Minister of State
Science and Technology

CANADA

Ministre d'État
Sciences et Technologie

The Honourable L'honorable
Tom Siddon

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Science, Technology and Economic Development

A Working Paper

1985

Canada

Science, Technology and Economic Development

A Working Paper

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FOREWORD

On February 4 and 5, 1985, the Honourable Tom Siddon, Minister of State for Science and Technology, met with the provincial and territorial ministers responsible for science and technology.

It was the first meeting of ministers responsible for science and technology since 1978 and a high degree of consensus was achieved on a number of matters of mutual concern.

Ministers jointly agreed that Canada must increase its commitment to promoting science, technology and innovation as key instruments of economic renewal, and urged that science and technology be considered as priority areas for investment and funding. They noted that investments in technology development pay significant benefits in economic growth and job creation.

As a highlight to the meeting, ministers also agreed to develop a comprehensive NATIONAL POLICY ON SCIENCE AND TECHNOLOGY designed to build upon provincial and territorial economic opportunities and priorities. The national policy will lead to a number of specific initiatives to most effectively employ finite monetary and human resources.

This paper on science and technology was prepared to aid discussion during the two-day meeting. Since that time, recently released data have been incorporated into the appendices. The text, however, remains unchanged.

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Science, Technology and Economic Development

INTRODUCTION

On November 8, 1984, the Economic and Fiscal Statement presented by the Federal Government identified ***private sector growth as the main engine of economic recovery.*** Canada must recognize that ***innovation is the key to that engine.***

"As much as two-thirds of recent economic growth has been attributed to technological change and there is every reason to believe that its influence will grow.

"If we are to be competitive, we must become effective in applying leading-edge technologies in producing goods and services."

(A New Direction for Canada:
An Agenda for Economic Renewal,
Department of Finance, 1984)

The combined challenges of the national deficit and high unemployment demand that the level of private sector research and development (R&D) performed in Canada be increased. Current indicators show that Canada now lags seriously behind many nations in several areas. Our international competitors invest more than twice as much in R&D as we do (Appendix B). The statistics for 1984 indicate that we have invested only 1.24% of our GNP in R&D, compared to the OECD (1981) average of over 2.2%. It is generally accepted that a positive relationship exists between technological advancement and economic growth (Appendix D).

Our mandate is clear. Federal, Provincial and Territorial governments must work together to ***inspire the private sector to immediately and significantly increase its investment in research, development and innovation.*** As a nation, we cannot afford to let the tremendous opportunities of technological advancement pass us by.

The expanding involvement of the provinces requires close collaboration to ensure that scarce human and material resources are effectively managed. The Economic and Regional Development Agreements (ERDA's) and their subsidiary agreements provide a basis for this purpose. The upcoming Science Ministers' Meeting, First Ministers' Conference and Economic Summit are other mechanisms.

A number of priorities should be identified if Canada is to remain at the forefront of technological advancement. These might include:

1. Increase private sector investment in innovation
2. Accelerate the rate of diffusion of technology/information
3. Redefine the role of government research and development
4. Recognize the importance of academic research and development.

Some government policy changes may be desirable in order to address each of these priorities. This paper offers some issues for discussion. While some of these issues do not fall within the jurisdiction of the Ministry of State for Science and Technology, they do affect our national industrial climate for innovation and, as such, are addressed here.

The issues presented here are not mutually exclusive. In a time of fiscal restraint, any future decisions regarding the possible implementation of selected issues will have to be made in this context.

Our economy is often eight to ten years behind other nations in the race to adopt new technologies. This lag in innovation reduces the quality, quantity and variety of goods we can produce. The higher production costs involved limited our markets. Thus, our reluctance to innovate results in higher levels of unemployment and a reduced balance of trade (Appendix B). Research and development intensive firms enjoy higher than average growth in output, employment and productivity (Appendix D). A recent study by F. Longo, Industrial R&D and Productivity, indicates that R&D investments offer a rate of return on average 10-15% higher than capital expenditures.

There is some public concern over the potential negative impacts of technological advancement. As a nation, we should be determined to maximize the benefits while at the same time minimizing any negative effects. In addition to its broader mandate, MOSST also addresses the social impacts of technological change in collaboration with other Ministries.

This paper is intended to provide a starting-point for discussions among Federal, Provincial and Territorial Ministers responsible for science.

SUMMARY OF PRIORITIES AND ISSUES

The following priorities are suggested as a basis for discussion:

1. INCREASING PRIVATE SECTOR INVESTMENT IN INNOVATION

Consideration could be given to the following:

- focus existing tax incentives in order to maximize benefits to innovative businesses
- simplify grant programs so that they better serve intended clients
- utilize Government procurement policies to support Canadian innovation
- update the Patent Act to encourage Canadian innovation
- promote the application of venture capital to innovative endeavours
- encourage foreign-owned firms to seek greater parent-subsidiary technology transfers and world product mandates

2. ACCELERATING THE RATE OF DIFFUSION OF TECHNOLOGY/INFORMATION

Possible areas to be addressed are:

- co-ordinate Provincial, Territorial and Federal activities within existing innovation centres
- co-ordinate the activities of these innovation centres with local universities
- modify NRC's Technical Information Service (TIS) and coordinate it with the Canada Institute for Scientific and Technical Information (CISTI) to increase their accessibility and relevance to businesses of all sizes across Canada
- encourage the Patent Office to decrease its response time and increase public awareness of its value as a source of current technological information
- recognize the importance of the Trade Commissioner and Science Counsellor Network

3. REDEFINING THE ROLE OF GOVERNMENT R&D

Discussions could be directed towards:

- consideration of a more effective review mechanism for S&T issues within the committee system of the House of Commons
- re-examination of current contracting-out policies within Federal R&D laboratories
- facilitate the involvement of the private sector and Provincial governments in the management of Federal in-house R&D activities
- determination of whether a need exists for a mechanism of assessment and approval of all Federal R&D activities
- encourage closer links between Federal and Provincial R&D efforts

4. RECOGNIZING THE IMPORTANCE OF ACADEMIC R&D

Some issues in this area could be:

- encourage joint academic/private activities
- use Federal-Provincial agreements to support individual university specializations
- use Government Support Programs to support individual university specializations

DISCUSSION OF PRIORITIES AND ISSUES

1. Increasing private sector investment in innovation

A. BACKGROUND

Industrial innovation is an investment issue. Business leaders must perceive both an economic incentive and an industrial opportunity for the investment. The incentive can be generalized as a chance to increase the firm's competitive edge in the marketplace. The opportunity will be the application of in-house R&D or, as is most often the case in Canada, the adaptation of foreign technology. This new technology may update existing R&D methods, modernize the production line, improve office communications and productivity, provide new marketing techniques or generate a new line of goods or services. Private investors must also recognize the potential benefits of innovative ventures.

In the words of the European Management Forum:

"***a country's overall investment rate must be regarded as an important indicator of its longer-term economic health and thereby of its international competitiveness.***"
(1985 EMF Report on International Competitiveness)

Canada is struggling to establish itself as a major technology performer. Comparisons of international data are presented in Appendix B to this paper. Comparisons of provincial data are presented in Appendix C.

Our growth in real Gross National Expenditures (GNE) and employment is similar to other OECD countries. However, we devote significantly less of our economy to R&D. The number of Canadian patent applications is ***at least one order of magnitude lower*** than that of our major international competitors. In addition, our weak balance of trade is highlighted by an exceptionally low export/import ratio for most categories of technical goods.

A recent Conference Board of Canada release indicates that the rate of increase in corporate spending for R&D is expected to fall from the 1984 level of 17.1% to 5.6% in 1986. This slowdown in R&D activity is likely to be concentrated in the primary and manufacturing sectors — the foundation of our economy.

Business leaders generally agree that our national level of R&D is insufficient. ***It remains a paradox, however, that they consider their own company's R&D investment to be adequate.*** These leaders hold a positive view of the current climate for R&D, recognize a national requirement for increased innovation and yet have not identified incentives for further investment by their own firms.

Provincial and Federal governments could jointly encourage firms to be more future-oriented and to invest in longer-term R&D activities. The risks may be perceived to be greater, but the rewards will include a larger and more dependable share of the international marketplace.

The recent Canadian Manufacturers' Association Paper, A Future That Works, states that:

- technology should be used as a "competitive weapon"
- the private sector must sustain its growth in R&D spending
- present government policies to support industrial R&D are working and do not need fundamental revision.

Nationally, we should strengthen our efforts in the area of cooperative industrial research. Examples of such programs are found in France (ESPRIT), Japan (ICOT), the U.S. (MCC) and Britain (ALVEY). Such cooperative programs would be instrumental in establishing Canadian expertise in emerging technologies (space, microelectronics, biotechnology, etc.).

In addition, joint R&D ventures appear to be particularly valuable in the primary industries. These industries are regionally fragmented and yet must compete in a fierce international market. Two Canadian examples exist in the forestry industry: Forintek Canada Corporation and the Pulp and Paper Research Institute of Canada.

Relatively few Canadian companies conduct large-scale R&D (10% or more of their annual sales). Unless a host of individual firms dramatically increase their in-house R&D activities, Canada will continue to be extremely vulnerable to foreign competitors who are vigorously developing materials to substitute for our natural resources (ceramics and plastics for metals and new fibres for wood). Consortia R&D enable firms to share research costs and scientific findings. Apparently it is also easier to direct cooperative research efforts and stop specific programs that fail to develop as expected. Such close management of R&D efforts will accelerate the flow of new ideas to production and the marketplace.

Canada should strengthen its scientific management expertise. A successful effort to increase our national level of private sector R&D will rely heavily on the decisions of well-trained managers with science and engineering backgrounds. This point will be raised again in the discussion of Priority 4: Recognizing the Importance of Academic R&D.

A healthy economic climate is crucial for sustained innovation and entrepreneurship. ***However, the mandate for innovation and resurged growth lies with the private sector.*** We cannot be subsidized into technological advancement. We must choose to invest in it so that we will remain internationally competitive.

Initial consultations with industry and university representatives have generated the following categories of issues:

i) Tax Environment

ii) Grant Programs

iii) Government Procurement Policies

iv) The Patent Act

v) Venture Capital

vi) International Trade Agreements and Technology Transfer

Responses and recommendations from the Provincial and Territorial governments will help to identify the key issues to be addressed. This list of issues is intended as a starting-point for discussion and in no way limits the possibility of other measures not yet identified. Nor is this list intended to represent items under active consideration.

B. ISSUES

i) Tax Environment

Currently, the tax system provides significant incentives to R&D. It is an essential means of stimulating investment in technology and innovation. It is recognized that some tax incentives targeted at selective technologies have been shown to directly increase economic activity, thereby increasing government revenues.

While R&D tax provisions are viewed favourably by industry, there are several issues which may need to be resolved, particularly relating to the types of investment eligible for Scientific Research Tax Credits (SRTC's) and the definition of R&D for tax purposes.

Following the moratorium announced on October 10, 1984, only long-term equity investments qualify for the SRTC's while the program is being reviewed. Some industry representatives suggest that the current uncertainty associated with the SRTC's should be resolved in order to restore investor confidence and avoid a slump in the affected industries. They believe that the allowance for debt and preferred shares, up to a specified ceiling, is beneficial to start-up businesses and should be included in the reformed credits, in addition to the current credit for common shares. In addition, it may be desirable to rewrite the spending requirements for the credits to encourage only actual product/process development.

Initial consultations with industry representatives have highlighted concerns about the definition of R&D for tax purposes. It has been suggested that the term itself be changed from "scientific research" to "research and development" thus emphasizing the equal weight given to the development aspects of the R&D process. The possible restrictive nature of the current requirement that expenditures be ***wholly*** attributable to research may warrant re-examination. Further, within the context of the general definition of R&D, the meaning of development with respect to software for commercial exploitation should be clarified.

A resolution of the R&D definition and SRTC application issues would help provide industry with confidence in the stability of the tax system, thereby contributing to a favourable investment climate. A number of other issues may be worth considering at the same time:

- How to promote the R&D efforts of the small business sector, particularly when these firms are in their start-up stage.

- As mentioned earlier, there is a rapidly growing number of cooperative industrial research ventures in other industrialised nations pursuing long-term projects. Are there ways to facilitate more such initiatives by Canadian business?

- Any possible implementation of selected issues to improve the R&D investment climate would have to be made in the context of fiscal restraint.

ii) Grant Programs

While tax incentives are primarily used by larger firms with well established cash positions, grant programs stimulate small businesses not yet earning the profits to which incentives can be applied. Grant programs also encourage large established firms that need to innovate to remain internationally competitive.

