Communications Canada

THE STATUS OF COMMUNICATIONS AND INFORMATION TECHNOLOGY IN CANADA

TECHNOLOGY, POLICY AND PLANNING BRANCH

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FEBRUARY 1989

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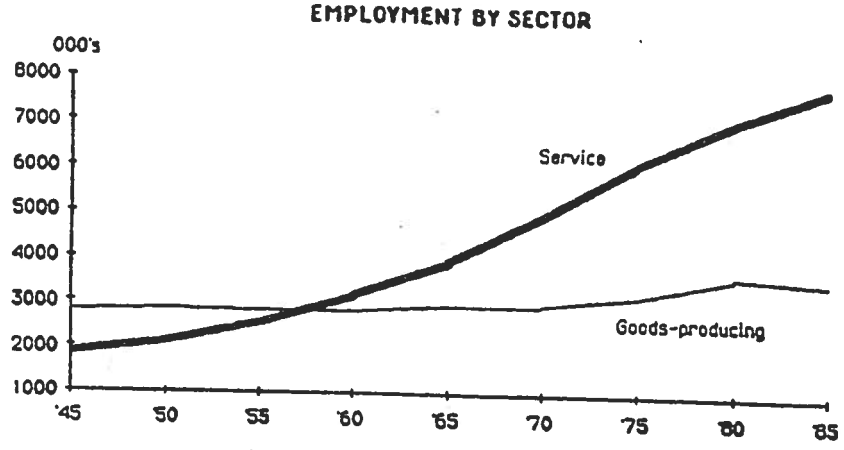
EXECUTIVE SUMMARY

Canada, like every other industrialized nation, is going through a transition towards a more information-based society, driven by the converging technologies of computers and communications, often called information technologies. The creation, communications and utilization of information has become progressively more important as a source of jobs, economic growth and social progress.

The purpose of this document is to outline our available information on the current status of the Canadian communications and information technology industries; the adoption of these new technologies in Canada; and the Canadian R&D situation in communications and information technologies.

The greatest growth in employment over the last 40 years has been in the service sector so that it now employs over two-thirds of all workers as illustrated below.

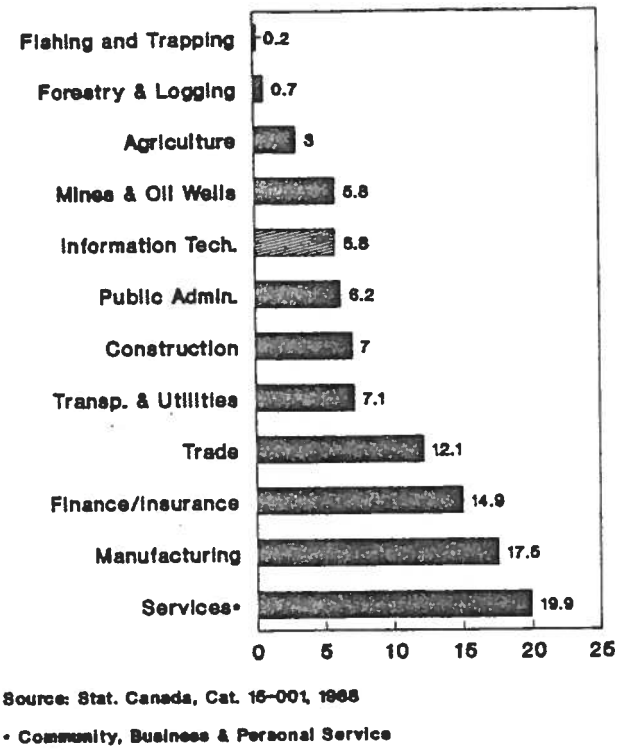
GROWTH OF SERVICE SECTOR EMPLOYMENT, 1945-1985



The service sector which includes everything from banks and retail stores to theatres, schools and libraries, has a high proportion of information workers. In fact, information workers now account for almost half of the total labour force. Rapid changes in the use of technologies are also changing the skills needed to function satisfactorily in the modern "information society."

Communications and information technologies (C&IT) have important implications for economic growth, both in terms of the strong growth of the C&IT sector itself and in terms of its contribution to the growth and productivity in other sectors of the economy. C&IT industries employ almost 3% of all working Canadians and accounted for 5.8% of Canada's gross domestic product (GDP) in 1987, which is more than agriculture, fishing, trapping, logging and forestry combined.

C&IT's SHARE OF GDP COMPARED TO OTHER ECONOMIC SECTORS

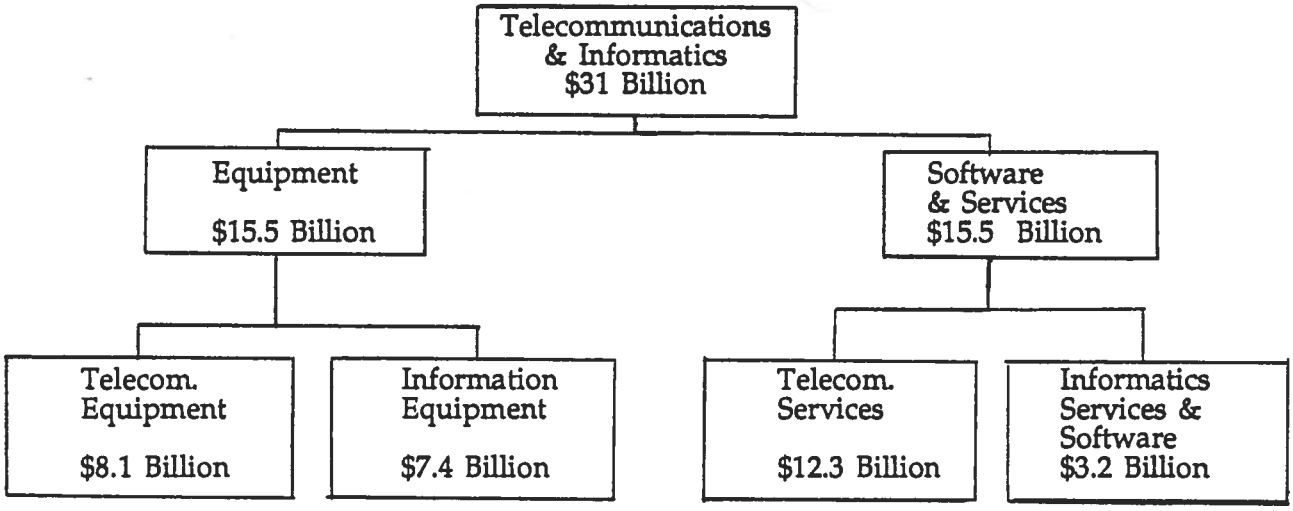


The C&IT sector in Canada is comprised of the following key industries: informatics equipment, informatics software and services, telecommunications equipment and telecommunications services.

Canada's informatics industry (i.e. hardware, software and services) had total revenues of $10.6 billion in 1987. Hardware suppliers dominate in terms of revenues generated, accounting for almost 70% of the total market. The computer industry, in terms of both hardware and software, is dominated by U.S. companies which control 66% of total revenue. Of the top 20 companies, 90% of the revenue is accounted for by foreign-owned companies.

Canada's telecommunications industry had revenues of about $20 billion in 1987. In contrast to the informatics industry, the telecommunications sector is dominated by service suppliers which account for over 70% of the total revenue. Both the hardware and software sectors of telecommunications are dominated by Canadian owned companies. In fact, Canada's Northern Telecom is a significant world player, with approximately 8% of total world telecommunications revenues in 1986.

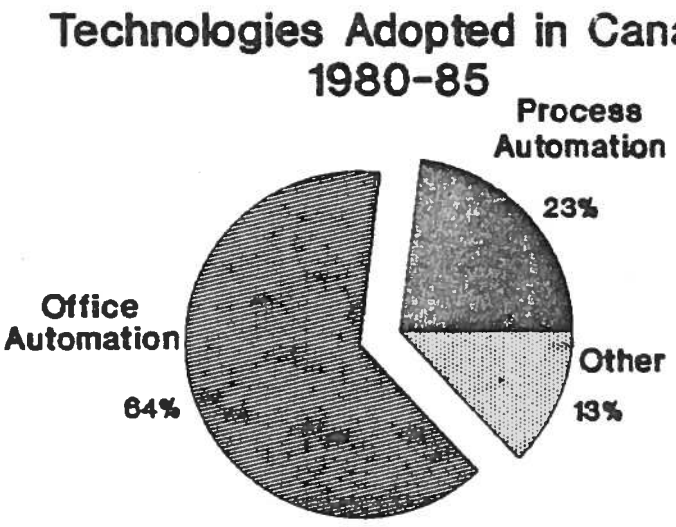
TELECOMMUNICATIONS AND INFORMATICS REVENUES IN 1987
(Billions of Current Dollars)



Note: Figures include exports.

For a number of years there has been concern about the slow rate of adoption of new technologies in Canada. Such delays are serious because rapid adoption of new technologies is vitally important to a country's future prosperity. In addition, the effective use of new technologies is part of a learning process. Thus, countries that are ahead of Canada in terms of technological adoption are also further along the learning curve.

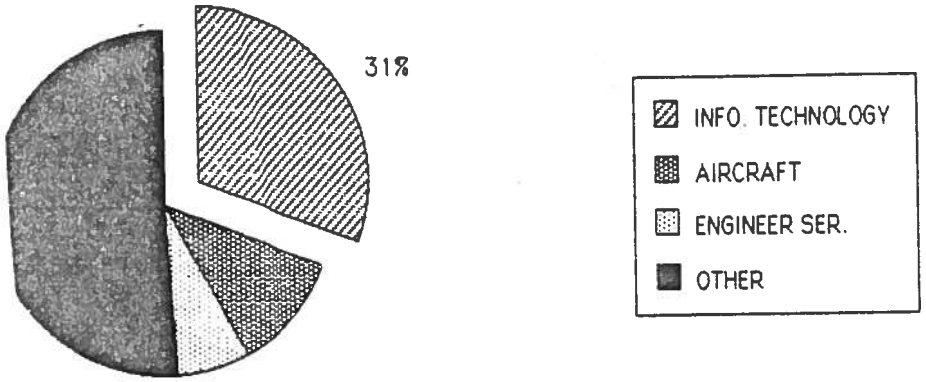
Studies by the Economic Council of Canada have found that office automation technologies, such as word processors and personal computers, have been the most widely adopted thus far.



The key factors driving the need to adopt new technologies appear to be increased productivity and competitive pressures. Major obstacles to introducing technological change are the cost of equipment, ability to finance/profitability, and the lack of skilled workers.

Statistics for total research and development (R&D) in Canada are extensive but information for communications and information R&D is still limited. Manufacturers of telecommunications equipment are the major performers of industrial R&D. The next largest ranking industries in terms of R&D expenditures are aircraft and parts, engineering and scientific services, business machines and computer services.

ESTIMATED 1988 R&D SPENDING FOR SELECTED INDUSTRIES



Canadian controlled firms account for the majority of R&D expenditures in telecommunications equipment, computer services, and engineering and scientific services. However, foreign controlled firms dominate the R&D in aircraft and parts and business machines.

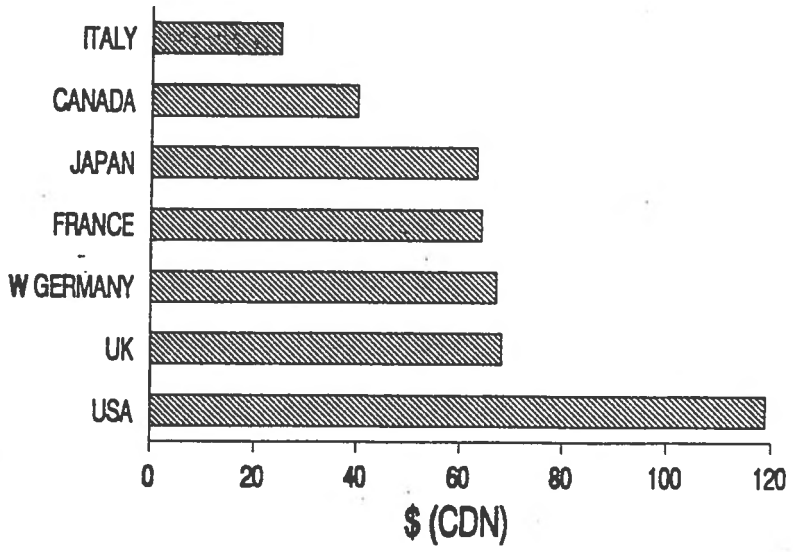
Bell Canada Enterprises is by far Canada's most important source of advanced research, accounting for almost 22% of industrial R&D expenditures within the country. Its next closest rivals are IBM and Mitel. The Department of Communications is the fourth largest R&D performer in communications and information technology in Canada.

MAJOR CANADIAN COMMUNICATIONS AND COMPUTER R&D SPENDERS, 1986
(In $ Millions)

Bell Canada Enterprises	623
IBM Canada	89
Mitel	52
DOC Research Program	44
B.C. Telephone	27.5
Control Data Canada	25
Gandalf Technologies	13
Spar Aerospace	12

In terms of international comparisons of national R&D efforts, Canada's overall efforts trail far behind that of the more industrialized OECD countries. Even in an area of strength such as communications and information technologies, Canada's efforts in terms of C&IT R&D expenditures per capita at $40 are low in comparison to the U.S., Western Europe and Japan.

C&IT R&D EXPENDITURES PER CAPITA, 1985



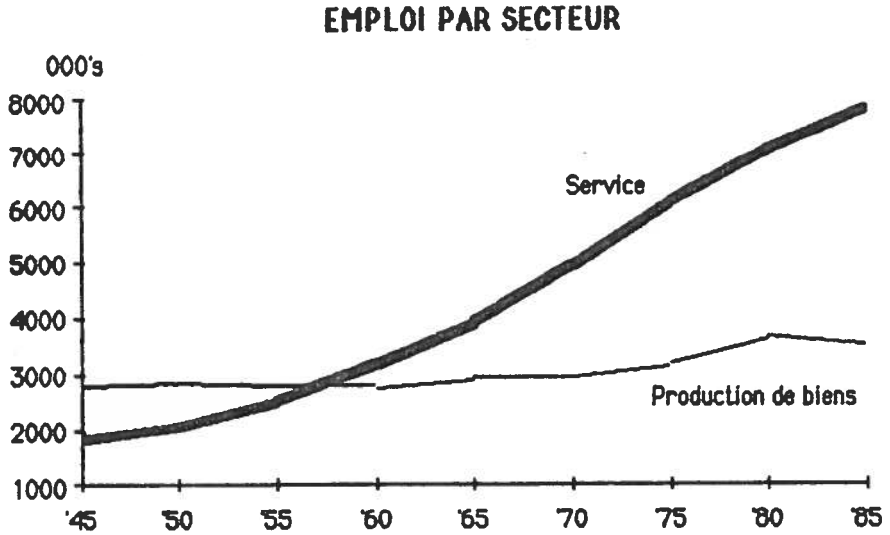
RÉSUMÉ DE L'ÉTUDE

Comme tous les autres pays industrialisés, le Canada traverse actuellement une période de transition qui le dotera d'une société plus fortement axée sur l'information, sous l'influence de la convergence de la technologie de l'informatique et de la technologie des communications, souvent désignées technologies de l'information. La création, la diffusion et l'utilisation de l'information ont gagné peu à peu de l'importance en tant que sources d'emploi, de croissance économique et de progrès social.

