164	Extramural (Total)
629	18	Industry
495	80	University
38	19	Private Non-Profit
38	9	Provinces, Municipalities, and PROs
97	23	Foreign
32	15	Other

Source: Statistics Canada,

More information regarding Finance Canada foregone revenue estimates for S&T-related incentives may be found in the Public Accounts Committee Records, Testimony by the DM of Finance Canada, May 31, 1985.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT (cont.)

FEDERAL INTRAMURAL RESEARCH AND DEVELOPMENT

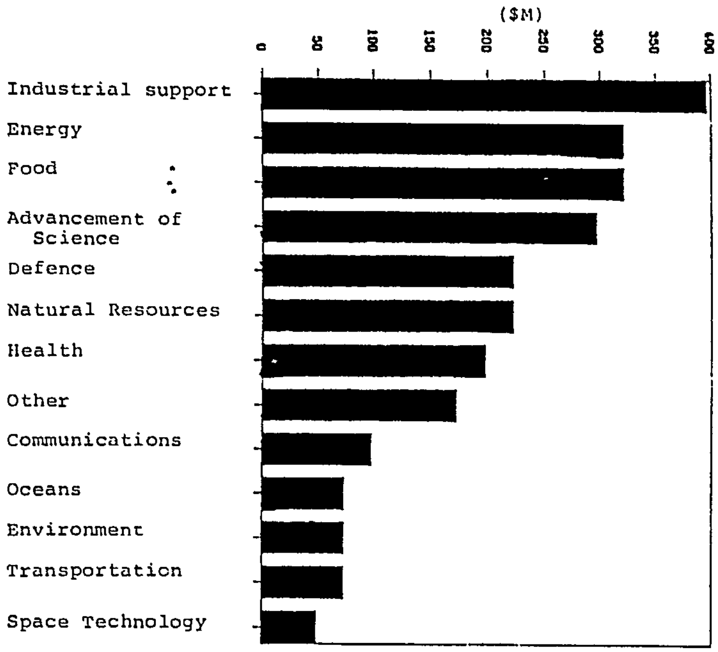
The following data present a cursory overview of estimated federal intramural natural science and engineering research and development expenditures in 1985/86.

Figure A.4

AREA OF APPLICATION

FEDERAL R&D ($2.6 Billion)

1985-86



Source: Government Research and Universities Sector, MSST.

According to a survey conducted by MSST, it is expected that total Federal expenditures in the strategic field of biotechnology will amount to $103.2 million for the 1985/85 fiscal year. This figure includes all intra- and extra-mural research and development, including grants and contracts. This figure represents 2.5% of the total estimated Federal science and technology budget for 1985/86.

This relatively small monetary investment in the strategic field of biotechnology is accompanied by 661 budgetted person-years.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT

Intramural Activities (cont.)

Further insight as to the nature and scope of federal activities is gained by studying the expenditures of the major departments. Activities at the National Research Council and the Departments of Agriculture and Energy, Mines and Resources account for over 50% of federally performed R&D. The reader is directed to "FEDERAL S&T EXPENDITURES", prepared by the Government Research and Universities Sector, for further information on federal intramural R&D expenditures.

The following brief regarding the budget of the National Research Council is presented in view of continued controversy over government funding of their activities.

THE NATIONAL RESEARCH COUNCIL (NRC)

The objective of this council is to create, acquire and promote the application of scientific and engineering knowledge to meet Canadian needs for economic, regional and social development.

The budget of the National Research Council is estimated to be about $ 466.2 million for the 1985/86 fiscal year.

(Stats. Can.)

The National Research Council employs about 3,300 people. The staff consist of 1238 scientists and engineers, 906 technical staff, 603 support staff, 260 maintenance and operations persons and 41 executive and senior management.

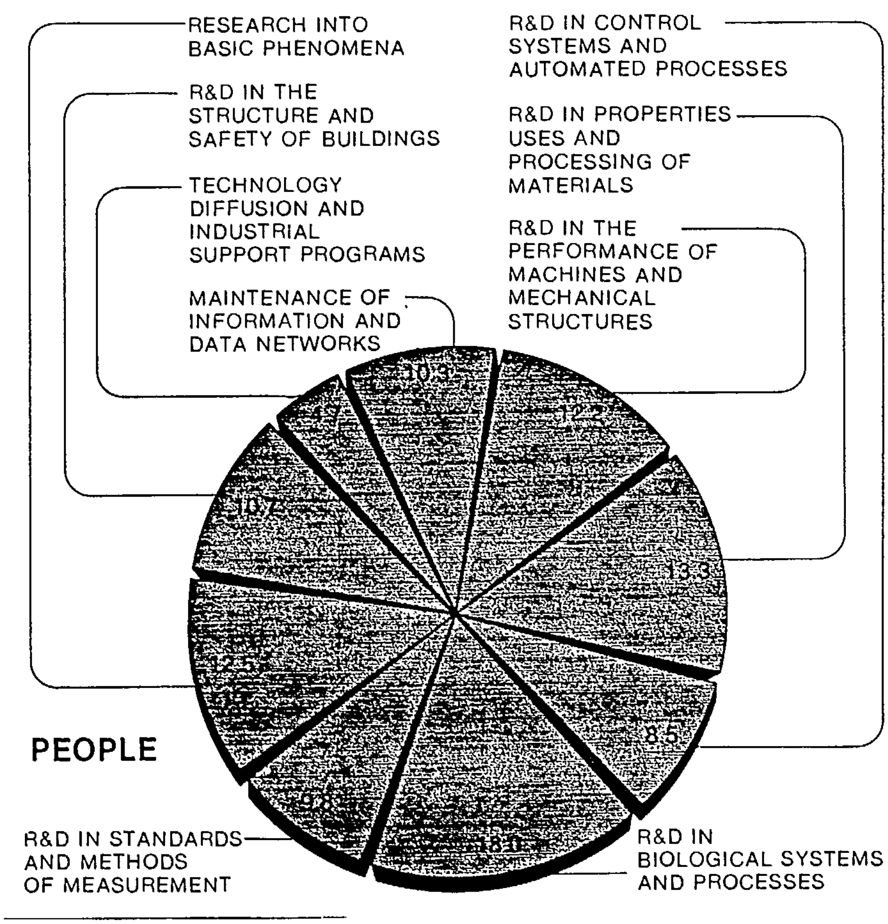
(NRC, A Practical Perspective, 1986-1990)

The Figures A.5 and A.6 illustrates the relative distributions of these resources.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. <u>THE FEDERAL GOVERNMENT</u> (cont.)

Figure A.5 The Distribution of NRC Human Resources by Activity

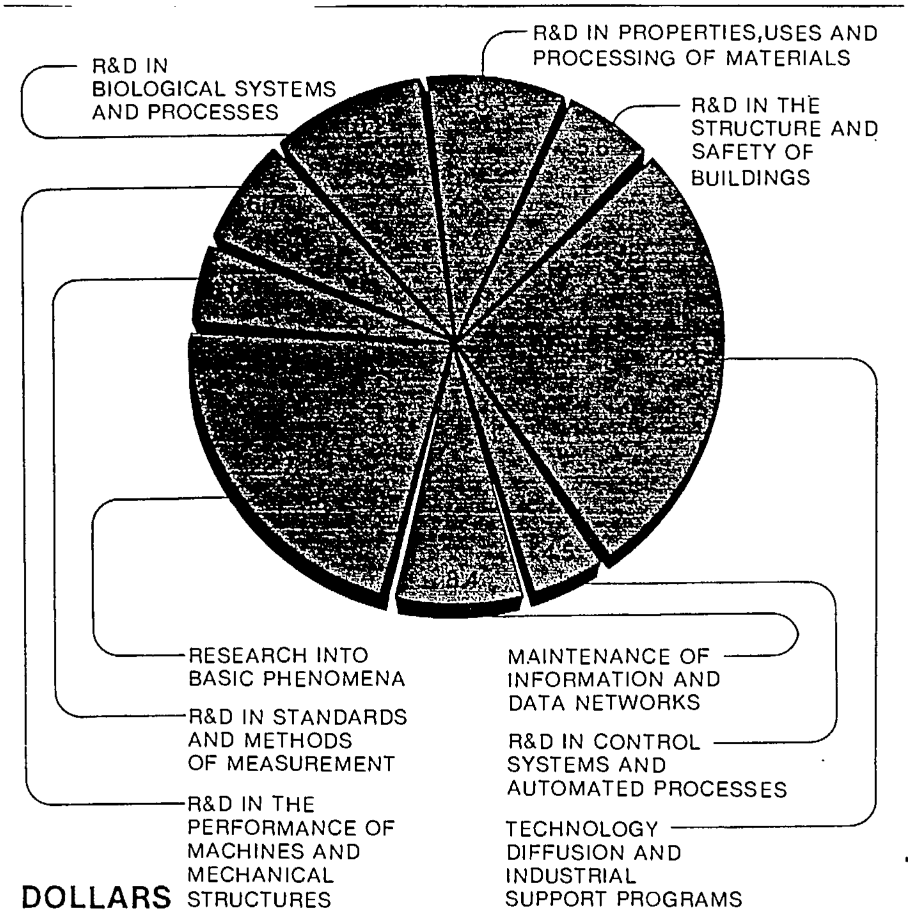


Source: The Practical Perspective The NRC Plan 1986-1990

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT (cont.)

Figure A.6 The Distribution of NRC Monetary Resources



Source: A Practical Perspective The NRC Plan 1986-1990

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT

Intramural Activities (cont.)

THE NATIONAL RESEARCH COUNCIL: NRC

The following highlights are from "A Practical Perspective, The NRC Plan 1986-1990":

- o The major role of the Council will be to assist technical innovation in industry
- o The industrial assistance program will be expanded to include marketing studies
- o The industrial assistance program will be streamlined to allow field officers to rule on most industrial applications in less than 40 days
- o A Technology Assessment Office will be established
- o A Technology Coordination Centre will promote collaboration between NRC, industries and universities
- o A restructuring of the Council will result in fewer, but larger research units; each having an external advisory board
- o Professional exchanges will be encouraged with industry and foreign research facilities.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT

Intramural Activities (cont.)

THE NATIONAL RESEARCH COUNCIL (NRC) (cont.)

The following table highlights budget trends at the NRC over the last seven years. During this period, the proportions of the budget spent intramurally and in the business and university sectors remained fairly constant at 65-70%, 20-25%, and 6-7%, respectively.

Figure A.7: National Research Council Annual Budget

Year	Total S&T Budget (millions of dollars)	R&D (NSE)
1979/80	205.2	173.8
1980/81	230.0	193.2
1981/82	285.5	239.8
1982/83	352.4	306.0
1983/84	411.5	361.1
1984/85	527.6	472.0
1985/86	466.2	406.6

(Statistics Canada, Cat. No. 88-204E, p.46
and discussion with E. Bradley
Science and Technology Division)

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT (cont.)

Extramural Activities

As shown in Figure A.3, the federal government spends over $ 1 billion on extramural R&D. These funds are disbursed as follows.

UNIVERSITY SUPPORT

University support in the form of NSE R&D grants exceeded $ 410 million in 1984/85. An additional $ 23.2 million supported research fellowships and almost $ 20 million was spent on NSE R&D contracts with universities.
(Stats. Can. , Cat. No. 88-204E, pp. 53,58)

NSERC provided about 55% of these grants, while MRC, NRC and the Department of Health and Welfare provided 33, 6 and 2%, respectively.

A common objective of these granting councils is to support research in universities and to contribute to the provision of highly qualified manpower in the fields of natural sciences and engineering. The 1984/85 budgets for NSERC and MRC were $ 292 and $ 157 million, respectively.

Note that the portion of the federal EPF (Established Program Financing) transfer payments to the provinces that is designated as for post secondary education (PSE) is not included in this discussion.

Refer to Section A.4, Education and Training for more information on this topic.

A.1 **RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)**

A.1.2. THE FEDERAL GOVERNMENT

Extramural Expenditures (cont.)

INDUSTRIAL R&D SUPPORT

It is estimated that in 1984/85, $ 525 million was paid in contracts to industry for R&D performed on behalf of the federal government.

Under the Contracting-out Policy, departments are required to contract their S&T activities to the private sector whenever feasible. The **Department of National Defence** and the **National Research Council** spend the largest amounts for R&D in industry accounting for about 57% of the total R&D contracts to industry.

The **Department of Regional Industrial Expansion** provides 49% of federal R&D grants and contributions to industry through its two major programs: IRDP (Industrial Regional Development Program) and DIPP (Defence Industry Productivity program).

The **NRC** spent $81 million in grants and contributions to industry through the IRAP (Industrial Research Assistance Program) and PILP (Program of Industry/Laboratory Projects).

(Stats. Can., Cat. No. 88-201 and Cat. No. 88-204E, pp. 55,56)

Since the Task force on Federal Policies and Programs for Technology Development (Wright Report-July 1984) praised the operation of the IRAP and PILP programs and warned of poor industry enthusiasm for the IRDP program, many groups have supported this view.

The "Federal Source Book" prepared by the National Science and Technology Policy Sector, contains a comprehensive assessment of Federal tax and grant programs in support of R&D. The reader is directed to that book for information regarding the effects of the latest budget and Nielson Task Force decisions on these initiatives.

The government also assists the private sector in its R&D activities by providing access to specialized S&T testing facilities maintained in government laboratories on a cost recovery or cost plus basis.

Finally, the federal government's procurement strategy is designed to strengthen Canada's industrial base. Federal purchases exceed $ 6 billion per annum. Advanced notice of proposed procurements is given to industry to allow Canadian shops to complete any development work necessary prior to bid preparation. Nationality of ownership is one of many considerations in the awarding of government contracts.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT

Extramural Expenditures (cont.)

FOREIGN R&D SUPPORT

Payments to organizations in foreign countries are dominated by those of **IRDC** and **CIDA** who together account for 60% of the total foreign S&T expenditures. Expenditures by these agencies are in direct support of their mandates to aid developing countries by tangible means.

Other departments and agencies use foreign performers when the needed cababilites are not available in Canada. Foreign expenditures include dues for affiliation in international science organizations, including $3 million for participating membership in the European Space Agency.

(Stats. Can., Cat. No. 88-204E, pp. 61)

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT

Extramural Expenditures (cont.)

FOREGONE REVENUES

In addition to direct intramural and extramural investments in R&D the federal government foregoes certain income 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.

Tax credits are considered to be of greatest benefit to medium and large firms with established cash flow. Smaller firms traditionally utilize government support in the form of contracts, grants and contributions. However, it is important to note that since April 19 1983, small business corporations can obtain a refund of 40% of their investment tax credits that cannot be used to offset taxes payable.

Finance Canada estimates that the amount of foregone revenue due to tax support available annually for industrial R&D activities will exceed $875+ million in 1984/85 and 1985/86.

This estimate may be broken down as follows:

- o Regular R&D related incentives as of 1983 = $ 225 million
- o Scientific Research Tax Credit annual estimate for 1983, 1984 and 1985 = $ 650 million
- o New refunds for Small Business introduced in 1984/85 budget (represented as "+" in above figure).

More information regarding Finance Canada foregone revenue estimates for S&T-related incentives may be found in the Public Accounts Committee Records, Testimony by the DM of Finance Canada, May 31, 1985.

These monies are sheltered from taxation by several initiatives.

Firstly, the "100% tax write-off" (or 100% deduction) allows R&D capital and operating costs incurred during the fiscal year to be treated as costs of doing business and thus be excluded from taxable income. This incentive has been strengthened by the revised R&D definition that includes expenditures that are "substantially attributable" to R&D and by the expansion of "scientific research" to include "scientific research and experimental development".

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT

Extramural Expenditures (cont.)

Foregone Revenues (cont.)

The Investment Tax Credit is claimed against federal taxes payable up to an amount depending upon the location and size of the company.

The controversial Scientific Research Tax Credit, expiring May 1986, catalysed a surge of industrial R&D. However the true nature and importance of the resultant R&D activities are uncertain.

The new Capital Gains Exemption of $500,000 announced in May 1985 is intended to encourage investment in R&D ventures.

(Stats. Can., Cat. Nos. 88-202, p.42 and 88-204E, pp. 64)

The risks normally associated with R&D investments are of primary concern to the average investor. The new $ 500,000 **capital gains exemption** currently before Parliament doesn't directly address this profit/risk decision. In fact, it could be argued that this new measure will act as a deterrent to investments in high-risk R&D companies.

In the past, losses incurred on such investments could at least be offset against capital gains from other sources and an additional $ 2,000 per year of the allowable loss could be offset against other income. It appears that the new legislation will not allow $2000 per year of allowable capital losses to be offset against other income. Since most individual investors will not be taxable on their other capital gains because they will fall under the $ 500,000 exemption, a typical investor may not be able to use capital losses to reduce income taxes payable for many years until she/he exceeds the $ 500,000 capital gains level, if ever.

Therefore, a capital loss could become more of a blow to an investor's balance sheet and the investor might be more likely to avoid prospects involving a higher than average risk-factor; such as R&D investments.

Changes to the rules governing RRSP fund investment are intended to encourage investment in fledgling R&D companies. Proposals that will allow a pension fund to establish a Small Businés Investment Corporation (SBIC) or a Small Business Investment Limited Partnership (SBILP) hope to provide small and medium businesses with (debt and equity) **venture capital** .

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.2. THE FEDERAL GOVERNMENT

Extramural Expenditures (cont.)

Foregone Revenues (cont.)

Proposed changes to the Income Tax Act will also make the establishment of labour-sponsored venture capital funds (such as found in Quebec) more attractive.

While it is generally agreed that the new measures contained in the May 1985 budget will have a positive effect on the financial positions of existing companies, it is unclear whether they will directly encourage a company to spend more on R&D and innovation.

The long term, risk nature of R&D requires that the business community have confidernce in the stability and fairness of the tax system.

A larger supply of venture capital is crucial to increased Canadian private sector investment in R&D, innovation and the formation of new technology-intensive enterprises. The reader is referred to Pension Funds and Venture Capital, a discussion paper prepared by the Science Council of Canada for more information on this topic.

Some provinces (notably Quebec, Ontario, Alberta) have established specific venture capital vehicles for business stimulation within their respective jurisdictions. A Federal initiative might prove even more successful in encouraging the establishment of new R&D intensive firms, rather than the relocation of existing business to another province.

The "Federal Source Book", which was referred to earlier in this paper, is also a good reference for information on Federal Taxation initiatives in support of research and development.

Finally, a comment on the "rate-of-return" on federal R&D tax incentives is pertinent to this discussion. The much-publicised findings of Mansfield and Switzer on this subject are not gospel. Other sources, (regrettably I didn't note the references, so further investigation is required), have quoted tax-incentive-induced business R&D as a much higher percentage of foregone revenues.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.3. THE BERD

The fractions of the GERD performed and funded by the business enterprise sector are important indicators of the aggressiveness of the business community. It is generally accepted that strong export performances, combined with large manufacturing sectors, imply the existence and need for strong R&D support.

The Canadian gross expenditure on Research and Development in the Business Enterprise sector (BERD) was presented in Figures A.1 and A.2 of this appendix. (pages A4 and A5)

The reader is reminded that OECD convention is to include R&D in the SSH fields in its BERD estimates.

The OECD estimates Canadian BERD trends from 1980 to 1985 as follows: $2126, 2494, 2518, 2795, 3044 million Canadian current dollars. These figures will be compared to those of other nations in Section B.1 of this paper.
"Selected S&T Indicators 1981-1986", OECD.

The business enterprise sector was expected to perform about 53% of all Canadian R&D in the natural sciences and engineering in 1985. This sector includes the activities of government-controlled corporations offering commercial goods and services (ex. PetroCan, CNR, Ontario Hydro). It also includes industrial research institutes such as the Pulp and Paper Research Institute of Canada.

The vast majority of Canadian firms do no R&D at all. Of the 1,435 companies performing R&D, about 25 (or 2%) account for more than half of all industrial R&D performed.

(Stats. Can., Cat. Nos. 88-201, pp. 82-82 and 88-202, pp. 26-38)

Lest the above statement should lead one to believe that Canada has some large industrial R&D labs by international standards, the following quote is offered as evidence to the contrary:

"One company in West Germany alone, Siemens, has 42% more people on its industrial research and development payroll than the entire country of Canada."

Notes for an address by Brian Mulroney, M.P., Leader of the Progressive Conservative Party of Canada, to a fundraising dinner for the P.C. Canada Fund, Vancouver, November 28, 1983.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.3. THE BERD (cont.)

Three major industries - Communications equipment, wells and petroleum products, and aircrafts and parts (a total of 151 firms) account for 45% of all private sector intramural expenditures on R&D.

(Statistics Canada, Cat. No. 88-202, p.29)

Most industrial R&D activity is funded by the firms doing the work. Direct federal government funding amounted to about 11% of the total in 1982, but the aircraft, communications equipment, and engineering and scientific services industries received roughly 56% of these funds.

Firms with the highest sales figures tend to have the largest R&D expenditures. Smaller firms spend proportionately more on R&D compared to their sales.