As approximately one-third of all Canadian private sector jobs are found within the small business sector, grant programs are an essential element in maintaining and increasing national employment levels. For example, the $41 million in 1983-84 IRAP expenditures is expected to help generate between 7,000 and 10,000 person years of employment. In an overall review of government support programs, the Wright Task Force highlighted the effectiveness of the administration of IRAP.

Small businesses are located throughout the country, so grant programs geared towards them have a positive regional impact. Consideration could be given to coordinating the administration of all government support programs to industry, at least for the lower scale grants, and administering them through regional offices, such as the Provincial Research Organizations. A decentralized, computer-linked system would bring the decision-making level closer to the actual level of funds disbursement. This would be of benefit to the applicant industries.

The specific government programs are:

I.R.D.P. — Industrial and Regional Development Program

I.R.A.P. — Industrial Research Assistance Program

P.I.L.P. — Program for Industry/Laboratory Projects

D.I.P.P. — Defence Industry Productivity Program

P.E.M.D. — Program for Export Market Development

Both the Lamontagne Senate Report, A Science Policy for Canada and the Report of the Task Force on Federal Policies and Programs for Technology Development (the Wright Report) recommend that an overall critical review of government grant programs be conducted in order to simplify application processes and shorten response times. The ultimate objective of such a review might be the most effective delivery of R&D and innovation incentives to industry. One concern of this review might be the level of export activity generated by each program.

The following questions may also be relevant regarding grant programs:

- Should the general thrust of grant programs be focussed less on the development of technology and more on its diffusion and marketing? If so, what new measures should be considered?

- Is Federal and Provincial government support adequate in certain strategic technologies such as microelectronics, biotechnology, advanced materials and computer integrated manufacturing? Should this be a major focus of federal support programs?

- Should the joint balance of support from both levels of government be reviewed in order to focus on the needs of start-up businesses?

iii) Government Procurement Policies

Government procurement is a very powerful tool for promoting industrial innovation. Federal government purchases amount to over $6 billion per annum.

All levels of government can use their procurement policies to encourage private sector innovation. Even within the limitations imposed by international agreements such as GATT, a major role in supporting Canadian technology development can still be played by government contracts for actual products, R&D and related scientific activities. We must be conscious of hidden subsidies behind foreign bids to government tenders. Long-term government procurement planning to enable the development of Canadian prototypes to compete with foreign goods is essential. Government procurement policies might play an important role in the support of strategic technologies.

It has been suggested that government procurements could pay special attention to purchases offering a substantial import replacement and export potential. Industrial representatives have also proposed the establishment of a leasing program to promote the use of Canadian-made research and development apparatus and instrumentation.

Existing supportive procurement programs for Canadian technology include the Unsolicited Proposals Program and the Source Development Fund. At least two-thirds of the funds allocated through these programs have gone to small business. The combined funding level for these two programs is approximately $20 million for 1984/85. Industry's initial response to these programs has been largely positive.

iv) The Patent Act

The Canadian Patent Act has a direct impact on the national industrial climate for innovation.

The Act is a tool for registering and diffusing research and product/process development. The present Act has not been amended since 1969. It is open to criticism for not keeping pace with technological advancement. The compulsory licensing of pharmaceuticals is now being re-examined. It has been suggested that the Act's definition of intellectual property may need to be broadened to include software and process systems.

There is a need to assist entrepreneurs in attaining the technological assessments necessary to secure venture capital. One possible mechanism of assistance might be the revitalization of Canadian Patent Development Limited (CPDL) as a clearing-house for innovative ideas. After initial start-up support, it could become a self-financing corporation.

Currently, intellectual property rights resulting from developmental contracts with the government reside with the Crown. Innovative companies are frequently reluctant to enter into developmental contracts on this basis. This policy results in a low rate of commercial exploitation for publicly financed R&D. Suggestions have been made that this policy be modified so that the rights to new technology developed under government contract reside with the performer.

v) Venture Capital

Small, innovative Canadian companies suffer from a lack of ready access to venture capital, even though significant amounts are available. Their international competitors have tapped the cash resources within their own nations and abroad. Encouragement is needed to direct the large pool of Canadian savings towards innovative ventures. Some provinces have already taken significant steps towards this goal. Canadian investors should be encouraged to regard R&D as a profitable option for investment.

vi) International Trade and Technology Transfer

A wide and secure access to foreign markets is a powerful stimulus to industrial R&D and innovation. Trade opportunities for Canadian businesses are promoted by GATT negotiations, special bilateral trade arrangements and improvements in policies and programs to facilitate exports. The growing technological protectionism of Canada's major industrial partners is being carefully monitored.

Foreign-owned firms might be encouraged to seek greater parent-subsidiary technology transfers and world product mandates. One possible proposal might be to make technology transfers and product mandates criteria for eligibility for government support programs. Conference Board of Canada studies indicate that world product mandates have a positive impact on the R&D efforts of foreign-controlled subsidiaries in Canada.

Canadian companies must also improve their access to foreign technologies and management practices.

2. Accelerating the rate of diffusion of technology/information

A. BACKGROUND

To be at the leading edge of technological advancement, Canadian firms must be acutely aware of innovations occurring around the world. They must identify sources of information, advice and assistance related to their technological needs. This encourages the adoption of technological advancements within existing industries. It is of particular importance to Canada's primary resource sector.

Provincial and Federal governments operate several mechanisms designed for the diffusion of technical information.

These mechanisms include:

i) Regional Innovation Centres, including Centres of Excellence and the Provincial Research Organizations

ii) The Technical Information System (TIS), including CISTI (Canadian Institute for Scientific and Technical Information), operated by the National Research Council

iii) The Patent Office

iv) The Trade Commissioner and Science Counsellor Network

Memoranda of Understanding between Federal and Provincial ministries are a basic element in the process of recognizing the importance of technology/information diffusion.

B. ISSUES

i) Regional Innovation Centres

Provincial and Federal governments, as well as private sector interest groups, have identified the need for regional sources of information and expertise regarding technical innovation. A number of innovation centres have been established in order to meet these needs. Improved coordination of the activities of these centres would avoid unnecessary and wasteful duplication of resources.

One example of a cross-sector agreement might be the proposed National Manufacturing Technology Information Centre. Such a centre could bring together the efforts of all levels of government and the private sector.

Innovation centres and existing university faculties might be further encouraged to enter into cooperative arrangements. The universities would benefit from scientifically and technically-oriented finance, marketing and trade expertise. The innovation centres would benefit from the universities' basic research and development capabilities.

ii) NRC's Technical Information System (TIS)

It may be desirable to modify the source base of TIS, and CISTI, through cooperation with agencies such as the Patent Office and the Trade Commissioner and Science Counsellor Network.

It has also been suggested that the TIS be made more readily available to small businesses. This goal might be achieved through decentralized, computer-linked regional offices. This could be achieved through cooperation with the Provincial Research Organization offices and other innovation centres.

iii) The Patent Office

Some industry representatives have suggested that the services of the Patent Office be more widely publicized in order to increase the effectiveness of the office. It is desirable to increase the number of Canadian patent application (Appendix B).

iv) Trade Commissioner and Science Counsellor Network

The main function of the Trade Commissioner Service is to assist Canadian businesses to market their goods and services abroad.

Science Counsellors are responsible for monitoring new S&T developments and foreign government policy trends abroad. This information is channelled to the relevant government departments.

Both of these services are operated by the Department of External Affairs. A pro-active approach by both services maximizes their effectiveness.

The Science Council of Canada recently issued a comprehensive statement on The Canadian Science Counsellors.

Suggestions for the improvement of the Trade Commissioner System have focused on increased publicity of services available and recognition of the expertise required by the post.

3. Redefining the role of government R&D

A. BACKGROUND

The Federal government spends about $2 billion annually in federal scientific establishments and employs approximately 8,000 scientists and engineers in natural sciences activities. Some 15 different government departments and agencies are responsible for directing the research and development carried out within these laboratories (Appendix F). They represent an important national source of innovative ideas, technology transfer, information and advice.

Activity in federal laboratories is very diverse, covering support for regulatory activities, standard setting, environmental protection and advanced research. Many also have industrial support as an integral part of their mission. In these cases, it is particularly important that the related R&D activities be relevant to industry needs.

For over a decade, this relevance has been questioned. In particular, the recent Task Force on Federal Policies and Programs for Technology Development made specific recommendations towards clarifying the objectives of these laboratories.

Several issues for achieving this goal have been identified:

i) Consideration of a more effective review mechanism for S&T issues within the committee system of the House of Commons

ii) A re-examination of current contracting out policies within Federal R&D laboratories.

iii) Facilitate the involvement of the private sector and Provincial governments in the management of Federal in-house R&D activities

iv) Determination of whether a need exists for a mechanism of assessment and approval of all Federal R&D activities

v) Encourage closer links between Federal and Provincial R&D efforts.

B. ISSUES

i) Review Mechanism Committee on S&T

A strong proposal for such a committee was made in the 1977 Lamontagne Senate Report: A Science Policy for Canada.

This was also a major recommendation of the Task Force on Federal Policies and Programs for Technology Development.

It has been suggested that the first task of such a Parliamentary Committee might be to assess existing Federal R&D activities.

ii) Contracting-Out of Federal R&D Requirements and Facilities

It has been proposed that the Federal government require individual departments to contract-out more of their R&D needs to industry and universities. Also, consideration might be given to allowing government laboratories to retain the revenues earned by selling specialized R&D services to industries at home and abroad. This approach is followed in a number of European countries.

iii) Improve Management of Government R&D

Some Federal laboratories might benefit from a greater degree of industry and provincial government involvement in their management. This might help to make laboratory programs more relevant to industrial needs and provincial priorities. A substantive strengthening of the external boards connected to most federal laboratories has been recommended by many government-initiated studies.

iv) Technical Assessment and Approval

Initial consultations with industry representatives generated a suggestion to establish a central Federal S&T authority responsible for the review and approval of all proposals for R&D expenditures before they receive authorized funding. This suggestion is similar to ones made in both the Wright and Lamontagne Reports.

v) Co-ordinated Federal & Provincial R&D Efforts

In addition to participating on the external boards of Federal R&D laboratories, Provincial governments might co-ordinate their R&D activities with relevant Federal laboratories operating within their province. Guidelines for such cooperation might be outlined within the framework of ERDA sub-agreements.

4. Recognizing the importance of academic research and development

A. BACKGROUND

Universities play a critical role in helping Canada meet the technology challenge. Their basic research keeps Canada in the forefront of important scientific advances around the world, and provides the strong scientific base from which new technologies can be developed. Most importantly, however, they produce highly qualified scientists, engineers, and technically literate managers — the future leaders of governments, industries and institutions. Canada is lagging in its development of these human resources (Appendix E). ***Academic R&D plays a vital role in the training of highly qualified personnel.***

However, restricted budgets, increasing enrollments, and rapidly escalating research and operating costs have placed universities in a ***critical financial crisis***. Canadian universities are operating with roughly half the resources per student of world-class American and European universities. This threat could seriously erode our university R&D effort, thereby reducing the quantity and quality of specialized human resources.

The recognition and resolution of this impending crisis should be a high priority for both Federal and Provincial governments. Financing and support agreements may have to be re-negotiated with the bilateral intention of providing adequate stable, long-term funding and leadership for our universities.

B. ISSUES

Closer cooperation between academic R&D and private sector innovation should be encouraged. Yet, at the same time, the need for basic scientific R&D within universities is recognized. Some possible issues are:

i) University-Industry Links
ii) Federal/Provincial Agreements
iii) Government Support Programs

i) University-Industry Links

In response to their financial squeeze, universities have increasingly been trying to forge stronger links with the private sector. Technology transfer from universities can be an important source of R&D expertise for industry. The recent Wright Report identified a number of possible tax changes designed to strengthen the university-industry interface and improve the financial climate for university R&D activities. These suggestions included encouragement of equipment donations to universities and of private companies that contract universities to conduct R&D on their behalf.

The operation of innovation centres within universities to respond to the scientific needs of industry, particularly small business, is another possible approach to encouraging closer academic and business cooperation regarding innovation. It might be possible to operate such centres on a cost recovery basis.

Such centres can prove to be very successful internationally. For example, the University of Waterloo is pursuing technology transfer agreements with China and Japan.

The Canadian Manufacturers' Association, the Canadian Advanced Technology Association, and other industry representatives have recognized that investing in people is extremely important and that improving our education and training systems should be a national priority.