Le présent document a pour objet d'exposer les renseignements dont nous disposons sur l'état actuel des industries canadiennes liées à la technologie des communications et à la technologie de l'information, de l'adoption de ces nouvelles technologies au Canada et de la R&D effectuée au Canada dans le domaine des technologies des communications et de l'information.

C'est le secteur tertiaire qui a connu le plus fort taux de croissance de l'emploi au cours des 40 dernières années, si bien qu'il emploie aujourd'hui plus des deux tiers de toute la main-d'oeuvre canadienne, comme en fait foi le tableau ci-dessous.

CROISSANCE DE L'EMPLOI DANS LE SECTEUR TERTIAIRE PENDANT LA PÉRIODE 1945-1985



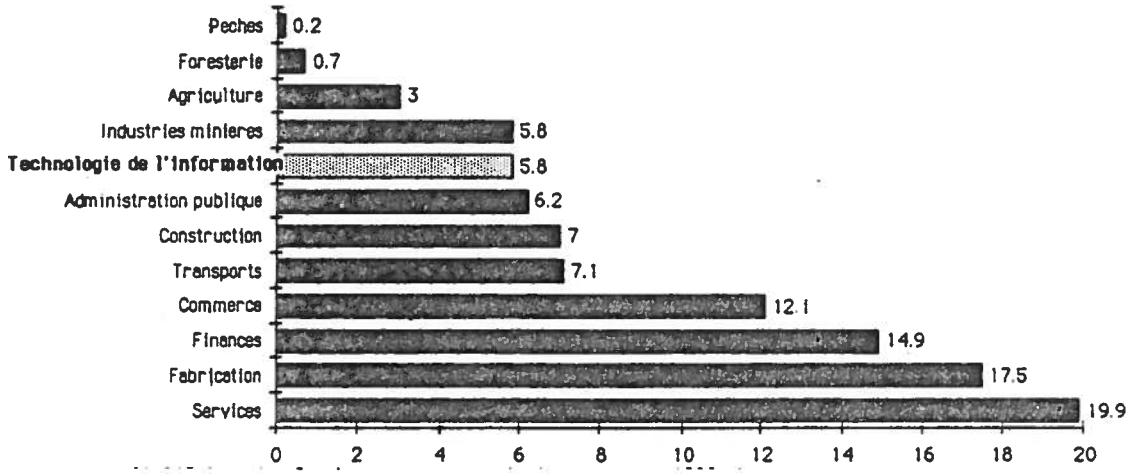
SOURCE: STATISTIQUE CANADA (71-001&71-529)

Le secteur tertiaire qui comprend les services bancaires, les comptoirs de vente au détail, les cinémas, les écoles, les bibliothèques et autres, compte une forte proportion de travailleurs de l'information. En effet, les travailleurs de l'information constituent à présent près de la moitié de la main-d'oeuvre globale. Les transformations accélérées qui s'opèrent dans le domaine de l'utilisation des technologies ont également des incidences sur les compétences dont il faut se doter pour bien se tirer d'affaire dans la "société de l'information" d'aujourd'hui.

Les technologies des communications et de l'information (TC&I) ont d'importantes répercussions tant sur la croissance économique du secteur des TC&I proprement dit que sur sa contribution à la croissance et à la productivité des autres secteurs de l'économie. Les industries liées aux TC&I emploient près de 3 p. 100 de la main-d'oeuvre canadienne globale et elles ont contribué dans une proportion de 5,8 p. 100 au produit intérieur brut du Canada (PIB) en 1987, contribution est qui supérieure à celle des secteurs de l'agriculture, des pêches, du piégeage, du bois de sciage et de l'exploitation forestière, pris collectivement.

COMPARAISON DE LA CONTRIBUTION DU SECTEUR DES TC&I ET DE LA CONTRIBUTION DES AUTRES SECTEURS DE L'ÉCONOMIE

Répartition en pourcentage de la contribution au PIB (1987)



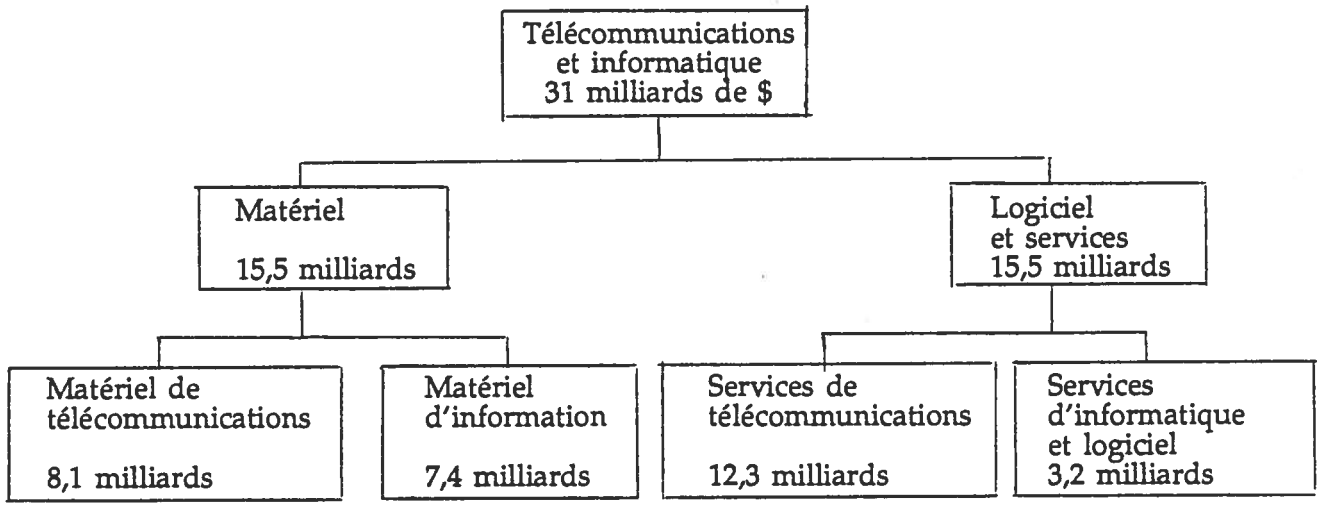
Source : Statistique Canada, n° de catalogue : 15-001, 1988
* Services communautaires, d'affaires et personnels

Le secteur des TC&I du Canada est constitué des principales industries ci-après : les industries de fabrication de matériel informatique, les fournisseurs de logiciels et de services informatiques, les industries de fabrication de matériel de télécommunications et les fournisseurs de services de télécommunications.

L'industrie canadienne de l'informatique (c'est-à-dire les fournisseurs de matériel, de logiciel et de services) a touché des recettes de l'ordre de 10,6 milliards de dollars en 1987. Ce sont les fournisseurs de matériel qui ont touché les recettes les plus fortes, c'est-à-dire près de 70 p. 100 de la valeur globale du marché. L'industrie de l'informatique, c'est-à-dire matériel et logiciel compris, est dominée par les entreprises américaines qui accaparent 66 p. 100 des recettes globales. Si l'on ne retient que les 20 principales entreprises, 90 p. 100 des recettes vont à des entreprises de propriété étrangère.

L'industrie des télécommunications du Canada a touché des recettes d'environ 12 milliards de dollars en 1986, ordre de grandeur qui se compare à celui des recettes touchées par l'industrie de l'informatique. Le secteur des télécommunications se démarque de l'industrie de l'informatique du fait qu'il est dominé par les fournisseurs de services dont les recettes équivalent à 70 p. 100 des recettes globales. Les secteurs du matériel et du logiciel de télécommunications sont l'un et l'autre dominés par des entreprises de propriété canadienne. En effet, la Northern Telecom du Canada est une importante intervenante qui a touché à elle seule près de 8 p. 100 de toutes les recettes mondiales perçues au titre des télécommunications en 1986.

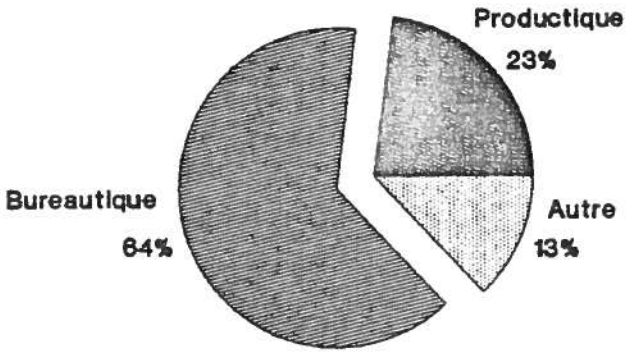
RECETTES PRODUITES PAR LE SECTEUR DES TÉLÉCOMMUNICATIONS ET DE L'INFORMATIQUE EN 1986
(en milliards de dollars courants)



Depuis un certain nombre d'années, on s'inquiète de la lenteur dont on fait preuve au Canada pour ce qui est de l'adoption des nouvelles technologies. Il s'agit de retards graves, car la rapidité de l'adoption des nouvelles technologies est un facteur crucial des possibilités de prospérité d'un pays. En outre, l'utilisation efficace des nouvelles technologies est partie intégrante du processus d'apprentissage. Par conséquent, les pays qui devancent le Canada dans le domaine de l'adoption des nouvelles technologies se situent également à un niveau supérieur de la courbe d'apprentissage.

Des études effectuées par le Conseil économique du Canada ont permis de constater que ce sont les technologies de la bureautique, notamment les machines de traitement de textes et les ordinateurs personnels, qui ont été les plus largement adoptées jusqu'à présent.

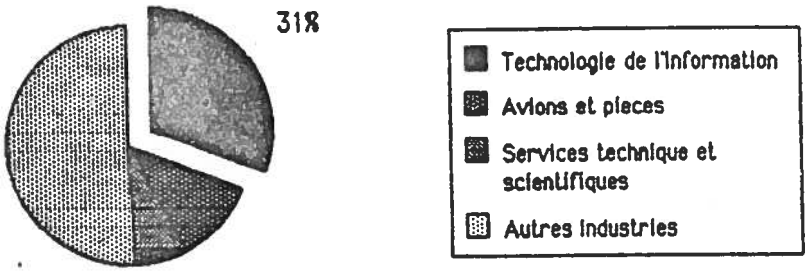
ADOPTION DES TECHNOLOGIES INFORMATIQUES AU CANADA ENTRE 1980 ET 1985



Il semble que les principaux facteurs qui soient à l'origine de la décision d'adopter les nouvelles technologies soient la volonté de réaliser des gains de productivité et de résister aux pressions exercées par les concurrents. Les principaux obstacles qui font échec à l'adoption des progrès technologiques sont le coût du matériel, la capacité de financement, la rentabilité, et le manque de main-d'oeuvre spécialisée.

On possède des statistiques volumineuses sur l'ensemble des travaux de recherche et développement (R&D) effectués au Canada, mais les renseignements concernant la R&D effectuée dans les domaines des communications et de l'information sont encore restreints. Les fabricants de matériel de télécommunications sont les principaux intervenants en matière de R&D effectuée dans l'industrie. Les industries qui les suivent par ordre décroissant d'importance des dépenses affectées à la R&D sont l'industrie des avions et pièces, les bureaux d'ingénieurs et de scientifiques, l'industrie des machines de bureau et les services d'informatique.

DÉPENSES ESTIMATIVES DE R&D POUR 1988 POUR CERTAINES INDUSTRIES



Ce sont des sociétés contrôlées par des intérêts canadiens qui ont consenti la plus grande partie des dépenses de R&D au titre du matériel de télécommunications, des services d'informatique et des bureaux d'ingénieurs et de scientifiques. Cependant, ce sont des sociétés contrôlées par des intérêts étrangers qui ont consenti les dépenses les plus importantes au titre de la R&D dans les domaines des avions et pièces et des machines de bureau.

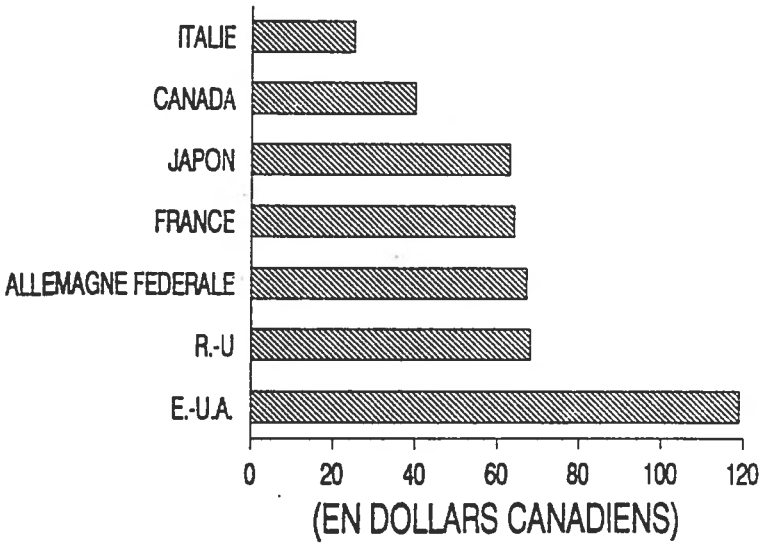
Les Entreprises Bell Canada constituent de loin la plus importante source de recherche de pointe au Canada, ayant contribué à près de 22 p. 100 de toutes les dépenses de R&D consenties à ce titre par l'industrie au pays. Les entreprises qui la suivent de plus près sont IBM et la Mitel. Le ministère des Communications est le quatrième intervenant en importance en R&D concernant la technologie des communications et de l'information au Canada.

DÉPENSES DES PRINCIPAUX INTERVENANTS CANADIENS EN R&D DANS LES DOMAINES DES TÉLÉCOMMUNICATIONS ET DE L'INFORMATIQUE (1986)
(En millions de dollars)

Entreprises Bell Canada	623
IBM Canada	89
Mitel	52
Programme de recherche du MDC	44
B.C. Telephone	12,5
Control Data Canada	25
Gandalf Technologies	13
Spar Aérospatiale Ltée	12

Si l'on compare les efforts déployés par le Canada en matière de R&D avec ceux des autres pays, on constate que dans l'ensemble, les efforts consentis par le Canada sont largement dépassés par ceux que consentent les pays plus industrialisés de l'OCDE. Même dans un domaine où le Canada fait figure de proue comme celui des technologies des communications et de l'information, les 40 $ par personne que le Canada affecte à la R&D concernant les TC&I font figure d'enfant pauvre au regard des sommes que les États-Unis, l'Europe occidentale et le Japon affectent au même titre.

VALEUR PAR PERSONNE DES DÉPENSES CONSENTIES EN 1985 AU TITRE DE LA R&D CONCERNANT LES TC&I



CHAPTER I

THE INFORMATION ECONOMY

1.1 Introduction

Canada, like all industrialized countries, is in the midst of a major period of change, driven by the converging technologies of computers and communications, often called information technologies. As the Science Council of Canada states:

> "At any given phase of economic development there tend to be a few key technologies whose mastery is essential for growth, competitiveness, and strategic independence." (1)

There is no doubt that communications and information technologies (C&IT) are one of those key technologies. Indeed, the U.S. Department of Commerce indicates that:

> "The telecommunications and information industries have advanced from a modest role in support of an industrial age economy to that of essential infrastructure for the information age."(2)

Hundreds of books and articles have documented the advent of the information society so named because the bulk of the labour force engages in informational activities. It is anticipated that few areas of work or leisure will not be affected profoundly by the widespread availability of low-cost computing and telecommunications capabilities. If this is so, the government through its programmes and policies must help Canadians make the most of the new opportunities and meet the challenges in the "Information Economy."