(Statistics Canada, Cat. No. 88-202, p.31)

In 1983, there were 1,435 firms that carried out R&D. Of these, 395 were under foreign control. Generally speaking, foreign firms are larger than Canadian ones. The former accounted for $1,012 million of total intramural R&D expenditures in 1983, compared to $1,506 million for Canadian-controlled companies. Ownership changes in the wells and petroleum products industries have led to a higher proportion of R&D expenditures attributable to Canadian-controlled firms.

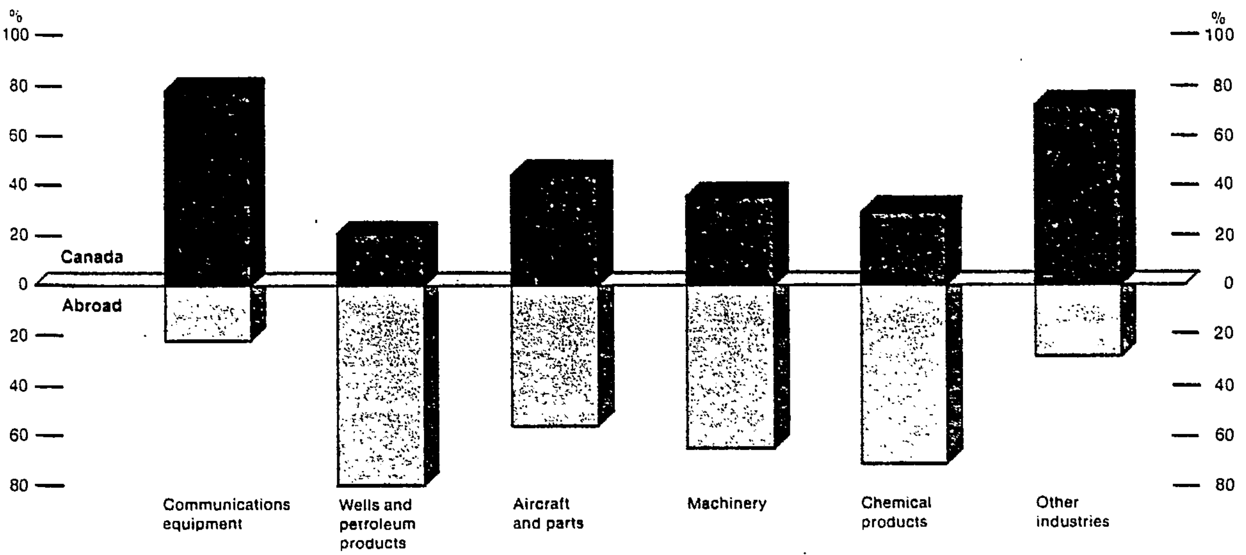
A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.3 The BERD (cont.)

The national importance of our machinery and chemical products industries might prove reason to encourage Canadian-owned expansion in these areas.

Figure A.8

Distribution of Intramural R&D Expenditures, by Country of Control of Performers, for Selected Industries, 1983



Source: Statistics Canada, Cat. No. 88-202, p.33.

Performing firms finance 70 to 75% of their intramural R&D activities. It is interesting to note that federal government and foreign source (affiliated companies) funding consistently account for about 20% of the overall industrial intramural R&D budget. As the size of the R&D budget decreases below $1 million, the federal share of funding increases roughly from 10 to 17%, as the foreign funding drops from 10 to 1%.
(Statistics Canada Cat. No. 88-202, p. 35)

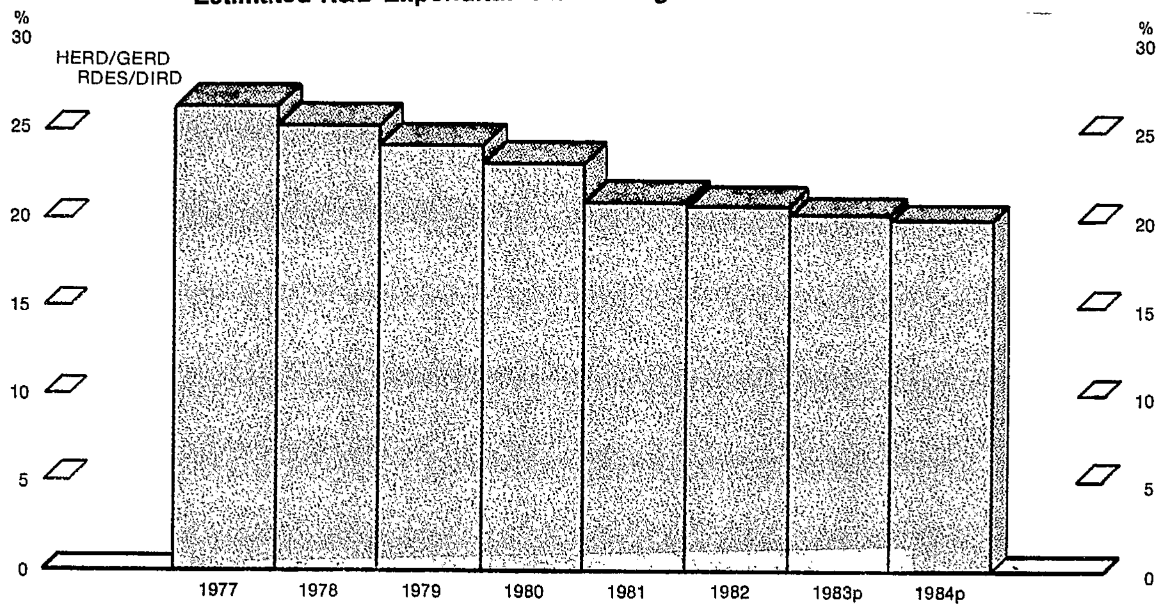
A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.3 THE HIGHER EDUCATION SECTOR

University research and development is very closely linked to the training of graduate students and is a responsibility of most university teachers. Figures A.1 and A.2 show the higher education share of the GERD. Most of the funding attributed to the universities originates from the various levels of government.

Although total research and development funding is slowly increasing in Canada, the proportion of the GERD accounted for by Higher Education R&D (HERD) activities has been decreasing since 1977.

Figure A.9 **Estimated R&D Expenditures in the Higher Education Sector and GERD, 1977-1984**



Source: Statistics Canada Cat. No. 88-203, p.29.

International comparisons, based on OECD data including the SSH, of gross expenditure on Research and Development in the Higher Education sector (HERD) are presented in Appendix B of this paper.

In the fulfillment of their dual role as institutes of education and research, our universities determine the potential of all sectors to expand Canada's expertise in these fields.

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.4. PROVINCIAL EXPENDITURES

Preliminary statistics indicate that $ 188 million dollars was spent on R&D performed within the provincial government and research organization sector in 1985. Provincial government departments utilized 60% of these funds with the remaining 30% going to the provincial research organizations.

(Statistics Canada; refer to Figure A.1)

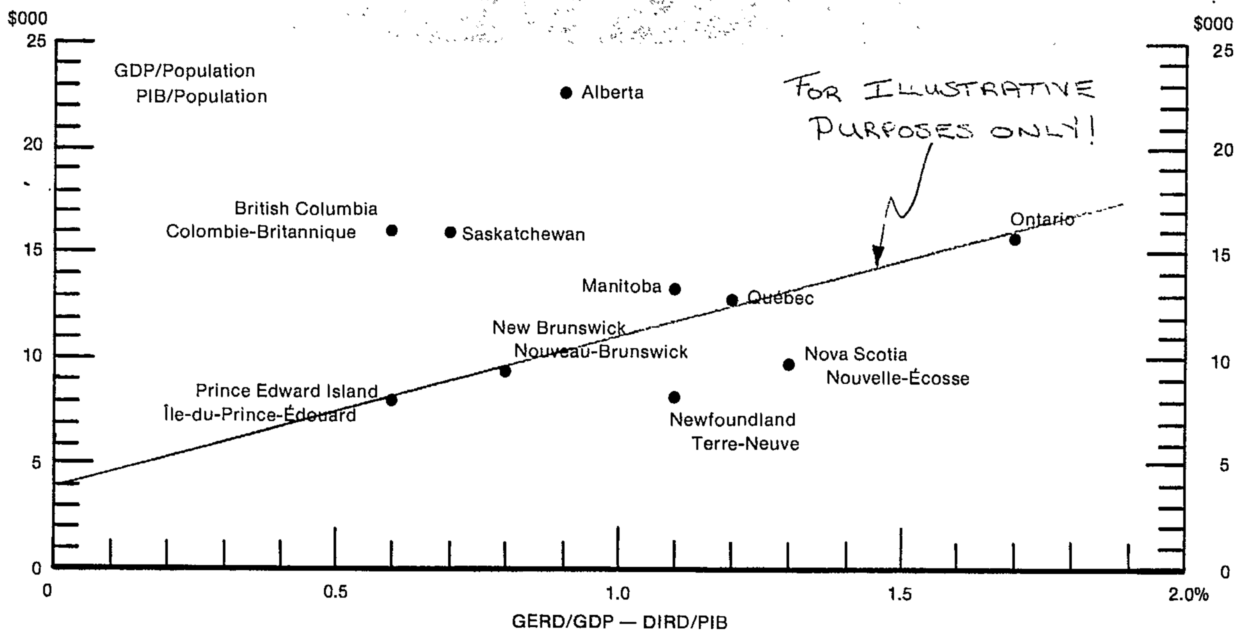
Eight provinces have established **Provincial Research Organizations.** Their common objectives are to carry out research and development activities of particular interest to the province, and to provide technological assistance to primary and secondary industries.

The reader is referred to "The Federal Source Book" and "the Provincial Source Books", prepared by the National Science and Technology Policy Secot of MSST, for further information on the contributions of the various provinces to Canada's research and development effort.

Figure A.10

Provincial GDP, Population and GERD, 1982

PIB, population et DIRD des provinces canadiennes, 1982



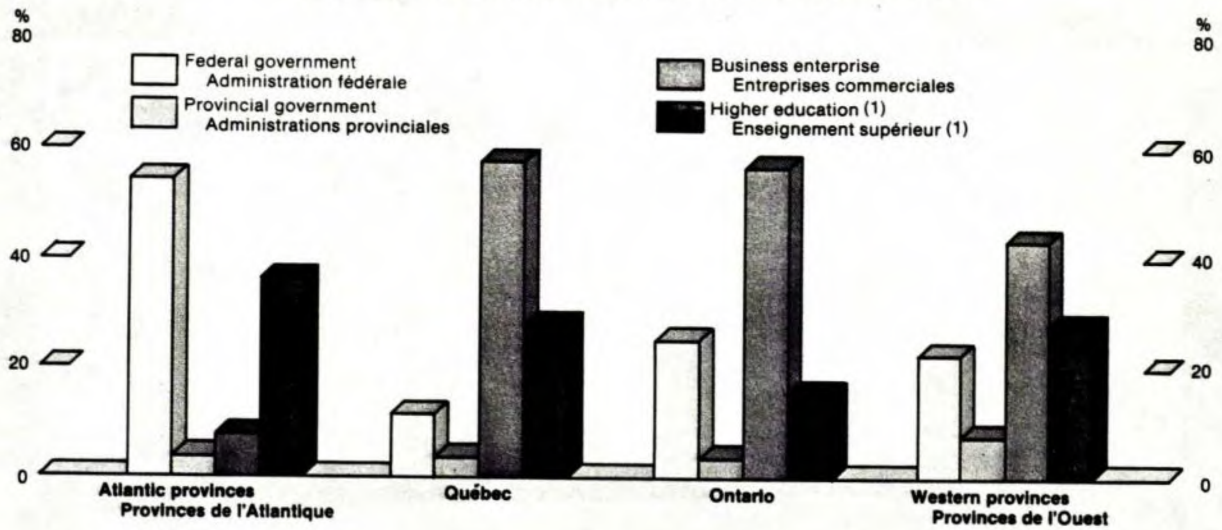
Source: Statistics Canada Cat. No. 88-203, p. 51.

A.2 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

A.1.4. THE PROVINCIAL GOVERNMENTS (cont.)

Figure A.11

Regional R&D Expenditures, by Performing Sector, 1982

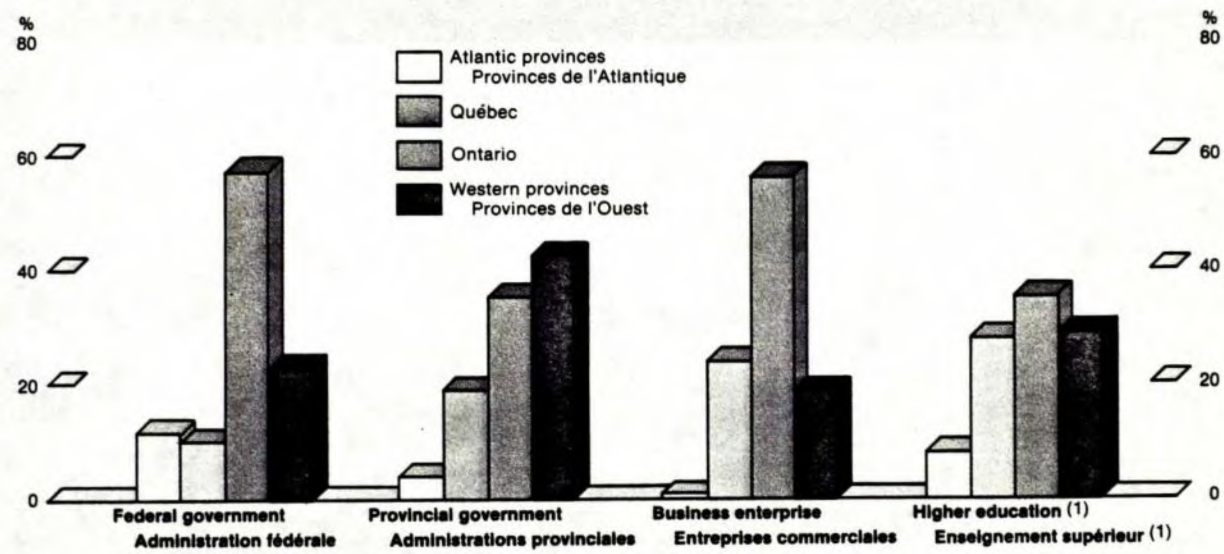


(1) Including private non-profit sector.

Figure A.12

R&D Expenditures by Performing Sector and by Region, 1982

Dépenses de R-D par secteur d'exécution et par région, 1982



(1) Including private non-profit sector.

Source For Both Figures: Statistics Canada Cat. No. 88-203, p.49

A.1 RESEARCH AND DEVELOPMENT EXPENDITURES (cont.)

PRIVATE NON-PROFIT ORGANIZATIONS

This is the smallest sector in the Canadian GERD accounts. It exists mainly as a source of funds for medical research in the higher education sector. Most of the funds attributed to this sector are donations from individuals and corporations to the health organizations dedicated to treatment and research for specific diseases or health problems.

About 80% of the R&D expenditures of these organizations are spent on university-performed R&D.

A.2 THE QUALITY OF RESEARCH PERFORMED

BIBLIOMETRICS

The relatively new field of bibliometrics has been developed to characterize the authors, users and subject matter of a specific group of documents. A bibliometric analysis includes counts of publications and citations; both of which are well-established indicators of research activity and impact.

Although there are at least 30,000 scientific journals published worldwide, the most influential core of research findings are published in ten mainstream journals. About 90% of all international scientific findings are published in fewer than 1,000 journals.

For a given group of journals, publication and citation files may be accumulated based on author, institution, or country. Levels and trends regarding the share of all papers published and the share of higher quality papers (as measured by the number of times the paper is cited) can be established and compared.

In 1978, Canada's world shares of papers cited in the three main journal classes of chemistry, biochemistry and medicine were estimated to be about 7, 3 and 3% respectively. These numbers are somewhat less despairing when one realizes that the U.S. is the only country to publish more than 10% of the relevant papers in any of the three main classes and that American papers account for over 50% of the relevant papers in each of the three classes!

(Statistics Canada Cat. No. 88-507E)

In 1978, the university sector accounted for 70% of all Canadian scientific papers published in that year. Hospitals, including university clinics accounted for 13%; as did the federal government. The business sector contributed 2% of published scientific papers and the provincial governments and non-profit organizations each accounted for 1%.

It is interesting to note that American universities account for a similar proportion of all scientific papers published from that country, but American industrial laboratories account for about 9% of this activity as opposed to a Canadian business contribution of 2%.

A.2 THE QUALITY OF RESEARCH PERFORMED (cont.)

Bibliometric analyses suggest that Canada's scientific strengths are most evident in the fields of medical biochemistry, applied physics and electronics. Main mathematics, physics, computer science, chemical analysis and ecological studies are also areas of relative Canadian expertise.

The quality of scientific activity at a given facility is not a simple function of its size, quantity of output or level of funding. Rankings of the top Canadian laboratories in various fields are presented below. In the field of applied physics and electronics, many key papers involved university collaboration with federal laboratories.

Figure A.13

Canadian Laboratories in the Top Percentile of Pharmacology and Clinical Chemistry, 1978 Reference Year

Canadian rank	Organization	Overall frequency	Frequency in top decile	Frequency in top percentile
1	McGill University	133	7	1
2	Queen's University	43	9	4
3	University of Saskatchewan	25	7	1
4	University of Toronto	159	23	2
5	Ontario Cancer Institute	7	1	1
6	University of Windsor	3	1	1

Figure A.14

Canadian Laboratories in the Top Percentile of Main Biochemistry, 1978 Reference Year

Canadian rank	Organization	Overall frequency	Frequency in top decile	Frequency in top percentile
1	McGill University	144	18	1
2	University of Toronto	282	40	4
3	National Research Council - Ottawa	82	12	2
4	Atomic Energy of Canada Ltd.	8	5	5
5	University of Montreal	71	9	1
6	Ontario Cancer Institute	16	6	1
7	University of Guelph	20	7	1

Source For Both Figures: Statistics Canada Cat. No. 507E, p.19

A.2 THE QUALITY OF RESEARCH PERFORMED (cont.)

Figure A.15

Canadian Laboratories in the Top Percentile of Biochemistry and Cell Biology, 1978 Reference Year

Canadian rank	Organization	Overall frequency	Frequency in top decile	Frequency in top percentile
1	University of Sherbrooke	16	4	1
2	University of Toronto	148	12	2
3	Carleton University	20	4	1
4	University of Western Ontario	32	4	2
5	Sick Children's Hospital	22	3	1
6	Laval University	24	10	1
7	Ontario Cancer Institute	2	1	1
8	Laval Centre Hospital	1	1	1
9	Simon Fraser University	13	1	1

Figure A.16

Canadian Laboratories in the Top Percentile of Applied Physics and Electronics, 1978 Reference Year

Canadian rank	Organization	Overall frequency	Frequency in top decile	Frequency in top percentile
1	University of Toronto	121	19	4
2	National Research Council	136	14	4
3	University of Windsor	18	3	1
4	Atomic Energy of Canada Ltd.	57	9	2
5	University of Saskatchewan	7	3	2
6	Queen's University	29	5	1
7	Trent University	2	2	2
8	University of Western Ontario	38	8	5
9	McMaster University	101	14	2
10	University of Montreal	48	9	2
11	University of Manitoba	23	3	1
12	University of Ottawa	13	1	1

Source For Both Figures: Statistics Canada Cat. No. 88-507E, p.20

A.2 THE QUALITY OF RESEARCH PERFORMED (cont.)

In 1974, Canadian scientists co-authored papers with counterparts in 13 foreign countries. This number increased to 19 in 1978. American scientists co-authored with 42 foreign countries. The total number of Canadian papers co-authored with foreign countries or within Canada remained constant through the Seventies.

With the growing importance of interdisciplinary, cross-sectoral and international research and development collaborations, a marked increase in the number of co-authored papers should be evident in the next revision of this data.

(Statistics Canada Cat. Nos. 88-507E, pp. 14-21 and
88-201, pp. 97-99)

PATENTS

Although not all inventions are patented and not all patents lead to new innovation, patent statistics do give insight into the generation of potentially marketable advances in products and processes.

It is estimated that less than half of Canadian corporate inventions are patented and that patent statistics tend to exaggerate the contribution of smaller firms and individuals.

According to the Statistics Canada publication Science and Technology Indicators 1984, in 1982 our major patenting institutions were:

Northern Telecom	(80 patents)	DND	(40 patents)
CGEC	(21)	Domtar	(13)
Imperial Oil	(12)	DuPont Can.	(12)
EMR	(11)	NRC	(10)
ERCO industries	(10)		

In general, Canadian patent statistics indicate that the rate of invention in Canada is stable, that we are not as active in newer technologies as our international competitors and our relative rate of invention (patents per capita) is lower than that of the U.S.A.

It is important to note the strong impact that federal government legislation has on the number and nature of patents applied for by Canadians both domestically and abroad. The federal government has committed itself to revising the Patent Act to facilitate Canadian research and development.

Revisions might include changes to the compulsory licensing provisions of the Act, modifications to the regulations regarding intellectual property rights, and streamlined operations to reduce the backlog of applications currently on

A.3 RESEARCH AND DEVELOPMENT PERSONNEL

The overall numbers of persons engaged in S&T and R&D activities and the characteristics of these select work forces offer additional indications of our nation's scientific and technological maturity and potential.