They also identify university cooperative programs, university-industry research agreements and corporate access to university resources as good means for strengthening the academic-private sector link.

ii) Federal-Provincial Agreements

The university financing problem must be addressed through consultations over the provisions with respect to post-secondary education of the Established Programs Financing Act. In these consultations, consideration might be given to full funding of specific university R&D activities requested by government. Consideration might also be given to the provision of specific support for changes in curricula aimed at increasing student exposure to industrial settings or otherwise broadening the range of courses for scientists and engineers.

On-going discussions between Federal and Provincial governments and universities might also highlight ways of combining innovation centre and university activities. Centres of excellence within a particular field might serve to encourage individual Canadian universities to attain world-class recognition in specific science and engineering disciplines.

iii) Government Support Programs

Federal support programs administered by the Natural Sciences and Engineering Research Council (NSERC), Social Sciences and Humanities Research Council (SSHRC), and the Medical Research Council (MRC) could also be directed towards encouraging existing innovation centres to operate within local universities.

These programs might identify and encourage individual Canadian universities to become world leaders in specific fields.

CONCLUSION

In this working paper, Science, Technology and Economic Development, a variety of issues have been presented for discussion. A selection of some of these issues, and others not yet identified, could serve to reconfirm the mandate for innovation in the private sector as a means to achieving the national goal of economic renewal.

Four science and technology priorities have been offered for consideration:

1. Increase private sector investment in innovation;
2. Accelerate the rate of diffusion of technology/information;
3. Redefine the role of government research and development; and
4. Recognize the importance of academic research and development.

Issues presented within each priority serve as a basis for ongoing discussions between the two levels of government.

To properly focus future discussions, initial Federal-Provincial consensus on two issues would be desirable. These are:

1. ***The accelerated application of technological advancements to Canadian products is the number one priority in the national effort to revitalize the economy.***

2. ***An expeditious solution to the current university financial crisis must be found.***

It is the joint responsibility of the Federal, Provincial and Territorial governments to ensure that Canada exploits the opportunities inherent in technological advancement to their fullest potential.

SCIENCE, TECHNOLOGY AND ECONOMIC DEVELOPMENT

A WORKING PAPER

APPENDICES

A

Appendix A
JOINT COMMUNIQUÉ

FEDERAL-PROVINCIAL-TERRITORIAL CONFERENCE OF MINISTERS OF SCIENCE AND TECHNOLOGY

Calgary, Alberta
February 5, 1985

For the first time since 1978, Ministers responsible for Science and Technology at the federal, provincial and territorial level met to discuss matters of mutual concern. The meeting was conducted under the chairmanship of the Honourable Tom Siddon, federal Minister of State for Science and Technology, on February 4 and 5, 1985, in Calgary.

Ministers highlighted the important role that science, technology and innovation must play in economic renewal, and recommended the First Ministers endorse science and technology as a priority area for investment and funding, identifying it as a source of economic growth and job creation. Ministers were presented with evidence of Canada's poor performance in exploiting the economic potential of science and technology in comparison to our major international competitors.

Ministers committed themselves to producing a comprehensive NATIONAL POLICY ON SCIENCE AND TECHNOLOGY, designed to build upon provincial and territorial economic opportunities and priorities. In pursuing this goal, Ministers emphasized the necessity for business and industry to play an increased role in support of this policy.

Ministers also agreed to more effective and continuing cooperation in both planning and implementing science and technology strategies, and pledged to meet again within a year to review progress on the National Policy.

Further agreement was reached on three fundamental priorities designed to:

i. Stimulate private sector investment in innovation.

ii. Encourage the transfer and application of technology.

iii. Support important basic research to develop longer term scientific expertise and industrial leadership for the country.

Ministers adopted an agenda for cooperative action, and identified specific proposals which the federal, provincial and territorial governments would jointly examine in the context of work on the National Policy. These included pledges to:

1. Work for more effective programs of grants, tax incentives and procurement targetted especially to small- and medium-sized technology-intensive ventures.

2. Review and evaluate all existing agreements and programs to support provincial and territorial industrial development, with a view to increasing their effectiveness in promoting new technology, leading to more productive and internationally competitive industries.

3. Review the possibilities for more efficient coordination and use of all governmental research laboratories, in order to ensure better coupling with industrial opportunities and priorities and thus new job potential.

4. Seek ways and means of improving access to federal and provincial programs of support for industrial R&D, and access to information. Ministers will, in particular, investigate the possibility of creating single-desk access to such assistance on a decentralized basis.

Provincial Ministers urged the federal government to continue to improve the federal 5-year plans in support of postgraduate research programs within Canadian universities. The provincial ministers said adequate and predictable funding was essential if the human resource requirements of a more technology intensive economy are to be met. They also called for reinstatement of some form of the Scientific Research Tax Credit (SRTC) which would be understandable and effective in enhancing research, innovation and new product development.

Finally, the Ministers agreed that the conclusions of their deliberations would be forwarded to their respective First Ministers, for consideration at their forthcoming Meeting in Regina, on February 14 and 15, 1985.

Appendix B

INTERNATIONAL COMPARISONS OF TECHNOLOGY PERFORMANCE

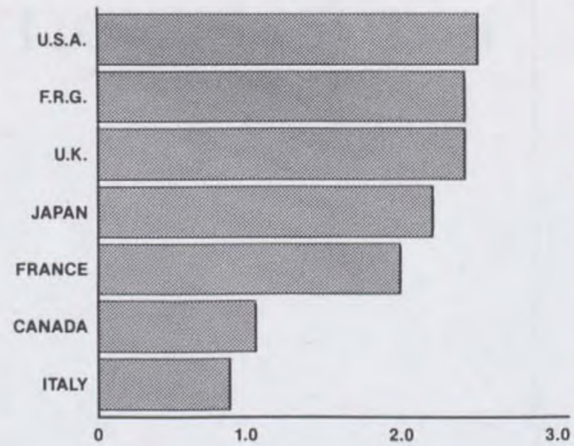
B

Appendix B1

R&D EXPENDITURE DATA

B1

G.E.R.D. AS A PERCENT OF G.D.P.
1981



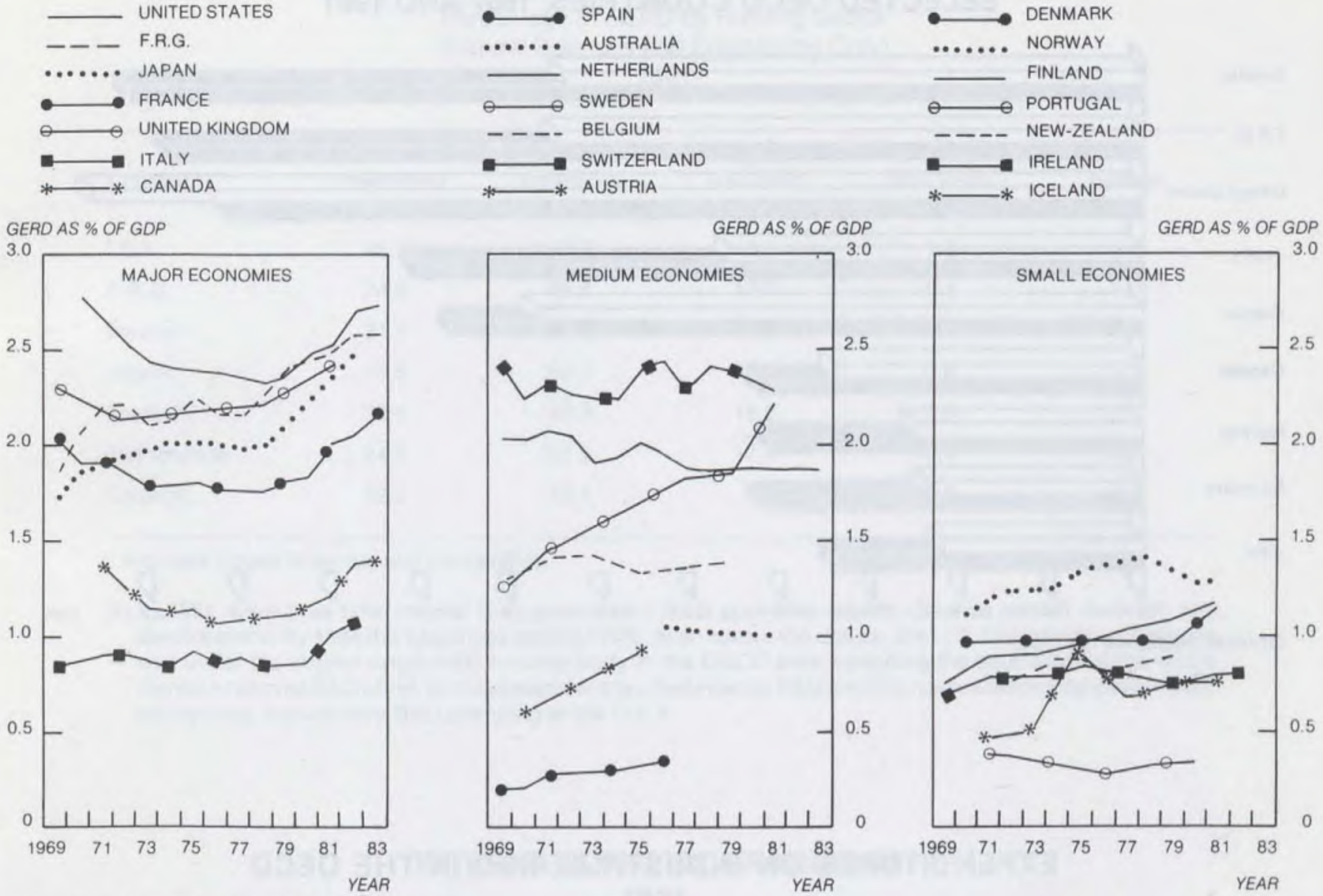
GROSS EXPENDITURE ON RESEARCH AND DEVELOPMENT (GERD)
AVERAGE ANNUAL REAL GROWTH RATES
1969-1981
(All fields of science)

COUNTRY	PERCENTAGE
Japan	8.1
Sweden	7.3
F.R.G.	5.4
Italy	4.7
France	3.5
Canada*	3.2
Netherlands	2.3
U.K.	2.0
United States	1.8
Switzerland	1.2

*Natural Sciences and Engineering only

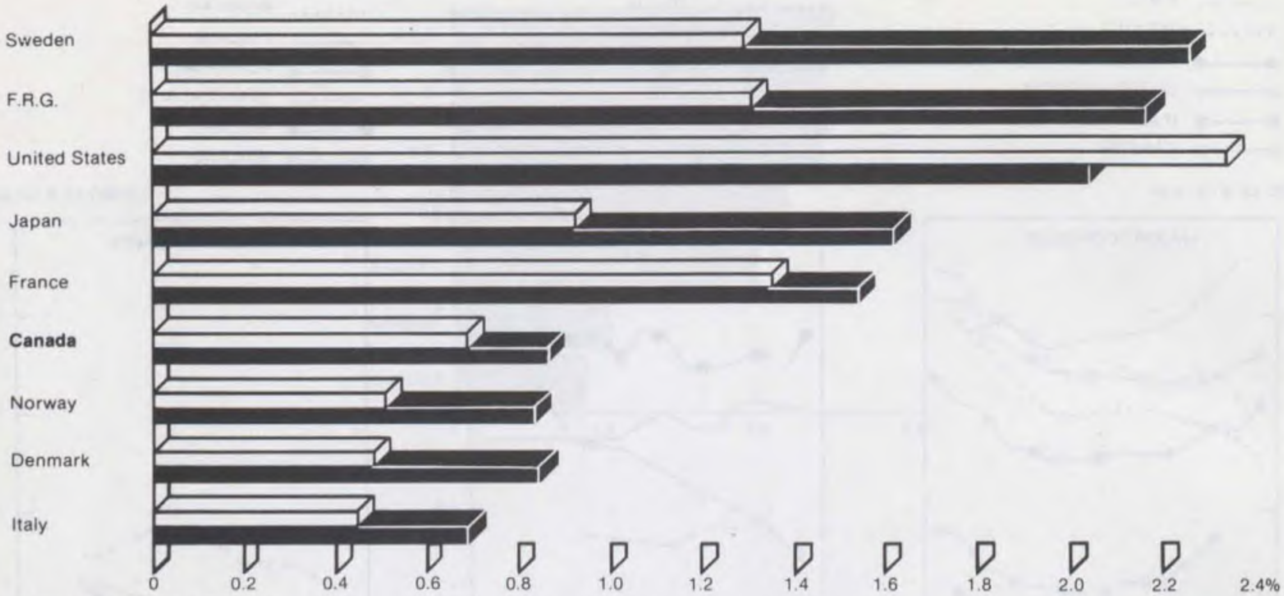
Source: OECD

GERD AS A PERCENT OF GDP*



* Includes Social Sciences and Humanities
Source: OECD

INDUSTRIAL R&D AS A PERCENT OF DOMESTIC PRODUCT OF INDUSTRY, SELECTED OECD COUNTRIES, 1967 AND 1981



Source: Statistics Canada

EXPENDITURES ON INDUSTRIAL R&D IN THE OECD
1981

COUNTRY	PER CENT OF TOTAL OECD	$ MILLION P.P.P.
United States	49.4	51,810
Japan	15.7	16,445
F.R.G.	10.3	10,825
U.K.	6.7	7,115
France	6.1	6,379
Italy	2.5	2,591
Canada	1.5	1,616
Sweden	1.4	1,482
Netherlands	1.3	1,345
Switzerland	1.3	1,328

Source: OECD

INTERNATIONAL COMPARISONS

Percentage of GERD by Funding Sector
(Natural Sciences and Engineering Only)
1981

Country	Government	Business Enterprise	Higher Education	Private Non-Profit	Foreign
USA	46.8(1)	48.7	3.1	1.3	0.0
F.R.G.	24.8	59.8	14.0	0.4	1.0
Sweden	21.4	51.3	18.7	1.0	1.5
Japan	15.5	69.1	14.6	0.6	0.1
France*	36.6	40.8	16.5	0.9	5.1
Netherlands	24.9	51.2	17.4	0.9	5.7
Canada	42.2	43.1	8.9	2.0	3.8

* Includes Social Sciences and Humanities.