Despite various studies efforts to analyze the information economy, there are still no clearcut answers about the social and economic implications of communications and information technologies. For example:

- Do the new technologies create or destroy jobs?
- Is Canada adopting the new technologies fast enough?
- How does Canada's R&D effort in C&IT compare with our major competitors?

The purpose of this document is to outline our available information on the current status of the Canadian communications and information technologies industries; the adoption of these new technologies in Canada; and the Canadian R&D situation.

1.2 Expert Opinions

The creation, communications and utilization of information has become progressively more important as a source of jobs, economic growth and social progress. As the Prime Minister pointed out in an address at the University of Waterloo in 1987,

> "The Western World is moving toward knowledge-based economies and Canada must move with it. We want to be known not only as a resource-rich nation, not only as a trading nation, but as a nation known for our brain power, our ideas, and our intellectual and educational achievements. The issue is no less fundamental than how Canada will earn a living in the 1990's and beyond." (3)

The Canadian Advanced Technology Association also stressed the importance of science and technology for economic renewal and employment growth.

> "We have entered a new era. Wealth and job creation, now and in the future, depend on the growth of knowledge intensive industries and on the application of technology to keep established industries competitive." (4)

The Information Technology Association of Canada points out that information technology plays a crucial role in the world economy.

> "The ability to transfer knowledge and data almost instantaneously has transformed information into a capital good, no less valuable than labour, materials and even finance."(5)

The Science Council has reinforced the view of the importance of C&IT by calling the computer-based communications infrastructure a transformative technology, and stating that it will have the greatest impact of all emerging technologies on societal change between now and the end of the century.

Despite the dazzling array of new products and services produced in the last 10 years, the OECD estimates that these changes constitute only 10 to 15 percent of the changes that we will see by the year 2000.

1.3 Strategic Use of C&IT in the Economy

Communications and information technologies are being recognized as having important implications for economic growth, both in terms of the strong growth of the C&IT sector itself and more importantly in terms of its contribution to growth and productivity in other sectors of the economy.

Communications and information technology is changing the nature of certain businesses by providing new approaches to existing markets and creating whole new product lines. Many companies are finding that access to adequate and timely information is often the key to economic success.

According to the Diebold Group Inc. of New York, "the convergence of information technologies is changing the way virtually all businesses are building a new competitive edge...as information technology becomes recognized as a competitive weapon." (6)

Hundreds of examples could be given of how businesses are using information technology to gain a competitive edge. Following are a few examples from each sector of the economy to show the pervasiveness of the use of communications and information technologies.

Resource Industries

Canada depends very heavily on its resources base in world trade and it is essential that we use new technologies to maintain their competitiveness with other world suppliers.

- In fisheries, more sophisticated navigational aids using microprocessors are being employed to aid in locating profitable fishing areas. Microelectronics are also used to spot impurities in the product or inferior fish in order to guarantee quality for overseas buyers.

- MacMillan Bloedel has integrated CAD/CAM into its sawmill process. A computer program determines the best way to cut the log to maximize the number of board feet and financial recovery.

- Energy, Mines and Resources Canada uses automated systems, which can handle masses of data in a fast, accurate and repeatable way, to interpret the vast quantities of data/photos collected by satellite and aircraft.

Manufacturing

New technologies have the potential to increase the productivity of manufacturing by improving utilization of raw materials, decreasing levels of stock on hand and optimizing the relationship between the different processes and activities.

- Chrysler's Windsor plant uses automation to produce a continual, predictable flow of material through 1,847 body, paint, trim and final-assembly stations at a predetermined schedule.

- The Waterloo Region Shoe Manufacturers Ltd. invested in a CAD system to significantly reduce turnaround time - from approximately 18 man-days to grade and cut a pattern manually to five hours.

- Construction companies such as Ellis-Don are using computerized spreadsheets and specialized software to manage huge projects, decide where to purchase land, and look for an edge in tendering for contracts.

Service Sector

A wide range of services will be made more effective and more efficient with the application of computer/communications technologies.

- C&IT allows conventional banking services to be provided faster and more efficiently through devices like automated tellers and electronic credit card verifications.

- Educational services are being affected through the enhanced role of computer-aided learning as a teaching aid in schools and training situations.

- Computerized medical records will lead to better diagnoses at an overall lower cost to society. Doctors and dentists are using CAD/CAM programmes to design and manufacture body implants and teeth, which reduces pain and saves time.

- Major hotel chains are introducing in-room video check-out systems, which enable guests to speed their departure by settling their bills without talking to the front desk.

- Pizza Pizza's success depends largely on its guarantee of 30-minute delivery - a guarantee made possible by its computerized ordering system which helps Pizza Pizza speed deliveries and provides it with extensive marketing information about where its customers live and their preferences in pizza.

1.4 Impact on the Labour Force

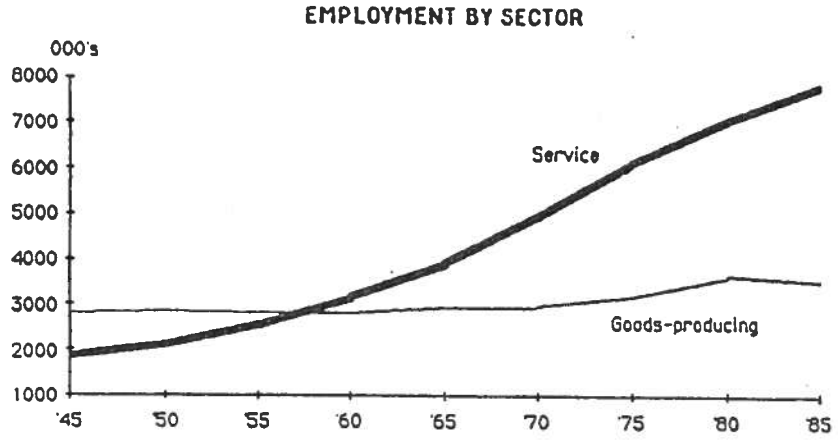
1.4.1 The Rise in the Number of Information Workers

Canada, like every other industrialized nation, is going through a transition towards a more information-based society in which more and more workers are employed in the information sector. This shift in employment is driven by the growth in new, information technology-based services resulting from the merger of computers and communications.

The greatest growth in employment over the last 40 years has been in the service sector so that it now employs over two-thirds of all workers as shown in Chart 1.1.

Graph 1.1

Growth of Service Sector Employment



Source: Statistics Canada, 71-001 and 71-529

The service sector which includes everything from banks and retail stores to theatres, schools and libraries, has the highest proportion of information workers. Information workers in these industries are primarily involved in the creation, dissemination and utilization of information. The number of information workers employed in the economy has been increasing to the point where they now account for almost half of the total labour force.

1.4.2 Changing Skills

The rapid changes in the use of technologies in daily life are changing the skills needed to function satisfactorily in the modern economy. In the industrialized world, it has been estimated that over the coming five years, four out of five people will be doing work differently from the way it has been performed in the previous fifty years. According to a recent report issued by the Canadian Manufacturer's Association:

> "The pressure of international competition and the need for rising levels of productivity and innovation will only increase in the coming years. Canadian manufacturers must be able to keep pace with a global economy that is information-based and driven by the convergence of computers and communications. Knowledge has become the primary material in the merging world economy. Hence, Canada's universities and community colleges are as much primary producers as the nation's farms, mines, or factories." (7)

The requirement for an increasingly sophisticated workforce will, thus, present Canada with growing requirements for improved education and training opportunities.

1.5 Technology Trends

Technological progress is the principal driver of growth in the telecommunications and computer industries.

Telecommunications technologies have undergone several major transformations which have greatly expanded communications capacity. In the last four or five years, with the introduction of fibre optics, the channel capacity has been doubling every year, and there is no end in sight. This implies that larger amounts of information can be moved from place to place without substantial increases in cost.

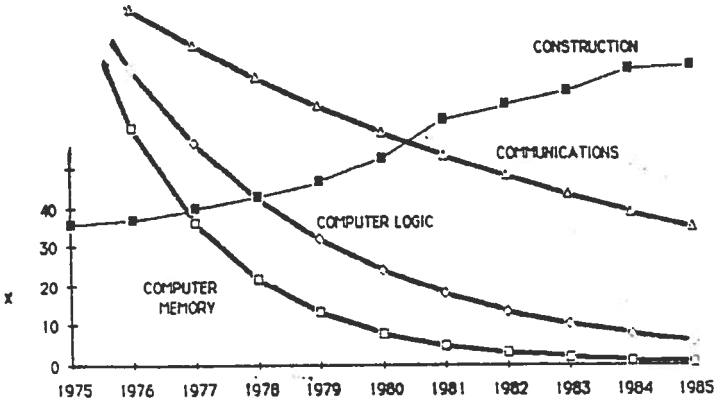
Similarly, advances in microelectronics have led to improvements in computer systems technology, to produce systems that are smaller in size, larger in capacity, and faster in operation. An illustration of the declining cost of computing power is provided by Tom Forester in his book "High-Tech Society".

> "A 1977 state-of-the-art personal computer processed 100,000 machine instructions per second and came with 64 kilobytes of main memory and 160 kilobytes of disk storage.
> A 1987 machine not only costs much less, but also has 20 times the processing power, 20 times the main memory and 500 times the disk storage capacity.(8)

Graph 1.2 below shows the improvements in terms of decreases in the cost of computer memory, computer logic and communications technology.

Graph 1.2

Decreasing Costs of Communications and Computer Technologies

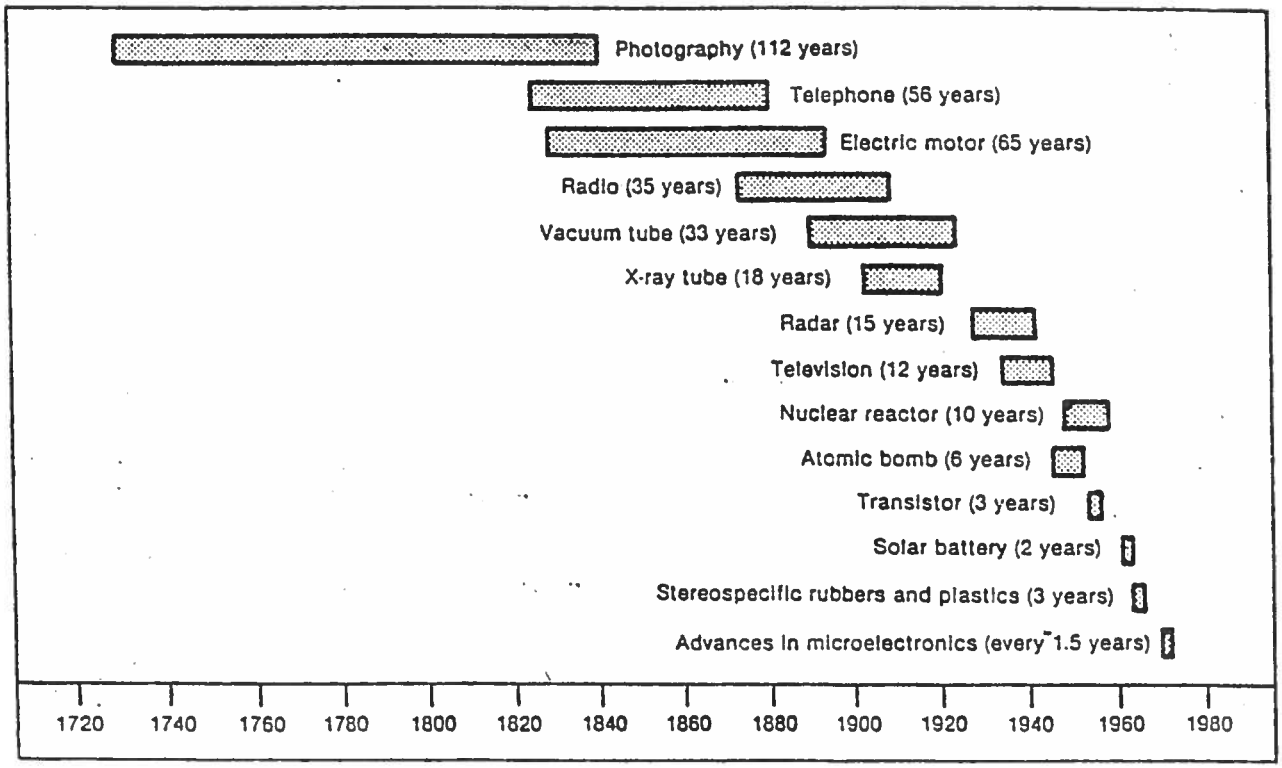


The convergence of computers and telecommunications is occurring because telecommunications systems are going digital. "This means that data processing and data transmission equipment will be talking the same language - the language of the binary code. ... Existing phone systems are based on analog devices which are slow, have a low capacity, and require translation before data can be transmitted on the network. Digital exchanges have no need for elaborate decoding equipment or services. Digital technology is fast, flexible, reliable - and is getting cheaper by the minute."(9) Because most computers process digital information, the progressive digitization of telecommunications begins to blur the distinctions between the communication of information and its processing.

In addition to the rapid technological improvements, another trend is much shorter times between discovery of a product and its commercialization as shown in Graph 1.3. This makes access to good information and communications facilities essential to business.

Graph 1.3

Shorter Interval Between Discovery and Commercialization



Source: "Facts and Trends: The Changing Information Environment; An Information Chart Book", Centre for Integrative Studies, SAED, State University of New York, 1972.

1.6 Conclusion

* In Canada, as in other industrialized countries, the creation, communication and utilization of information has become progressively more important as a source of jobs, economic growth and social progress.

* C&IT is being recognized as having important implications for economic growth, both in terms of the strong growth of the C&IT sector itself and more importantly in terms of its contribution to the growth and productivity of other sectors of the economy.

* As Canada moves towards an information-based economy, the number of information workers has increased to the point where they account for almost half of the total labour force.

* Rapid changes in the use of technologies are also changing the skills needed to function satisfactorily in the modern economy. The requirement for an increasingly sophisticated workforce presents Canada with growing requirements for improved education and training opportunities.

* Over the past twenty years, there have been dramatic improvements in the performance of communications and information technologies, while their size and price have decreased at even faster rates.

CHAPTER II

AN INDUSTRY PROFILE

2.1 Introduction

Not only is communications and information technology pervasive throughout the economy, as was shown in chapter 1, it has grown to become a significant part of our economy. This chapter gives the overall size of communications and information technology in terms of market revenues, as a share of gross domestic product, number of persons employed by the information technology producing sector and international trade. It also gives a brief overview of industries involved in the provision of telecommunications and computer equipment and services.

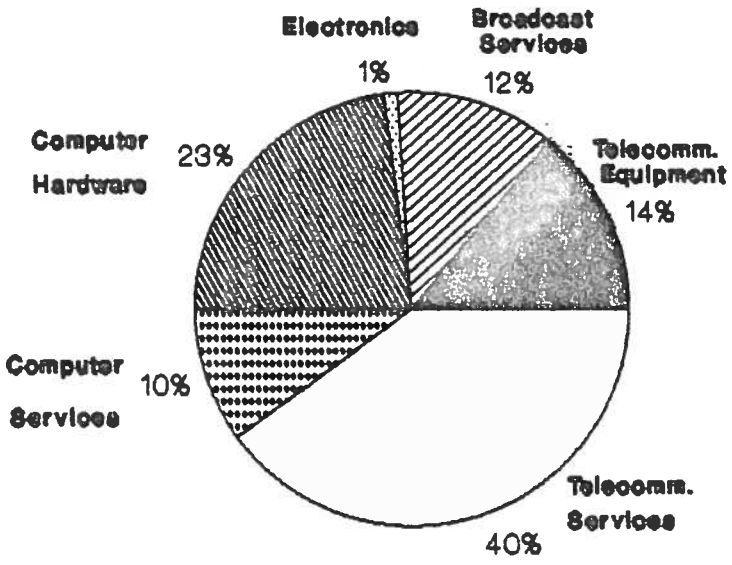
2.2 Importance of Information Industry

2.2.1 Information Industry Revenues

Graph 2.1 shows the Canadian communications and information industries (C&IT) market in 1986 generated total revenues of about $30 billion. This figure includes exports of $2 billion. Telecommunication services accounted for over 40% of the total revenue.