At the time of the 1981 census, the total labour force in Canada was 12,267,075 people.
(Statistics Canada, Cat. No. 92-920)

In 1981, 514,000 Canadians were working as scientists, engineers or technologists. This category represents about 5% of the total labour force.
(Stats. Can., Cat. No. 88-201)

Most people engaged in R&D activities do not devote 100% of their working time to research as such. Administration and teaching are the most common secondary occupations of Canadian researchers. This part-time balance between job responsibilites is accounted for by quoting full-time equivalent number of positions.

In 1983, 72,470 persons were engaged in R&D in Canada. This represented about 0.6% of the total work force. These seventy-odd thousand positions were filled roughly 45% by scientists and engineers, 30% by technicians and 25% by support staff.

The distributions of research and development personnel and SET personnel according to GERD sectors are illustrated below.

(Stats. Can., Cat. Nos. 88-201, 88-202, 88-203, pp.34-40)

Figure A.17 DISTRIBUTION OF RESEARCH AND DEVELOPMENT PERSONNEL

(1983)

Sector	Number of R&D Personnel
Federal Govt.	17,170
Provincial Govts.	4,550
Business Enterprise	35,400
Higher Education	13,630
Private Non-Profit	1,720
Total	**72,470**

Source: Statistics Canada,

A.3 RESEARCH AND DEVELOPMENT PERSONNEL (cont.)

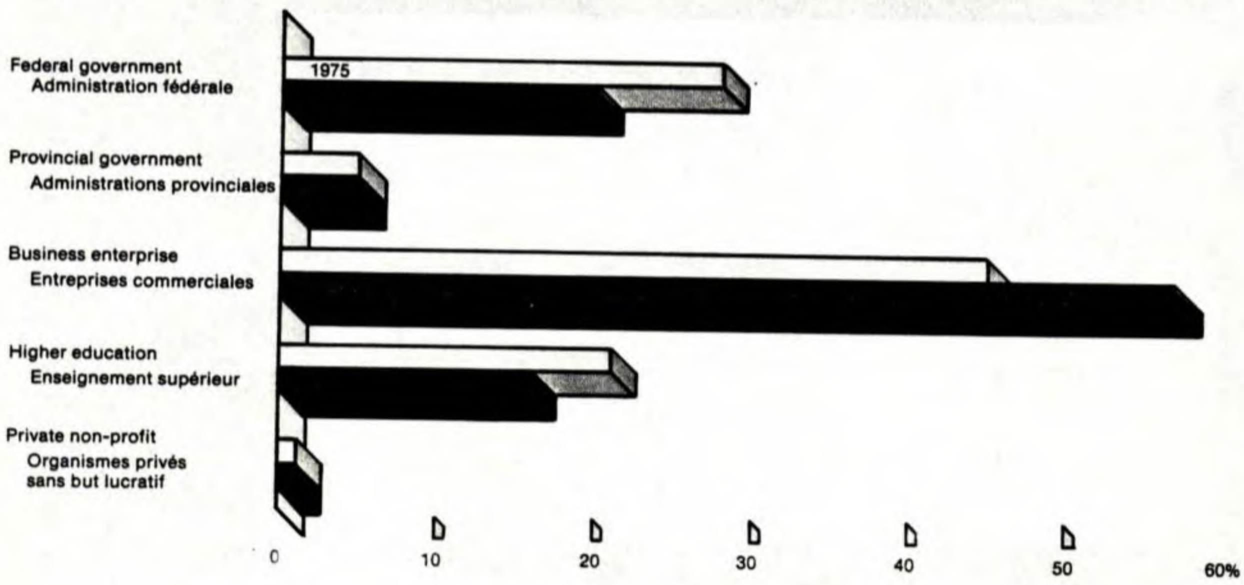
The number of people engaged in research and development activities in Canada increased by 35% over the 1972-82 period. The number of scientists and engineers within this group increased 52%. Growth was slow only in the federal government and higher education sectors.

(Stats. Can. Cat. Nos. 88-203, p. 34 and 88-201, p. 30)

Figure A.18

Distribution of Scientists and Engineers, by Sector, 1975 and 1982

Répartition des hommes de science et des ingénieurs par secteur, 1975 et 1982



Source: Statistics Canada Cat. No. 88-203, p.35

A.3 RESEARCH AND DEVELOPMENT PERSONNEL (cont.)

Within the federal government, the number of people engaged in research and development activities has increased by less than 10% in the last decade. The fraction of scientists and engineers within this group increased by 802 people, the number of technicians dropped slightly, as did the number of military personnel. The number of persons filling executive positions for research and development activities grew by 175 people.

(Stats Can Cat. No. 88-001, Vol.9, No.9, August 1985)

The business enterprise sector accounts for over 50% of all Canadian R&D personnel. There has been a 66% growth in this sectoral work force from 1975-82. The service industries in particular had a 284% growth in R&D personnel. Communications equipment and aircraft & parts accounted for over 32% of human resources devoted to industrial R&D in 1982.
(Stats. Can. Cat. No. 88-203, p. 40)

Within private industry, the highest growth rate in R&D personnel was in the scientists and engineers category (91%), compared with 63% for technicians and 30% for support staff categories.

Within industry, about 40% of SET personnel work in the service industries followed by the public administration (19%), and the manufacturing sectors. The latter sector, along with the construction, transportation and communications industries account for the bulk of this country's economic activity.

Refer to Section A.4 for information regarding human resources in the higher education sector. Person-years devoted to R&D in the higher education are not has accurate as those quoted for the other sectors.

A.4 EDUCATION AND TRAINING

Research and development comprise the first component of the national science and technology perspective. Education and training in the fields of science and technology form the second component. Obviously, the two components are highly interrelated.

> "In circumstances such as those of today, the economic health and future development of Member countries depend to a very considerable extent on the capacity of their education system, notably their university education and research system to train and prepare the young generations. This task must be considered in a long-term perspective. Focusing education and scientific research on short-term economic needs and immediate benefits at a time when all the parameters of economic activity are changing, could jeopardise the achievement of the longer term requirements. It is these however that will be really decisive in determining that the challenges raised by the changes underway be met successfully."
>
> Committee for Scientific and Technological Policy, Scinece, Technology and Competitiveness, Analytical report of the Ad Hoc Group, OECD, Jan. 1985, SPT(84), DSTI 3749S, pp. 41,42.

UNIVERSITY TEACHING STAFF

Post secondary teachers in the fields of S&T constitute a very important sector of the pool of human resources for this field because:

1. They are the leading producers of scientific reference material
2. They educate younger generations of highly skilled S&T personnel
3. They are a major consumer of scientific and technical goods and services.

A.4 EDUCATION AND TRAINING (cont.)

In 1981, there were over 33,600 full-time university teachers in Canada, a rise of 25% from 1971.
(Stats. Can. Cat. No. 88-201, p.35)

The proportion of total teaching staff in the NSE fields was about 45% in 1981. Two-thirds of this staff were working in the health sciences, mathematics and physical sciences. The remainder were in engineering (8%) and agriculture and biological sciences (7%).
(Stats. Can. Cat. No. 88-201, p. 36)

"Following the post-war baby boom, Canada like most industrialized nations, experienced a slowdown in population growth. This inevitably has led to the ageing of the population and by 2001, 11% to 12% of Canada's population is expected to be 65 or over, compared to under 9% in 1976. A similar trend is seen in the teaching population. "
(Statistics Canada Catalogue Number 88-201, p. 37 and Canada Year Book, 1981, p.112)

Figure A.19

Median Age of Full-time University Teachers, by Selected Teaching Field
Âge médian des professeurs d'université à plein temps, selon certains domaines d'enseignement

Teaching field Domaine d'enseignement	1970	1975	1981
		years – années	
Social sciences Sciences sociales	34.2	37.1	40.1
Agriculture and biological sciences Sciences agricoles et biologiques	39.1	40.2	42.2
Engineering and applied sciences Génie et sciences appliquées	37.2	41.0	44.1
Health sciences Sciences de la santé	40.0	41.1	43.1
Mathematics and physical sciences Mathématiques et sciences physiques	36.0	39.0	42.2
All fields **Ensemble des domaines**	**37.1**	**39.2**	**42.2**

Source: Statistics Canada Cat. No. 88-201, p. 38.

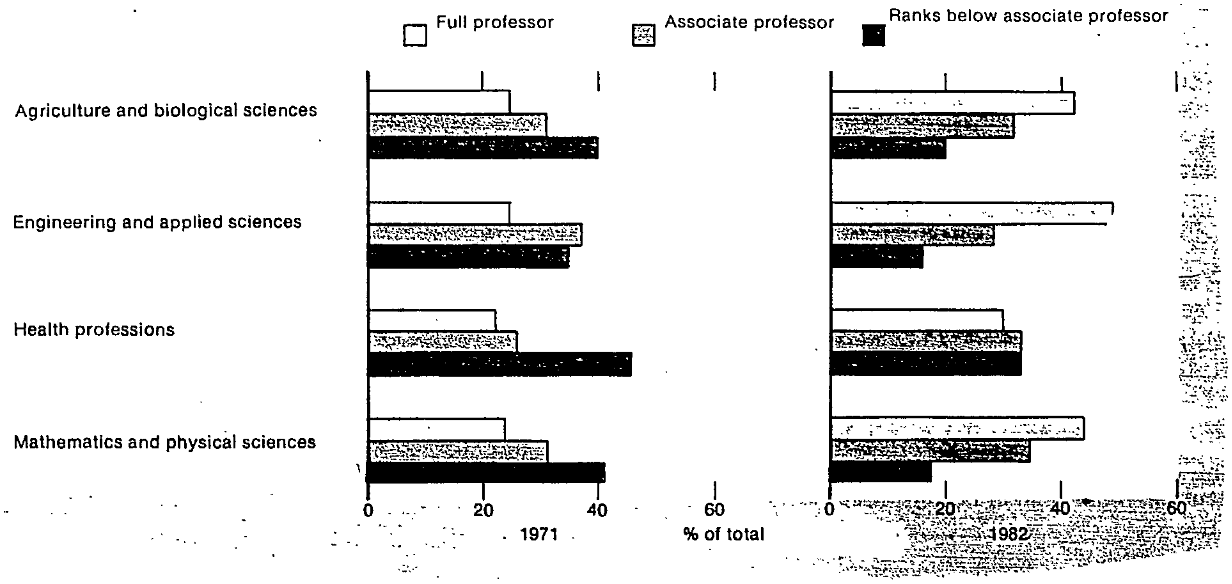
A.4 EDUCATION AND TRAINING (cont.)

> "The average age of engineering and applied science teachers showed the greatest increase in median age. This might imply that the renewal of staff in this field was less than in others. This ageing of the teaching population could point to a slowdown in the acquistion of new knowledge, since new, younger staff often contribute ideas that help break new ground in scientific research."
> (Statistics Canada, Catalogue Number 88-201, p.38)

The ageing trend that occurred over the Seventies is also reflected in the hierarchal structure of NSE academia. From 1970 to 1981, the pyramid-shaped distribution of full, associate, assistant professorships and other technical staff inverted to reveal a top-heavy environment dominated by full professors. This trend was less pronounced in the health sciences field, as was the relative increase in median teaching age of this field.

Figure A.20

Distribution of Full-time University Teachers in the NSE, by Academic Rank



Source: Statistics Canada Cat. No. 88-201 p.40.

A.4 EDUCATION AND TRAINING (cont.)

This trend highlights the practice of promoting academic professionals on the basis of age and seniority rather than research or/and teaching ability.

This practice may be a factor in the low interest in academic careers displayed by Canadian youth. The perquistes, rewards and opportunities available to successful academic researchers may not be adequately developed or communicated.

Are there new options that should be considered for the management and development of scientific academic careers? Might these options also be applicable to other fields and levels of research and education?

STUDENT POPULATION

"...had it not been for the strength in foreign student participation (prior to the significant increase in Canadian enrollment in the early 1980's), many (university) departments would have had difficulty maintaining their graduate programs and research. With the introduction of significantly higher student fees by a growing number of provinces, the growth in foreign student enrollment is expected to level off."

NSERC, Research Talent in the Natural Sciences and Engineering, May 1985.

Since 1960, full-time student enrollment in Canadian universities increased by about 300%, with much of that growth coming in the eighties. Part-time enrollments have increased over 300% in less than twenty years.

Changing Economic Circumstances: The Challenge for Postsecondary Education and Manpower Training, Statement of the Council of Ministers of Education, Canada, October, 1985.

In the early 1980's, the growth in enrollment escalated. It is postulated that the renewed interest by young Canadians both at the under- and post-graduate levels was a direct result of the recession that dried-up the job market for many fresh university graduates.

A.4 EDUCATION AND TRAINING (cont.)

HIGHLY QUALIFIED MANPOWER

For the past number of years, the Natural Sciences and Engineering Research Council (NSERC) has maintained that increased funding of university research grants is needed to increase the numbers of highly qualified persons available both for private and public sector employment and for continuation of academic research and instruction.

Research Talent in the Natural Sciences and Engineering, NSERC, May, 1985:

"Manpower will be a major challenge in the attainment of future increases in R&D activity. Shortages are likely to be most severe in the fields of Computer Science, some fields of Engineering, some fields of forestry, and Biotechnology.

In view of recent unemployment statistics, this arguement must be sharpened. In fact, there is not a shortage of highly qualified manpower available for employment. This statement is based on three observations:

1. According to Statistics Canada, two years after their graduation, 6.3% of the 1982 engineering graduates were unemployed. It is important to note that this figure does not include recent graduates who either have not been able to penetrate the job market or who are employed in jobs not directly related to their educational background. This figure may be compared with the national unemployment rate in 1984 of 11.3%.

2. Discussions with local school boards reveal that they experience no difficulty whatsoever in hiring well-qualified science and mathematics teachers at all levels.

3. While some industrial employers have expressed concern over a lack of qualified applicants, the vacant positions are in specialized fields and often require previous industrial experience.

It is presumed that the unemployment rate for university graduates in the natural sciences is at least equal to that for engineers since the latter group has traditionally been more readily absorbed into the labour force.

A.4 EDUCATION AND TRAINING (cont.)

Having established that there are unemployed engineers and scientists in Canada, it is important to recognize that the unemployment rates for these groups falls dramatically at the Ph.D. level of expertise. Granting that the relative numbers in this sub-group are few, nevertheless the unemployment rate for Ph.D. level engineers is only 3.3%.

Statistics Canada quotes a "participation rate" for various population sub-groups. This participation rate is the labour force of the sub-group expressed as a percentage of the population of that sub-group. In other words, the percentage of that group who are either actively seeking work or are gainfully employed.

The unemployment rate represents the number of unemployed persons who are actively seeking employment as a percentage of the labour force for that group.

Then, for a given population group, it would be most desirable to see a high participation rate and a low unemployment rate.

This is indeed the case for university graduates, as is shown below.

Further research is needed to analyse the apparent enhanced "employability" of post secondary education graduates.

Figure A.21

ESTIMATES BY EDUCATIONAL ATTAINMENT, NOVEMBER 1985

ESTIMATIONS SELON LE NIVEAU D'INSTRUCTION, NOVEMBRE 1985

	POPULATION 15 YEARS AND OVER / POPULATION DE 15 ANS ET PLUS	LABOUR FORCE / POPULATION ACTIVE: TOTAL	LABOUR FORCE / POPULATION ACTIVE: EMPLOYMENT / EMPLOI	LABOUR FORCE / POPULATION ACTIVE: UNEMPLOYMENT / CHOMAGE	NOT IN LABOUR FORCE / POPULATION INACTIVE	PARTICIPATION RATE / TAUX D'ACTIVITE	UNEMPLOYMENT RATE / TAUX DE CHOMAGE	EMPLOYMENT/POPULATION RATIO / RAPPORT EMPLOI-POPULATION
	THOUSANDS - MILLIERS					PER CENT - POURCENTAGE		
CANADA	19,452	12,673	11,427	1,246	6,779	65.2	9.8	58.7
0-8 YEARS - 0 A 8 ANNEES	3,633	1,447	1,264	183	2,185	39.8	12.7	34.8
HIGH SCHOOL (1) - ETUDES SECONDAIRES (1)	9,734	6,448	5,702	745	3,286	66.2	11.6	58.6
SOME POST-SECONDARY - ETUDES POSTSECONDAIRES PARTIELLES	1,805	1,274	1,161	113	531	70.6	8.9	64.3
POST-SECONDARY CERTIFICATE OR DIPLOMA - CERTIFICAT OU DIPLOME D'ETUDES POSTSECONDAIRES	2,307	1,827	1,697	130	480	79.2	7.1	73.6
UNIVERSITY DEGREE - GRADE UNIVERSITAIRE	1,973	1,676	1,603	74	297	85.0	4.4	81.2

Source: Statistics Canada, Cat. No. 71-001, November 1985, p31.

A.4 EDUCATION AND TRAINING (cont.)

The statistics presented in this section tend to suggest that a modification to the present argument for university funding may be justified. The impetus for government funding for higher education may be less a matter of filling an existing or projected demand from industry and more a matter of providing the younger population with the education, confidence and wherewithal to actively seek and maintain employment.

A.4 EDUCATION AND TRAINING (cont.)

GROSS EXPENDITURE ON R&D IN THE HIGHER EDUCATION SECTOR (HERD)

At the beginning of this appendix figures A.1 and A.2 illustrated the important role of universities in our national research and development effort.

According to OECD statistics that are presented in Section B.4 of this paper, our national investment in R&D performed by universities, both in terms of amounts and trends, is not unlike that of other nations, perhaps with the exception of Japan and Sweden.

Other university funding statistics do raise grave cause for concern.

According to "The University Research Sector", December 1985 draft report prepared by the University Research and Granting Council Branch of MSST, the growth in federal transfer payments to the provinces via the Established Program Financing (EPF) agreements for postsecondary education have not been matched by increasing funds from the provinces. In fact, although education has traditionally been a provincial responsibility, the average federal PSE contribution via EPF was 80% of total PSE operating grants in 1984-85. For five provinces, the federal PSE contribution exceeded the total PSE operating grant issued by the province. This is in stark contrast to the balance of funding just seven years ago, when federal payments comprised only 65% of the PSE operating budget.

Provincial neglect of postsecondary education is amplified by higher enrollments resulting from the national economic slowdown. The recession also triggered a renewed emphasis on university research and development as a catalyst to industrial innovation.

At the beginning of this decade, university operating expenditures per full-time student dropped significantly:

1977-78	1982-83
$3,072	$2,746

Universities are being asked to educate more students and perform more research with fewer dollars. This fincancial squeeze has been the prime motivating factor for the recent trend towards university/industry collaborative research and development activites.

A.4 EDUCATION AND TRAINING (cont.)

GROSS EXPENDITURE ON R&D IN THE HIGHER EDUCATION SECTOR (HERD)

Federal and provincial governments have been consistent in their vows to support university education and reserach. This "fundamental priority" has been restated at every federal/provincial conference on Science and Technology since September 4, 1984.

According to the aforementioned MSST paper,

"It is generally agreed that universities can and should play a stronger role in the commercial research interests of industry and government's shorter-term economic objectives. It is also recognized that (these) roles can only be effective and sustained to the extent that (they) are built on excellence in basic research and quality teaching."

The current era of fiscal restraint compels all funders of research and development activities to reexamine the cost/benefits of their programs; thereby triggering the performers of research and development in Canada to reexamine their position in the national scientific and technological community.

Under these conditions it is entirely logical for the federal government to give serious consideration to the gradual transfer of some research staff and operating programs to the university sector.

A gradual flow of basic scientific research expertise and responsibility from government to universities would encourage the "critical mass" of brain power that is deemed necessary in the current generation of "big science". It would enable a scale-down of federal administration, but not of funding as this responsibility would still lie with the two levels of government and industry. It would strengthen the depth of university NSE research expertise and opportunities, thus enabling a larger and more flexible PSE operating budget.

The resulting enhancement of university research capabilites would have a significant positive impact on the education mission of the universities. Such a gradual transfer of scientific and technical staff and operations would be in keeping with the "Contracting-out Policy" of the Federal government.

A.4 EDUCATION AND TRAINING

The importance of liberal arts and humanities studies at the university level must not be undermined by the national urgency for increased scientific and technological competence. In the future, increased cooperation between NSE and SSH personnel will be an advantage in the research, development and successful commercialization of new goods and services.

The service sector is one of our fastest growing sectors of our economy. It accounts for 68% of the American GNP and 74% of American employment.
Report on Business, B10, The Globe and Mail, January 1, 1986.

THE VITAL INTERNATIONAL COMPONENT - REVERSING THE BRAIN DRAIN

The fields of science and technology are truly international. Analogies are found in the arts, music and sports communities. These communities are an immense source of national pride and identity. We enjoy and perhaps sometimes prefer foreign performances, but would feel a sense of loss and shame if there were no comparable Canadian talent.

As Canadians, we take pride in the achievements of our compatriots but have grown accustomed to the exodus of our brightest stars. Until recently, this was inevitable. But as our population grows and we mature as a nation, we are developing the infrastucture and support systems needed to encourage and challenge the best talent from home and abroad. This development will continue as Canada establishes its own role models and mentors for the coming generations.