(1) In 1981 more than 50% of total U.S. government R&D spending was on defence related research and development. By 1984 the figure had reached 70%. Even before the upturn, the U.S. Department of Defence was by far the largest single R&D funding body in the OECD area, spending the equivalent of the whole German national R&D effort. At the same time, the private sector R&D funding now exceeds total government military and non-military R&D spending in the U.S.A.

INTERNATIONAL COMPARISONS

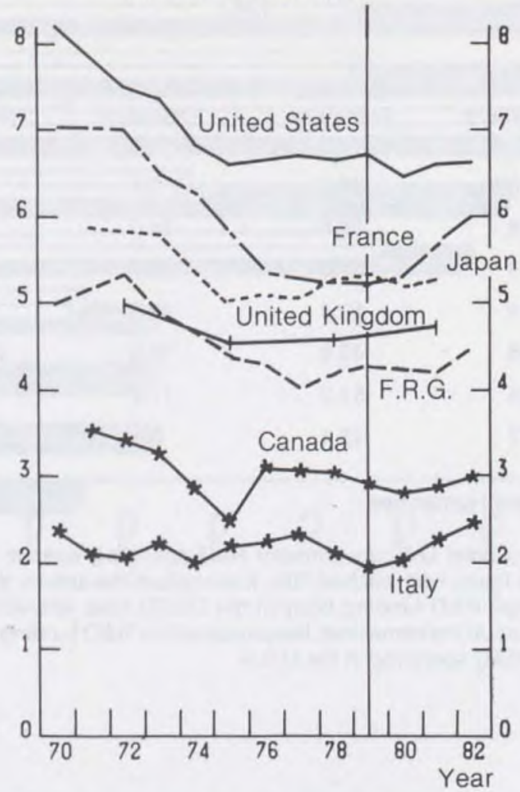
Percentage of GERD by Performing Sector
(Natural Sciences and Engineering Only)
1981

Country	Government	Business Enterprise	Higher Education	Private Non-Profit
USA	12.1	70.4	14.4	3.1
F.R.G.	13.5	71.8	14.3	0.4
Sweden	6.4	66.6	26.8	0.3
Japan	11.8	67.7	16.5	4.0
France*	23.6	58.9	16.4	1.1
Netherlands	19.7	59.0	19.0	2.3
Canada	25.9	51.9	21.4	0.8

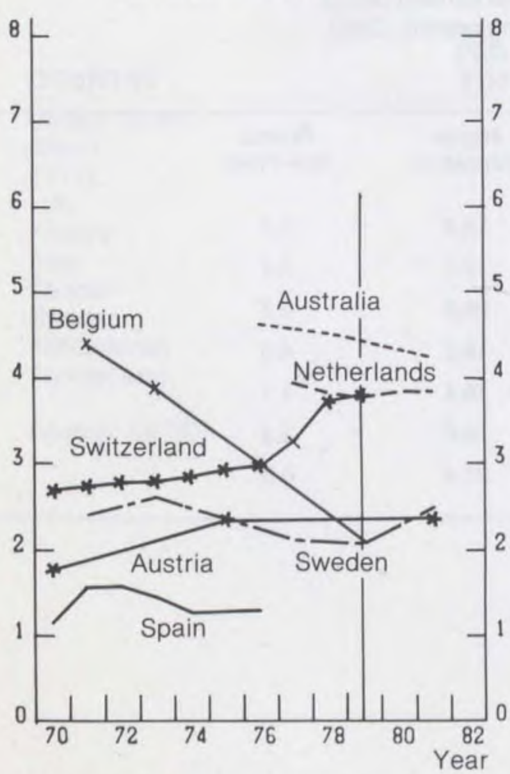
* Includes Social Sciences and Humanities
Source: OECD

GOVERNMENT EXPENDITURE ON R&D AS A PERCENTAGE OF TOTAL GOVERNMENT DISBURSEMENTS(*)

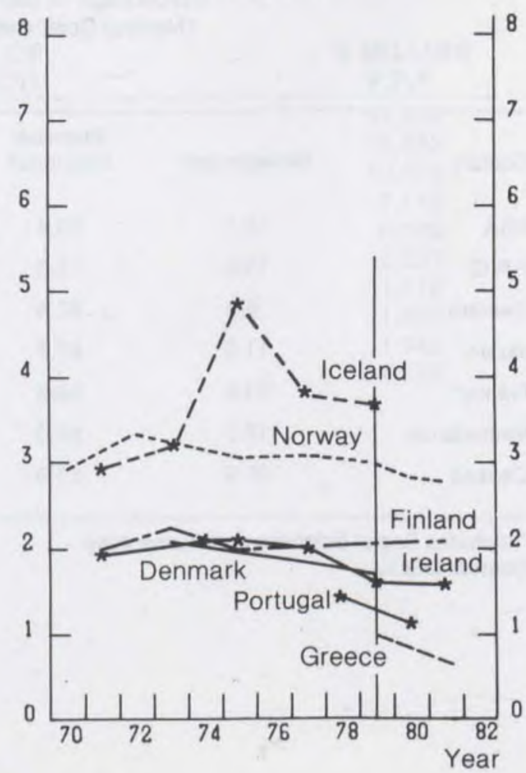
MAJOR ECONOMIES



MEDIUM ECONOMIES



SMALL ECONOMIES



(*) Current disbursements plus current transfers of the general government.
Source: STIU Databank

R&D RESOURCES DEVOTED TO THE HIGHER EDUCATION SECTOR IN THE OECD COUNTRIES: LEVELS AND TRENDS

(All fields of sciences)

	In millions current ppp $ 1981	Number of Researchers (FTE) 1981	Average annual real growth (in %)			
			69-81	69-75	75-81	81-82
UNITED STATES	10,648.0	98,700	1.2	-0.9	3.4	-2.9
JAPAN	6,549.7	163,264(xx)	6.8	8.4	5.2	4.7
F.R.G.	2,670.0	30,229	4.2	6.7	1.8	-2.5
FRANCE	1,777.5	32,700	3.9	2.6	5.1	3.4
UNITED KINGDOM	1,531.0	..	4.3	7.5	1.2	..
ITALY	822.9	24,754	1.8	2.5	1.2	-1.8
CANADA	917.7	7,520	-0.5(x)	-2.5(x)	1.6	-0.2
NETHERLANDS	585.9	6,123	3.0	5.3	0.8	..
SWEDEN	597.0	5,600	10.3	12.6	8.1	..
SWITZERLAND	355.9	..	6.0	6.5	5.5	..
OECD (x)	28,240.0	424,300	3.3	2.9	3.7	..

(x) OECD estimates
(xx) Japan not in full-time equivalent.

Source: OECD
DSTI/SPR/84.45

Appendix B2

INDICATORS OF CREATIVITY

DOMESTIC PATENT APPLICATIONS

	1979	1980	1981	1982
AUSTRALIA	4,744	6,582	6,341	6,603
AUSTRIA	2,446	2,327	2,390	2,233
CANADA	1,602	1,785	1,951	2,000
FRANCE	11,303	11,000	10,945	10,681
F.R.G.	30,879	30,314	29,841	30,668
ITALY	--	6,369	--	--
JAPAN	150,623	165,730	191,621	210,897
NETHERLANDS	2,049	1,826	1,897	1,873
SWEDEN	4,116	4,106	3,914	4,087
SWITZERLAND	4,441	4,049	3,712	3,845
UNITED KINGDOM	19,468	19,612	20,808	20,530
UNITED STATES	60,635	62,098	62,404	63,316

Source: Statistics Canada

NATIONAL CREATIVITY

COUNTRY	CREATIVITY INDEX(1)
JAPAN	34.33
SWITZERLAND	27.65
SWEDEN	17.42
UNITED STATES	15.82
FRANCE	14.24
F.R.G.	13.33
UNITED KINGDOM	9.44
CANADA	6.02
NETHERLANDS	3.36
ITALY	3.17

(1) Average annual number of patents granted to residents per 100,000 inhabitants, 1980-82

Source: European Management Forum (E.M.F.) Foundation the world economic forum Report on International Competitiveness, 1985

INTERNATIONAL OWNERSHIP OF TECHNOLOGY

COUNTRY	INDEX(1)
Switzerland	129.5
F.R.G.	57.0
Sweden	55.3
Netherlands	43.6
France	25.0
United States	24.4
Japan	20.5
United Kingdom	18.6
Italy	10.8
Canada	8.3

(1) Number of patents secured by residents of a country (i.e. external patents) in the rest of the world per 100,000 inhabitants, 1982

Source: European Management Forum (E.M.F.) Foundation the world economic forum Report on International Competitiveness, 1985

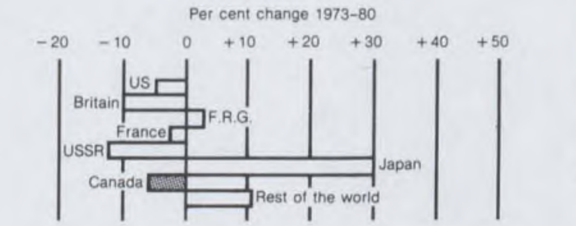
EXTERNAL PATENT APPLICATIONS

	1979	1980	1981	1982
UNITED STATES	80,744	79,078	73,895	67,197
F.R.G.	49,539	48,650	42,323	39,816
JAPAN	33,766	35,945	34,903	37,505
UNITED KINGDOM	18,701	17,400	16,890	16,734
FRANCE	19,276	18,839	15,533	15,963
SWITZERLAND	15,650	14,925	12,043	11,286
ITALY	11,066	10,207	8,998	8,798
NETHERLANDS	9,063	8,272	7,147	6,326
SWEDEN	7,662	6,862	6,227	5,351
CANADA	4,071	3,884	3,962	—

Source: OECD/STIU Data Bank — 10 December 1984

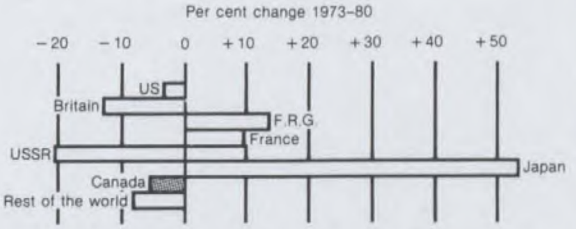
Share of scientific publications worldwide

	1973	1975	1977	1979	1980
	(per cent)				
US	38.2	37.3	37.1	37.1	36.5
Britain	9.2	9.5	8.9	8.3	8.3
F.R.G.	6.0	6.4	6.3	6.3	6.2
France	5.6	5.8	5.6	5.3	5.4
USSR	9.0	7.9	7.9	8.0	7.9
Japan	5.3	5.4	6.0	6.4	6.8
Canada	4.4	4.3	4.4	4.4	4.1
Rest of the world	22.3	23.5	23.8	24.3	24.8



Share of scientific citations worldwide

	1973	1975	1977	1979	1980
	(per cent)				
US	49.8	49.2	49.0	48.1	48.2
Britain	11.2	10.9	10.7	10.1	9.7
F.R.G.	5.1	5.7	5.8	5.9	5.8
France	3.9	4.1	4.1	4.2	4.3
USSR	4.1	3.4	3.2	3.2	3.2
Japan	3.7	4.2	4.6	5.1	5.6
Canada	4.5	4.4	4.3	4.4	4.2
Rest of the world	17.8	18.2	18.3	19.1	19.1