Graph 2.1

C&IT Industry Revenue (1986)



Total Industry Revenue = $ 29.5 Billion

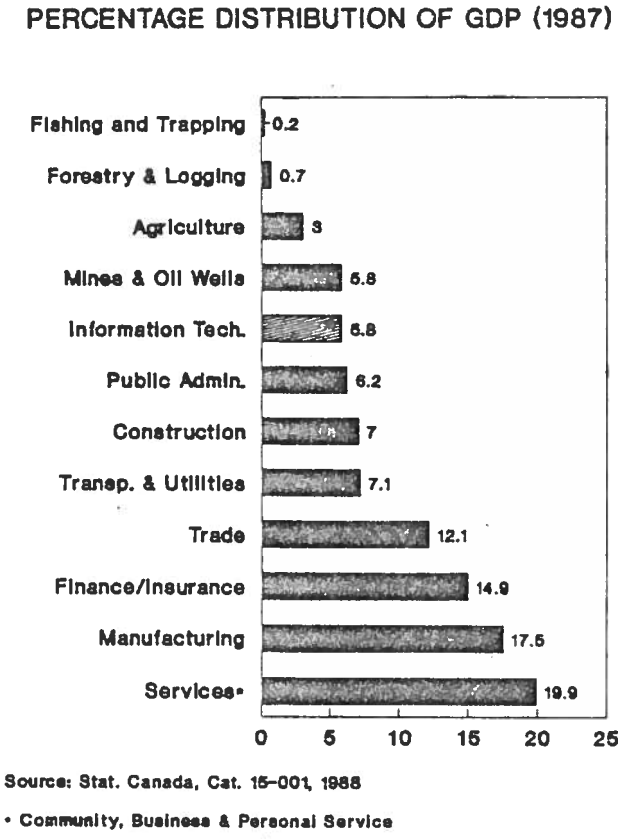
Source: Evans Research EDP In-Depth Report, March 1988,
Statistics Canada, Catalogue 56-204, and Company Annual Reports.

2.2.2 Comparison of Information Technology with other Economic Sectors

Communications and information industries represented a significant portion (5.8%) of gross domestic product in 1987.

Graph 2.2

C&IT Share of GDP Compared to Other Economic Sectors



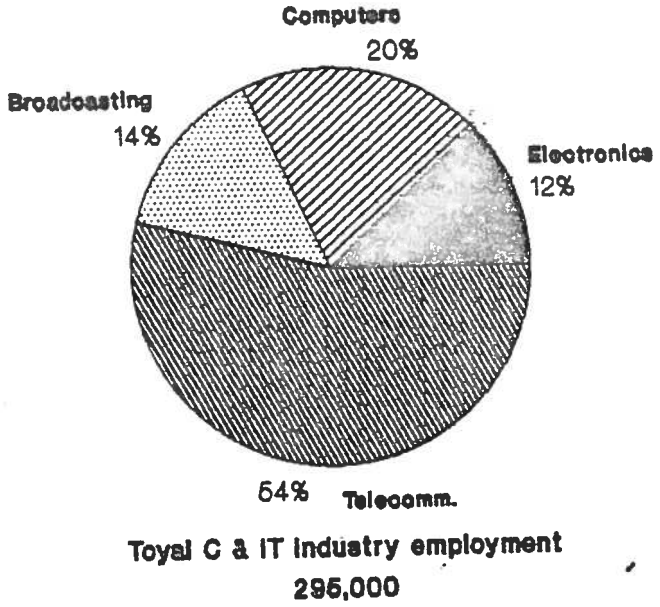
As a percentage of Gross Domestic Product (5.8%), information technology contributes more to the Canadian economy than agriculture, fishing, trapping, logging and forestry combined whose total share was 3.9%.

2.2.3 Employment in Information Technology Industries

Graph 2.3 shows that 295,000 people were employed in the various segments of the communications and information technology industry in 1986. This represents 2.6% of total employed Canadians.

Graph 2.3

C&IT Industry Employment (1986)



Source: Statistics Canada 72-002

The communications and information technology employment share of 2.6% is less than half of its GDP's share of 5.8%. This is due to the fact that we import most of our computers and related hardware and, therefore, do not employ as many people in these manufacturing areas.

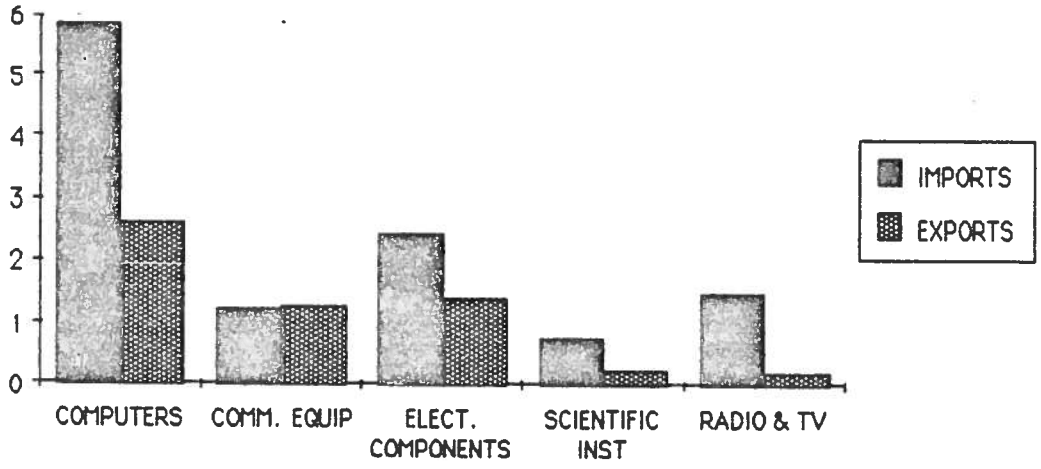
2.2.4 International Trade in Information Technology

Graph 2.4 shows the trade balance for major C&IT technology products for 1987. C&IT products accounted for total imports of about $12 billion (approximately 10% of all Canadian imports) and total exports of about $6 billion (approximately 5% of all exports), thus resulting in a net deficit of $6 billion in 1987. All areas except telecommunications equipment had a trade deficit. Our reliance on foreign technologies is greatest for computers and electronics.

Graph 2.4

1987 Trade Balance of C&IT Products

($ Billion)



Source: Re$earch Money, June 15, 1988. (Based on Statistics Canada Data).

Although a negative trade balance in C&IT products is usually regarded as unfavourable, Statistics Canada points out that rising imports of these products may, in fact, be a favourable indicator given their contribution to productivity improvement.

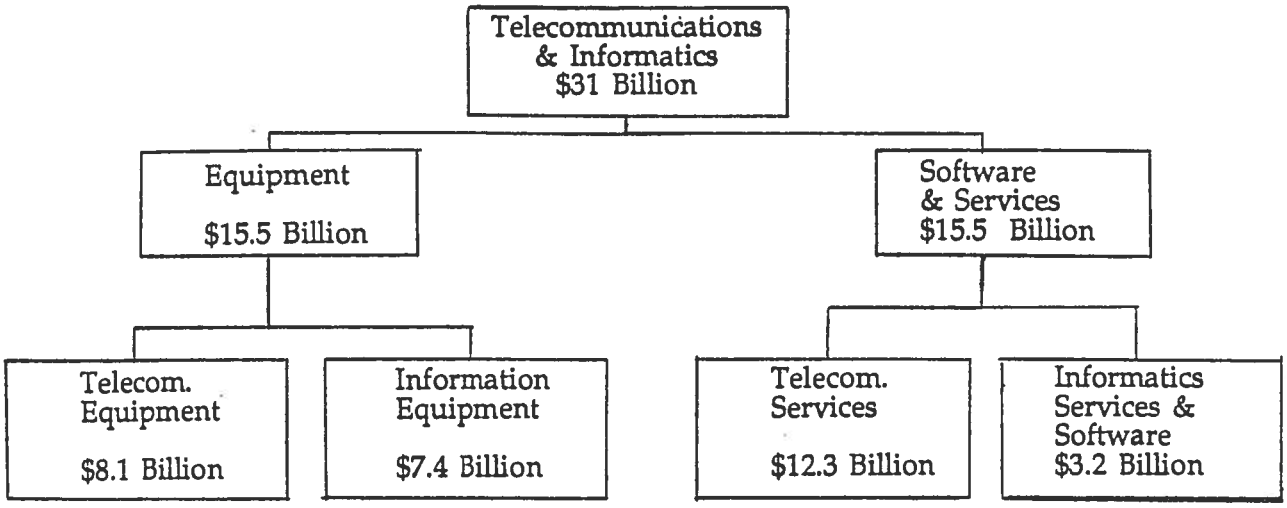
2.3 Information Technology Suppliers

The rest of this chapter gives a brief overview of industries supplying information technologies, specifically the information processing and communications industries. Graph 2.5 shows the revenues, including exports, for these two subsectors broken down by equipment and services.

Graph 2.5

Telecommunications and Informatics Revenues (1987)

(Billions of Current Dollars)



Source: Statistics Canada and Evans Research

2.4 Canadian Information Processing Industry

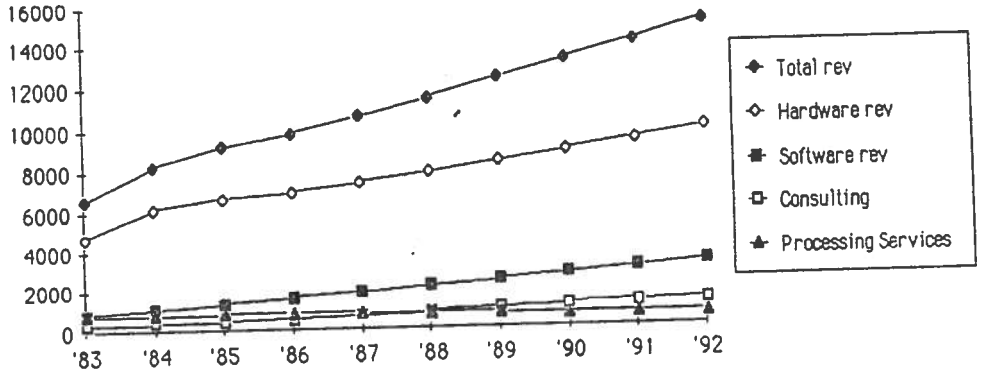
2.4.1. Total Revenues

The total revenues (both hardware and software) of the Canadian information processing industry grew from $6.5 billion in 1983 to $10.6 billion in 1987. It is forecasted to grow to $15 billion by 1992 for a healthy average growth rate of 10% between 1983 and 1992. In 1988, there were 240 companies in Canada with EDP revenues of $1 million or more.

Graph 2.6

Canadian Information Processing Revenues

($ Million)

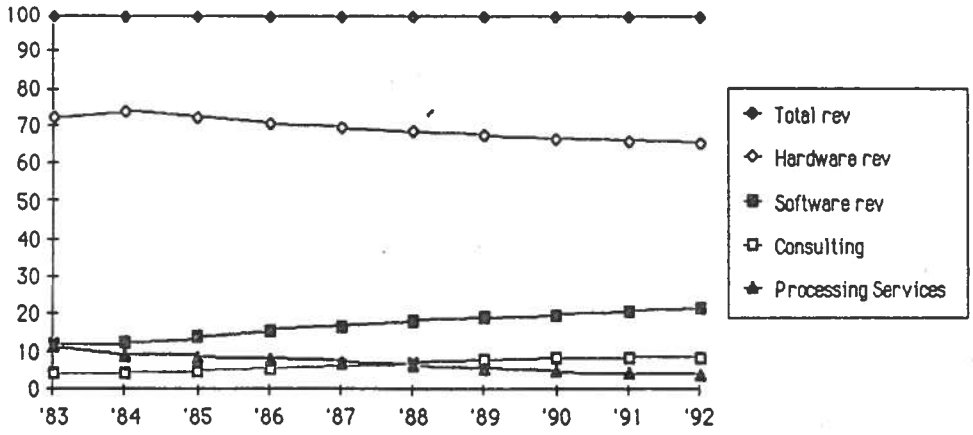


Source: Evans Research Corp., EDP In-Depth Reports, March 1988.

In terms of revenues generated, hardware products dominate the marketplace. Hardware accounted for 69.5% of total revenue in 1987 and is expected to maintain its share at much the same level (66%) in 1992.

Graph 2.7

Canadian Information Industry Revenues Percentage Shares by Sector



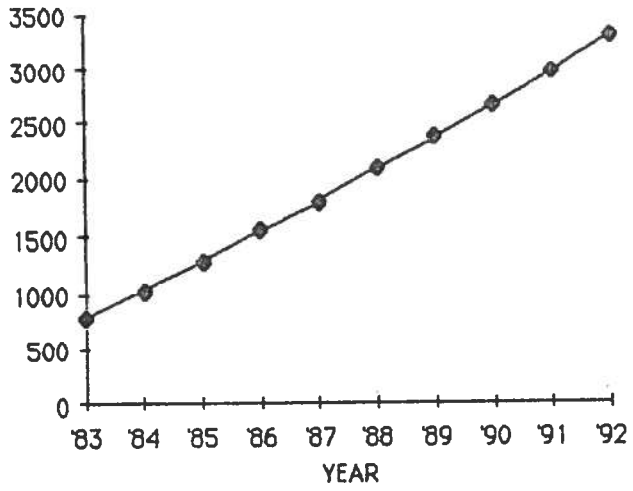
Source: Evans Research Corporation, EDP In-Depth Reports, March 1988.

The share of processing services (a Canadian strength) has declined from 11.4% in 1983 to 7% in 1987 and is expected to further decrease to 3.7% by 1992. This is due to decreasing costs of computing power which allows more and more users to buy in-house computing facilities rather than rent them from outside service bureaus.

2.4.2 Canadian Software Industry

Graph 2.8

Canadian Software Revenues
($ Million)

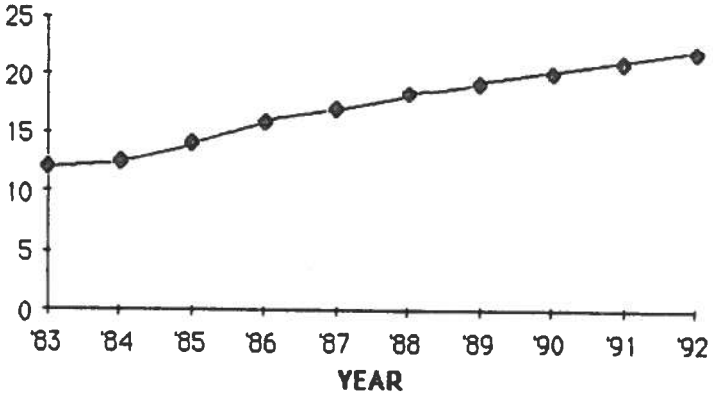


Source: Evans Research Corp., EDP In-Depth Reports, March 1988.