This ability to support our finest scientists and engineers and to attract those from other countries is essential to our economic stability and growth.

The economic potential inherent in each of Canada's best scientists, engineers and technologists is greater than that of the elite of any other field of endeavour.

A.4 EDUCATION AND TRAINING

The E.W.R. Steacie Memorial Fellowship is one of Canada's most prestigious science awards. The backgrounds of the four 1985 winners of this award underscore both the international nature of scientific research and the critical importance of attracting and maintaining top-notch expertise.

Robert Emery Prud'homme has excelled in the study for polymer structures. His work may lead to new uses for commonly produced industrial polymers. Born in Quebec, Mr. Prud'homme was an NSERC postgraduate scholar. He obtained a Ph.D. at the University of Massachussets.

Dr. Euan G. Nisbet is described as "one of the most able, innovative and original earth scientists of his generation". Raised in Zimbabwe, Dr. Nisbet graduated from Cambridge University, England. He also worked in Switzerland. Mr. Nisbet joined the University of Saskatchewan in 1981.

Dr. Tak Wah Mak received his Ph.D. in biochemistry in 1981 from the University of Alberta after completing undergraduate and graduate studies at the University of Wisconsin. Since 1974, he has been a senior staff scientist at the Ontario Cancer Institute as well as a member of the Department of Medicsal Biophysics and Immunology at the University of Toronto. In 1985, Dr. Mak led a Canadian research team to an important international breakthough in immune research.

Born in Toronto, David Handleman received his undergraduate training at the University of Toronto and his graduate degrees at McGill University. Following a one-year NATO fellowship in West Germany and a session as lecturer at the University of Utah, Dr. Handleman joined the University of Ottawa where he is now a full professor and member of the Royal Society of Canada. He is an international leader in the theory of operator algebras, an area of mathematics useful in describing complicated physical phenomena.

A.4 EDUCATION AND TRAINING

In this analysis it would be remiss to omit the important contribution made by Canadian community colleges. These colleges train the technicians and technologists who play an increasingly vital role in scientific research and development. As the fields of science and technology merge, the expertise of technicians and technologists enables increased research productivity.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE

Evaluation of this third component to the science and technology mosaic is the most challenging and, perhaps, the most meaningful.

It is interesting to note that the Federal govenment budgeted $500 million for scientific data collection and information services for 1984-85.
(Stats. Can. Cat. No. 88-201, p. 55)

THE DIFFUSION OF KNOWLEDGE

According to Statistics Canada:

"Scientific and technological information is a prerequisite to any activity within these fields. Today we build from ever larger bases. An increasingly vast foundation of scientific and technological knowledge must be efficiently absorbed to prevent useless or wasteful employment of our chief source of wealth, the human intellect."

In The Bottom Line, the Economic Council of Canada made a number of recommendations for the improvement of Canadian productivity.

These recommendations included, among others, the following points:

- The provincial governments should allocate funds to the diffusion of existing best-practice techniques of operation within the non-market industries that fall within provincial or municipal jurisdiction - mainly the hospital and medical-care, education and public administration sectors.
  (This recommendation could be expanded to include the non-market industries falling under federal jurisdiction and government procurement at all levels.)

- Trade associations in the service sector should adopt as one of their primary responsiblities the collection and dessemination to member firms of information on new ideas and best-practice technology and management methods in use in Canada and abraod.

There are no statistics directly detailing the trends in and costs of collection, storage and use of scientific and technological information in Canada. In the absence of such data, a few outstanding examples of the literally hundreds of Canadian establishments handling scientific and technological information are presented.

2.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

Within the Federal government, the National Research Council operates two major sources of S&T information.

The Canadian Institute for Scientific and Technical Information **(CISTI)** provides a wide range of information services including access to the world's published scientific literature and computerized scientific data bases. CISTI's client base can be described as roughly 50% industrial, 30% government and 20% university. About $5 million of a total budget of approximately $30 million are recovered from users.

The NRC's Industrial Research Assistance Program **(IRAP)** offers both a Field Advisory Service and a Technical Information Service. Both services offer information to industry regarding the latest and best technological methods available for industrial application. The field advisory sevice operates 25 regional offices in conjunction with some provincial reserach organizations. The technical information service is located in Ottawa and recieves over 20,000 enquiries annually from over 500 firms.

In the Council's proposed five year plan, there is an increased emphasis on technology transfer and diffusion. The National Research Council has been recognized as having significant strength in this area. The Council shared the 1985 Canada Award of Excellence Gold Medal for Technology Transfer with Lumonics Inc. These two organizations have teamed together to very successfully commercialize the technology of high-powered lasers.

In fact, this degree of excellence is not new to the NRC. In 1984, the Council shared a gold medal with Sciex Inc., a Toronto-based manufacturer of mass spectrometers.

A third important federal initiative for the disemmination of scientific and technical information is the **Patent Office.** Operated by the Department of Consumer and Corporate Affairs, this office is undergoing changes designed to provide the S&T community with easier access to international and Canadian patent information and assessments of current leading edge technology or science in a specifc field.

In the provincial sector, there are three types of organizations that each have a responsibility to disseminate S&T information.

The Provincial Research Organizations **(PROs)** have been established in eight provinces to perform research and development of particular interest to the province and to provide technical information and advice to SMEs.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

Most provicial governments are complementing the work of their PROs with a mechanism for transferring technology to provincial industries. Some of the more active provinces have established **Provincial Technology Centres** to this aim.

Centres for Industrial Research and Technology have sprung up to encourage interaction between industry, university and PRO activities and needs. Their technical expertise and assistance includes contract research.

Within the industrial sector, it is often the **trade associations** that initiate cooperative R&D activities. There are an estimated 20 **Industrial Research Associations,** some of whom receive some government support. Some of the beeter known associations are: Forintek Canada Corporation, The Pulp and Paper Research Institute of Canada, The Welding Institute of Canada, the Canadian Gas Research Instititute and the Sulphur Development Institute of Canada.

Yet another type of initiative along this vein is just beginning to appear on university campuses. **Industrial Innovation Centres** assist the marketing efforts of inventors, study the entrepreneurial process and teach students how to establish their own companies for the exploitation of new products and processes.

The reader is directed towards the **Federal and Provincial Source Books** compiled by the National Science and Technology Policy Sector for further details regarding specific government initiatives for the dissemination of S&T information.

In the business enterprise sector, the transfer of technical information can be divided between transfers within multinational enterprises **(MNEs)** and transfers between unrelated companies. Transfers from universities to private firms are playing an increasingly important role.

The formation of MNEs has, to a large degree, been encouraged by the presence of international trade barriers. MNEs provide fertile ground for international technology transfers. However, often the price a nation pays for the freer access to such information is in increased imports from the country of control of the MNE.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

According to statistics on direct investments during 1978:

" one could postulate ... that there could be a net inflow of technology to Canada from the U.S.A., and a net outflow of technology from Canada to other countries."

Statistics Canada, "Science and Technology Indicators 1984", p. 149.

It is important to note that different types of direct investment by MNE's in the host country have varying degrees of positive effect on the scientific and technological capacities of the host. The extent and nature of R&D performed by the MNE is critical. Minor testing and trouble-shooting projects will be much less catalysing to the host environment than major R&D and innovative projects.

"MNEs can be relied on to ensure the most rapid forms of technology diffusion, both internationally and domestically. They will also make a contribution to the development of indigenous scientific and technical capacities in host countries, but will generally do so , of course, within the limits of sound business practice and **in the context of clearly defined domestic policies.**"

Committee for Scientific and Technological Policy, Scinece, Technology and Competitiveness, Analytical report of the Ad Hoc Group, OECD, Jan. 1985, SPT(84), DSTI 3749S, p. 39.

Non-related companies traditionally transferred or exchanged technology by means of **licensing agreements**. The relatively new practice of **cooperative research and development programs** is another route for technology tranfer between independent firms.

"Cooperative arrangements are increasing in high-technology areas where there are many opportunities but research costs and the costs of developing new products are high, where foreign market entry requires participation with local firms (author's note: ex. Japan), where there are possibilities for rationalization, or where competititve conditions are changing rapidly."

Organization for Economic Co-operation and Development, Committee for Scientific and Technological Policy, "The International Flow of Technologies - Draft Progress Report to the Council", OECD, Paris, 17 January 1984, pp. 4&5.

As stated previously for coauthored patents, a marked increase in the number of cooperative industrial international R&D projects and licensing agreements should be evident in the next series of Canadian scientific and technological statistics.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

THE APPLICATION OF KNOWLEDGE

The simple phrase "application of knowledge" belies the creativity, ingenuity and expertise that is brought to bear on a problem. It is the application of knowledge that leads to scientific and technological advances.

The following presentation will focus on the application of knowledge in the busines enterprise sector. In this context, technological advance and innovation will refer to the same occurrence, the introduction of something new - borrowed, bought or unique ideas - to the production of goods and services.

Four factors are required for industrial innovation:

1. **profit incentive** ;
2. **vision** of improved product, process or service;
3. **source of information** regarding means to envisoned improvement; and,
4. **capital** available for investment in new equipment, materials and personnel.

Presently, it is the scarcity of both capital and vision that is inhibiting innovation in Canadian industries.

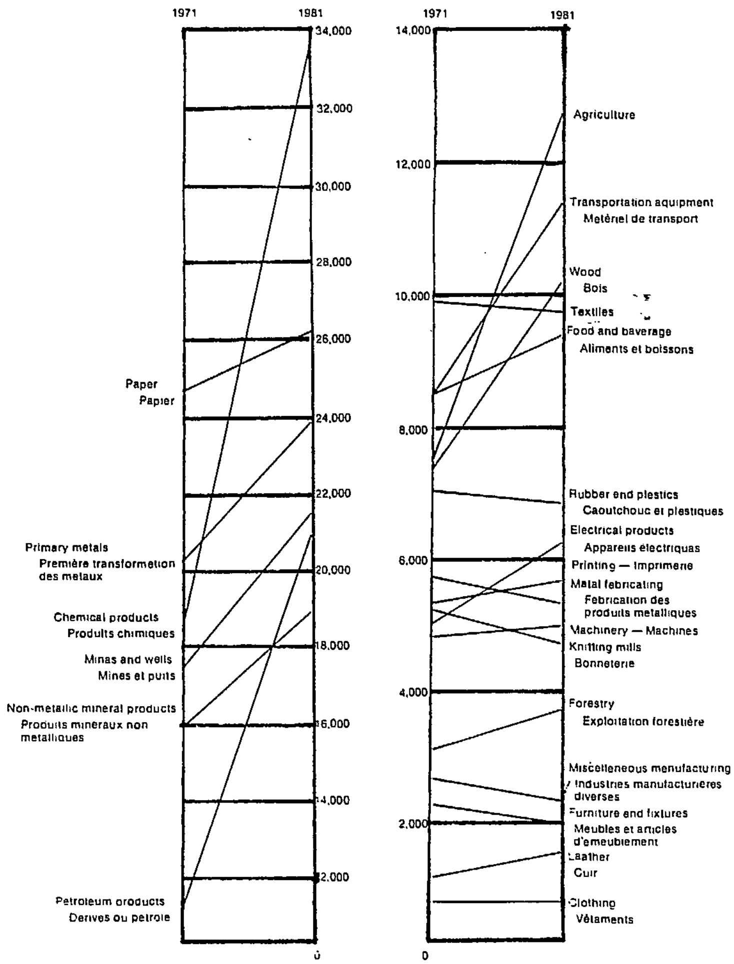
The dependency of the Canadian economy on the resource-based industries is reflected in the fact that 50% of the total machinery and equipment for all industries is accounted for by the agriculture, mines and wells and paper and primary metals sub-sectors.
(Stats. Can. Cat. No. 88-201, p. 128)

The exploitation of these natural resources is now very capital intensive.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

Figure A.22

Capital Investment Per Employee In Selected Industries, 1971 and 1981
Capital investi par employé dans certaines industries, 1971 et 1981



Source: Statistics Canada Cat. No. 88-201, p.129.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

Advances in microelectronics, lasers, robotics, computer-aided design and computer-assisted manufacture are revolutionizing manufacturing processes. Advanced automation is an absolute neccessity to match and exceed the quality and affordability of competitive products.

Net fixed capital formation is the value of new equipment purchased during the year, other than that purchased to replace wornout equipment. It is used as a rough indicator of new real investment.

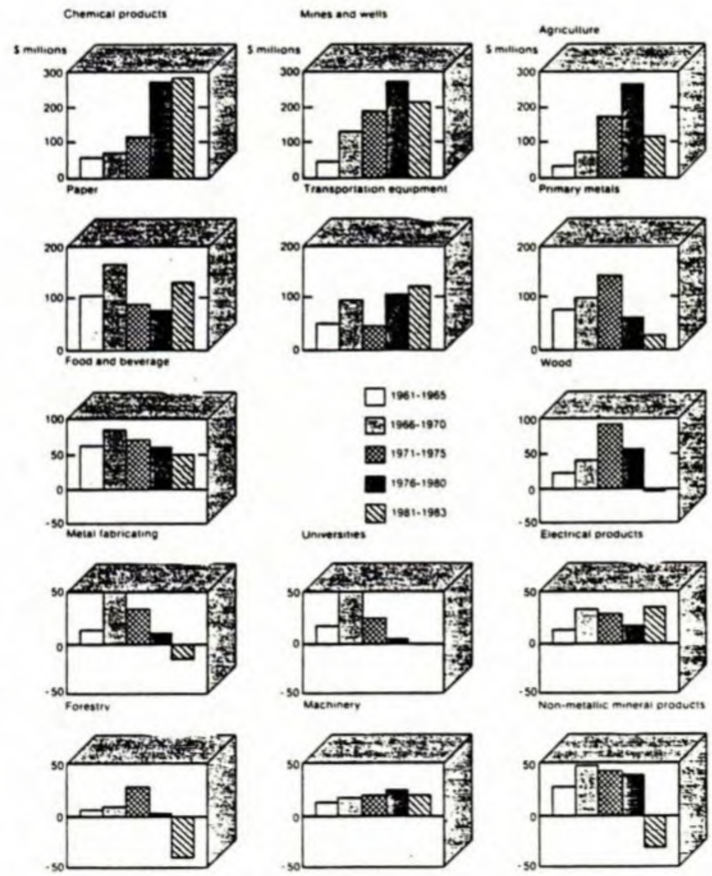
According to the following figure, not only are many Canadian industries not investing in modern production equipment, some industries are failing even to fully replace obsolete machinery. This implies a serious lack of "knowledge application" within the business community.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

Figure A.23

Net Fixed Capital Formation of Machinery and Equipment, Selected Industries, 1961-1983

(annual averages, in 1971 dollars)



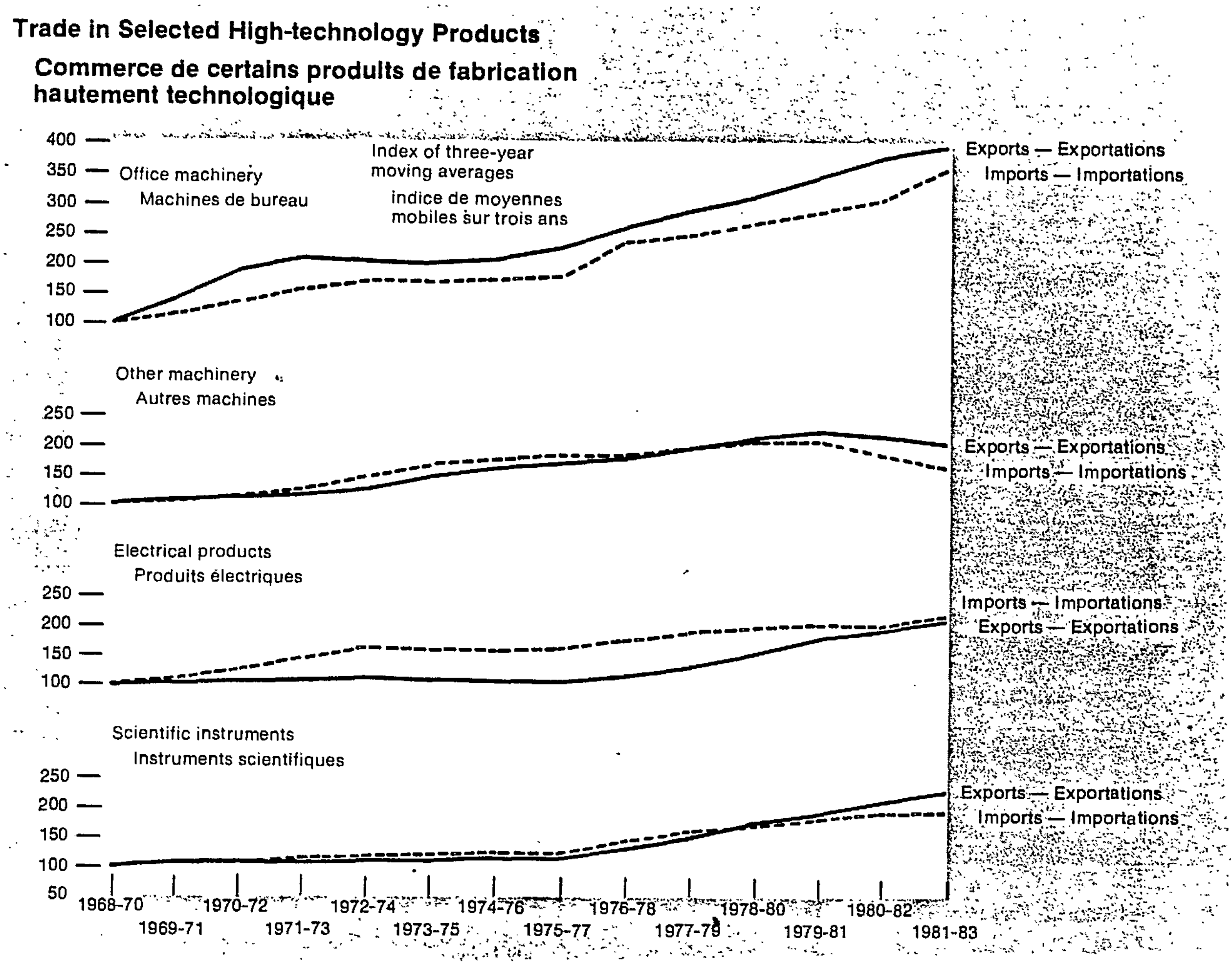
Source: Stats. Can. Cat. No. 201-p131 t5.6

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

Canada's international trade position is an important reflection of our ability to apply knowledge.

The following figures are presented as a summary of Canada's current trade position.