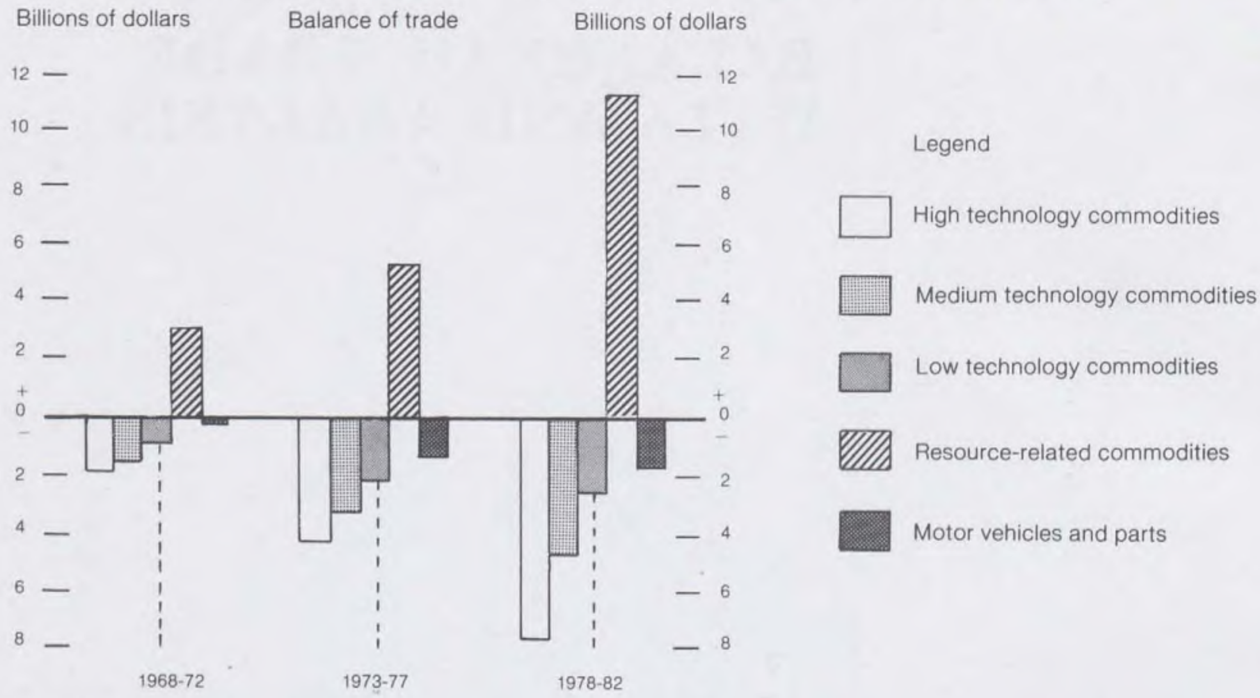
Source: New Scientist, 8 November, 1984

Appendix B3

BALANCE OF TRADE DATA AND ANALYSIS

B3

CANADA'S BALANCE OF TRADE IN MANUFACTURED PRODUCTS



Source: Statistics Canada

Canada normally has a small positive balance of trade, i.e., the value of commodities exported exceeds the value of commodities imported.

Within the manufactured products commodity group, only resource-related commodities have an average positive balance of trade. *Trade in high technology commodities is the largest component of the group's deficit.* In 1982 exports of such products were $9 billion while imports were almost $17 billion. These commodities accounted for about 17% of exports and 31% of imports in manufactured products.

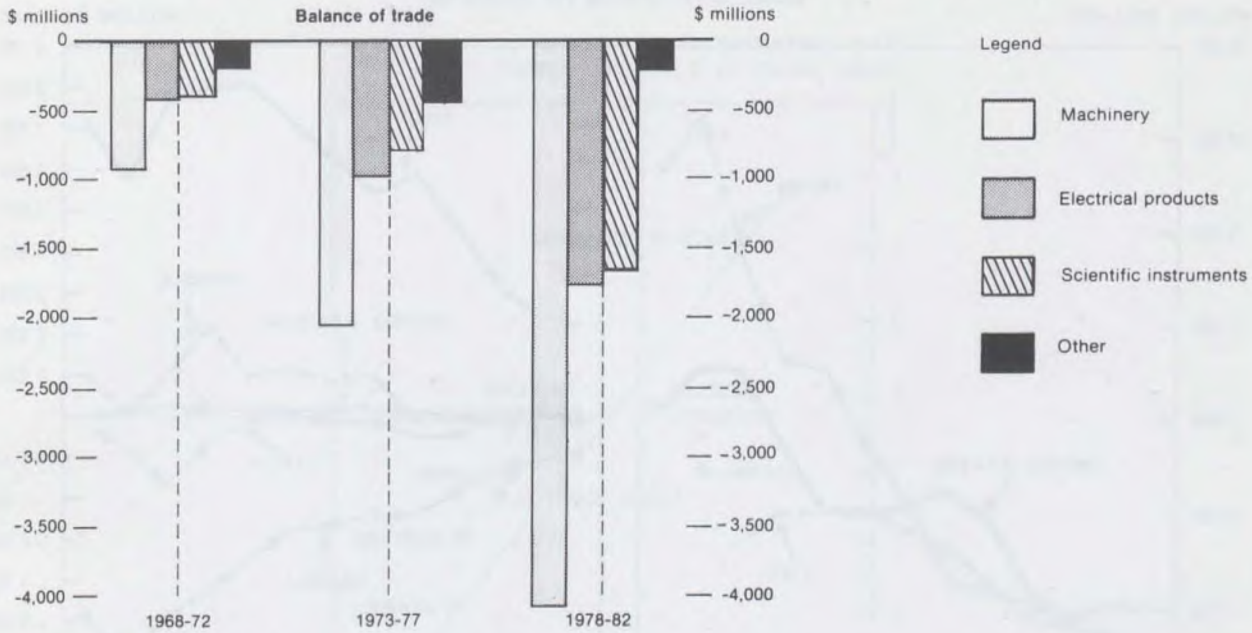
BALANCE OF TRADE IN MANUFACTURED PRODUCTS 1975-1982

($ BILLIONS)

Year	Technology Commodities High	Technology Commodities Medium	Technology Commodities Low	Resource Related	Motor Vehicles	Total
1972	-2.3	-1.9	-1.1	3.2	-0.2	-2.4
1973	-3.1	-2.3	-1.2	3.7	-0.7	-3.5
1974	-4.1	-3.3	-2.1	4.9	-1.4	-6.0
1975	-4.4	-3.4	-2.2	4.9	-1.8	-6.9
1976	-4.6	-3.2	-2.5	6.2	-1.2	-5.2
1977	-5.1	-3.8	-2.6	7.3	-1.2	-5.3
1978	-5.8	-4.5	-2.7	8.7	-0.8	-5.2
1979	-7.3	-4.6	-3.0	9.1	-3.3	-9.2
1980	-8.1	-4.6	-2.8	13.2	-2.7	-5.0
1981	-9.7	-5.6	-1.8	12.7	-2.9	-7.3
1982	-7.6	-3.7	-2.0	12.6	1.5	0.9

Source: Statistics Canada

EXTERNAL TRADE IN HIGH TECHNOLOGY COMMODITIES



Source: Statistics Canada

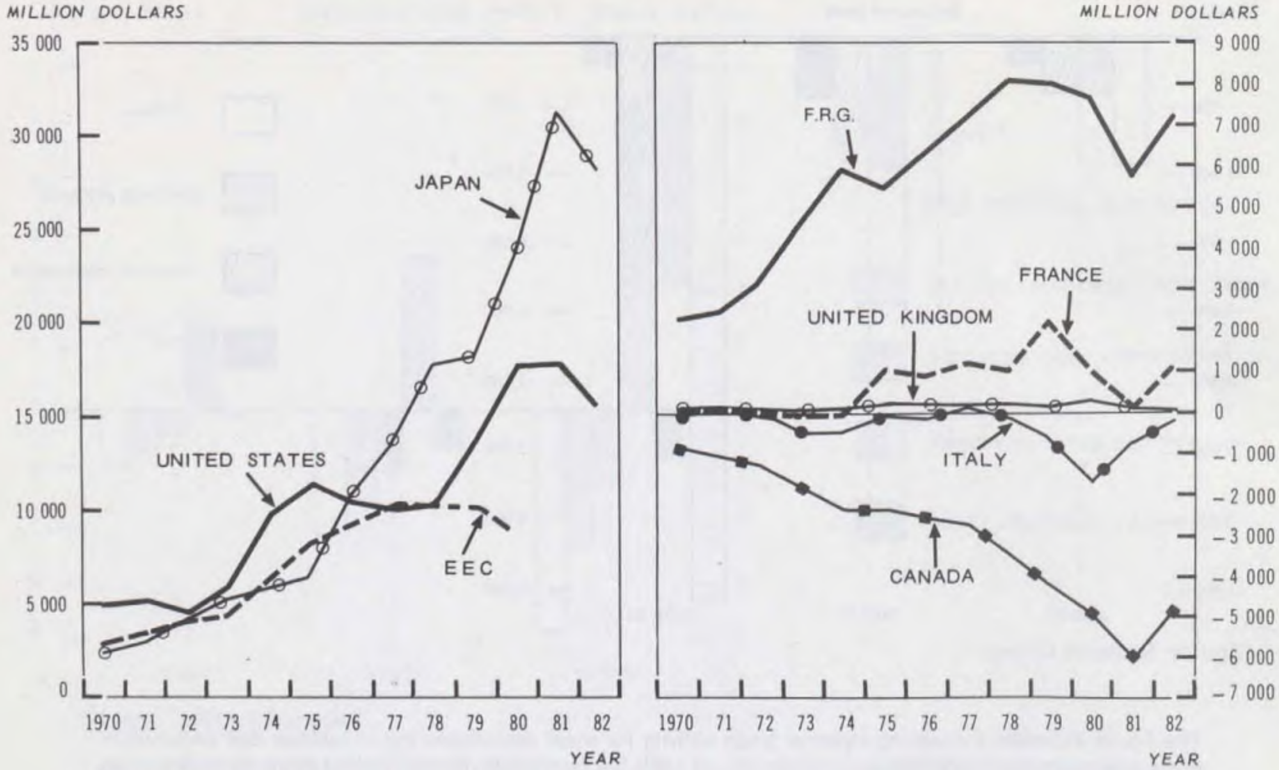
The figure indicates increasing external trade activity for most manufacturing industries, but particularly those producing high technology commodities. In 1980, the machinery, transportation equipment, electrical products and scientific equipment industries had a negative trade balance of almost $13 billion.

During the last five years, machinery accounted for 36% of the exports of high technology commodities and 45% of the imports. In 1982, the imports of machinery exceeded exports by over $4 billion.

The exploitation of natural resources and the production of agricultural commodities now depend on advanced machinery so that part of the trade surplus in these areas is counter-balanced by a deficit in the associated trade in machinery. For example, in 1982, the trade deficit in mining, drilling and excavating equipment was almost $600 million while the deficit in farm machinery was over $1 billion.

It appears that the greater the amount of technology required, the greater our relative dependence on goods produced abroad.

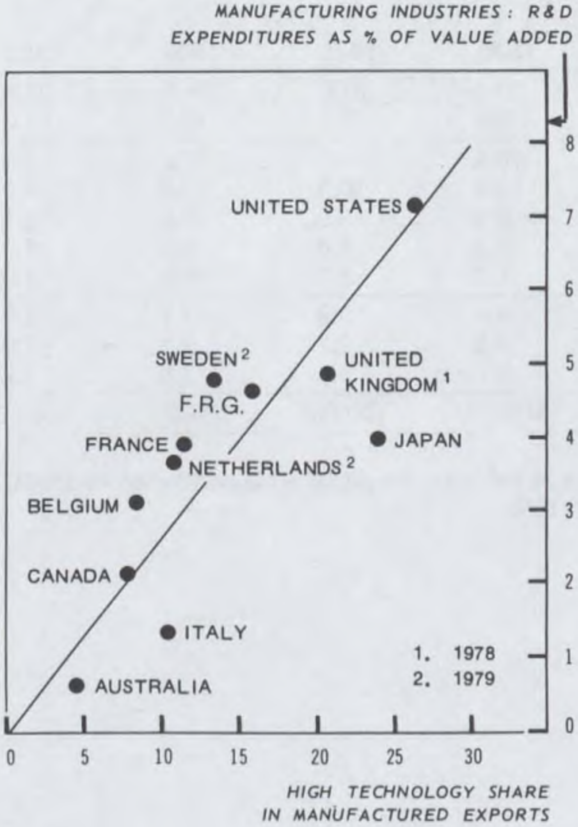
TRADE BALANCE OF HIGHLY R&D INTENSIVE INDUSTRIES



Source: OECD

High technology commodities are goods which require advanced technology to produce. *The terms of trade in them may indicate the state of a portion of a country's industrial technology in relation to that of other countries.* Trade, even in products which compete mainly on scientific or technical advantage, is influenced by many factors. However, a substantial relative balance, either positive or negative, in a country's trade in high technology commodities does imply that its industrial technology may well be relatively advanced or *undeveloped compared to the levels in at least its major trading partners.*

R&D INTENSITY AND HIGH TECHNOLOGY SHARE IN EXPORTS 1980



Source: OECD

The comparison of R&D intensity of the manufacturing industries (ratio of R&D expenditure/value added) and the ratio of exports in high-technology industries to total manufacturing industries shows that there is a link between these two indicators. The higher the R&D intensity the higher the ratio of high technology to total manufacturing exports.