As shown in graph 2.8, revenues from the sale of Canadian software more than doubled from less than a billion dollars in 1983 to almost $2 billion in 1987 and is expected to almost double again by 1992.

Graph 2.9

Software Revenue as a Percentage of Total Revenue

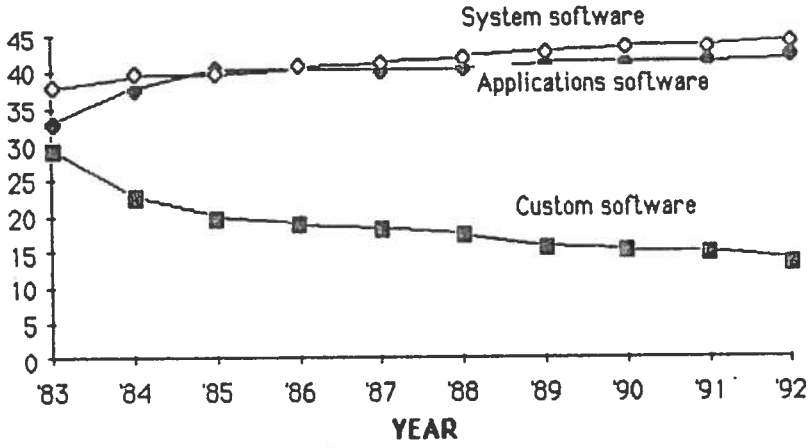


Source: Evans Research Corp., EDP In-Depth Reports - March, 1988.

As a percentage share of total revenue for all information processing products, the share of software increased from 12% in 1983 to 17% in 1987 and is expected to further increase to 22% by 1992. Rather than developing software for each application, the trend is to buy off-the-shelf packages where possible.

Graph 2.10

Percentage Shares of Different Types of Software



Source: Evans Research Corp., EDP In-Depth Reports, March 1988.

Graph 2.10 shows the relative share of different types of software:

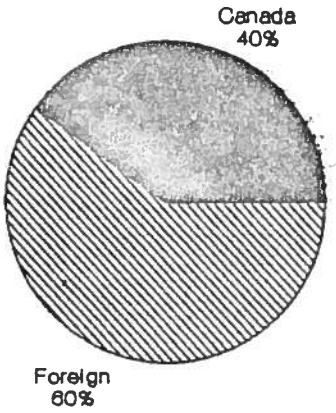
* Applications software increased its share of the total software market from 33% in 1983 to 40% in 1987 and is expected to increase to 42% by 1992.

* The systems software also increased its share from 38% in 1983 to 41% in 1987 and is expected to increase to 44% by 1992.

* The increases in the application and systems software sales have been at the expense of custom developed software whose share decreased from 24% in 1983 to 18% in 1987 and is further expected to decrease to 13% by 1992.

Graph 2.11

Canadian Software Revenue by Company Ownership



Total 1987 Software Rev. = $ 1.5 Billion

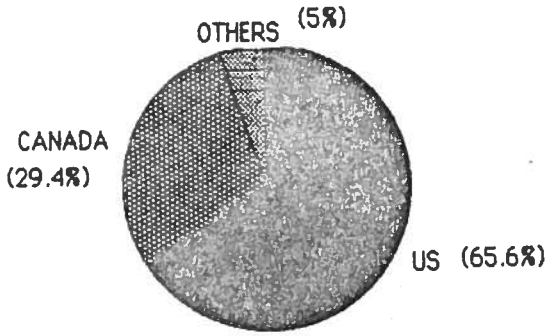
Source: The Canadian Software Market, Evans Research Corp., December, 1988.

In 1987 foreign owned companies like IBM and DEC accounted for 60% of the total software revenues. Canadian owned companies accounted for only 40% of the total revenues.

2.4.3 Computer Company Ownership in Canada

Graph 2.12

Canadian Total Computer Industry Revenues by Country of Ownership



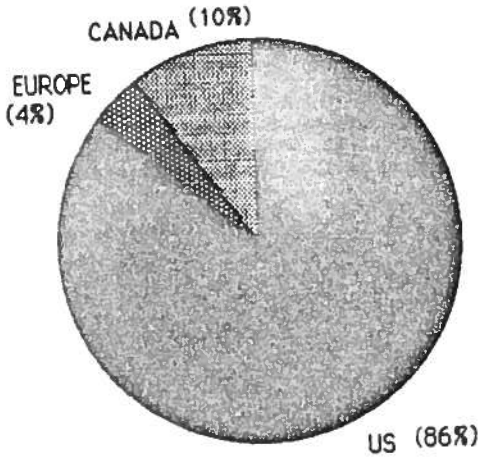
Source: The Top 200 Computer Companies in Canada Evans Research Corp., August, 1988.

In terms of total computer industry revenues, the Canadian owned companies account for only 29% of the total revenues. The industry is dominated by U.S. companies such as IBM, UNISYS, NCR etc., which control 66% of the revenues. The remaining 5% goes to other foreign owned companies.

Graph 2.13

Revenue Shares of the top 20 Companies

by Country of Ownership



Source: The Top 200 Computer Companies in Canada, Evans Research Corp., August, 1988.

The top 20 companies in the Canadian information processing industry accounted for 63% of the total industry revenues. Of these 20 companies, U.S. owned companies accounted for 86% of the total revenues. The Canadian companies accounted for 10% and the remaining 4% was accounted for by the European companies. Of the 10% share for the Canadian companies, almost half or 5% was due to a distribution company which retails mostly the U.S. products and the other 5% was accounted for by two computer service companies.

2.4.4 Structure of the Canadian Owned Companies

In 1987, Canadian owned companies accounted for about $3 billion of the total $11 billion revenues, representing approximately 30% of total revenue. Table 2.14 shows the revenues of Canadian-owned companies by type of company.

* Canada has no large system companies and accounts for less than 10% of the revenues for small, medium,and PC/OA companies.

* Canadian owned companies derive $786 million, almost 25% of their total revenues from distribution/retailing (mainly U.S. products).

* Canadian owned companies account for 87% ($580 million) of total service bureau revenues. Unfortunately service bureaus are the lowest growth area as more and more people buy their own computers.

* In terms of software companies, Canadian owned companies account for 58% of total revenues. This figure is overstated because a majority of the software is sold by hardware companies, such as IBM which are not classified here as software companies.

Table 2.14

1987 Revenues of Canadian Owned Companies

Canadian Owned Companies	Revenues $ million	% of total Industry Revenues
Large Systems Companies	0	0
Small/Medium Systems Companies	177	8%
PC/OA Companies	89.7	9%
Terminal/Peripherals Companies	114	23%
Data Communications Companies	343.6	66%
Leasing Companies	225.5	81%
Maintenance	68.1	85%
Distribution/Retail	786.2	85%
VAR/Systems Integrators	451.3	95%
Service Bureaus	580.2	87%
Consulting Companies	182.7	100%
Software Companies	247.2	58%
Total Revenue	**3,265.5**	**29%**

Source: The Top 200 Computer Companies in Canada, Evans Research Corp., August, 1988.

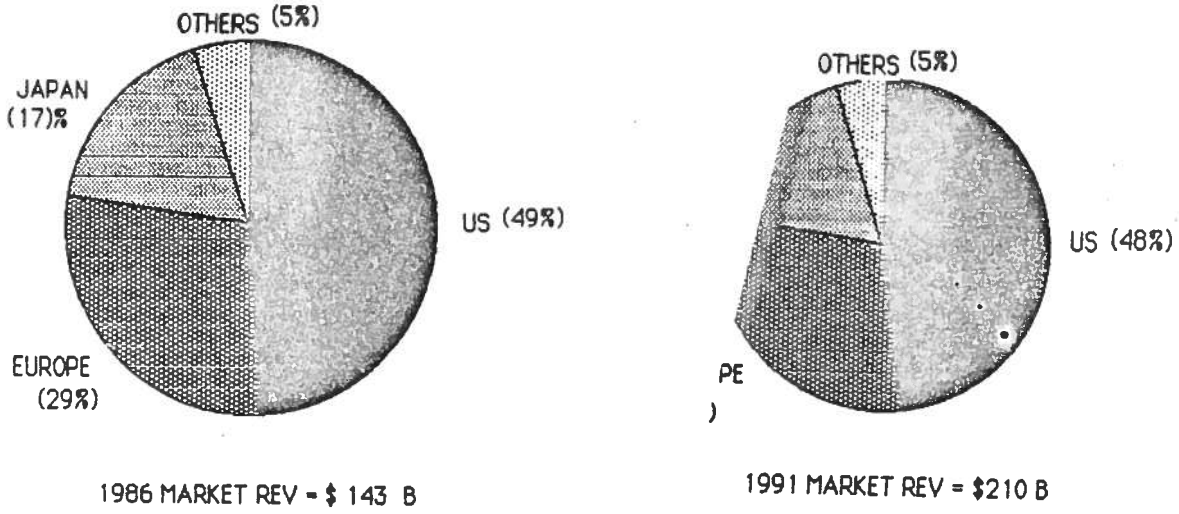
2.4.5 International Suppliers

Market Size

According to A.D. Little (Graph 2.15), the total world market for information processing products is expected to increase from $143 billion in 1986 to $210 billion by 1991 for an average growth rate of 11%. The United States accounted for almost half of the total world market in 1986 and its share is expected to stay about the same over the next 5 years. Europe accounts for 29% and Japan for 17%.

Graph 2.15

World Market for Information Technology Processing Products by Region

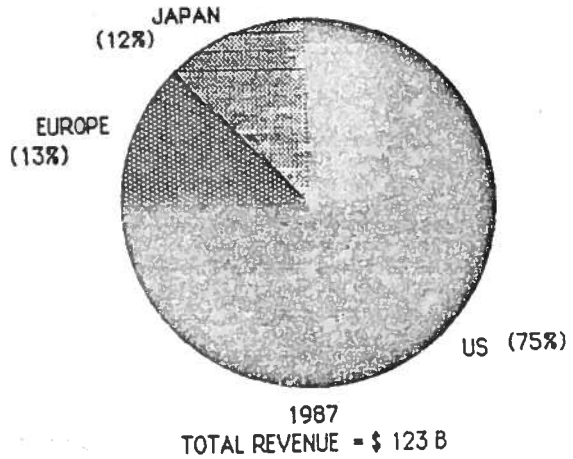


Source: Arthur D. Little, Information Systems Industry Overview, March 1987.

The top 20 worldwide suppliers of information processing products accounted for $123.2 billion or 86% of total revenues in 1987. The U.S. suppliers dominated the market with a share of 75% (Graph 2.16). IBM alone accounted for almost 40% of the total revenues for this group. The Japanese suppliers accounted for 13% and the Europeans accounted for the remaining 12%.

Graph 2.16

Revenue Shares of Top 20 Information Technology Suppliers by Region



Source:Spectrum, Information Systems and Technologies Overview, February, 1988, A.D. Little

2.5 Telecommunications Suppliers

2.5.1 Canadian Telecommunications Service Suppliers

The total revenues of all telecommunications companies supplying services in Canada were about $12 billion in 1986. Telecom Canada companies dominate with 87% of total revenues.

Table 2.17

Telecommunications Services Revenues, 1986

	Total Operating Revenues ($ Millions)	Shares (%)
Telecom Canada Companies	10,309.1	86.6
Other Telephone Companies	748.0	6.3
CNCP Telecommunications	343.8	2.9
Teleglobe Canada	273.8	2.3
Radio Common Carriers	200.0	1.7
Total	**11,874.7**	**100.0**

Source: Annual Returns of Telecommunications Companies

Table 2.18 provides a more detailed breakdown of total revenues in terms of individual companies. Bell Canada is the dominant supplier with a revenue share of 52% with BC Tel a distant second with a share of 11%.

Table 2.18

Telecommunications Services Revenues by Company, 1986

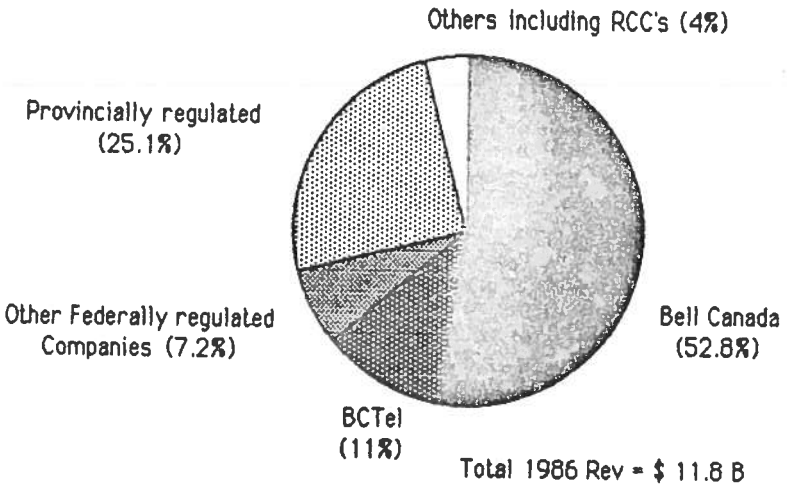
	Total operating revenues ($ Millions)	Share (%)
TELECOM CANADA		
B.C. Tel	1,308.0	11.0
AGT	1,067.1	9.0
SaskTel	449.6	3.8
MTS	349.6	2.9
Bell Canada	6,254.6	52.3
NBTel	256.6	2.2
Maritime Tel & Tel	336.4	2.8
Island Tel	35.9	.3
Newfoundland Tel	146.2	1.2
Telesat	105.3	.9
Subtotal	**10,309.1**	**86.8**
OTHER TELEPHONE COMPANIES		
Edmonton Tel	238.2	2.0
Northern Tel	29.5	.2
Northwest Tel	64.9	.5
Québec Tél	182.7	1.5
Télébec Ltée	114.3	1.0
Terra Nova Tel	44.4	.4
Thunder Bay Tel	24.0	.2
Others	50.0	.2
Subtotal	**748.0**	**6.3**
CNCP Tel	343.8	2.9
Teleglobe Canada	273.8	2.3
Radio Common Carriers	200.0	1.7
Total	**11,874.7**	100

Source: Annual Returns of Telecommunications Companies

Graph 2.19 gives the revenue breakdown by type of regulation. Federally regulated companies account for 71% of the total revenues, while the provincially regulated companies account for 25%.

Graph 2.19

Telecommunications Services Revenues by Regulation, 1986



Source: Annual Returns of Telecommunications Companies

Table 2.20 compares the Canadian use of telecommunication services with the U.S. in terms of service revenues. Canadian market revenues are about 9 percent of the U.S., similar to its population proportion in comparison with the U.S..

Table 2.20

Comparison of Canadian and U.S. Telephone Carriers Revenues
($ Million)

Year	Canadian	U.S.	Canadian as a % of U.S.
1977	3,853	43,322	8.9
1978	4,472	52,343	8.5
1979	5,151	59,283	8.7
1980	5,848	66,329	8.8
1981	6,987	79,735	8.8
1982	7,865	91,013	8.6
1983	8,533	96,243	8.9

Source: Statistics Canada Catalogue, 56-201, 56-203 and Federal Communications Commission, U.S.

2.5.2 Top 10 Canadian Telecom Equipment Suppliers

Table 2.21 shows the revenues of the top 10 Canadian Telecommunications companies from the Canadian marketplace. Unlike the computer equipment market, where 90% of the market (for the top 20 companies) is controlled by foreign companies, in the case of telecommunications equipment, over 90% of the market is controlled by Canadian companies.