Figure A.24



Source: Statistics Canada Cat. No. 88-201, p. 139

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

Figure A.25

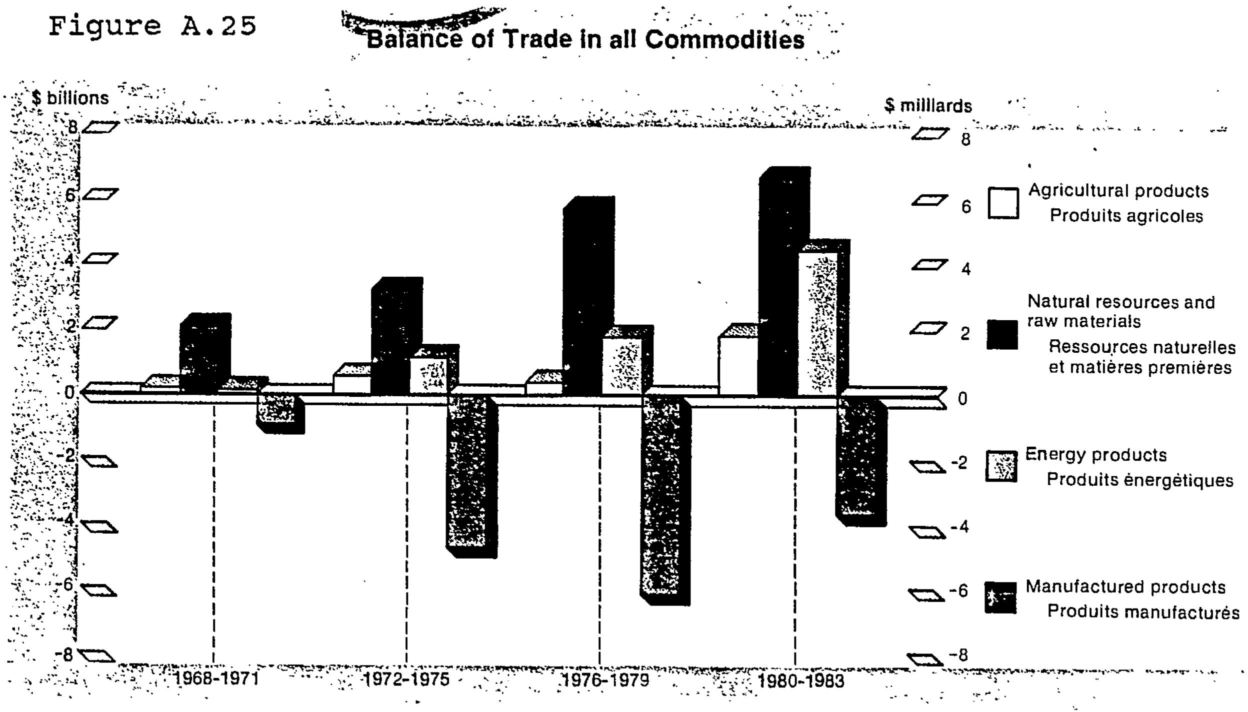
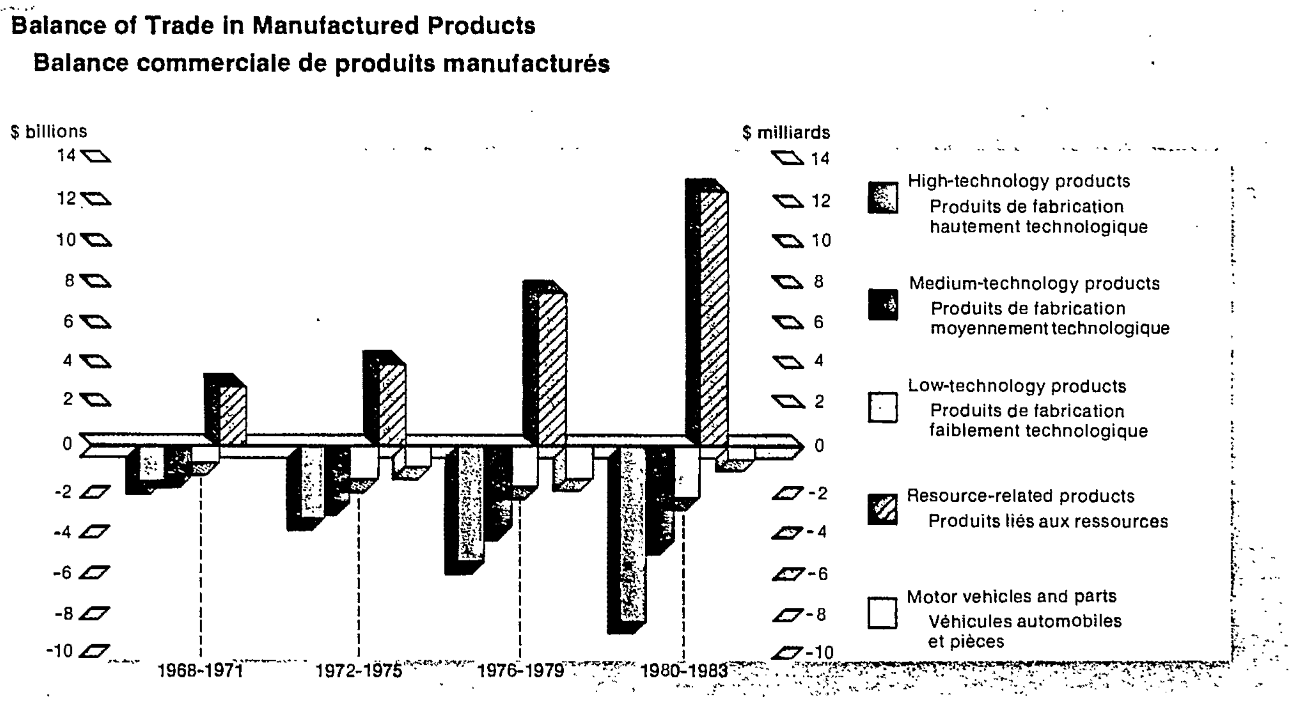


Figure A.26



Source For Both Figures: Statistics Canada Cat. No. 88-201, pp. 140 and 141.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

Figure A.27

Balance of Trade in High-technology Products

Balance commerciale de produits de fabrication hautement technologique

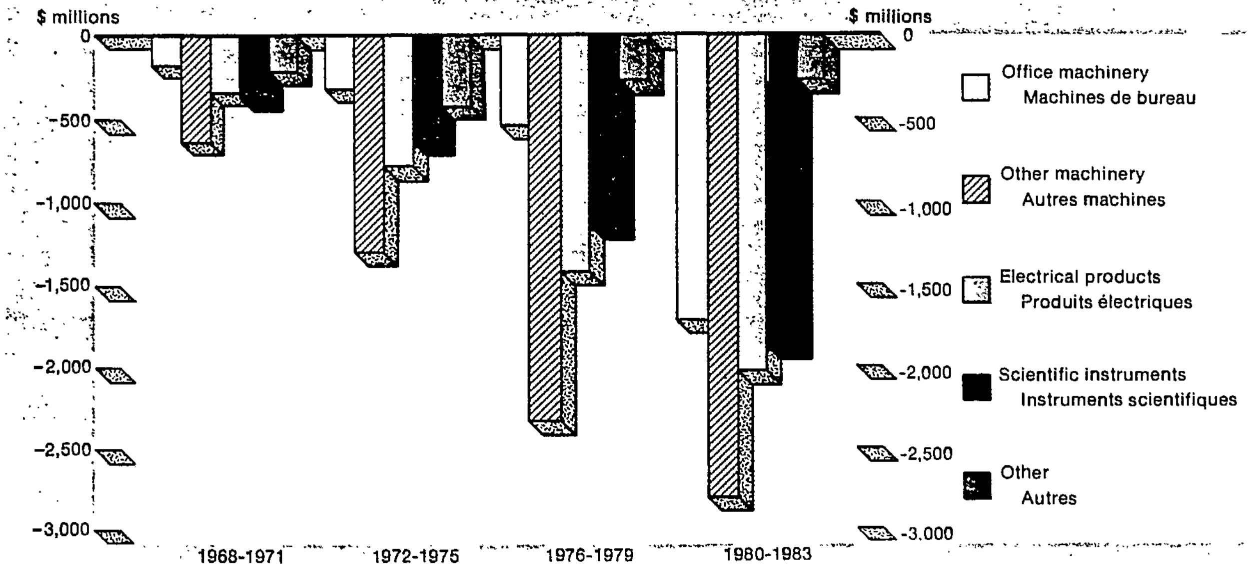
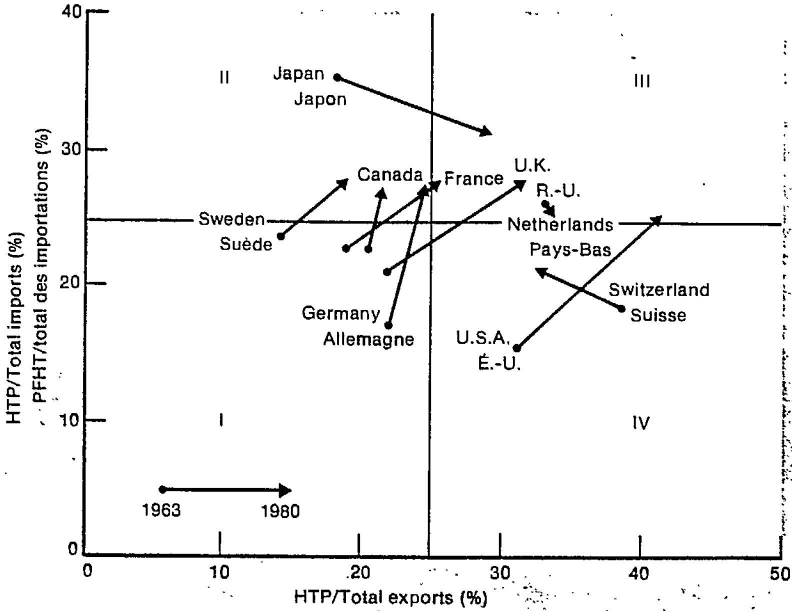


Figure A.28

Shares of High-technology Products in the Exports and Imports of Manufactured Products for Selected OECD Countries, 1963 and 1980

Pourcentages de produits de fabrication hautement technologique dans les exportations et importations de produits manufacturés pour certains pays membres de l'OCDE, 1963 et 1980



Source: "International Trade in High Technology Products: An Empirical Approach", DSTI/SPR/83.13, Part 2, OECD, Paris, April 1983, pp. 34-35.

Source: "Le commerce international des produits de haute technologie: une approche empirique", DSTI/SPR/83.13, Partie 2, OCDE, Paris, avril 1983.

Source For Both Figures: Statistics Canada Cat. No. 88-201, pp. 142 and 143.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

Figure A.29

Share of High-technology Products in Manufactured Exports, Selected OECD Countries
Proportion de produits de fabrication hautement technologique dans les exportations de produits manufacturés de certains pays de l'OCDE

Country Pays	1963	1967	1973	1975	1980
			per cent – pourcentage		
Canada	20	20	19	19	21
France	19	23	22	22	25
Germany Allemagne	22	22	23	23	24
Japan Japon	18	23	27	23	29
Netherlands Pays-Bas	33	32	32	32	33
Sweden Suède	14	16	18	19	19
Switzerland Suisse	38	39	36	36	33
United Kingdom Royaume-Uni	22	25	25	25	31
United States États-Unis	31	36	40	37	41

Source: Statistics Canada Cat. No. 88-201, p.144.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

All trends presented seem to indicate a maintenance of the status quo. Even the apparent improvement in balance of trade figures for maufactured goods, as presented in Figure A.26, is mainly attributable to an increase in export of resource-related products (wood and paper, fertilizers, iron and steel and non-ferrous metals).

According to Statistics Canada :"A substantial excess of a wide range of high technology products (in imports) may be due to two main causes: the importing country (Canada) may be improving its technology so that its products can become more competitive or the importing country (Canada) may have to rely on external sources for most of its high-technology products because it cannot manufacture them efficiently."
(Stats. Can. Cat. No. 88-201, p. 143)

The same source goes on to speculate that there is some evidence, as presented in Figure A.29, that Canada may be slowly moving towards a position of technical strength. This comment may be interpreted as a warning that if we are not using our increasing national debt in high-technology products in a strategy to position ourselves more favourably within the international market, then we may be jeopardizing our national security and independence.

A recent discussion paper prepared for MSST, "Canadian Trade in High Technology: An Analysis of Issues and Prospects", does not encourage the optimism expressed by Statistics Canada. Some highlights of this report were:

- Canada's trade deficit in high technology is the worst among the Economic Summit countries. It stood at about $12 billion in 1984 and continues to grow.

- Canada is the only major industrialised country with trade deficits in <u>all high-technology commodity groups.</u>

- Canada ranks 8th in terms of market shares of OECD exports of high-technology products. Moreover, Canada is losing its market share over time, from 4.4% in 1970 to 3.5% in 1983.

- Canada ranks 8th in terms of national expenditures on R&D as a percentage of GNP.

- A recent OECD study confirms that the higher a country's R&D expenditures relative to total value-added, the higher is its high-technology share in manufactured exports.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

There is a major Canadian success story to be told regarding applied research and development, technology diffusion and commercial application. It is the story of Canadian Space science development.

"With a relatively low level of expenditure we have become one of the largest users of space systems and have developed a world-class, export-oriented space industry. The development and use of space technology is one of the technology areas in which Canada excels.

"This country is now one of the world's largest users of space systems, meeting national needs in fields as diverse as telecommunications, broadcasting, remote sensing for resource management and surveillance, weather forecasting, search and rescue and nagivation.

"Over the years the Canadian space policy has ... pursue(d) three fundamental objectives:

1. To encourage the use of space technology to meet national needs;

2. To develop an indigenous space operations and manufacturing industry; and

3. To maintain a position of scientific excellence.

"A recent study by the OECD identified Canada as one of the few countries where its space industries sell more than the government itself spends on space programs and activiities."

Notes for an address by the Honourable Frank Oberle, P.C. M.P. to the High Tech Update '85 Conference, December 12, 1985, Ottawa.

A.5 DIFFUSION AND APPLICATION OF KNOWLEDGE (cont.)

National unemployment statistics reflect the urgent national need for the coming of age of science and technology in Canada.

As of November, 1985, the seasonally adjusted level of unemployment in Canada was 1,305,000. The unemployment rate was highest for people between the ages of 15 to 19 years of age - 18.8%. Between the ages of 15 and 24 years the rate was 16.2%.

Improvements in both the quality and accessibility of postsecondary education will help to decrease the threat of unemployment to young and old Canadians, alike.

Modernisation and innovation of existing industries will create new short and long term job opportunities.

It is the promise of new technologies which holds the greatest employment potential for Canadians. Pockets of new industries will generate new sources of capital, new ideas, enthusiasm, unique material and personnel requirements and unique advantages to the regional and national communities.

APPENDIX B

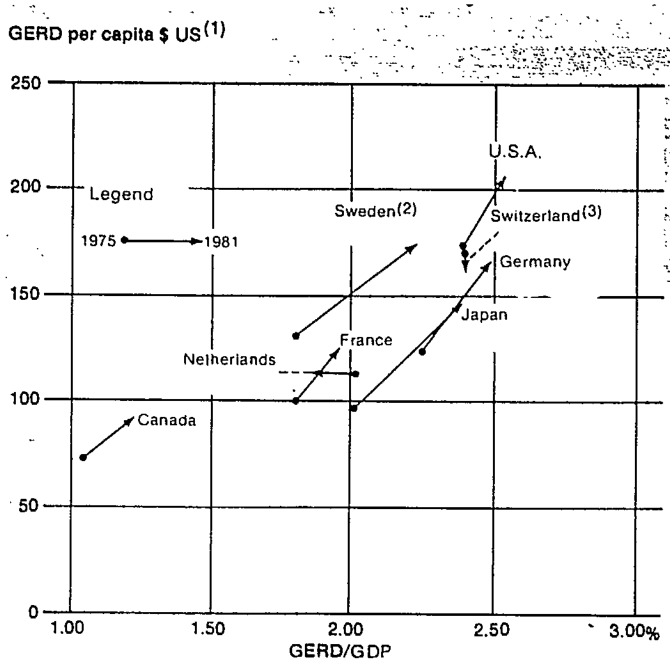
LOOKING AROUND US: The International Environment

B.1 Research and Development Expenditures

B.1.1 The GERD

The following raw statistics present international GERD comparisons.

GERD, GDP and Population, for Selected OECD Countries



(1) GERD in 1975 U.S. dollars are GERD's in national currencies divided by the U.S. purchasing power parities; 1981 values are deflated to 1975 values by dividing by 1.554, the U.S. GNP price deflator.

(2) NSE only.

(3) 1979 date.

Source: Statistics Canada Cat. No. 88-201, pp. 92 and 93.

B.1 Research and Development Expenditures

B.1.1 The GERD

The following data is extracted from the recent OECD report: Science and Technology Indicators, Basic Statistical Series, Selected S&T Indicators 1981 - 1986, Recent Results, DSTI 7601S, October 1985.

4. GERD AS A PERCENTAGE OF GDP

	1981	1982	1983	1984	1985	1986
AUSTRALIA	1.01	..	..	..	..	..
AUSTRIA	1.17	1.22 C	1.23 C	1.25 C	1.27 C	..
BELGIUM	..	..	..	..	..	..
CANADA	1.24	1.36	1.36	1.35	..	..
DENMARK	1.07	1.13 C	..	..	..	..
FINLAND	1.19 A	..	1.32	..	..	..
FRANCE	2.01 A	2.10	2.15	2.22 C	2.27 C	..
GERMANY	2.48	2.58 C	2.58 C	..	..	..
GREECE	0.21 A	..	..	..	..	..
ICELAND	0.75	..	..	..	..	..
IRELAND	0.75	0.75	..	..	..	..
ITALY	1.01	1.04	1.20 B	1.19 B	..	..
JAPAN	2.37	2.47	2.61	..	..	..
NETHERLANDS	1.88	1.98 A	2.03 C	2.00 C	..	..
NEW ZEALAND	0.96 E	..	..	..	..	..
NORWAY	1.29	..	1.41 C	..	..	..
PORTUGAL	..	0.35	..	..	..	..
SPAIN	0.39	..	..	..	..	..
SWEDEN (G)	2.22 A	..	2.47	..	..	..
SWITZERLAND	2.29 D	..	2.28AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	2.42 D	..	2.27 B	..	..	..
UNITED STATES	2.51	2.66	2.70	2.70 C	2.80 C	..
YUGOSLAVIA	0.76	..	..	..	..	..

5. PERCENTAGE OF GERD FINANCED BY PUBLIC SOURCES

	1981	1982	1983	1984	1985	1986
AUSTRALIA	75.8	..	..	..	..	..
AUSTRIA	43.8	..	..	..	..	..
BELGIUM	..	..	..	..	..	..
CANADA	51.5	53.1	53.5	54.5	..	..
DENMARK	..	..	..	..	..	..
FINLAND	46.0 A	..	42.3	..	..	..
FRANCE	52.8 A	55.1	54.8	54.4 C	..	..
GERMANY	41.6	42.1 C	40.9 C	..	..	..
GREECE	84.4 A	..	..	..	..	..
ICELAND	85.6	..	..	..	..	..
IRELAND	56.5	56.5	..	..	..	..
ITALY	47.2	48.5	55.4 B	56.7 B	..	..
JAPAN	26.9	25.5	24.0	..	..	..
NETHERLANDS	47.2	48.4 A	.. C	.. C	..	..
NEW ZEALAND	81.9 B	..	..	..	..	..
NORWAY	57.2	..	..	..	..	..
PORTUGAL	..	61.9	..	..	..	..
SPAIN	52.9	..	..	..	..	..
SWEDEN (G)	39.9 A	..	..	..	..	..
SWITZERLAND	..	..	22.6AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	49.0 D	..	50.2 E	..	..	..
UNITED STATES	49.2	48.6	49.1	49.2 C	49.3 C	..
YUGOSLAVIA	36.1	..	..	..	..	..

6. PERCENTAGE OF GERD FINANCED BY INDUSTRY

	1981	1982	1983	1984	1985	1986
AUSTRALIA	21.0	..	..	..	..	..
AUSTRIA	50.2	48.8 C	49.0 C	49.1 C	49.3 C	..
BELGIUM	..	..	..	..	..	..
CANADA	40.4	38.0	37.7	36.8	..	..
DENMARK	..	..	..	..	..	..
FINLAND	51.9	..	55.6	..	..	..
FRANCE	40.8 A	40.2	42.0	41.3 C	..	..
GERMANY	57.0	56.9 C	58.1 C	..	..	..
GREECE	15.6 A	..	..	..	..	..
ICELAND	5.7	..	..	..	..	..
IRELAND	37.7	37.7	..	..	..	..
ITALY	50.1	46.5	42.5 B	41.5 B	..	..
JAPAN	62.3	63.7	65.2	..	..	..
NETHERLANDS	46.3	44.9	..	..	..	..
NEW ZEALAND	18.1 E	..	..	..	..	..
NORWAY	40.1	..	..	..	..	..
PORTUGAL	..	30.0	..	..	..	..
SPAIN	45.9	..	..	..	..	..
SWEDEN (G)	57.3 A	..	..	..	..	..
SWITZERLAND	68.3 D	..	77.4 AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	41.3 D	..	42.1 B	..	..	..
UNITED STATES	48.8	49.4	49.0	48.9 C	48.9 C	..
YUGOSLAVIA	57.2	..	..	..	..	..

16. BERD AS A PERCENTAGE OF GERD

	1981	1982	1983	1984	1985	1986
AUSTRALIA	22.4	..	..	..	..	..
AUSTRIA	55.8	..	..	..	..	..
BELGIUM	..	..	..	..	..	..
CANADA	49.1	49.7	46.4	48.0 C	..	..
DENMARK	50.7	..	..	..	..	..
FINLAND	54.7	..	56.8	..	..	..
FRANCE	58.9	57.9	56.8	56.8 C	..	..
GERMANY	68.3	69.7 C	69.8 C	..	..	..
GREECE	22.5	..	..	..	..	..
ICELAND	9.6	..	..	..	..	..
IRELAND	43.6	43.6	..	..	..	..
ITALY	56.4	56.8	53.5 B	53.4 B	..	..
JAPAN	60.7	61.9	63.5	..	..	..
NETHERLANDS	53.3	51.6 A	53.7 C	54.0 C	..	..
NEW ZEALAND	21.7 B	..	..	..	..	..
NORWAY	52.1	..	54.7 C	..	..	..
PORTUGAL	..	31.2	..	..	..	..
SPAIN	48.3	..	..	..	..	..
SWEDEN (G)	66.6 A	..	67.5	..	..	..
SWITZERLAND	74.2 D	..	74.3AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	61.8 D	..	61.0 B	..	..	..
UNITED STATES	70.3	71.5	71.1	70.7 C	71.2 C	..
YUGOSLAVIA	56.4	..	..	..	..	..