In a constantly changing international climate where one is witness to the birth of new industries and the progressive decline of the older ones, technology is at the heart of this change.

New products which, for the most part, incorporate technologies requiring a significant R&D effort, constitute the motivating force for increased industrial production and especially international trade. For this reason, the expansion of high-technology industries is expected to be a topic of great interest for the 1980s.

MARKET SHARES OF OECD EXPORTS OF HIGH R&D INTENSITY PRODUCTS

COUNTRY	1970	1975	1980	1983	RANK (1)	RANK (2)
UNITED STATES	30.4	27.5	25.5	27.4	1	1
JAPAN	8.2	9.5	12.3	16.3	2	2
F.R.G.	16.4	16.8	16.2	15.0	3	3
UNITED KINGDOM	10.4	10.5	11.8	9.0	4	4
FRANCE	6.9	8.5	9.0	8.1	5	5
ITALY	4.8	4.4	4.5	4.3	6	6
NETHERLANDS	4.7	5.0	4.5	4.0	9	7
CANADA	4.4	2.8	2.7	3.5	7	8
SWEDEN	2.5	2.7	2.1	2.0	8	10
SWITZERLAND	5.7	5.3	3.6	3.2	10	9
TOTAL OECD	100.00	100.00	100.00	100.00		

(1) According to percentage share of the total industrial R&D performed by OECD member countries in 1981
(2) According to market shares in 1983

Source: OECD, DSTI/IND/84.60

RATIO OF EXPORTS TO IMPORTS — 1983

Country	Drugs	Scientific Instruments	Electrical Transmission Equipment	Communications Equipment & Components	Office Machines & Computers	Aircraft and Parts
Canada	0.40	0.26	0.53	0.47	0.44	0.65
France	1.96	0.75	1.40	1.27	0.65	1.50
F.R.G.	1.77	1.40	2.07	1.16	0.91	0.08
Italy	1.00	0.59	1.11	0.90	0.89	1.37
Japan	0.28	6.06	3.92	6.92	5.01	0.09
Netherlands	1.21	1.05	0.92	1.29	0.75	0.70
Sweden	1.32	0.57	0.83	1.94	0.82	0.44
Switzerland	3.71	2.88	2.70	0.86	0.36	0.18
United Kingdom	2.19	0.92	1.27	0.83	0.66	1.57
United States	2.04	0.88	1.67	0.76	1.80	4.26

Source: OECD/Data Bank

Appendix B4

GENERAL ECONOMIC INDICATORS

RECENT OECD ECONOMIC INDICATORS
1966-1983

	Average 1966-1973	Average 1974-1978	Average 1979-1983	1979	1980	1981	1982	1983
				(Per cent)				
Growth in real GNE/GDP[1,4]								
United States	3.9	2.8	1.3	2.8	-0.3	2.6	-1.9	3.3
Japan	10.7	3.7	4.1	5.9	5.4	3.8	3.0	3.0
F.R.G.	4.3	2.0	1.2	4.4	1.8	-0.3	-1.1	1.3
France	5.4	3.1	1.5	3.3	1.1	0.4	1.9	0.5
United Kingdom	2.8	1.3	0.2	1.4	-2.1	-1.7	2.0	2.5
Italy	5.4	2.1	1.4	4.9	3.9	0.1	-0.3	-1.5
Canada	5.5	3.2	1.2	3.2	1.0	3.4	-4.4	3.0
Seven major countries	5.4	2.7	1.9	3.6	1.2	1.9	-0.3	2.4
Employment growth[4]								
United States	2.3	2.5	1.0	2.9	0.5	1.1	-0.9	1.3
Japan	1.3	0.6	1.2	1.3	1.0	0.8	1.0	2.0
F.R.G.	0.0	-0.9	-0.5	1.3	0.9	-0.8	-1.9	-2.0
France	0.6	0.4	-0.3	-0.7	0.1	-0.7	-0.1	-0.8
United Kingdom	-0.1	0.0	-1.3	1.1	-1.3	-3.6	-1.7	-0.8
Italy	-0.2	1.0	0.5	1.0	0.8	0.5	-0.4	-0.3
Canada	2.9	2.6	1.3	4.0	2.8	2.6	-3.3	0.8
Seven major countries	1.4	1.2	0.6	1.9	0.7	0.5	-0.7	0.6
Unemployment rate[2,4]								
United States	4.5	7.0	8.0	5.9	7.2	7.6	9.7	9.6
Japan	1.2	1.9	2.3	2.1	2.0	2.2	2.4	2.8
F.R.G.	0.9	3.5	5.3	3.3	3.3	4.6	6.9	8.5
France	2.2	4.2	7.2	5.9	6.3	7.3	8.0	8.3
United Kingdom	2.2	4.1	8.4	4.7	5.7	9.0	11.0	11.5
Italy	5.7	6.3	8.5	7.6	7.5	8.3	9.1	10.0
Canada	4.8	7.2	9.1	7.5	7.5	7.6	11.0	11.9
Seven major countries	3.2	5.3	6.8	5.0	5.7	6.5	8.1	8.5
Consumer price inflation[3,4]								
United States	4.4	8.0	8.8	11.3	13.5	10.3	6.1	3.2
Japan	6.2	11.3	4.2	3.6	8.0	4.9	2.7	1.9
F.R.G.	3.9	4.8	4.8	4.1	5.5	5.9	5.3	3.0
France	5.1	10.7	11.8	10.8	13.6	13.4	11.8	9.6
United Kingdom	6.1	16.1	11.2	13.4	18.0	11.9	8.6	4.6
Italy	4.5	16.7	17.4	14.8	21.2	19.5	16.6	14.6
Canada	4.3	9.2	9.7	9.1	10.2	12.5	10.8	5.8
Seven major countries	4.7	9.6	8.5	9.3	12.2	10.0	6.9	4.5
Growth of productivity[1,4]								
United States	1.5	0.3	0.4	0.0	-0.8	1.5	-1.1	2.0
Japan	9.3	3.1	2.8	4.5	3.1	3.0	1.9	1.3
F.R.G.	4.3	3.0	1.7	3.1	0.9	0.4	0.7	3.3
France	4.8	2.7	1.8	4.2	1.1	1.1	1.9	1.3
United Kingdom	3.1	1.3	1.5	0.3	-0.1	1.9	3.8	3.3
Italy	5.6	1.1	0.9	3.9	3.1	-0.3	0.0	-1.3
Canada	2.5	0.6	-0.1	-0.8	-1.7	0.8	-1.2	2.2
Seven major countries	3.9	1.4	1.2	1.7	0.5	1.5	0.3	1.8

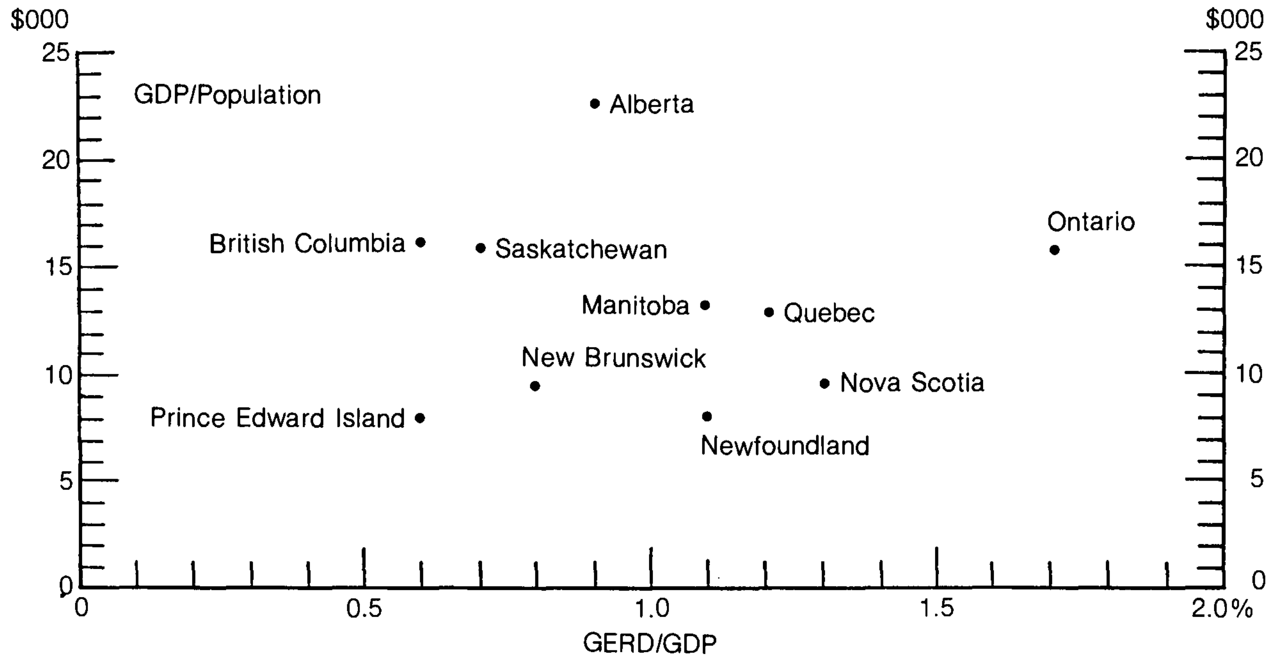
[1]GNE numbers are reported for the United States, Japan, Germany and Canada, while GDP numbers are reported for France, the United Kingdom and Italy.
[2]Unemployment rates are on the basis of national definitions.
[3]As measured by the year-over-year variation in the CPI.
[4]Averages are calculated by using weights based on the GNE/GDP respective shares in 1981.
Source: OECD, *Economic Outlook*, December 1983, *Main Economic Indicators*, updated in certain cases with more recent information; Statistics Canada, *National Income and Expenditure Accounts, The Labour Force*, and *Consumer Prices and Price Indexes*, U.S. Department of Commerce, *Survey of Current Business*; and U.S. Department of Labour *Monthly Labour Review.*

Appendix C

PROVINCIAL COMPARISONS OF TECHNOLOGY PERFORMANCE

C

PROVINCIAL GDP, POPULATION AND GERD, 1982



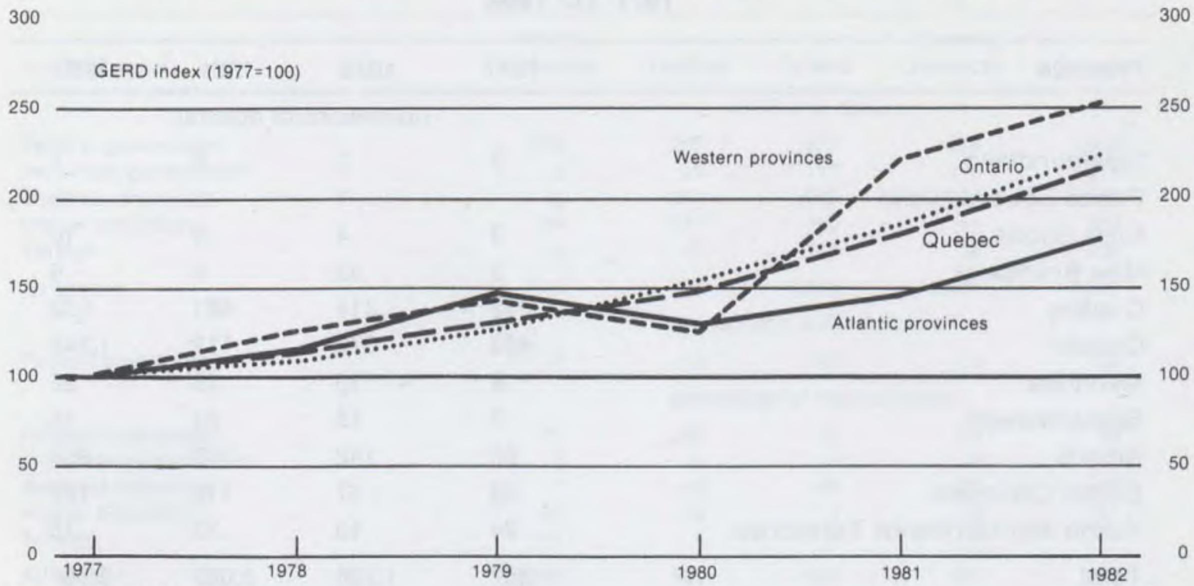
Source: Statistics Canada

GERD, GDP AND POPULATION, BY PROVINCE, 1982

Province	GERD	GDP	Population	GERD/GDP	GDP/population
	$000,000		'000	%	$000
Newfoundland	51	4,698	573	1.1	8.2
Prince Edward Island	6	990	123	0.6	8.0
Nova Scotia	110	8,299	855	1.3	9.7
New Brunswick	52	6,630	702	0.8	9.4
Quebec	983	83,236	6,494	1.2	12.8
Ontario	2,338	137,183	8,751	1.7	15.7
Manitoba	156	13,930	1,038	1.1	13.4
Saskatchewan	114	15,702	983	0.7	16.0
Alberta	474	53,056	2,333	0.9	22.7
British Columbia	290	44,709	2,802	0.6	16.0
Canada	**4,591**	**369,605**	**24,726**	**1.2**	**14.9**

Source: For GDP, Population Economic Accounts, 1964-1982, Statistics Canada, Catalogue No. 13-213; for population, Canadian Statistical Review, Statistics Canada, Catalogue No. 11-003E, April 1984.