In fact, in the case of computers, 65% of the software market is also controlled by foreign companies whereas in the case of telecommunications, services suppliers are mainly Canadian controlled.

Table 2.21

Revenues of the Top 10 Canadian Telecom Equipment Companies, 1986

Company	Revenue ($ million)	Share (%)
Northern Telecom	1600	62.2
Mitel	460	17.8
Microtel	161	6.3
TIE/COM	95	3.7
Bell Comm. System	62	2.4
AT&T Canada	60	2.3
Canadian Tel Group	55	2.1
Rolm Canada	45	1.7
TTS	34	1.3
TOTAL	**2577**	**100**

Source: Compiled by DGTA from several sources.

2.5.3 Top 20 International Telecommunications Equipment Suppliers

Tables 2.22 and 2.23 show the 1986 revenues of the top 20 telecommunications equipment suppliers. Canada's Northern Telecom has a reputable share of approximately 8%.

The domestic markets for telecommunications equipments have been traditionally closed to foreign competitors other than the domestic manufacturer which is generally a subsidiary of the domestic telecommunications monopoly supplier. It is quite likely that the telecommunications equipment sector may have had a similar concentration as the computer industry, had there been no domestic protection due to monopoly structures of telecommunications. Thus, Northern Telecom, Siemens, Erricsons may have come about more as the result of regulatory actions rather than technology geniuses.

Table 2.22

Top 20 Telecommunications Equipment Suppliers

Manufacturer	1986 Revenue ($ billion)	Share (%)
AT&T Technologies	10.2	18.1
Alcatel	8.0	14.2
Siemens	5.4	9.6
NEC	4.5	8.0
Northern Telecom	**4.4**	**7.8**
IBM (Rolm)	3.3	5.8
Motorola	3.1	5.5
Erricson	3.1	5.5
Futjisu	2.1	3.7
Philips	2.0	3.5
GEC	1.9	3.4
GTE	1.6	2.8
Plassey	1.4	2.5
Italtel	1.0	1.8
Rockwel	1.9	1.6
OKI	.8	1.4
Harris	.8	1.4
Racal	.7	1.2
ANT Nachrichtentechnik	.7	1.2
Hitachi	.6	1.0
Total Top 20	**56.5**	**100**

Source: Spectrum, Telecommunications Industry Equipment, A.D. Little, February, 1988

Unlike the computer suppliers where US companies dominate the world market with a revenue share of 75 % (for the top 20 companies), in the case of telecommunications, the US companies account for 38.6 % of the total revenues. The European companies account for a slightly larger share (39.5 %) and the Japanese companies account for 14%.

Table 2.23

Top 20 Telecom Equipment Suppliers by Country, 1986

	Revenue ($ billion)	Share %
U.S.	21.8	38.6
Canada	4.4	7.8
Europe	22.3	39.5
Japan	8.0	14.2
	56.5	**100**

Source: Spectrum, Telecommunications Industry Equipment, A.D. Little, February, 1988.

2.5.4 International Market for Telecommunications Equipment

The total world market for telecommunications equipment is expected to increase from $105.6 billion in 1988 to $158.6 billion by 1993 for an annual growth rate of 8.5%.

The U.S. share is expected to decrease slightly from 40.5 % in 1988 to 37.8 % by 1993. The share of Western Europe is also expected to decrease slightly from 20 % in 1988 to 18.2 % in 1993 while that of Japan is expected to increase slightly from 8 % to 9.2%.

Table 2.24

World Expenditures for Telecommunications Equipment

by Geographic Market
(Billions of 1987 Dollars)

	1988 Revenue	Share %	1993 Revenue	Share %
U.S.	42.8	40.5	59.9	37.8
W. Europe	21.1	20.0	28.9	18.2
Japan	8.5	8.0	14.6	9.2
Rest of World	33.2	31.4	55.1	34.7
Total	**105.6**	**100.0**	**158.6**	**100.0**

Source: Spectrum, Telecommunications Industry Equipment, A.D. Little, January, 1988.

2.6 Conclusion

* Information technology is a big business representing almost 6% of GDP which is higher than agriculture, fishing, trapping, logging and forestry combined. The information technology industries employed almost 3% of all Canadian workers.

* In terms of international trade, IT products resulted in a net deficit of about $6 billion in 1987. Rising imports of IT products, however, should not be viewed with alarm since their use contributes to the competitiveness of all other sectors of the economy as was illustrated in chapter 1.

* The computer industry is dominated by hardware suppliers, they account for approximately 70% of the total market revenues. In contrast, the telecommunications sector is dominated by service suppliers, which account for over 70% of the total revenues.

* The computer sector, in terms of both hardware and software, is dominated by foreign owned suppliers. Of the top 20 companies, 90% of revenue is accounted for by foreign-owned companies.

* In the case of telecommunications both hardware and software sectors are dominated by Canadian owned companies. In fact, of the top 10 telecommunications equipment suppliers, over 90% of the revenues is accounted for by the Canadian owned companies.

CHAPTER III

ADOPTION OF INFORMATION TECHNOLOGY

3.1 Introduction

For a number of years there has been concern about the slow rate of adoption of new technologies in Canada as demonstrated by the following references:

> "Canada's persistent lag in the introduction and use of computer-based technologies is an urgent national problem of major proportions... The challenge, therefore, is for all Canadians to embrace technological change openly and for Canada to improve its innovation performance relative to its major trading partners." (10)

> "Canadian industry in the 1980's is competing for its survival. ... Over the next decade, the battle will be won with robotics, computers and high-level automation. On the surface it may appear that Canadian manufacturers are moving in this direction but in general they have fallen gravely behind in adopting advanced manufacturing technology compared to countries such as Japan and West Germany."(11)

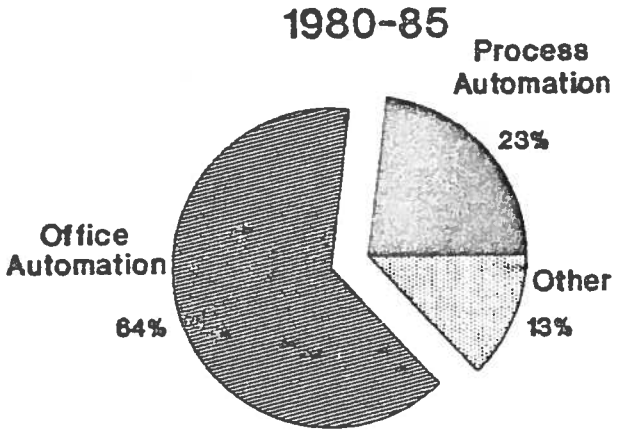
Although some Canadian firms are at the leading edge in adopting technology and using it effectively, there seems to be some consensus from the studies that many Canadian organizations lag far behind in using technology. The purpose of this chapter is to review the available studies and statistics on the adoption of information technologies in Canada.

3.2 Adoption of Information Technology in the Office

Studies have found that office automation technologies have been the most widely adopted. According to an Economic Council study, almost two-thirds of the technological changes introduced between 1980-85 were office automation, such as word processors and personal computers. Process automation technologies such as computer assisted manufacturing and computer assisted design accounted for another 23% of all innovations adopted. The remainder (13%) consisted primarily of specialized computer applications in a few industries.

Graph 3.1

Technologies Adopted in Canada



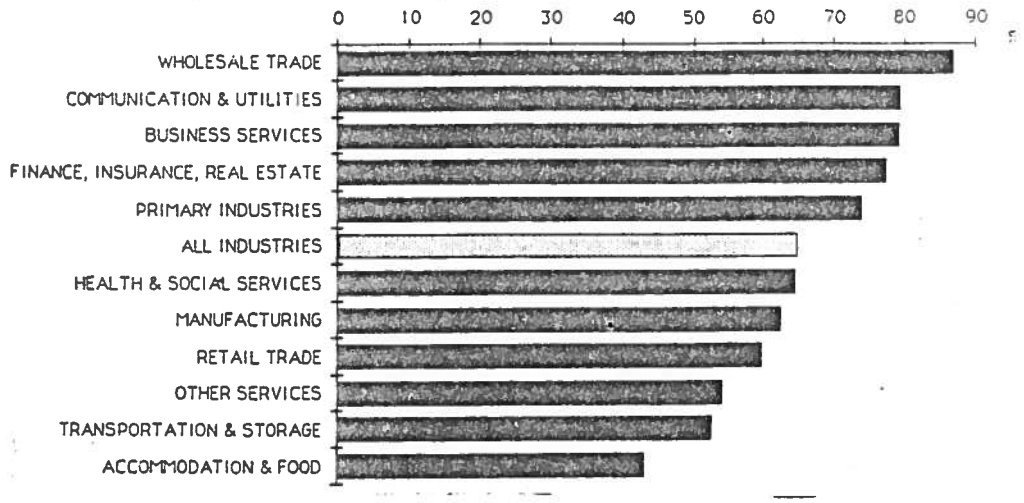
Source: "Innovation and Jobs in Canada," Economic Council, 1987

The predominance of office automation over process automation during the first half of the 1980's can be partly explained by the cost of the technologies. Compared with process automation, office technologies tend to require low levels of investment when they are introduced.

Wholesale trade, communications and utilities, business services, and finance, insurance and real estate industries had particularly high adoption rates of office automation technologies as shown in Graph 3.2. The introduction of office automation technologies ranged from a high of 87% of wholesale trade establishments to a low of 43% of accommodation and food operations.

Graph 3.2

Introduction of Office Automation Technologies by Industry
1980-1985



Source: "Innovation and Jobs In Canada", Economic Council, 1987.

3.3 Adoption of Information Technology in Manufacturing

In the Economic Council survey, forty-three percent of the manufacturing establishments reported some form of process automation was introduced between 1980 and 1985. Within manufacturing industries, there was considerable variation in the level of penetration (Table 3.3).

The machinery, chemicals, and electrical and electronic products industries were the most active innovators, followed closely by the fabricated metals, paper, rubber and plastics industries. Adoption levels in leather, textiles, and clothing; food, beverages, and tobacco; wood and furniture were relatively low compared with other manufacturing industries.

Table 3.3

Scale of Introduction of Process Automation in the Manufacturing Sector
1980-85

Manufacturing Industry	Proportion of establishments with any process automation
Machinery	65.5
Chemicals	57.7
Electrical & Electronic Products	55.6
Fabricated Metals	53.5
Rubber and Plastics	52.6
Paper	52.2
Primary Metals	45.8
Transportation Equipment	44.4
Food, Beverages and Tobacco	33.3
Wood and Furniture	33.3
Other Manufacturing	33.3
Leather, Textiles and Clothing	27.7
Printing and Publishing*	25.0
All Manufacturing	43.0

Source: Working with Technology Survey, Economic Council
* If industry specific type process automation is included, the total becomes 66%.

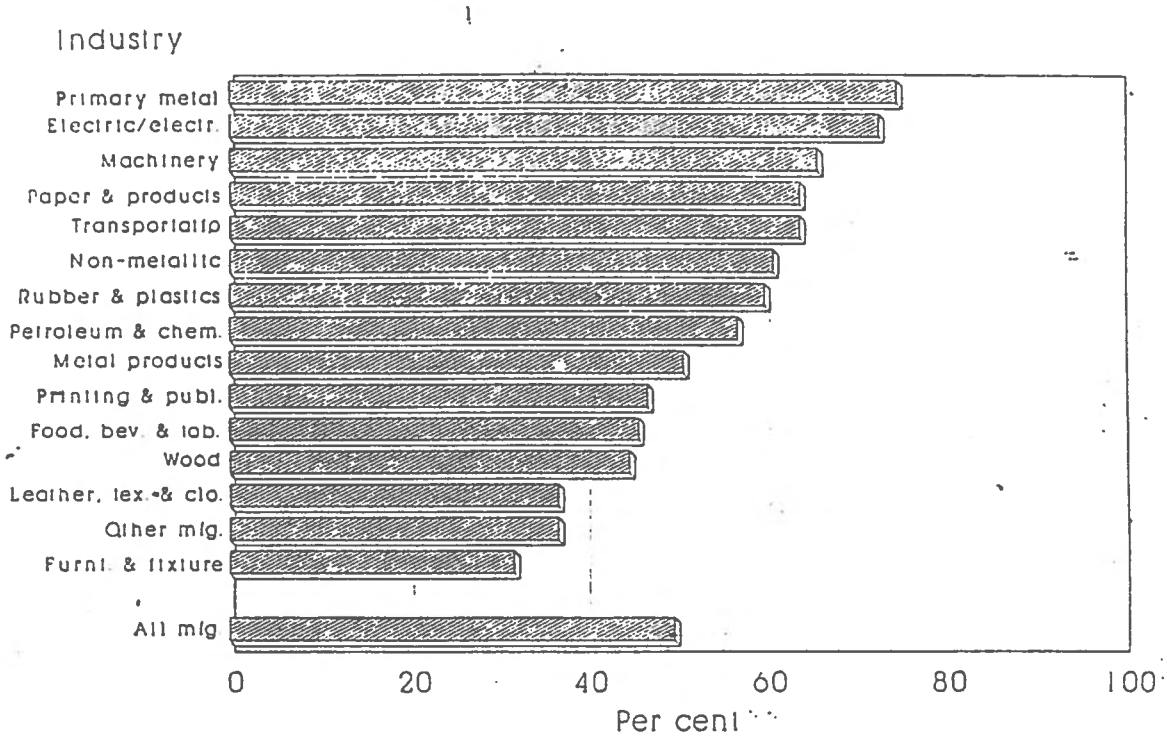
A more recent survey (June 1987) of 4,687 large and medium sized manufacturing establishments was undertaken by Statistics Canada. Firms were questioned on their use of eighteen key industrial technologies. Fifty percent of the responding establishments used at least one of the 18 technologies.

Communications and control technologies such as local area networks and programmable controllers were the most used, followed by fabrication and assembly technologies such as computer numerically controlled machines and robots. The lowest penetration was in the automated material handling technologies.

The leading industries using these technologies were: primary metal, electrical and electronic products, machinery, paper and allied products and transportation equipment. More traditional industries such as furniture manufacturing and leather, textiles and clothing did not employ the surveyed technologies very much.

Graph 3.4

Percentage of Establishments Using at Least One of the Technologies



Source: Survey of Manufacturing Technology, Statistics Canada, 1987

3.4 Technological Intensity

The Economic Council developed two measures of technological intensity. The first measure is financially based and considers technologies in the 1980-85 period as a ratio of the establishment's sales over the period.

- Average expenditures on computer-based technologies amounted to just over one-half of 1 percent of sales.

- Manufacturing and business services spent the most on computer equipment as a proportion of sales.

The second measure considers the percentage of employees in each establishment who actually worked with a computer-based technology in 1985.

- On average, 16% of the workers in each establishment were working with computer-based technology in 1985.
- Retail trade and finance, insurance and real estate had more employees working with computers relative to the other industries.

Foreign-controlled firms out-performed Canadian-controlled establishments in the use of technologies as shown in Table 3.5.

Table 3.5

Measures of Technological Intensity by Control of Establishments

1980-85

Control	Establishments that introduced automation	Employees working with computers 1985 (Percent)	Expenditures on computer equipment as % of sales
Canadian	72.5	15.7	0.55
Foreign			
U.S.	94.1	18.5	0.66
Other	87.5	17.4	0.38

Source "Innovation and Jobs in Canada", Economic Council

3.5 Technology Adoption by Region

The Economic Council's survey, Working With Technology, findings by region were as follows:

- Ontario and Quebec rank highest in terms of expenditures on computer equipment as a percent of sales
- the Prairie provinces and B.C. reported the highest percentage of employees working with computers
- the lagger was the Atlantic provinces.