36. GOVERNMENT & PRIVATE NON-PROFIT PERFORMANCE AS A % OF GERD

	1981	1982	1983	1984	1985	1986
AUSTRALIA	47.9	..	..	..	..	..
AUSTRIA	11.4	..	..	..	..	..
BELGIUM	..	..	..	..	..	..
CANADA	24.7	24.5	28.2	27.0	..	..
DENMARK	..	..	..	..	..	..
FINLAND	23.1 A	..	22.4	..	..	..
FRANCE	24.7 A	26.1	27.4	28.8 C	..	..
GERMANY	14.8	14.3 C	14.4 C	..	..	..
GREECE	63.1 A	..	..	..	..	..
ICELAND	64.4	..	..	..	..	..
IRELAND	40.4	40.4	..	..	..	..
ITALY	25.7	24.7	..	..	..	..
JAPAN	15.2	14.5	13.5	..	..	..
NETHERLANDS	23.5	21.8	21.4	..	..	..
NEW ZEALAND	62.6 B	..	..	..	..	..
NORWAY	18.9	..	19.3 C	..	..	..
PORTUGAL	..	40.2	..	..	..	..
SPAIN	33.8	..	..	..	..	..
SWEDEN (G)	6.6 A	..	5.5	..	..	..
SWITZERLAND	5.9 D	..	8.3AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	24.9 D	..	25.1 B	..	..	..
UNITED STATES	15.2	14.9	15.5	16.0 C	15.6 C	..
YUGOSLAVIA	24.6	..	..	..	..	..

35. GOVERNMENT R & D FUNDING AS A PERCENTAGE OF GDP

	1981	1982	1983	1984	1985	1986
AUSTRALIA	0.76	0.81	0.77	..	..	..
AUSTRIA	0.50	0.52	0.53	0.53	0.55	..
BELGIUM	0.62	0.63	0.58	0.57	..	..
CANADA	0.61	0.67	0.70	..	..	..
DENMARK	0.49	0.47	0.51	0.50	..	..
FINLAND	0.57	0.60	0.61	0.62	0.63	..
FRANCE	1.31 A	1.32	1.41	1.47	..	..
GERMANY	1.15	1.21	1.14 A	1.13	..	..
GREECE	0.21	0.20	0.22	0.13	..	..
ICELAND	..	..	0.42	0.58	0.63	..
IRELAND	0.40 A	0.39	0.41	0.39	..	..
ITALY	0.65 A	0.64	0.71	0.72	..	..
JAPAN	0.64	0.63	0.63	..	..	..
NETHERLANDS	0.98	1.06 A	1.01	0.97 C	0.94 C	0.96 C
NEW ZEALAND	0.79 B	0.80 B	0.77 B	..	..	..
NORWAY	0.75	0.79	0.77	..	..	..
PORTUGAL	..	..	..	..	..	..
SPAIN	0.27	0.28	0.26	..	..	..
SWEDEN	1.15	1.23	1.31	1.31	..	..
SWITZERLAND (HI)	0.30	..	..	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	1.41	1.33	1.33	1.35	1.34	..
UNITED STATES (HIJ)	1.15	1.19	1.18	1.22	1.30	1.41
YUGOSLAVIA	..	..	..	..	..	..

40. GOVERNMENT CIVIL R & D FUNDING AS A PERCENTAGE OF GDP

	1981	1982	1983	1984	1985	1986
AUSTRALIA	0.69	0.73	0.70	..	..	..
AUSTRIA	0.50	0.52	0.53	0.53	0.55	..
BELGIUM	0.61	0.63	0.58	0.57	..	..
CANADA	0.58	0.64	0.66	..	..	..
DENMARK	0.48	0.47	0.51	0.50	..	..
FINLAND	0.56	0.59	0.59	0.61	0.62	..
FRANCE	0.81 A	0.85	0.95	1.01	..	..
GERMANY	1.05	1.10	1.03 A	1.02	..	..
GREECE	0.20	0.20	0.22	0.13	..	..
ICELAND	..	..	0.42	0.58	0.63	..
IRELAND	0.40 A	0.39	0.41	0.39	..	..
ITALY	0.61 A	0.61	0.67	0.65	..	..
JAPAN	0.63	0.62	..	..	..	..
NETHERLANDS	0.95	1.02 A	0.98	0.94 C	0.91 C	0.93 C
NEW ZEALAND	0.78 B	0.79 B	0.76 B	..	..	..
NORWAY	0.70	0.73	0.70	..	..	..
PORTUGAL	..	..	..	..	..	..
SPAIN	0.26	0.27	0.24	..	..	..
SWEDEN	0.97	0.99	1.03	1.01	..	..
SWITZERLAND (HI)	0.26	..	..	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	0.72	0.70	0.67	0.67	0.66	..
UNITED STATES (HIJ)	0.52	0.46	0.42	0.41	0.42	0.39
YUGOSLAVIA	..	..	..	..	..	..

39. DEFENCE R & D AS A PERCENTAGE OF TOTAL GOVERNMENT R & D FUNDING

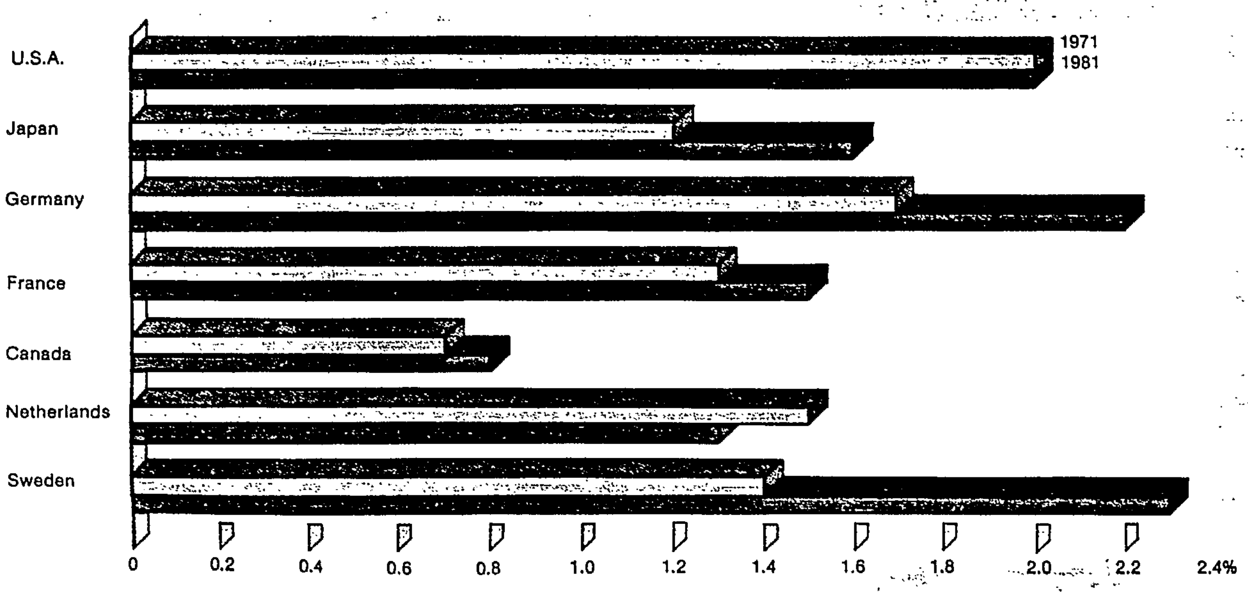
	1981	1982	1983	1984	1985	1986
AUSTRALIA	9.8	10.5	10.2	..	..	..
AUSTRIA	0.1	0.0	0.0	0.1	0.1	..
BELGIUM	0.3	0.5	0.3	0.2	..	..
CANADA	5.4	5.3	5.7	..	..	..
DENMARK	0.3	0.2	0.2	0.2	..	..
FINLAND	1.9	2.0	1.9	2.0	1.9	..
FRANCE	38.5 A	35.4	32.7	31.3	..	..
GERMANY	8.9	8.5	9.6 A	9.8	..	..
GREECE	5.2	..	..	..	..	..
ICELAND	..	..	0.0	0.0	0.0	..
IRELAND	0.0 A	0.0	0.0	..	..	..
ITALY	6.5 A	4.8	5.7	8.9	..	..
JAPAN	2.0	2.0 B	..	..	..	..
NETHERLANDS	3.1	3.2 A	2.8	3.1 C	3.0 C	2.6 C
NEW ZEALAND	1.5 B	1.5 B	1.7 B	..	..	..
NORWAY	6.5	7.7	9.6	..	..	..
PORTUGAL	..	..	..	..	..	..
SPAIN	5.0	6.2	6.5	..	..	..
SWEDEN	16.0	19.2	21.8	22.9	..	..
SWITZERLAND (HI)	12.7	..	..	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	48.6	47.7	49.3	50.4	50.6	..
UNITED STATES (HIJ)	54.6	61.1	64.3	66.2	68.0	72.7
YUGOSLAVIA	..	..	..	..	..	..

B.1 Research and Development Expenditures

B.1.2 The BERD

The following raw statistics present international BERD comparisons.

Industrial R&D Expenditures as a Per Cent of the Domestic Product of Industry for Selected OECD Countries



Source: Statistics Canada Cat. No. 88-201, p. 94.

B.1 Research and Development Expenditures

B.1.2 The BERD

The following data is extracted from the recent OECD report: Science and Technology Indicators, Basic Statistical Series, Selected S&T Indicators 1981 - 1986, Recent Results, DSTI 7601S, October 1985.

15. BERD AVERAGE ANNUAL GROWTH (FIXED PRICE)

	1981	1982	1983	1984	1985	1986
AUSTRALIA	0.9	..	..	..	..	..
AUSTRIA	6.0	..	..	..	..	..
BELGIUM	3.6	..	4.0	..	..	..
CANADA	22.4	6.3	-4.1	7.8 C	6.3 C	..
DENMARK	5.4	..	10.3	..	..	..
FINLAND	10.3	..	10.5	..	..	..
FRANCE	6.7	4.8	1.5	5.0 C	..	..
GERMANY	2.0	5.0 C	1.0 C	..	..	..
GREECE	..	..	..	..	..	..
ICELAND	5.8	..	..	..	..	..
IRELAND	15.1	1.6	..	..	..	..
ITALY	12.9	3.5	6.9 B	1.7 B	..	..
JAPAN	12.5	9.4	12.2	..	..	..
NETHERLANDS	2.3	0.1	7.5	1.0 C	..	..
NEW ZEALAND	12.0 B	..	..	..	..	..
NORWAY	4.4	..	9.5 C	..	..	..
PORTUGAL	..	9.5	..	..	..	..
SPAIN	-9.3	..	..	..	..	..
SWEDEN (G)	.. A	..	7.9	..	3.4 C	..
SWITZERLAND	-.1 D	..	.. A	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	2.1	..	-1.2	..	..	..
UNITED STATES	6.9	4.5	3.8	6.2 C	8.1 C	..
YUGOSLAVIA	..	..	..	..	..	..

17. BERD AS A PERCENTAGE OF DPI

	1981	1982	1983	1984	1985	1986
AUSTRALIA	0.24	..	..	..	..	..
AUSTRIA	0.85	..	..	..	..	..
BELGIUM	1.29	..	1.39	..	..	..
CANADA	0.84	0.96	0.89	..	..	..
DENMARK	0.86	..	0.98	..	..	..
FINLAND	0.88	..	1.02	..	..	..
FRANCE	1.52	1.57	1.58	1.63 C	..	..
GERMANY	2.15	2.28 C	2.28 C	..	..	..
GREECE	0.06	..	..	..	..	..
ICELAND	..	..	..	..	..	..
IRELAND	0.46	0.46	..	..	..	..
ITALY	0.69	0.72	0.78 B	..	..	..
JAPAN	1.62	1.72	1.86	..	..	..
NETHERLANDS	1.29	1.31	1.40	..	..	..
NEW ZEALAND	0.25 B	..	..	..	..	..
NORWAY	0.82	..	0.95 C	..	..	..
PORTUGAL	..	..	..	..	..	..
SPAIN	0.23	..	..	..	..	..
SWEDEN (G)	2.27 A	..	2.57	..	..	..
SWITZERLAND	..	..	..	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	2.12	..	1.93	..	..	..
UNITED STATES	2.03	2.19	2.21	..	..	..
YUGOSLAVIA	0.47	..	..	..	..	..

18. PERCENTAGE OF BERD FINANCED BY INDUSTRY

	1981	1982	1983	1984	1985	1986
AUSTRALIA	88.0	..	..	..	..	..
AUSTRIA	88.4	..	..	..	..	..
BELGIUM	94.5	..	95.7	..	..	..
CANADA	83.3	79.6	80.3	80.3 C	80.4 C	..
DENMARK	86.7	..	84.3	..	..	..
FINLAND	90.1	..	92.5	..	..	..
FRANCE	68.2	71.0	73.0	..	..	..
GERMANY	81.7	..	..	..	..	..
GREECE	69.4	..	..	..	..	..
ICELAND	53.2	..	..	..	..	..
IRELAND	80.5	80.5	..	..	..	..
ITALY	86.9	83.6	77.6 B	76.1 B	..	..
JAPAN	97.9	98.1	98.1	..	..	..
NETHERLANDS	84.3	84.2	..	..	..	..
NEW ZEALAND	83.6 B	..	..	..	..	..
NORWAY	73.2	..	..	..	..	..
PORTUGAL	..	92.9	..	..	..	..
SPAIN	93.6	..	..	..	..	..
SWEDEN (G)	84.6 A	..	87.8	..	..	..
SWITZERLAND	89.6 D	..	98.6AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	61.3	..	63.0	..	..	..
UNITED STATES	68.4	68.2	67.8	68.2 C	67.6 C	..
YUGOSLAVIA	75.0	..	..	..	..	..

21. PERCENTAGE OF BERD FINANCED BY GOVERNMENT

	1981	1982	1983	1984	1985	1986
AUSTRALIA	9.8	..	..	..	..	..
AUSTRIA	7.4	..	..	..	..	..
BELGIUM	5.1	..	4.2	..	..	..
CANADA	10.7	12.4	11.2	11.3 C	11.2 C	..
DENMARK	10.5	..	13.1	..	..	..
FINLAND	9.0	..	6.6	..	..	..
FRANCE	24.6	24.2	22.4	..	..	..
GERMANY	16.9	..	..	..	..	..
GREECE	30.6	..	..	..	..	..
ICELAND	38.3	..	..	..	..	..
IRELAND	13.7	13.7	..	..	..	..
ITALY	8.8	11.7	18.8 B	20.8 B	..	..
JAPAN	1.9	1.7	1.7	..	..	..
NETHERLANDS	7.5	7.2	..	..	..	..
NEW ZEALAND	16.4 B	..	..	..	..	..
NORWAY	25.0	..	..	..	..	..
PORTUGAL	..	1.6	..	..	..	..
SPAIN	4.1	..	..	..	..	..
SWEDEN (G)	13.6 A	..	10.4	..	..	..
SWITZERLAND	1.3 D	..	1.4AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	30.0	..	30.2	..	..	..
UNITED STATES	31.6	31.9	32.2	31.8 C	32.4 C	..
YUGOSLAVIA	22.7	..	..	..	..	..

19. INDUSTRY-FINANCED BERD AVERAGE ANNUAL GROWTH (FIXED PRICES)

	1981	1982	1983	1984	1985	1986
AUSTRALIA	1.9	..	..	..	..	..
AUSTRIA	5.3	..	..	..	..	..
BELGIUM	3.8	..	4.7	..	..	..
CANADA	19.8	1.5	-3.1	7.7 C	6.3 C	..
DENMARK	5.5	..	8.8	..	..	..
FINLAND	9.1	..	12.0	..	..	..
FRANCE	4.6	9.1	4.4	..	..	..
GERMANY	3.5	..	..	..	..	..
GREECE	..	..	..	..	..	..
ICELAND	8.2	..	..	..	..	..
IRELAND	10.3	1.6	..	..	..	..
ITALY	13.2	-.5	-.7 B	-.3 B	..	..
JAPAN	12.4	9.6	12.2	..	..	..
NETHERLANDS	1.9	0.0	..	..	..	..
NEW ZEALAND	15.5 B	..	..	..	..	..
NORWAY	13.8	..	..	..	..	..
PORTUGAL	..	9.8	..	..	..	..
SPAIN	-10.4	..	..	..	..	..
SWEDEN (G)	6.7 A	..	9.9	..	..	..
SWITZERLAND	..	..	..	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	1.3	..	0.1	..	..	..
UNITED STATES	6.8	4.3	3.2	6.9 C	7.1 C	..
YUGOSLAVIA	..	..	..	..	..	..

20. INDUSTRY-FINANCED BERD AS A PERCENTAGE OF DPI

	1981	1982	1983	1984	1985	1986
AUSTRALIA	0.21	..	..	..	..	..
AUSTRIA	0.75	..	..	..	..	..
BELGIUM	1.22	..	1.33	..	..	..
CANADA	0.70	0.77	0.71	..	..	..
DENMARK	0.74	..	0.82	..	..	..
FINLAND	0.79	..	0.94	..	..	..
FRANCE	1.04	1.12	1.15	..	..	..
GERMANY	1.76	..	..	..	..	..
GREECE	0.04	..	..	..	..	..
ICELAND	..	..	..	..	..	..
IRELAND	0.37	0.37	..	..	..	..
ITALY	0.60	0.60	0.60 B	..	..	..
JAPAN	1.59	1.68	1.83	..	..	..
NETHERLANDS	1.09	1.10	..	..	..	..
NEW ZEALAND	0.21 B	..	..	..	..	..
NORWAY	0.60	..	..	..	..	..
PORTUGAL	..	..	..	..	..	..
SPAIN	0.21	..	..	..	..	..
SWEDEN (G)	1.92 A	..	2.26	..	..	..
SWITZERLAND	..	..	..	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	1.30	..	1.22	..	..	..
UNITED STATES	1.39	1.50	1.50	..	..	..
YUGOSLAVIA	0.35	..	..	..	..	..

14. BERD (MILLION CURRENT PPP $)

	1981	1982	1983	1984	1985	1986
AUSTRALIA	344.4	..	..	..	..	..
AUSTRIA	427.4	..	..	..	..	..
BELGIUM	950.1	..	1148.7	..	..	..
CANADA	1902.9	2163.2	2168.0	..	..	..
DENMARK	273.8	..	372.3	..	..	..
FINLAND	272.9	..	372.3	..	..	..
FRANCE	6304.4	7060.6	7461.1	..	..	..
GERMANY	10686.3	11993.9 C	12649.0 C	..	..	..
GREECE	22.9	..	..	..	..	..
ICELAND	1.7	..	..	..	..	..
IRELAND	67.7	73.6	..	..	..	..
ITALY	2563.1	2839.2	3169.7 B	..	..	..
JAPAN	15517.3	18148.5	21270.0	..	..	..
NETHERLANDS	1336.0	1431.7	1607.1	..	..	..
NEW ZEALAND	52.0 B	..	..	..	..	..
NORWAY	309.1	..	414.2 C	..	..	..
PORTUGAL	..	48.3	..	..	..	..
SPAIN	442.7	..	..	..	..	..
SWEDEN (G)	1442.1 A	..	1874.6	..	..	..
SWITZERLAND	1324.8 D	..	1471.0 AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	7029.7	..	7652.9	..	..	..
UNITED STATES	51810.0	57927.0	62816.0	69250.0 C	77500.0 C	..
YUGOSLAVIA (K)	294.4	..	..	..	..	..

B.1 Research and Development Expenditures

B.1.3 The HERD

The following data is extracted from the recent OECD report: Science and Technology Indicators, Basic Statistical Series, Selected S&T Indicators 1981 - 1986, Recent Results, DSTI 7601S, October 1985.

29. HERD AS A PERCENTAGE OF GERD

	1981	1982	1983	1984	1985	1986
AUSTRALIA	29.7	..	..	..	..	..
AUSTRIA	32.8	..	..	..	..	..
BELGIUM	..	..	..	..	..	..
CANADA	26.3	25.8	25.3	25.0	..	..
DENMARK	..	..	..	..	..	..
FINLAND	22.2 A	..	20.8	..	..	..
FRANCE	16.4 A	15.9	15.8	14.3 C	..	..
GERMANY	16.8	16.0 C	15.8 C	..	..	..
GREECE	14.5 A	..	..	..	..	..
ICELAND	26.0	..	..	..	..	..
IRELAND	16.0	16.0	..	..	..	..
ITALY	17.9	18.6	..	..	..	..
JAPAN	24.2	23.6	23.0	..	..	..
NETHERLANDS	23.2	26.6 A	24.9 B	..	..	..
NEW ZEALAND	15.8 B	..	..	..	..	..
NORWAY	29.0	..	26.0	..	..	..
PORTUGAL	..	20.6	..	..	..	..
SPAIN	17.4	..	..	..	..	..
SWEDEN (G)	26.8 A	..	27.0	..	..	..
SWITZERLAND	19.9 D	..	17.4AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	13.3 D	..	13.8 B	..	..	..
UNITED STATES	14.5	13.6	13.4	13.4 C	13.2 C	..
YUGOSLAVIA	18.9	..	..	..	..	..