ESTIMATED REGIONAL DISTRIBUTION OF GERD, 1977-1982



Source: Statistics Canada

ESTIMATED REGIONAL DISTRIBUTION OF GERD

Year	Atlantic provinces	Quebec	Ontario	Western provinces	Canada[1]
			millions of dollars		
1977	123	451	1,046	410	2,050
1978	141	515	1,148	515	2,342
1979	182	591	1,321	581	2,689
1980	161	665	1,615	728	3,187
1981	179	812	1,935	905	3,864
1982	219	973	2,348	1,034	4,591

[1]Includes the Yukon and Northwest Territories.
Source: Statistics Canada

TOTAL INDUSTRIAL INTRAMURAL R&D EXPENDITURES, BY PROVINCE, 1977 TO 1982

Province	1977	1979	1981	1982
	(in millions of dollars)			
Newfoundland	2	2	8	1
Prince Edward Island	–	1	1	–
Nova Scotia	3	4	9	10
New Brunswick	2	33	5	5
Quebec	232	314	481	559
Ontario	463	672	1,112	1,349
Manitoba	8	13	28	26
Saskatchewan	7	15	24	38
Alberta	80	142	262	255
British Columbia	36	57	119	122
Yukon and Northwest Territories	24	13	33	16
Total	857	1,266	2,082	2,381
Metropolitan areas:				
Montreal	195	270	404	476
National Capital Region[1]	..	..	..	330
Toronto	158	228	471	551

[1]Available only as of 1982.
Source: Statistics Canada

GERD, BY SECTOR OF PERFORMANCE, BY PROVINCE AND REGION, 1982

Province and region	Federal government	Provincial government	Business enterprise	Higher education	Private non-profit	Total
	millions of dollars					
British Columbia	59	17	122	91	1	290
Alberta	59	44	255	114	2	474
Saskatchewan	28	7	38	41	–	114
Manitoba	82	3	26	43	2	156
Western provinces	228	71	441	289	5	1,034
Ontario	588	60	1,349	325	26	2,348
Quebec	107	32	559	261	14	973
Central provinces	695	92	1,908	586	40	3,321
New Brunswick	26	2	5	19	–	52
Nova Scotia	58	4	10	38	–	110
Prince Edward Island	6	–	–	–	–	6
Newfoundland	28	1	1	21	–	51
Atlantic provinces	118	7	16	78	–	219
Yukon and Northwest Territories	1	–	16	–	–	17
Canada	**1,042**	**170**	**2,381**	**953**	**45**	**4,591**

Source: Statistics Canada

THE FUNDING OF REGIONAL R&D, 1982

Funding sector	Atlantic provinces	Quebec	Ontario	Western provinces	Canada[1]
			millions of dollars		
Federal government	153	252	873	376	1,655
Provincial government[2]	6	79	117	115	316
Business enterprise	15	444	1,082	354	1,908
Higher education[3]	44	151	160	151	507
Foreign	1	47	116	38	205
All sectors	219	973	2,348	1,534	4,591
			percentage of Canada total		
Federal government	9	15	53	23	100
			percentage of regional totals		
Federal government	70	26	37	25	36
Provincial government[2]	3	8	5	8	7
Business enterprise	7	46	46	23	42
Higher education[3]	20	15	7	10	11
Foreign	1	5	5	3	5
All sectors	100	100	100	100	100

[1]Including the Yukon and Northwest Territories.
[2]Including provincial research councils and foundations.
[3]Including private non-profit organizations.

Source: Statistics Canada

EMPLOYMENT: Canada and by Region 1980-1983 (Thousands)

Year	Canada	Atlantic Region	Quebec	Ontario	Prairie Region	British Columbia
1980	10,708	795	2,694	4,053	1,953	1,213
1981	11,006	801	2,726	4,171	2,038	1,270
1982	10,664	775	2,585	4,067	2,013	1,204
1983	10,734	789	2,642	4,096	2,001	1,197

UNEMPLOYMENT: Canada and by Region 1980-1983 (Thousands)

Year	Canada	Atlantic Region	Quebec	Ontario	Prairie Region	British Columbia
1980	865	98	294	297	88	88
1981	898	104	314	293	96	91
1982	1,314	129	413	440	165	166
1983	1,448	139	427	474	217	192

Source: Statistics Canada

PERSONAL INCOME PER CAPITA: Canada and by Province 1980-1982

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.
1980	10,613	6,641	7,179	8,018	7,383	9,570	10,937	9,015	9,137	11,103	11,307
1981	11,810	7,680	7,927	9,068	8,325	11,061	12,681	10,999	11,774	13,028	12,835
1982	12,839	8,580	8,894	10,090	9,229	12,021	13,842	11,987	12,372	14,025	13,811
PERCENT CHANGE											
1980	12.1	9.4	14.5	10.0	8.3	12.9	11.4	9.7	11.7	13.9	12.7
1981	16.2	15.6	10.4	13.1	12.8	15.6	15.9	22.0	26.4	17.3	13.5
1982	8.7	11.7	12.2	11.3	10.9	8.7	9.2	9.0	5.1	7.7	7.6

Source: Statistics Canada

Appendix D

ESTABLISHING THE RELATIONSHIP BETWEEN TECHNOLOGY, ECONOMIC GROWTH AND EMPLOYMENT

D

Establishing the Relationship Between Technology, Economic Growth and Employment

The relationship between R&D efforts, economic growth and employment is generally accepted as a positive one.

This Appendix presents MOSST data and conclusions on the benefits of R&D to employment and real output. It also summarizes some important new Organization for Economic Cooperation and Development (OECD) findings on R&D and output, as well as giving some brief comments on the conclusions.

1. PERFORMANCE OF CANADIAN MANUFACTURING INDUSTRIES BY LEVELS OF RESEARCH INTENSITY

Research and development is defined as investigative work carried out to acquire new scientific and technological knowledge, to devise and develop new products and processes, or to apply newly acquired knowledge in making technically significant improvements to existing products or processes. Some years ago (1978) [1] the Ministry of State for Science and Technology endeavoured to classify industries according to levels of research intensity. This classification was based on parameters such as R&D expenditures against percentage of output value-added, an index of number of R&D personnel engaged, etc. High research-intensive industries included such sectors as machinery industries, electrical products, petroleum products and chemicals. Medium research industries were represented by paper and allied products, primary metals and transportation equipment. By contrast, low research-intensive industries included food and tobacco, textiles, wood industry, furniture, etc. Other industries were classified as performing no research such as knitting mills, leather industries, clothing industries, and printing. High research-intensive and medium research-intensive industries accounted for over 88 percent of total intramural R&D performed by Canadian manufacturing and for 87 percent of the total personnel engaged in R&D.

AVERAGE ANNUAL RATES OF GROWTH
1961-1974
(PERCENT)

	Employ-ment	Real[1] Output	Productivity[2]	Prices[3]
High Research-Intensive Industries	2.42	6.41	4.49	1.39
Medium Research-Intensive Industries	2.75	6.60	3.95	1.64
Low Research-Intensive Industries	1.61	5.19	3.47	3.13
No Research Industries	0.73	3.85	3.14	3.25
Total Manufacturing	1.87	5.79	3.82	2.37

[1] 1971 Dollars
[2] Real Output Per Person
[3] Value-added implicit price index

Source: Based on data from Statistics Canada

[1] Performance of Canadian Manufacturing Industries by Levels of Research Activity, MOSST Background Paper No. 4, Ottawa, 1978

In the critical area of real output, the high and medium research-intensive industries were well ahead of the low- or no-research groups. Similarly, they show growth above average for all manufacturing. Moreover, the overall real economic growth of Canada in this period was approximately 5.5% annually, so the high- and medium-research groups beat the GNP as a whole. ***These figures argue that they were the "leading edge" of the economy.***

Moreover, growth in employment is impressive. Exactly the same pattern repeats itself. The high and medium research-intensive industries had a higher growth rate in employment.

2. INTERNATIONAL COMPARISONS OF HIGH RESEARCH-INTENSIVE INDUSTRIES?

A 1984 OECD paper [2] investigates the relative performance of high, medium and low research-intensive industries across OECD countries. Accordingly, this comparison does not examine one country's performance against another, but rather investigates how industries compare regardless of their national distribution. The OECD data shows the relatively higher research-intensive industries in a good light. The classification is not dissimilar to the one used by MOSST in its earlier work: R&D expenditure is related as a percentage of total value of output. By this index, the 1980 rankings of the industries used by the OECD would be as follows:

INDEX OF RESEARCH INTENSITY

HIGH	1. Aerospace	22.7	
	2. Office machines, computers	17.5	
	3. Electronics & components	10.4	
	4. Drugs	8.7	
	5. Instruments	4.8	
	6. Electrical machinery	4.4	Average 11.4
MEDIUM	7. Automobiles	2.7	
	8. Chemicals	2.3	
	9. Other manuf. ind.	1.8	
	10. Non-electrical machinery	1.6	
	11. Rubber, plastics	1.2	
	12. Non-ferrous metals	1.0	Average 1.7
LOW	13. Stone, clay, glass	0.9	
	14. Food, beverages, tobacco	0.8	
	15. Shipbuilding	0.6	
	16. Petrol refineries	0.6	
	17. Ferrous metals	0.6	
	18. Fabricated metal products	0.4	
	19. Paper, printing	0.3	
	20. Wood, cork, furniture	0.3	
	21. Textiles, footwear, leather	0.2	Average 0.5

From the OECD figures, one can compare these industries with their growth in total output (volume) over the ten-year period 1970–1980.

[2] Specialization and competitiveness in high, medium and low R&D intensity manufacturing industries, Working Paper No. 4, Directorate for Science, Technology and Industry, OECD, Paris, 1984.