Although there appears to be a strong geographic component to the diffusion process, the Economic Council notes that it is economics (particularly structural differences in terms of industrial and commercial specialization and company size), not geography that explains the gaps between the regions.

3.6 Motivations and Obstacles to Diffusion

The key factors driving the need to adopt new technologies were increased productivity and competitive pressures according to the Economic Council's study.

Table 3.6

Motivations for Technological Change

	% of Situations
1. Increased productivity	67
2. Reduce labour costs	48
3. Improve product quality	39
4. Increase production control	27
5. Compatibility with customer/supplier	20
6. Reduce inventory needs	14
7. Reduce material or energy costs	14
8. New product line	11

Major drawbacks or obstacles to introducing technological change are the cost of equipment, ability to finance/profitability, and the lack of skilled workers.

Table 3.7

Obstacles to Technological Change

	% Reporting Obstacle
1. Cost of equipment	52
2. Lack of qualified personnel	32
3. Low return on investment	32
4. System integration difficulties	24
5. Employee reluctance	20
6. Management reluctance	14
7. Collective agreement provisions	7

The OECD study on Technology Diffusion indicates the following factors to be significant for diffusion in Canada: "...the degree of foreign ownership of Canadian industry; the relatively small size of firms; the low level of domestic R&D; the shortage of skilled labour; and the cost and availability of capital. What is most important appears to vary widely from sector to sector."(12)

A recent study entitled "Case Studies of the Development of Information Technology", sponsored by DRIE and ITAC, examines the factors leading to successful introduction of information technology in small to medium sized Canadian companies. A summary of the relative importance of various factors is presented below.

Table 3.8

Importance of Factors in Successful IT Introduction

Factors	Relative Importance
Role of the Champion	36
Cost Savings Justification	32
Fit with Corporate Plan	30
Supplier Competence	30
Clearly Set Objectives	29
Evaluation of User Needs	28
Cost-Benefit Analysis	20
Previous IT Experience	17

3.7 International Comparisons

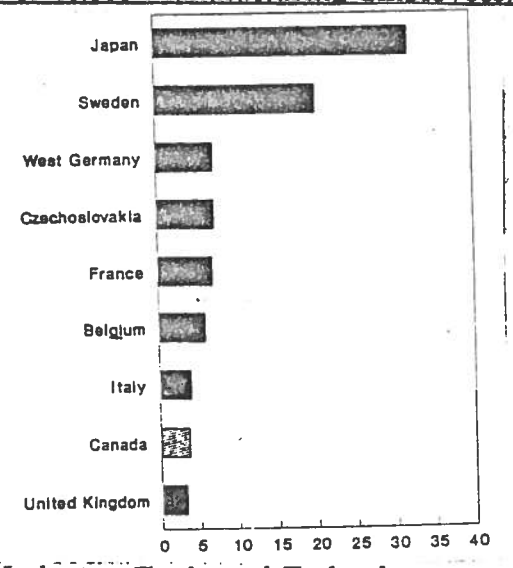
The reports which perform international comparisons focus predominantly on the manufacturing sector, and more specifically on two technological innovations within that sector: numerically controlled (NC) machines and robots.

Canada with 4.4% NC machine tools in use as a proportion of all machine tools, ranked well behind Japan (38%), the U.S. (13%) and the United Kingdom (8%).

In terms of robot usage, Canada ranked 9th out of 10 countries in 1984, lagging considerably behind Japan and Sweden.

Graph 3.9

Robots Per 10,000 Manufacturing Employees, 1984



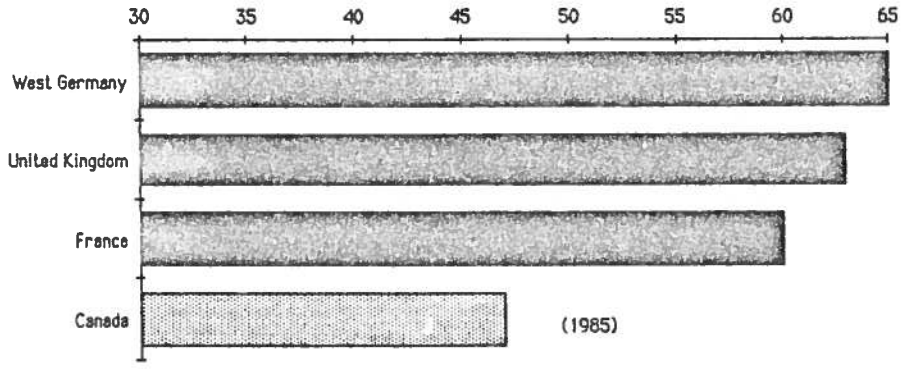
Source: Ontario Ministry of Industry, Trade and Technology

A European study entitled Microelectronics In Industry: An International Comparison: Britain, Germany, France found that approximately 60% of establishments used microelectronics in processes. This compares to a Canadian proportion in 1985 of less than 50% according to the Economic Council.

Graph 3.10

Use of Microelectronics in Manufacturing

Selected Countries, 1983 and 1985



Source: "Microelectronic in Industry" and "Working with Technology" Survey

More work is required for supportable conclusions on Canada's relative international position, particularly for the service industries. Care must be taken to ensure that comparisons between countries are compatible in terms of the definitions of specific technologies, time frames and methodologies.

3.8 Conclusion

Office automation technologies have been the most widely adopted in Canada. In particular, wholesale trade, communications and utilities, business services, and finance, insurance and real estate industries had particularly high adoption rates.

A recent survey of the use of manufacturing technologies indicates that communications and control technologies such as local area networks and programmable controllers were the most used, followed by computer numerically controlled machines.

The key motivating factors in adopting new technologies were increased productivity and competitive pressures. Major obstacles to introducing technological change are the cost of equipment, ability to finance/profitability, and the lack of skilled workers.

Canada appears to lag behind other industrialized OECD countries, in terms of robot usage and the use of microelectronics in manufacturing. However, more work is required for supportable conclusions on Canada's relative international position, particularly for the service industries.

CHAPTER IV

CANADA'S R&D EFFORT

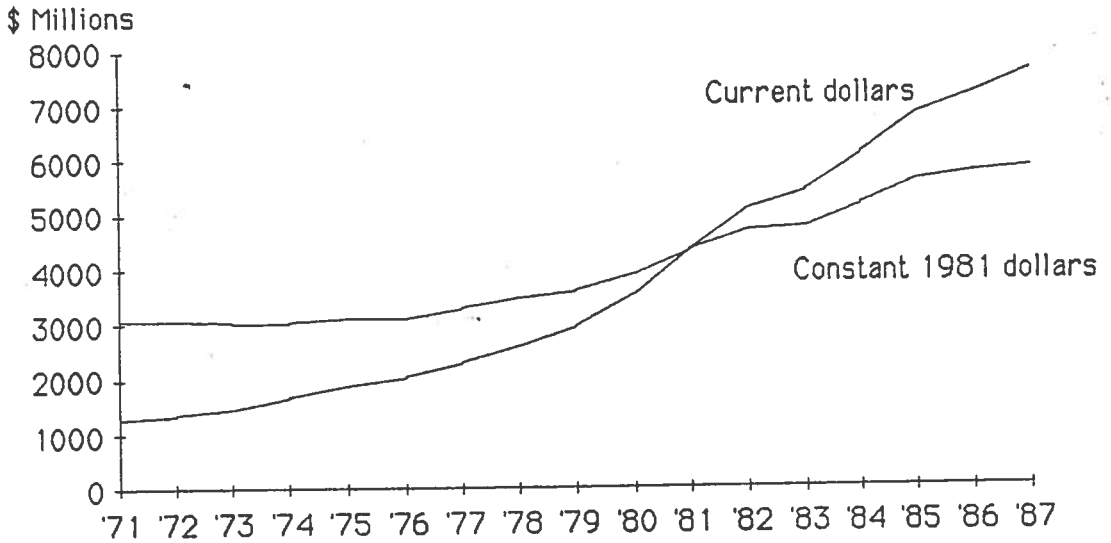
4.1 Canada's R&D Structure

Most of the statistics in this chapter refer to total R&D in Canada not just communications and information technology R&D. Limited statistics are available for C&IT R&D and a current research project is examining the feasibility of developing an C&IT R&D database for Canada.

In 1987 Canada's gross domestic expenditures on R&D (GERD) were $7.6 billion, a 6% increase over 1986 ($7.2 billion). R&D expenditures in 1988 are expected to amount to about $8 billion. Graph 4.1 indicates Canada's total expenditures on R&D for the period 1971 to 1987.

Graph 4.1

Total Expenditures on R&D in Canada, 1971-1987



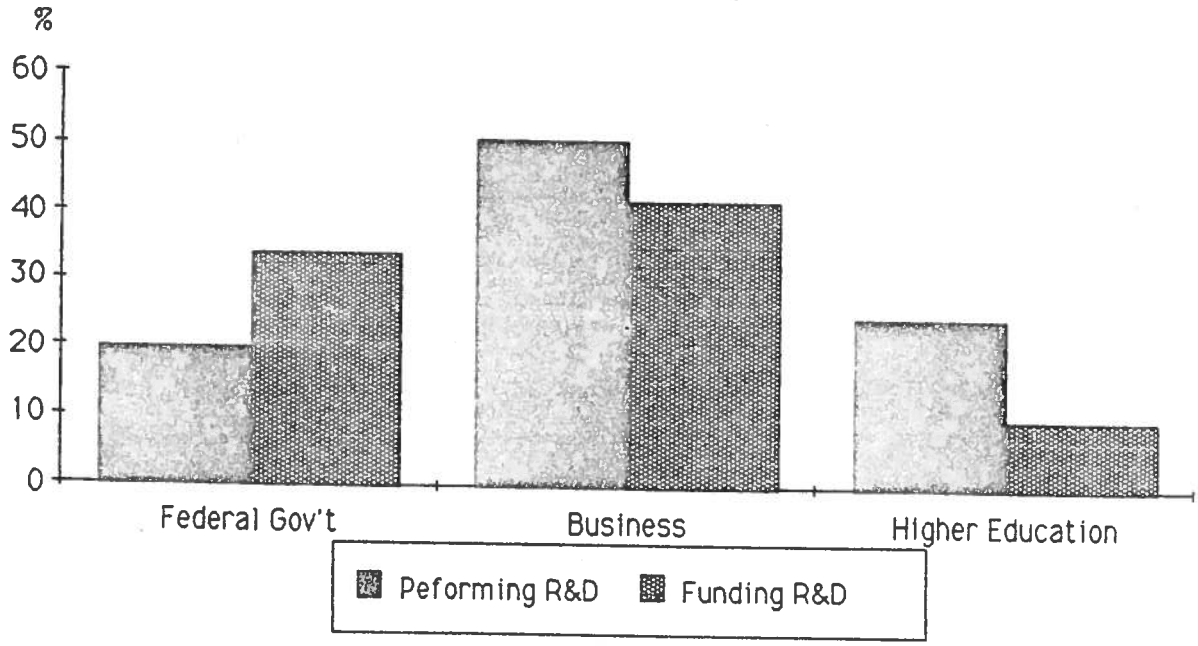
Source: Statistics Canada, Catalogue 88-001, Vol. 12, No. 6

The business sector is the largest performing and funding sector of R&D. Industrial R&D expenditures have grown steadily from 33% of GERD in 1971 to 51% in 1987. Most R&D activity within the business sector is funded by the firms doing the work.

The federal government performed R&D amounting to $1.34 billion in 1987-88 but funded $2.46 billion, in particular supporting business ($477 million) and universities ($509 million). The relative importance of the federal government as a performing sector has decreased over the years and its present share of the GERD (20%) is closer to comparable ratios of the more industrialized OECD countries.

Graph 4.2

Performing and Funding Sectors of GERD, 1987



Source: Statistics Canada, Catalogue 88-203

Universities perform about 25% of all research and development in Canada. The universities themselves fund about 40% of the R&D they perform. The federal government is the largest single external funder of university research, providing 35% of all university research or about 60% of all outside sources of funding.

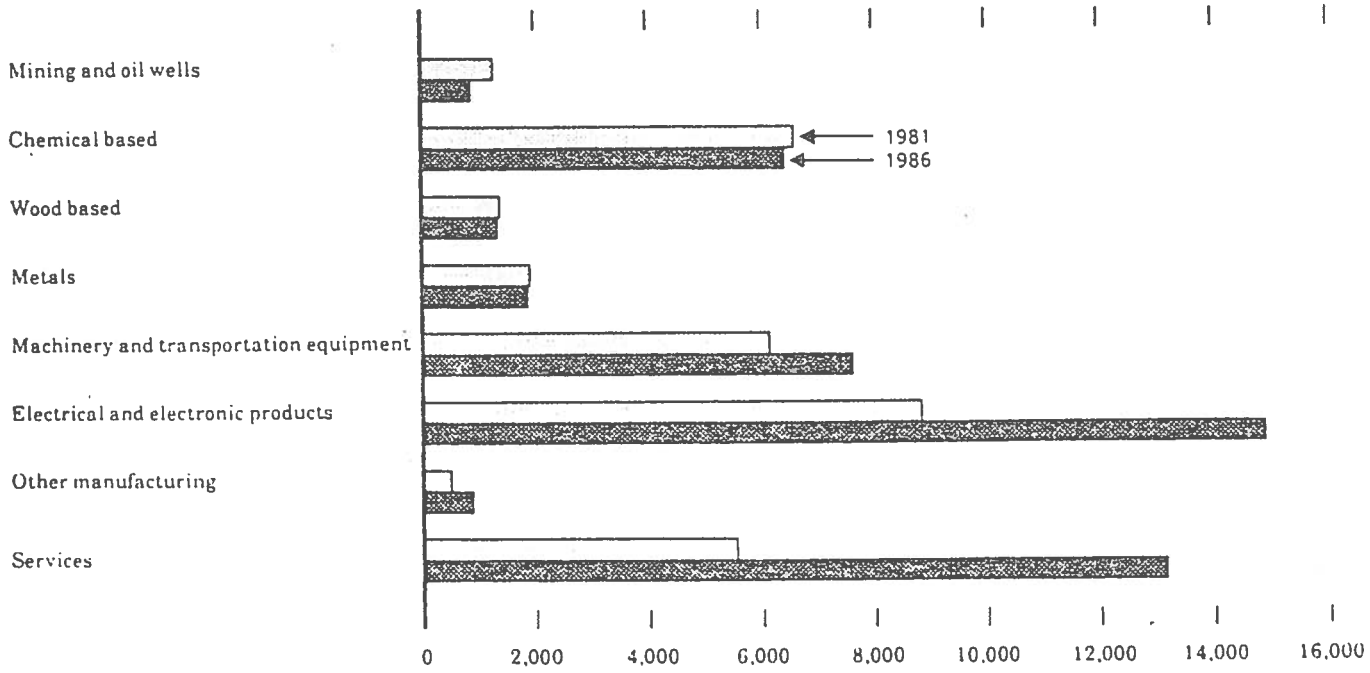
4.2 Industrial R&D

Industrial R&D spending in 1987 was estimated at $4.2 billion, of which $3.6 billion was intramural expenditures and $0.6 billion capital expenditures. In fact, industrial R&D expenditures have grown significantly, from $631 million in 1975 to $3.6 billion in 1987. In current dollars this increase amounts to 475% over the ten year period and to about 166% in constant dollars.