30. HERD AS A PERCENTAGE OF GDP

	1981	1982	1983	1984	1985	1986
AUSTRALIA	0.30	..	..	..	..	..
AUSTRIA	0.38	..	..	..	..	..
BELGIUM	..	..	..	..	..	..
CANADA	0.33	0.35	0.34	0.34	..	..
DENMARK	..	..	..	..	..	..
FINLAND	0.26 A	..	0.27	..	..	..
FRANCE	0.33 A	0.33	0.34	0.32 C	..	..
GERMANY	0.42	0.41 C	0.41 C	..	..	..
GREECE	0.03 A	..	..	..	..	..
ICELAND	0.20	..	..	..	..	..
IRELAND	0.12	0.12	..	..	..	..
ITALY	0.18	0.19	..	..	..	..
JAPAN	0.57	0.58	0.60	..	..	..
NETHERLANDS	0.44	0.53 A	0.51 B	..	..	..
NEW ZEALAND	0.15 B	..	..	..	..	..
NORWAY	0.37	..	0.37	..	..	..
PORTUGAL	..	0.07	..	..	..	..
SPAIN	0.07	..	..	..	..	..
SWEDEN (G)	0.60 A	..	0.67	..	..	..
SWITZERLAND	0.45 D	..	0.40 AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	0.32 D	..	0.31 B	..	..	..
UNITED STATES	0.36	0.36	0.36	0.36 C	0.37 C	..
YUGOSLAVIA	0.14	..	..	..	..	..

28. HERD ANNUAL AVERAGE GROWTH (FIXED PRICES)

	1981	1982	1983	1984	1985	1986
AUSTRALIA	1.0	..	..	..	..	..
AUSTRIA	4.6	..	..	..	..	..
BELGIUM	..	..	..	..	..	..
CANADA	1.0	3.3	0.6	3.0	..	..
DENMARK	..	..	..	..	..	..
FINLAND	.. A	..	4.9	..	..	..
FRANCE	.. A	3.5	2.9	-5.2 C	..	..
GERMANY	5.4	-2.4 C	-.2 C	..	..	..
GREECE	..	..	..	..	..	..
ICELAND	1.8	..	..	..	..	..
IRELAND	-.9	1.6	..	..	..	..
ITALY	31.3	6.6	..	..	..	..
JAPAN	5.0	4.8	6.4	..	..	..
NETHERLANDS	-5.5	.. A	-3.1 B	..	..	..
NEW ZEALAND	4.1 B	..	..	..	..	..
NORWAY	-1.8	..	1.3	..	..	..
PORTUGAL	..	6.7	..	..	..	..
SPAIN	7.8	..	..	..	..	..
SWEDEN (G)	.. A	..	7.4	..	..	..
SWITZERLAND	6.5 D	..	.. A	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	4.5 D	..	1.3 B	..	..	..
UNITED STATES	4.2	-3.3	3.1	6.6 C	5.8 C	..
YUGOSLAVIA	..	..	..	..	..	..

B.2 The Quality of Research Performed

The following data is extracted from Statistics Canada Cat. No. 88-201, Science and Technology Indicators 1984.

BIBLIOMETRICS

International Research Performance in Main Medicine, 1978 Reference Year

Country	Share of relevant papers	Share of relevance	Share of top decile relevance	Share of top percentile relevance
U.S.A.	70.0%	70.0%	71.5%	70.8%
England	10.6	8.9	7.7	7.9
Canada	3.4	3.3	3.0	1.9
Scotland	1.9	1.3	1.0	1.9
Japan	1.7	2.0	2.2	2.4
France	1.5	2.0	2.0	2.5
Sweden	1.3	1.9	2.2	3.3
Australia	1.2	1.4	1.4	1.0
West Germany	1.2	1.3	1.3	0.7

International Research Performance in Main Biochemistry, 1978 Reference Year

Country	Share of relevant papers	Share of relevance	Share of top decile relevance	Share of top percentile relevance
U.S.A.	56.1%	61.0%	64.9%	63.2%
England	9.4	9.7	9.6	12.1
West Germany	4.7	4.0	3.1	0.5
France	4.6	3.7	3.3	3.7
Japan	3.7	2.7	2.2	0.4
Canada	3.2	2.9	2.7	2.1
Sweden	2.0	2.8	3.0	5.0
Netherlands	1.8	1.4	0.8	0.7
Israel	1.8	1.9	1.9	2.6
Italy	1.6	0.7	0.3	0.2
Switzerland	1.5	1.9	2.1	2.6
Australia	1.4	1.1	1.0	0.2
Scotland	1.0	1.1	1.2	2.1
Belgium	1.0	0.6	0.4	0.2

International Research Performance in Main Chemistry, 1978 Reference Year

Country	Share of relevant papers	Share of relevance	Share of top decile relevance	Share of top percentile relevance
U.S.A.	53.2%	49.3%	45.8%	42.7%
Japan	9.7	6.9	6.3	8.9
West Germany	8.7	14.6	17.2	25.2
Canada	7.4	6.2	5.5	3.6
France	4.1	4.7	5.3	3.4
Switzerland	2.7	2.1	1.7	0.4
England	2.5	3.8	4.6	5.7
Italy	2.4	2.5	2.8	2.7
Israel	1.3	0.9	0.6	0.4
Netherlands	1.0	1.4	1.8	0.4

B.2 The Quality of Research Performed

Changes in World Shares of Papers in Three Journal Classes, 1974 and 1978

Country	1974	1978
	per cent	
Main Chemistry		
U.S.A.	46.9	43.3
Japan	11.0	11.9
West Germany	8.0	11.0
Canada	7.4	6.9
France	4.8	5.3
Switzerland	2.5	2.3
England	5.2	4.8
Italy	2.5	2.6
Israel	1.4	1.0
Netherlands	1.3	1.4
Main Biochemistry		
U.S.A.	57.0	55.5
England	9.8	8.6
West Germany	3.9	4.4
France	4.0	4.5
Japan	3.4	4.3
Canada	3.6	3.1
Sweden	2.0	1.8
Netherlands	1.4	2.1
Israel	1.7	1.7
Italy	1.7	1.7
Switzerland	1.2	1.6
Australia	1.6	1.5
Scotland	1.2	1.0
Belgium	0.8	1.1
Main Medicine		
U.S.A.	64.8	62.6
England	14.6	15.0
Canada	3.0	3.1
Scotland	2.4	2.2
Japan	1.2	1.6
France	1.4	1.8
Sweden	1.4	1.6
Australia	1.3	1.1
West Germany	0.9	1.0

B.2 The Quality of Research Performed

PATENTS

When comparing international patent statistics it must be remembered that one invention may be represented by patents in many countries and that patent legislation differs between countries. Japan awards a patent for each claim for an invention, while most other countries issue one patent to cover all claims made on one invention.

Of the 22 nations generally reffered to as the industrialised nations, Canada ranks 12th both in terms of national creativity (per capita patents) and of private sector ability to market new inventions.

(European Management Forum (EMF), 1985 Report on Industrial Competitiveness, pp. 185, 186)

The following data is extracted from Statistics Canada Cat. No. 88-201, Science and Technology Indicators 1984.

B.2 The Quality of Research Performed

Patent Applications Filed in Canada
Demandes de brevet déposées au Canada

Country of applicant Pays du déposant	1978	1979	1980	1981	1982
	number (rounded) - nombre (arrondi)				
Canada	1,870	1,600	1,780	1,950	1,940
Germany Allemagne	1,810	1,960	2,150	2,190	2,210
Japan Japon	1,600	1,870	2,020	2,230	2,450
United Kingdom Royaume-Uni	1,320	1,280	1,190	1,380	1,380
United States États-Unis	13,600	12,770	13,120	12,940	12,430
Other Autres	4,480	4,470	4,710	4,810	4,880
Total	**24,680**	**23,950**	**24,970**	**25,500**	**25,290**

Patent Applications Filed by Canadian Residents in Selected OECD Countries
Demandes de brevet déposées par des Canadiens dans certains pays membre de l'OCDE

Country of application Pays de la demande	1978	1979	1980	1981	1982
	number (rounded) - nombre (arrondi)				
Canada	1,870	1,600	1,780	1,950	1,940
Germany Allemagne	230	200	170	120	100
Japan Japon	220	240	270	270	270
United Kingdom Royaume-Uni	540	400	350	290	260
United States États-Unis	2,050	2,060	1,970	2,200	2,140

B.3 Research and Development Personnel

The following data is extracted from the recent OECD report: Science and Technology Indicators, Basic Statistical Series, Selected S&T Indicators 1981 - 1986, Recent Results, DSTI 7601S, October 1985.

9. TOTAL R & D PERSONNEL PER 1000 LABOUR FORCE

	1981	1982	1983	1984	1985
AUSTRALIA	6.5	..	..	..	..
AUSTRIA	5.6	..	..	..	..
BELGIUM	..	..	..	..	..
CANADA	5.5	5.7	..	..	..
DENMARK	..	..	..	..	..
FINLAND	7.2 A	..	7.9	..	..
FRANCE	10.6	..	11.0	..	..
GERMANY	13.6	..	..	..	..
GREECE	..	..	..	..	..
ICELAND	6.8	..	..	..	..
IRELAND	4.3	4.2	..	..	..
ITALY	4.5	4.6	..	..	..
JAPAN	11.4 F	11.6 F	12.1 F	..	..
NETHERLANDS	9.7	10.0 A	..	..	..
NEW ZEALAND	..	..	..	..	..
NORWAY	7.5	..	..	..	..
PORTUGAL	..	2.0	..	..	..
SPAIN	2.3	..	..	..	..
SWEDEN (G)	10.0 A	..	..	..	..
SWITZERLAND	..	..	..	..	..
TURKEY	..	..	..	..	..
UNITED KINGDOM	..	..	..	..	..
UNITED STATES	..	..	..	..	..
YUGOSLAVIA	..	..	..	..	..

12. TOTAL RSE (OR UNIVERSITY GRADUATES) PER 1000 OF LABOUR FORCE

	1981	1982	1983	1984	1985
AUSTRALIA	3.5	..	..	..	..
AUSTRIA	2.0	..	..	..	..
BELGIUM	..	..	..	..	..
CANADA	2.5	2.7	..	..	..
DENMARK	..	..	..	..	..
FINLAND	..	..	3.7	..	..
FRANCE	3.6	..	3.9	..	..
GERMANY	4.7	..	..	..	..
GREECE	..	..	..	..	..
ICELAND	3.1	..	..	..	..
IRELAND	2.1	2.1	..	..	..
ITALY	2.3	2.5	..	..	..
JAPAN	6.9 F	7.0 F	7.4 F	..	..
NETHERLANDS	3.5	..	..	..	..
NEW ZEALAND	..	..	..	..	..
NORWAY	3.8	..	..	..	..
PORTUGAL	..	0.7	..	..	..
SPAIN	1.1	..	..	..	..
SWEDEN (G)	3.5 A	..	..	..	..
SWITZERLAND	..	..	..	..	..
TURKEY	..	..	..	..	..
UNITED KINGDOM	..	..	..	..	..
UNITED STATES	6.2	6.3	6.4	..	..
YUGOSLAVIA	..	..	..	..	..

22. TOTAL INDUSTRIAL R & D PERSONNEL (FTE)

	1981	1982	1983	1984	1985
AUSTRALIA	7923	..	..	..	..
AUSTRIA	11636	..	..	..	..
BELGIUM	18944	..	19218	..	..
CANADA	32435	34950	35400	..	..
DENMARK	8818	9386	..	..	..
FINLAND	8367	..	9660	..	..
FRANCE	127640	132228	132200	..	..
GERMANY	242544	..	..	..	..
GREECE	..	..	..	..	..
ICELAND	72	..	..	..	..
IRELAND	1468	1549	..	..	..
ITALY	50368	49900	..	..	..
JAPAN	363851 F	376474 F	410860 F	..	..
NETHERLANDS	27140	27140	27180	..	..
NEW ZEALAND	..	..	..	..	..
NORWAY	6679	..	..	..	..
PORTUGAL	..	1891	..	..	..
SPAIN	12006	..	..	..	..
SWEDEN (G)	27348 A	..	30038	..	32033 C
SWITZERLAND	..	..	..	..	..
TURKEY	..	..	..	..	..
UNITED KINGDOM	195000	..	186000	..	..
UNITED STATES	..	..	..	..	..
YUGOSLAVIA	24375 F	..	..	..	..

35. HIGHER EDUCATION RSE (OR UNIV. GRADS.) AS A % OF TOTAL RSE

	1981	1982	1983	1984	1985
AUSTRALIA	56.2	..	..	..	..
AUSTRIA	45.4	..	..	..	..
BELGIUM	..	..	..	..	..
CANADA	25.2	24.6	..	..	..
DENMARK	..	..	..	..	..
FINLAND	..	..	40.0	..	..
FRANCE	38.2 A	..	36.5	..	..
GERMANY	23.6	..	..	..	..
GREECE	..	..	..	..	..
ICELAND	37.2	..	..	..	..
IRELAND	51.2	49.9	..	..	..
ITALY	47.5	..	..	..	..
JAPAN	41.6	41.9	40.4	..	..
NETHERLANDS	31.5	..	..	..	..
NEW ZEALAND	..	..	..	..	..
NORWAY	38.7	..	..	..	..
PORTUGAL	..	42.0	..	..	..
SPAIN	52.3	..	..	..	..
SWEDEN (G)	36.8 A	..	..	..	..
SWITZERLAND	..	..	..	..	..
TURKEY	..	..	..	..	..
UNITED KINGDOM	..	..	..	..	..
UNITED STATES	14.4	14.2	14.0	13.9 C	..
YUGOSLAVIA	30.4	..	..	..	..

31. HIGHER EDUCATION TOTAL R & D PERSONNEL (FTE)

	1981	1982	1983	1984	1985
AUSTRALIA	18241	..	..	..	..
AUSTRIA	4778	..	..	..	..
BELGIUM	..	..	..	..	..
CANADA	13120	13240	..	..	..
DENMARK	..	..	..	..	..
FINLAND	4950 A	..	5483	..	..
FRANCE	55200 A	..	57220	..	..
GERMANY	73134	..	..	..	..
GREECE	.. A	..	..	..	..
ICELAND	238	..	..	..	..
IRELAND	1578	1609	..	..	..
ITALY	32125	..	..	..	..
JAPAN	214077 F	222265 F	228331 F	..	..
NETHERLANDS	13060	16160 A	..	..	..
NEW ZEALAND	..	..	..	..	..
NORWAY	4939	..	..	..	..
PORTUGAL	..	2330	..	..	..
SPAIN	..	..	..	..	..
SWEDEN (G)	12400 A	..	..	..	..
SWITZERLAND	..	..	..	..	..
TURKEY	..	..	..	..	..
UNITED KINGDOM	..	..	..	..	..
UNITED STATES	..	..	..	..	..
YUGOSLAVIA	18083 F	..	..	..	..

B.4 Education and Training

The reader is referred to Section B.1.3 The HERD.

B.5 Diffusion and Application of Knowledge

No data is presented in this section. Future revisions to this paper may include pertinent statistics on this topic.

B.6 The Japanese Industrial Subsidy Strategy

The Japanese government uses government subsidies to industry as instruments of a coherent, long-term industrial strategy.

Subsidies to declining industries are smaller and shorter-term than those to future growth sectors. Subsidies to declining industries are dependent upon demonstrable structural changes to rationalize production, improve performance and potential.

Research and development asssistance is provided on joint basis with industry. The Japanese industrial strategy emphasises "knowledge-intensive" industry.

Subsidies are used to ease, not forestall, industrial and employment transitions; transferring material, monetary and human resources to rising industries.

Susidies are used to foster "strategic" industries, including new industries to revitalize the aging base.

Source: Report on Business, B1, Brian Milner, The Globe and Mail, December 30, 1985.

B.7 Science Policy in Sweden

The Current Swedish S&T Environment:

- o Like Canada, a resource rich nation; Sweden's industrial policy encourages high value-added industrial exports.
- o At the beginning of the eighties, Swedeish government was investing about 40% of its industrial subsidies in the shipbuilding industry. Only 15% went to export assistance and research and development.
- o Major Swedish shipyards have gone bankrupt, shipyard employment has fallen drastically, and the state-owned yard has lost large sums of money.
- o The Swedish government has slowly been decreasing subsidies to failing industries and will halt them altogether in the near future.
- o The Swedish government is emphasising taxation and financing methods of support rather than direct subsidies.

Source: Report on Business, B1, Brian Milner, The Globe and Mail, December 30, 1985.

An OECD background report, "Review of Science and Technology Policies in Sweden", prepared by the Swedish government under the direction of the Prime Minister's office, makes the following points:

- o Swedish government proposals regarding scientific and technological policies are presented to their "parliament" in comprehensive "Bills of Research" every three years.
- o In spite of Sweden's relatively large spending on research and development, the size of the country is a limiting factor. Swedish technology and trade are highly dependent on international trade and technological development.
- o Swedish scientists need to be active members of the international scientific community.

B.7 Science Policy in Sweden

The Current Swedish S&T Environment:

- There are few government research institutes outside of the universities. The major portion of research within the government sector is carried out within the universities.
- Sweden currently spends about 2.6% of GNP on R&D as compared to 1.7% in 1961-62.
- One-third of Sweden's GNP is sold as exports. Exports make up roughly half of total production.
- In the last decade, the level of private sector R&D has doubled to roughly 40% of total industrial investment.
- The Swedish government has maintained for many years that research supported by society should mainly be carried out within the university system. As a logical consequence of this philosophy there are very few separate government laboratories in Sweden.

The report asks the OECD conmmittee to focus on the following questions regarding the financing and management of national science and technology effort:

How is high quality in research and development maintained?

How is flexibility for the mobilisation of resources to new areas maintained?

What is the proper balance between a wide spectrum of R&D activites and concentration of research efforts and how is this acheived?

How can the various objectives concerning fundamental research and mission-oriented research be combined and supported in the higher education system?

How can we keep qualified teachers and researchers in the universities and how is the recruitment of bright students to professions in science and technology within the universiites and outside secured?

How is bureaucracy kept at a minimum in such big entities as universities?

When resources are scarce at the national level, how is the experienced lack of basic resources - including equipment - handled?

B.7 Science Policy in Sweden

A Historical Summary of Swedish Science Policy

Highlights of Swedish industrial policy measures taken over the past twenty-odd years are presented for information. Note the close relationship between industrial policy and scientific and technological policy. Of special note are the senior Swedish cabinet responsibilities for science and technology.

1967 - The Ministry of Industry was created, through it money is channelled for industrial R&D and procurement.

1967 - State-owned investment bank was created to facilitate restructuring finance in industry.

1968 - State-owned development company was created to accelerate development in important sectors of society. A complete restructuring and reorientation was done in 1975.

1968 - National Board for Technical Development (STU) formed.

1972 - start of Swedish space program.

1973 - tax incentives aimed at increasing private secor R&D introduced.

1975 - Energy Research Bill.

1977 - measures to foster industrial renewal.

1977 - network of regional development funds established along with a venture capital vehicle and a comprehensive innovation policy.

1977 - Reform of higher education system implemented.

1978 - Energy Research Program expanded.

1979 - Space budget increased and emphasis placed on industrial projects.

1981 - tax incentives redesigned.

1982 - tax incentives abolished in favour of basic research and technical services to small and medium companies.

B.7 Science Policy in Sweden

1982 - Appointment of Deputy Prime Minister responsible for "Advisory Council on R&D Policy". Responsibility for coordination of research affairs given to Minister of Science and an Under-Secretary of State.

1982 - Research Policy Bill focusing on priorities and planning of national R&D effort.

1983 - National microelectronics program.

1984 - Industrial Renewal and Growth Bill increased support to small, technology-based firms and concentrated research support in strategic technologies.

1984 - Bill on Research quality and funding; confirmation of 1982 decisions.

1979 and 1984 - precursor and comprhensive Bill on new job structure for teaching and research positions within the higher education system.

1985 - Confirmation of direction of energy research program.

B.8 Main Economic Indicators

Indicators of Economic Structure for Selected OECD Countries, 1980

Country	Agriculture, mining and manufacturing/GDP	Manufacturing/GDP	Exports/imports
		per cent	
Canada	20	29	106
Netherlands	24[1]	28[1]	103
Sweden	21	25	105
United States	23	29	91
Japan	30	35	94
Germany	36	39	106
France	26	31	100

[1] 1978 values.

Source: Statistics Canada Cat. No. 88-201, p.95.

The following data is extracted from the recent OECD report: Science and Technology Indicators, Basic Statistical Series, Selected S&T Indicators 1981 - 1986, Recent Results, DSTI 7601S, October 1985.

V - MAIN ECONOMIC INDICATORS

A. GROSS DOMESTIC PRODUCT (MILLION NATIONAL CURRENCY)

	1981	1982	1983	1984	1985	1986
AUSTRALIA	150683	165499	187405	212757	233990	256723
AUSTRIA	1056250	1138090	1205820	1285339	1366910	1460680
BELGIUM	3641081	3943792	4189965	4496251	4780808	5058752
CANADA	349526	368952	399301	430610	455720	485823
DENMARK	407790	467299	515399	567649	609506	641924
FINLAND	218455	245172	275084	304574	334955	361375
FRANCE	3110606	3566982	3935007	4277161	4579638	4881436
GERMANY	1544120	1600320	1667480	1743340	1827130	1919617
GREECE	2046831	2547849	3065765	3738958	4509744	5357266
ICELAND	21330	32692	56070	73132	93942	93942
IRELAND	11058	12989	14452	15998	17216	18617
ITALY	401579000	471390000	535904000	608670100	670598500	731803200
JAPAN	252546000	264798000	274920000	292610600	311822300	332371400
NETHERLANDS	352850	367750	376720	397328	412367	424820
NEW ZEALAND	29296	32240	34435	38651	43010	47349
NORWAY	327674	363714	401769	447540	482694	516966
PORTUGAL	1472700	1856900	2289600	2846728	3507739	4257693
SPAIN	17327400	19970400	22682900	25917390	28682780	31534560
SWEDEN	573040	627678	704474	780754	854292	910531
SWITZERLAND	184755	195980	203860	215015	227004	237332
TURKEY	6413610	8620394	11467864	18204560	27334140	38940220
UNITED KINGDOM	253453	276417	300228	320038	345309	370754
UNITED STATES	2934911	3045279	3275728	3631420	3880671	4126948
YUGOSLAVIA	2410245	3158702	..	..	..	..