AVERAGE ANNUAL GROWTH OF OUTPUT (VOLUME) (1970-1980) — per cent

Electronics	8.1	Electrical	2.8	Oil refining	1.7
Computers	7.5	Food	2.8	Wood/cork/ furniture/	1.6
Drugs	6.8	Shipbuilding	2.4	Ferrous metals	1.4
Automobiles	5.7	Other manuf. industry	2.3	Non ferrous metals	1.3
Chemicals	5.0	Paper/printing	2.1	Manuf. of metal	1.3
Instruments	4.9	Stone/clay/ glass	2.0	Textiles, footwear/ leather	0.8
Rubber/plastics	4.3				

Of the seven industries in the high-growth category, four are high research-intensive, and three are medium research-intensive. Moreover of the three latter industries, it is noteworthy that two are "on the border" between medium and high research. ***This indicates that the higher research-intensive industries are providing, throughout the developed world, a principal thrust of economic growth.***

As well, high research industries have increased their share of employment over time;

EMPLOYMENT WEIGHTS OF HIGH, MEDIUM AND LOW R&D INTENSITY IN MANUFACTURING INDUSTRIES

Country	High Intensity			Medium Intensity			Low Intensity		
	1970	1975	1982	1970	1975	1982	1970	1975	1982
United States	18.4	18.4	21.6[c]	32.0	31.0	32.9[c]	49.2	50.5	45.5[c]
Japan	16.7	16.0	1.82[b]	33.3	32.0	33.3[b]	50.1	52.0	48.5[b]
Germany	16.3	16.6	1.75	33.0	34.2	39.8	50.7	49.2	42.7
France[d]	—	13.6[a]	14.1[a]	—	35.2	36.2	—	51.2	49.7
United Kingdom	16.8	17.2	19.9[b]	30.8	31.8	33.9[b]	52.4	51.0	46.2[b]
Italy[c]	—	13.7[a]	13.5[c]	—	30.0	32.9[c]	—	56.3	53.6[c]
Canada	13.0	11.9	12.9[c]	24.1	24.5	24.7[c]	62.9	63.6	62.4[c]
Australia	—	12.8	12.9[c]	—	22.6	22.6[c]	—	64.6	64.5[c]
Sweden	13.8	14.5	15.7[c]	28.6	30.4	31.3[c]	57.6	55.8	53.0[c]

[a] Not involving aerospace industry
[b] 1980
[c] 1981
[d] Secretariat estimate

However, Canada shows a relatively poor employment record in high research-intensive industries; ***we have fewer high research-intensive industries in the first place and spend relatively less on R&D generally.***

3. CONCLUSIONS

High R&D industries have many characteristics in common. A large number of structural variables show that the high R&D industries:

- account for a preponderant share of research;
- account for a relatively small share of output, but a slightly larger share of exports and imports;
- have an output which in volume terms in growing faster than that of other industries;
- have a lower labour productivity than other industries but one that is improving more rapidly;
- are more labour- than capital-intensive (the share of employment in these industries is practically twice as great as their share in the total output of manufacturing industry).

The strong growth of these industries would indicate that they are at the start of the innovation cycle or more exactly in the growth phase, whereas the other industries have more or less reached maturity. The fact that these industries have remained for so long in the growth phase would indicate that the lifecycle of their products is very short and that they are constantly embarking on new cycles and so remaining in the growth phase.

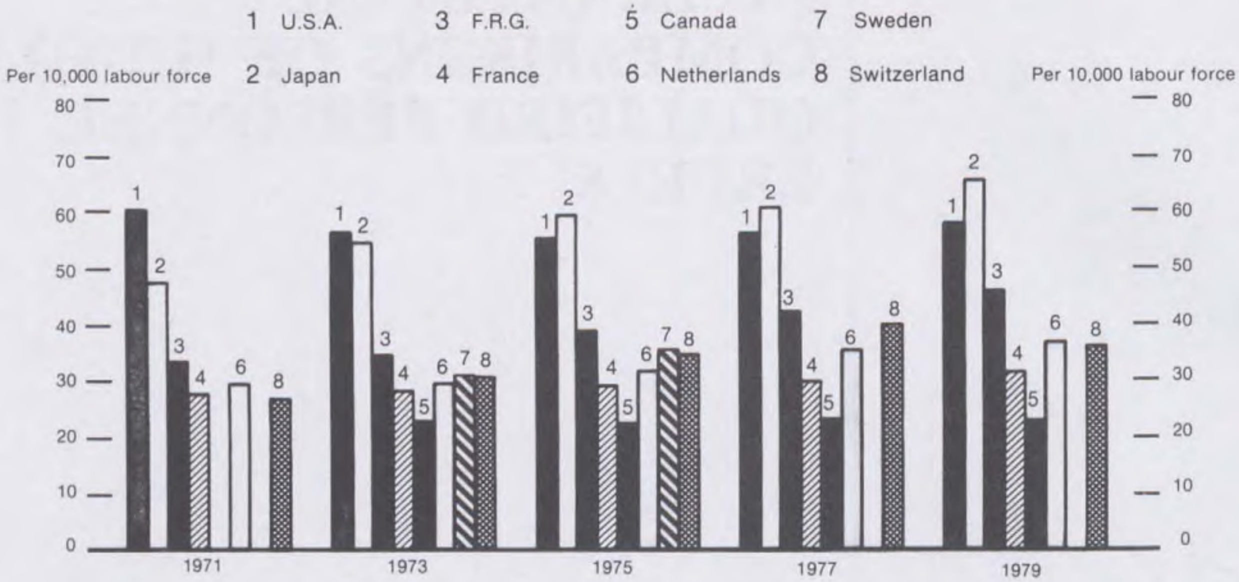
Although there are many factors which contribute to the economic health of the manufacturing sector and the economy generally, ***R&D and indeed the whole innovation process are crucial factors in achieving improved economic performance leading to such national economic goals as a higher standard of living, high levels of employment, and stable prices.***

Appendix E

INTERNATIONAL COMPARISONS OF HIGHLY QUALIFIED PERSONNEL LEVELS

E

RESEARCH SCIENTISTS AND ENGINEERS (NSE + SSH) ENGAGED IN R&D PER 10,000 LABOUR FORCE POPULATION FOR SELECTED OECD COUNTRIES, 1971-1979



SCIENTISTS AND ENGINEERS (NSE + SSH) ENGAGED IN R&D PER 10,000 LABOUR FORCE POPULATION, FOR SELECTED OECD COUNTRIES

Country	1971	1973	1975	1977	1979
United States	60.4	56.5	55.5	56.4	58.0
Japan	47.7	54.8	59.5	60.8	65.6
F.R.G.	33.5	37.4	39.2	42.6	46.1
France	27.8	28.4	29.3	30.0	31.6
Canada	. .	23.2	22.8	23.5	23.3
Netherlands	29.6	29.7	31.8	35.6	36.9
Sweden	. .	31.1	35.7	—	—
Switzerland	27.0	30.8	34.9	40.3	36.1

Sources: "Science and Technology Indicators Basic Statistical Series — Volume C, Total R&D Personnel", OECD, DSII/SPR/82,59, Paris, 1982.
Statistical Year Book, UNESCO, Paris, 1981.

Appendix F

FEDERAL SCIENCE AND TECHNOLOGY EXPENDITURES

F

FEDERAL S&T EXPENDITURES 1984/85
(MILLIONS OF DOLLARS)

TOTAL S&T
4,005

	NSE S&T 3,234		SSH S&T 771	
	R&D 2,425	RSA 809	R&D 141	RSA 630
INTRAMURAL	1,344	611	59	544
INDUSTRY	519	98	6	12
UNIVERSITIES	454	43	44	47
OTHERS	109	57	33	27

Source: Statistics Canada

By international convention Science and Technology (S&T) activities are divided into two types: Natural Sciences and Engineering (NSE) and Social Sciences and Humanities (SSH). These two are further divided into Research and Development (R&D) and Related Scientific Activities (RSA).

Total expenditures on R&D within a country are referred to as GERD (gross expenditures on R&D), but in Canada this term is commonly applied only to R&D expenditures in the natural sciences and engineering. Thus, of the $4.0 billion federal expenditures on S&T activities in 1984, the GERD component was only about one-half.

About $1.9 billion was allocated to the intramural NSE programs of the federal scientific departments and agencies. Of this amount, $1.3 billion was for R&D, $600 million for RSA and $57 million for the administration of extramural programs. Grants, contributions and contracts under these programs will amount to about $1.3 billion in 1984/85.

FEDERAL S&T EXPENDITURES BY MAJOR S&T PERFORMING DEPARTMENTS AND AGENCIES NSE, 1984/85

DEPARTMENT OR AGENCY	TOTAL S&T ($M)	% OF TOTAL S&T							
		R&D				RSA			
		INTRA-MURAL	INDUSTRY	OTHERS	TOTAL	INTRA-MURAL	INDUSTRY	OTHERS	TOTAL
NRC	524.5	55.8	24.6	8.2	88.6	11.0	0.2	0.2	11.4
EMR	377.2	44.7	20.3	5.4	70.3	16.7	6.6	6.4	29.6
DOE	331.3	19.5	1.2	1.2	21.9	74.4	0.6	3.1	78.1
DOA	292.0	90.4	3.0	2.7	96.2	3.8	0.0	0.0	3.8
F&O	258.4	53.1	2.8	1.2	57.0	40.6	2.1	0.3	43.0
DND	201.2	54.6	41.0	3.5	99.2	0.8	—	—	0.8
AECL	148.1	82.8	3.7	1.5	87.9	6.0	6.0	0.0	12.0
DOC	99.9	66.6	16.6	15.7	98.9	0.0	1.0	0.0	1.1
NHW	87.0	22.2	0.7	10.1	33.1	61.9	0.6	4.4	66.9
FORESTRY	67.0	75.4	5.6	12.2	93.2	6.0	0.1	0.6	6.8
DOT	36.4	22.5	46.4	4.4	73.3	17.1	8.3	1.3	26.7
OTHERS	73.2	13.2	7.4	3.0	23.6	63.4	4.2	8.8	76.4

Source: Statistics Canada

Over 60 different departments and agencies either perform S&T activities or have budgetary allocations to fund S&T. The above table focuses on a dozen departments which are major performers of S&T in the natural sciences and engineering and have their own scientific establishments. The departments and agencies without scientific establishments and which are often major funders of extramural S&T are not included. These include DRIE ($174.1M), major funder of industrial S&T in NSE; NSERC ($292.2M) and MRC ($157.3M) main funders of university S&T in NSE.

The above table shows that the departments responsible for regulatory activities such as DOE and NHW spend approximately 2/3 of their S&T budgets on RSA while others such as DOA, DND and DOC spend more than 95% on R&D.

Some departments spend most of their S&T budgetary allocations intramurally — DOE (94.2%); AECL (88%); F&O (93.7%) while others such as DND and DOT contract-out 41% and 54.7% respectively to industry.

FEDERAL R&D EXPENDITURES (NSE) IN SELECTED APPLICATION AREAS, 1983-84 ($ MILLIONS)

Application Areas	DOA	AECL	DOC	EMR	DOE	F&O	ITC	MRC	DND	NHW	NRC	NSERC	DOT	OTHERS	TOTAL
Adv. of Science	—	—	—	0.3	0.4	—	—	—	—	—	57.1	184.9	—	0.2	242.8
Communications	—	—	26.6	0.1	—	—	—	—	—	—	4.0	3.2	—	2.9	36.9
Energy	6.9	110.6	—	103.7	7.6	1.6	8.0	—	—	—	68.7	8.3	8.5	6.0	330.0
Environmental Issues	—	—	—	5.5	21.3	11.3	—	—	—	—	6.1	3.6	—	2.8	50.6
Food[1]	172.8	—	—	—	—	42.6	0.5	—	—	—	17.4	4.0	—	3.6	240.9
Agriculture	172.8	—	—	—	—	—	0.5	—	—	—	17.4	4.0	—	2.5	197.2
Fisheries	—	—	—	—	—	42.6	—	—	—	—	—	—	—	0.6	43.2
Health	—	6.9	—	1.3	—	—	—	116.2	—	22.1	18.5	—	—	0.4	165.4
Oceans	—	—	—	8.5	—	44.2	—	—	—	—	6.1	3.0	—	1.2	63.0
Resources	33.5	—	—	37.0	64.1	—	—	—	—	—	—	—	—	1.7	136.3
Forestry	—	—	—	—	53.2	—	—	—	—	—	—	—	—	0.4	53.6
Mineral	—	—	—	35.3	—	—	—	—	—	—	—	—	—	0.2	35.5
Others	33.5	—	—	1.7	10.8	—	—	—	—	—	—	—	—	1.0	47.1
Security	—	—	—	0.4	—	—	—	—	156.5	—	2.2	—	—	0.2	159.3
Space	—	—	64.7	0.1	3.4	—	—	—	—	—	25.0	—	—	2.1	95.4
Transportation	—	—	—	0.9	—	0.2	—	—	—	—	44.0	—	18.2	0.9	64.3
Industrial Support[2]	—	—	—	—	—	—	170.3	—	—	—	78.2	—	—	—	248.4
Others[3]	—	—	—	32.7	12.7	—	0.3	—	—	—	17.1	5.4	—	54.2	122.5
TOTAL	213.2	117.5	91.4	190.7	109.6	100.0	179.0	116.2	156.5	22.1	344.4	212.5	26.7	76.3	1,955.9

1 — Food = Agriculture + Fisheries + Other food related
2 — General industrial support that is not associated with a specific application area
3 — Includes construction ($20M), developing nations ($45M) and application areas not elsewhere classified (n.e.c.)

Source: Statistics Canada

NOTES

NOTES