D. DOMESTIC PRODUCT OF INDUSTRY (MILLION NATIONAL CURRENCY)

	1981	1982	1983	1984	1985
AUSTRALIA	141973	156001	..	..	..
AUSTRIA	808690	869730	915050	..	..
BELGIUM	2814649	3025732	3214417	..	..
CANADA	251919	259124	283268	..	..
DENMARK	259541	300255	333279	..	..
FINLAND	161821	180340	202027	..	..
FRANCE	2418040	2754346	3040961	3307345	..
GERMANY	1216990	1264720	1315210	..	..
GREECE	1668295	2037339	2427760	..	..
ICELAND	..	..	..	..	..
IRELAND	7969	9302	..	..	..
ITALY	331639000	388908000	441026000	..	..
JAPAN	224227000	235189000	244550000	..	..
NETHERLANDS	274520	287370	294290	..	..
NEW ZEALAND	24903	27495	..	..	..
NORWAY	266377	293935	324914	..	..
PORTUGAL	1262217	..	..	..	..
SPAIN	14559100	16757700	..	..	..
SWEDEN	372918	406418	456586	..	..
SWITZERLAND	..	..	..	..	..
TURKEY	5819261	7767967	10358773	..	..
UNITED KINGDOM	178920	197494	215387	..	..
UNITED STATES	2553418	2640541	2842603	..	..
YUGOSLAVIA	2191942	2598168	..	..	..

C. LABOUR FORCE (THOUSANDS)

	1981	1982	1983	1984	1985
AUSTRALIA	6823	6968	7055	..	..
AUSTRIA	3345	3342	3326	..	..
BELGIUM	4173	4197	4213	..	..
CANADA	11978	12033	12258	12474	..
DENMARK	2674	2700	2732	..	..
FINLAND	2513	2556	2574	2600	..
FRANCE	23532	23753	23690	23830	..
GERMANY	27373	27465	27486	..	..
GREECE	3678	3707	3808	..	..
ICELAND	110	113	115	..	..
IRELAND	1272	1296	1309	..	..
ITALY	22820	22927	23185	..	..
JAPAN	57070	57740	58890	..	..
NETHERLANDS	5593	5748	5839	..	..
NEW ZEALAND	1332	1332	1355	..	..
NORWAY	1972	1998	2024	..	..
PORTUGAL	4415	4356	4321	..	..
SPAIN	13391	13534	13699	..	..
SWEDEN	4332	4357	4375	..	..
SWITZERLAND	3060	3046	3020	..	..
TURKEY	17797	18033	18273	..	..
UNITED KINGDOM	26718	26757	26776	..	..
UNITED STATES	110315	111872	113226	..	..
YUGOSLAVIA	..	..	..	..	..

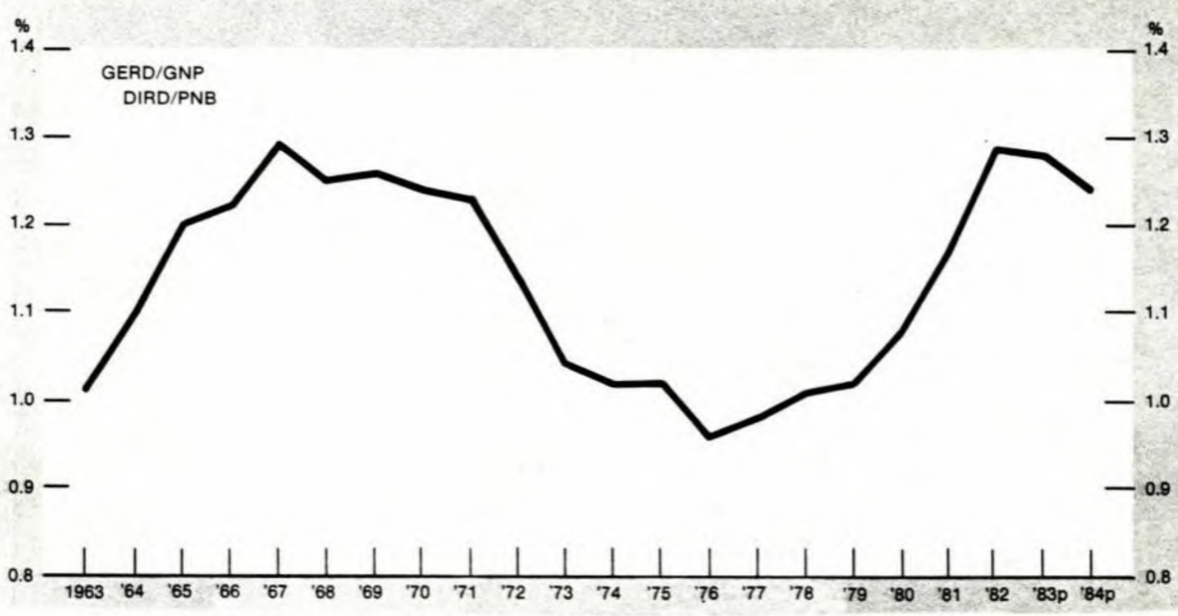
E. PURCHASING POWER PARITIES

	1981	1982	1983	1984
AUSTRALIA	0.99	1.03	1.07	..
AUSTRIA	16.11	16.07	15.96	..
BELGIUM	38.30	38.30	38.87	..
CANADA	1.12	1.15	1.16	..
DENMARK	8.11	8.44	8.73	..
FINLAND	5.20	5.30	5.54	..
FRANCE	5.84	6.14	6.45	..
GERMANY	2.45	2.40	2.37	..
GREECE	41.94	48.84	56.00	..
ICELAND	8.89	12.85	22.13	..
IRELAND	0.54	0.58	0.61	..
ITALY	891.94	982.78	1082.43	..
JAPAN	233.92	222.55	214.39	..
NETHERLANDS	2.65	2.62	2.56	..
NEW ZEALAND	1.17	1.22	1.20	..
NORWAY	7.11	7.30	7.48	..
PORTUGAL	37.12	42.35	50.05	..
SPAIN	74.82	79.53	85.05	..
SWEDEN	5.88	5.97	6.26	..
SWITZERLAND	2.37	2.37	2.35	..
TURKEY	50.14	59.56	71.56	..
UNITED KINGDOM	0.54	0.54	0.54	..
UNITED STATES	1.00	1.00	1.00	1.00
YUGOSLAVIA (K)	34.97	50.28	92.84	..

- LATE ADDITIONS -

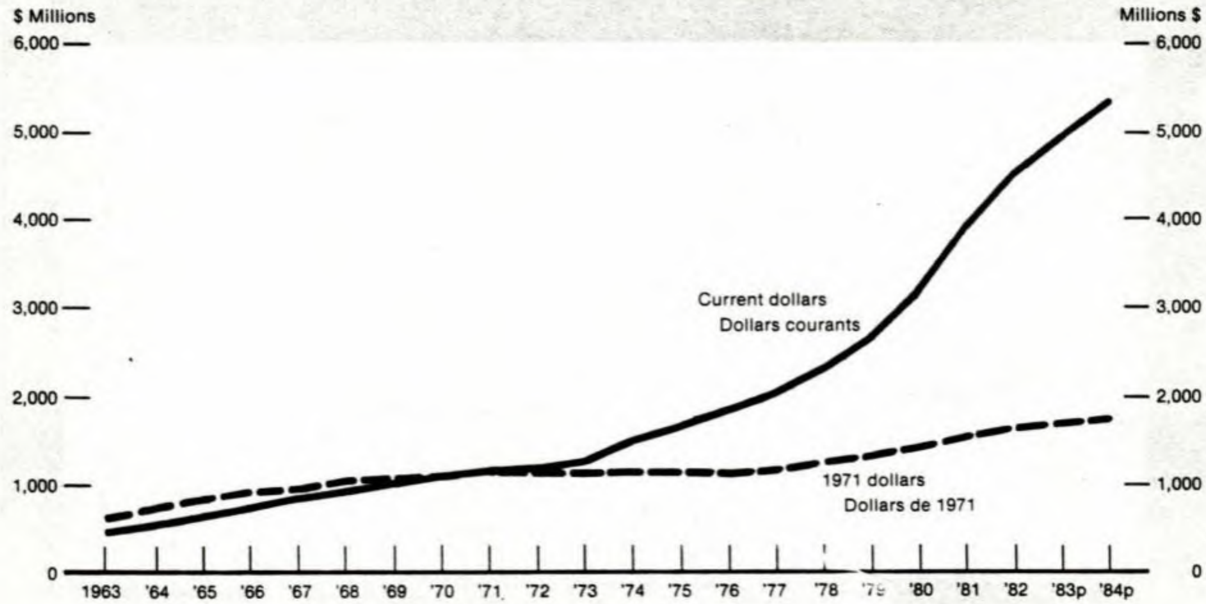
Total Expenditures on R&D as a Per Cent of GNP, 1963-1984

Dépenses totales au titre de la R-D en pourcentage du PNB, 1963-1984



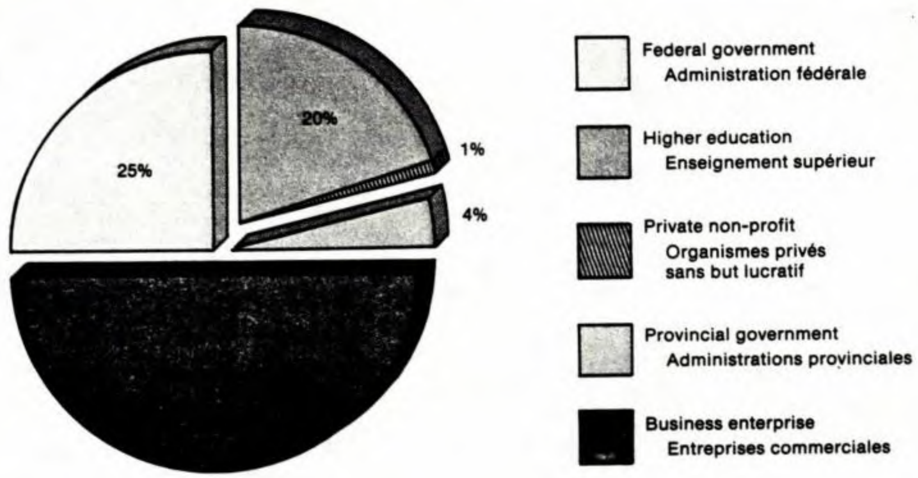
Total Expenditures on R&D in Canada, 1963-1984

Dépenses totales au titre de la R-D au Canada, 1963-1984



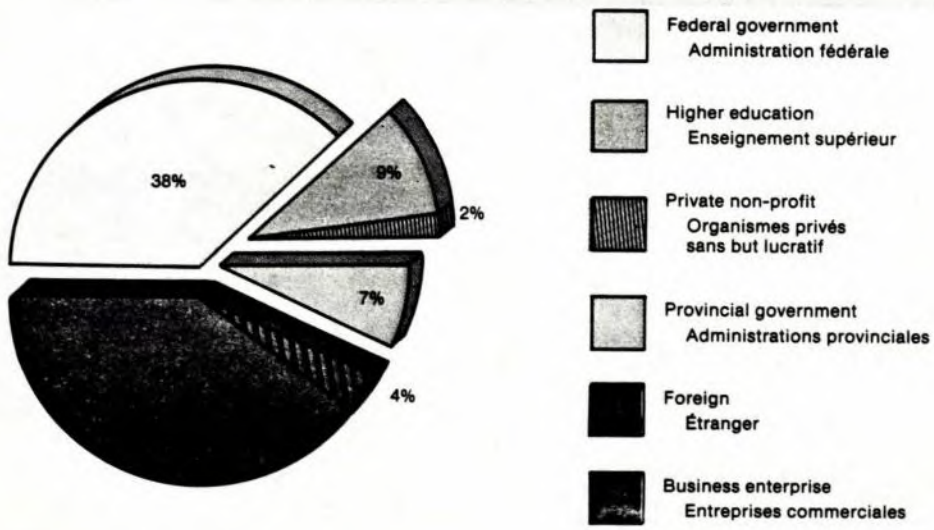
Share of GERD by Performing Sector, 1984

Ventilation de la DIRD par secteur d'exécution, 1984



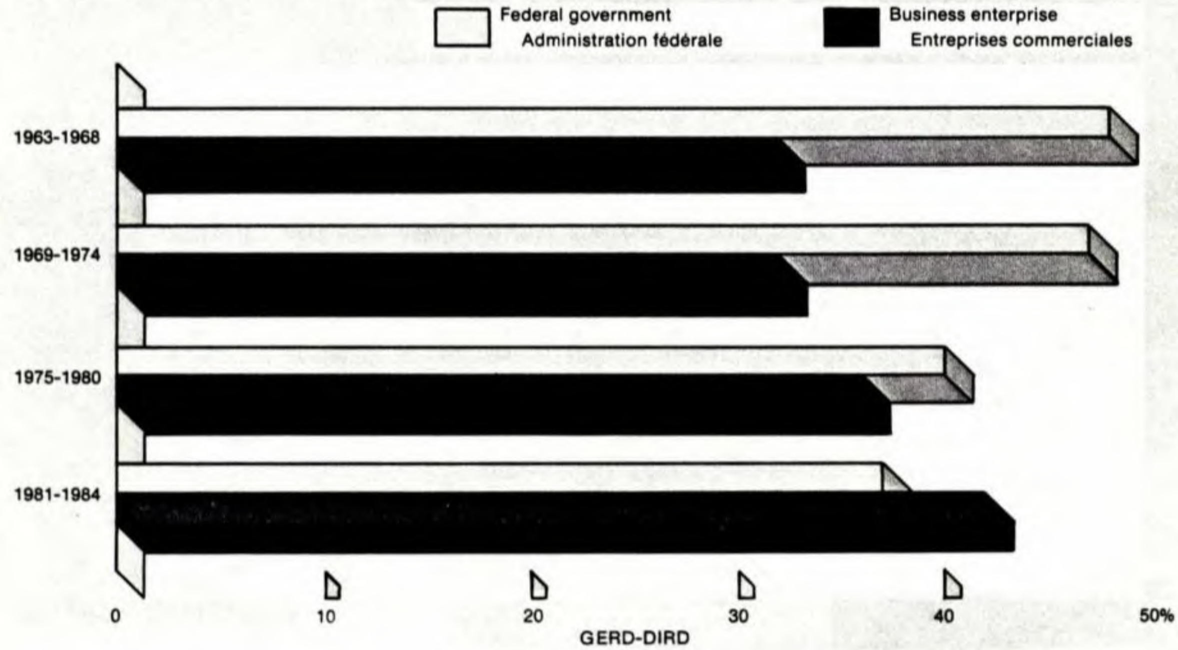
Share of GERD by Funding Sector, 1984

Ventilation de la DIRD par secteur de financement, 1984

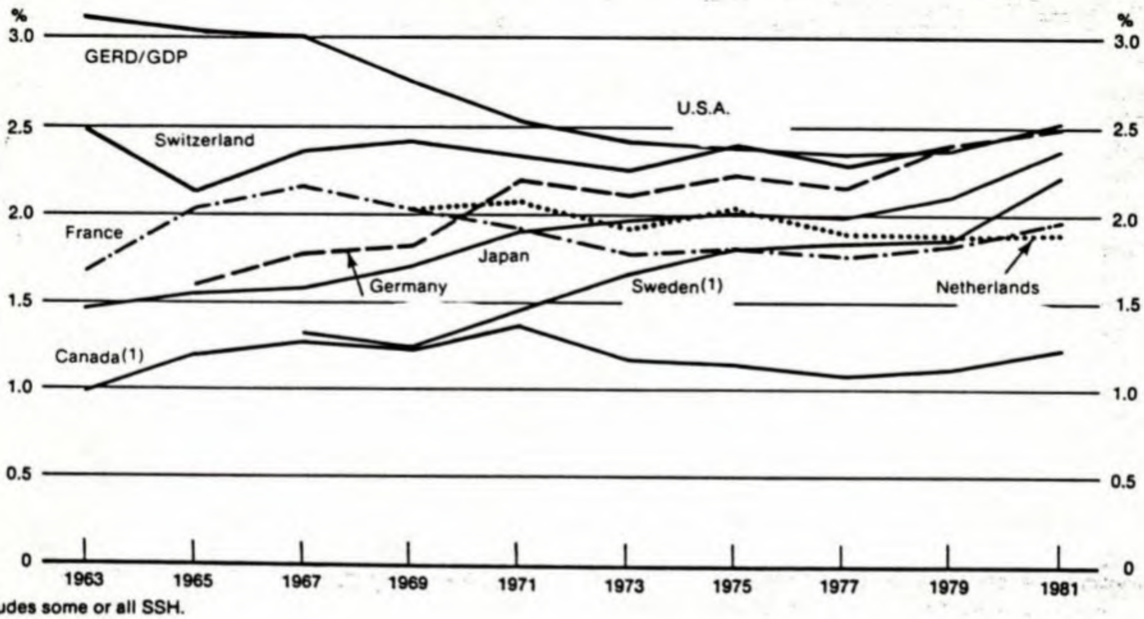


Federal and Business Enterprise Funding of R&D, 1963-1984

Financement de la R-D par l'administration fédérale et les entreprises commerciales, 1963-1984

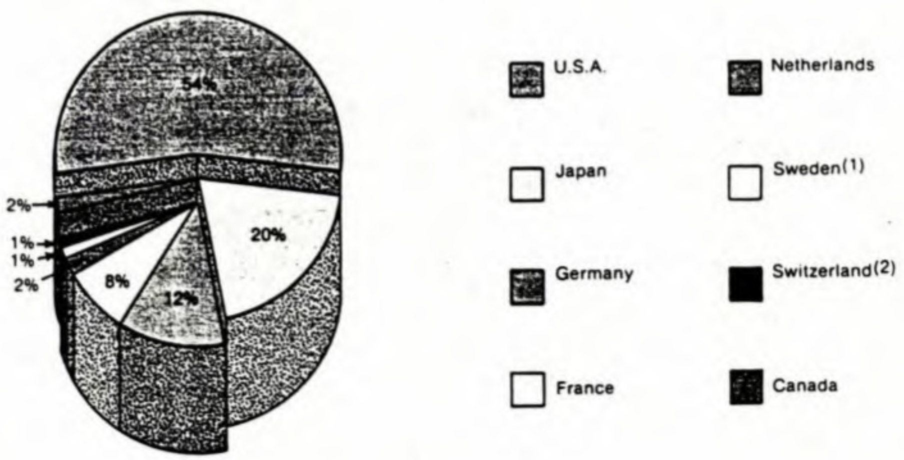


Proportion of the Economy Devoted to R&D for Selected OECD Countries



(1) Excludes some or all SSH.

Total R&D Expenditures for Selected OECD Countries, Relative Shares, 1981



(1) NSE only. (2) 1979 GERD used. Source: Appendix Table 37.

27. HERD (MILLION CURRENT PPP $)

	1981	1982	1983	1984	1985	1986
AUSTRALIA	457.6	..	..	..	..	..
AUSTRIA	251.0	..	..	..	..	..
BELGIUM	..	..	..	..	..	..
CANADA	1018.6	1125.0	1183.0	..	..	..
DENMARK	..	..	..	..	..	..
FINLAND	111.0 A	..	136.5	..	..	..
FRANCE	1756.8 A	1942.9	2081.0	..	..	..
GERMANY	2635.8	2748.6 C	2867.1 C	..	..	..
GREECE	14.8 A	..	..	..	..	..
ICELAND	4.7	..	..	..	..	..
IRELAND	24.9	27.1	..	..	..	..
ITALY	814.2	929.0	..	..	..	..
JAPAN	6180.1	6921.6	7694.5	..	..	..
NETHERLANDS	581.9	737.4 A	746.1 B	..	..	..
NEW ZEALAND	37.9 B	..	..	..	..	..
NORWAY	171.7	..	197.0	..	..	..
PORTUGAL	..	31.8	..	..	..	..
SPAIN	158.2	..	..	..	..	..
SWEDEN (G)	580.8 A	..	748.8	..	..	..
SWITZERLAND	355.0 D	..	345.2AJ	..	..	..
TURKEY	..	..	..	..	..	..
UNITED KINGDOM	1512.5 D	..	1733.8 B	..	..	..
UNITED STATES	10649.0	11015.0	11863.0	13125.0 C	14373.0 C	..
YUGOSLAVIA (K)	98.8	..	..	..	..	..