Total personnel engaged in industrial R&D exceeded 47,000 in 1986. As indicated in Graph 4.3, more than 59% of all industrial R&D personnel are concentrated in two industry groups: electrical and electronic products (32%) largely due to the telecommunications equipment industry, and services with engineering and scientific services being the largest employing group.

Graph 4.3

R&D Personnel by Industry Group, 1981 and 1986



Source: Statistics Canada, Catalogue 88-202

Most industrial R&D in Canada is performed by a small number of firms. Out of the 3,414 companies which reported performing R&D in 1986, the top 100 companies accounted for almost 70% of total intramural R&D expenditures.

Table 4.4

Concentration of Industrial R&D Among Companies, 1986

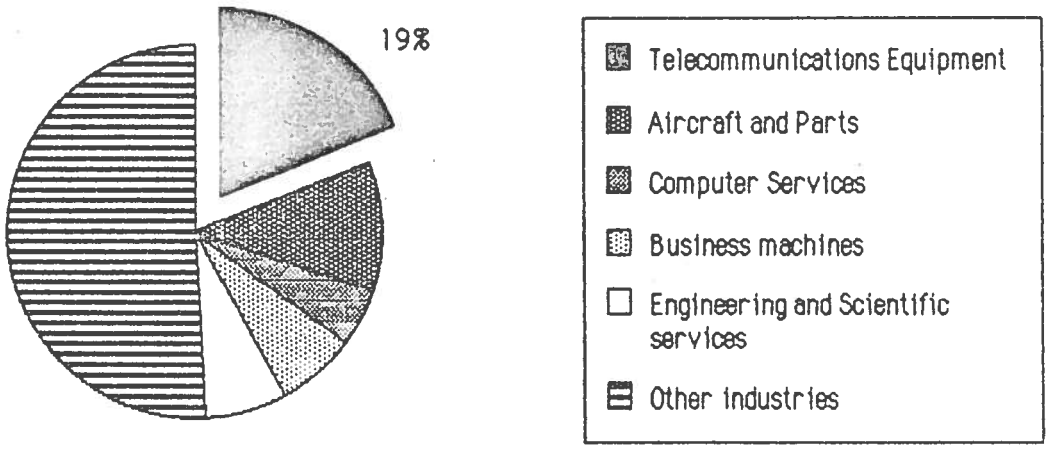
Number of Companies	% of Total Intramural R&D Expenditures
Top 10	34%
Top 20	47%
Top 50	57%
Top 75	63%
Top 100	67%

Source: Statistics Canada, Catalogue 88-202

Manufacturers of telecommunications equipment are the major performers of R&D as shown in Graph 4.5. The next largest ranking industries in terms of R&D expenditures are aircraft and parts, engineering and scientific services, business machines and computer services. These five groups account for approximately half of the total R&D expenditures for the business sector.

Graph 4.5

Estimated 1988 R&D Spending for Selected Industries



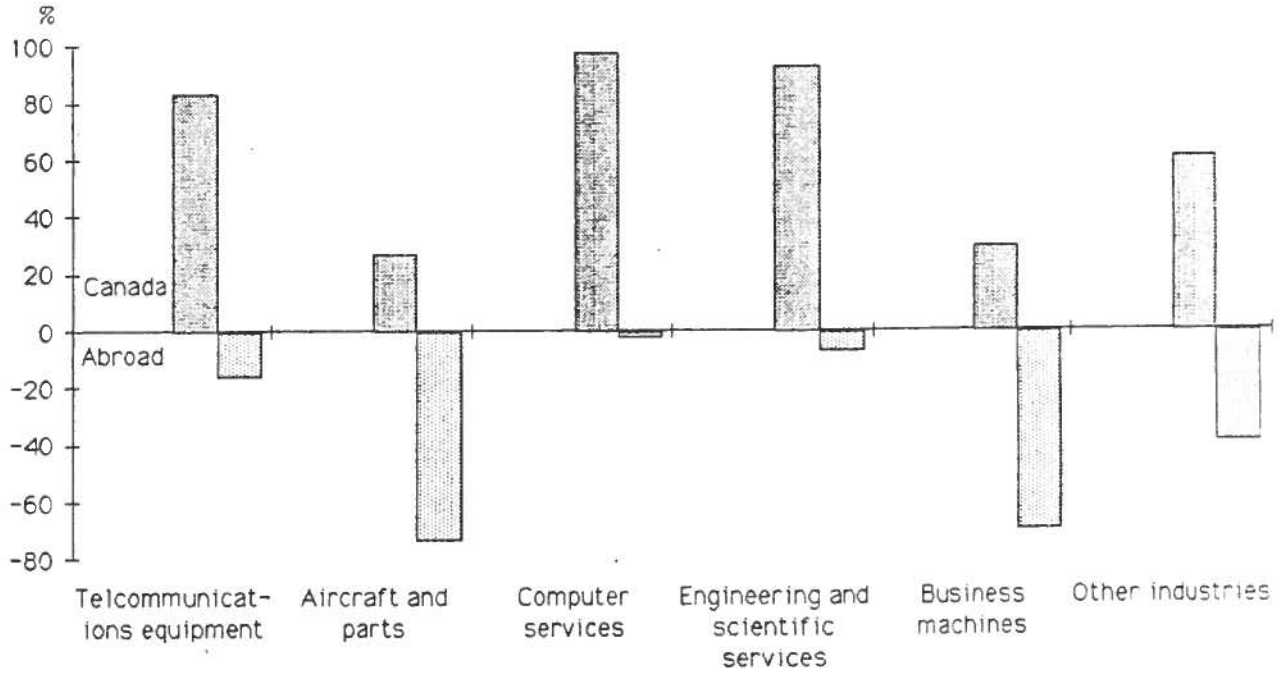
Source: Statistics Canada, Catalogue 88-202

As might be expected, firms with the highest sales also have the largest R&D expenditures. The average R&D intramural expenditures of firms with sales over $400 million was $18 million in 1986, whereas firms with sales under $1 million had an average of only $0.2 million. However, smaller firms spend proportionately more on R&D compared to their sales (38.9%) as compared to only 0.9% for large firms.

Canadian controlled firms accounted for the majority of R&D expenditures in telecommunications equipment, computer services, engineering and scientific services. However, foreign controlled firms dominated the R&D in aircraft and parts and business machines.

Graph 4.6

Distribution of Intramural R&D Expenditures by Country of Control of Performers, 1986

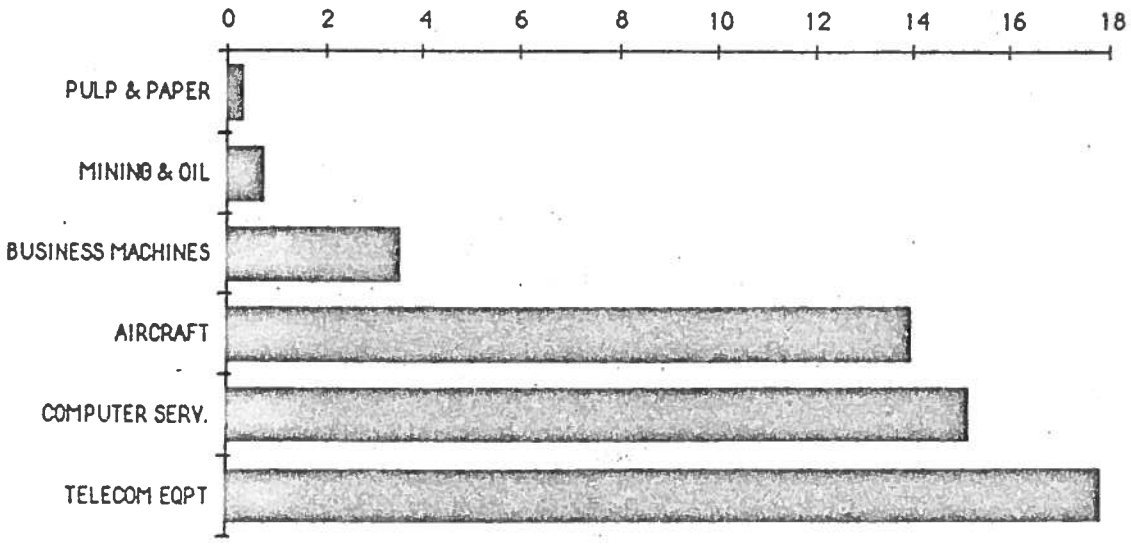


Source: Statistics Canada, Catalogue 88-202

Research and development activities are particularly crucial for communications and information technology industries as indicated in Graph 4.7. Telecommunications equipment industries in 1986 spent 17.8% of sales on R&D. R&D was equally significant for companies in computer services and aircraft and parts. R&D expenditures as a percentage of sales for business machines at 3.5% was surprisingly low. This is likely explained by the presence of subsidiaries of multinationals in Canada, where the parent company often undertakes the major share of R&D for the corporation. For example, IBM in the U.S. spent 10.2% of revenue on R&D in 1986 whereas IBM Canada spent only 4.3%.

Graph 4.7

R&D Expenditures As a Percent of Sales by Industry (1986)



Source: Statistics Canada, Catalogue 88-202

The Northern Telecom/BNR/Bell Canada group is by far Canada's most important source of advanced research. This single group accounts for almost 22% of industrial R&D expenditure within the country. Its next closest rivals are IBM and Mitel (which has been purchased by British Telecom). After these companies, the Department of Communications is the most important R&D performer in communications and information technology in Canada.

Table 4.8

Major Canadian Communications and Computer R&D Spenders, 1986

(in $ Millions)

Bell Canada Enterprises	623
IBM Canada	89
Mitel	152
DOC Research Program	44
B.C. Telephone	27.5
Control Data Canada	25
Gandalf Technologies	13
Spar Aerospace	12

Source: Financial Post, October 25, 1986 and DOC

Although Northern Telecom's efforts dominate the Canadian C&IT R&D situation, international R&D expenditures by leading data processing companies shows that even Northern Telecom is seriously challenged to maintain its competitive edge as shown by Table 4.9.

Table 4.9

Leading Worldwide Data-Processing Companies, 1986

Company	Country	Corp. R&D 1986	R&D as % of Total Revenue
IBM	U.S.	5,221.0	
Siemens AG	Germany	2,488.5	10.2
AT&T Co.	U.S.	2,278.0	11.5
N.V. Phillips	Netherlands	1,706.9	6.7
NEC Corp.	Japan	1,431.6	7.6
Unisys Corp.	U.S.	992.0	9.5
Nippon Teleg. & Tel	Japan	949.4	10.4
Digital Equip. Corp.	U.S.	898.3	3.0
Hewlett-Packard Co.	U.S.	824.0	10.7
Northern Telecom	Canada	474.5	11.6
			10.8

Source: "Special Programmes for the Promotion of Information Technology R&D", Annexes, OECD, ICCP(87)13

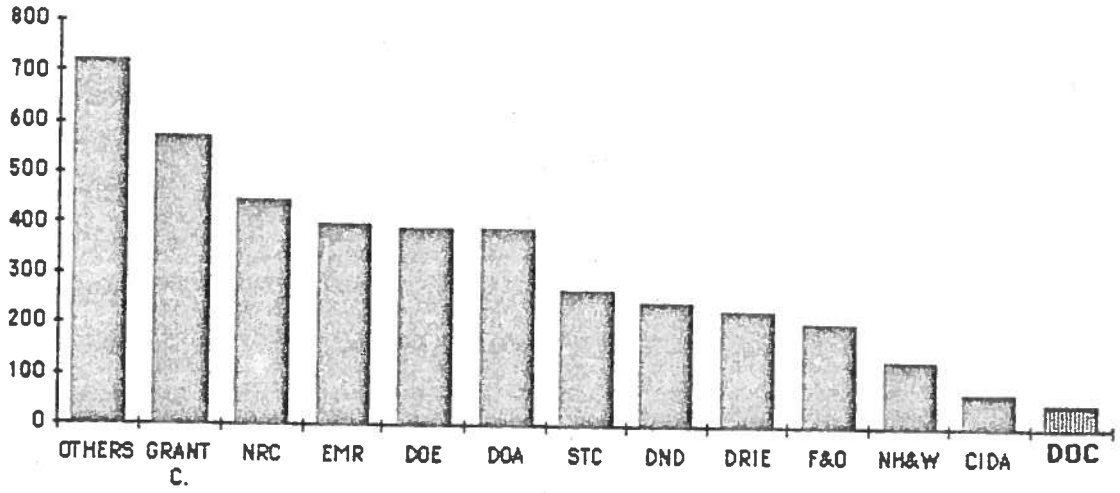
4.3 Federal Government R&D

Federal government expenditures on scientific and technological (S&T) activities in 1988-89 represent 3.3% of the total federal budget, which is less than the share that was spent a decade ago (3.8% in 1978-79). Expressed as a percentage of the discretionary budget, the proportion spent on S&T has increased to 10.8% in 1988-89 from 9.4% in 1978-79.

In the federal government there are over 60 departments and agencies either performing science and technology activities or contracting them out to industry and universities. As Graph 4.10 shows, the leading departments/agencies in terms of estimated S&T expenditures in 1987-88 are: the University Granting Councils, the National Research Council, Energy, Mines and Resources, Environment, and Agriculture.

Graph 4.10

Federal S&T Expenditures by Department/Agency, 1987-88

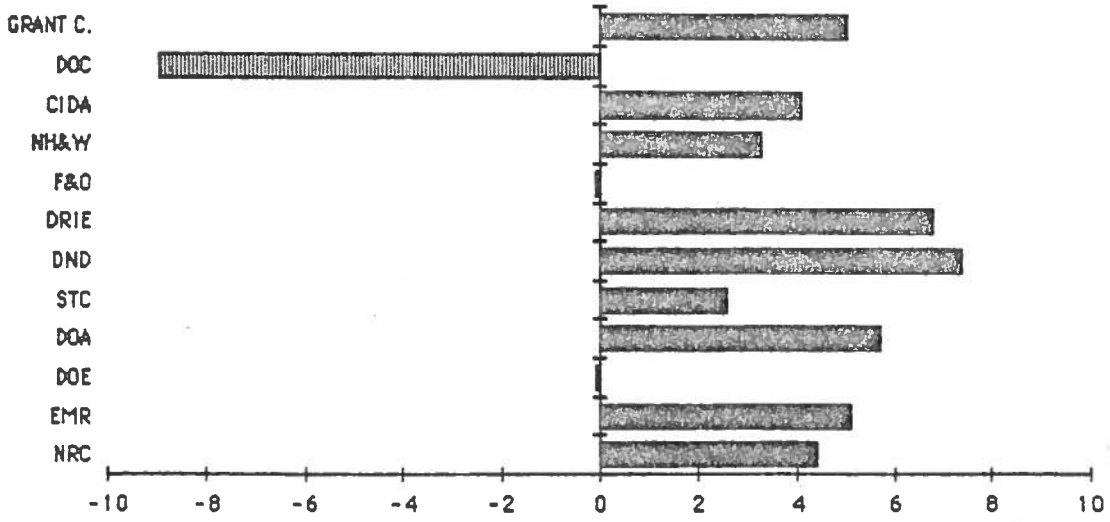


Source: Statistics Canada, Catalogue 88-204

Not only are DOC's resources limited in comparison to other federal departments, it has been hardest hit by government cutbacks as shown in Graph 4.11. During the period 1980-88, the real average annual growth rate for federal S&T was 3.4% whereas DOC's R&D budget declined 9%. Overall, the government invests less in communications R&D than in any other mission area.

Graph 4.11

Federal R&D Expenditures by Department
(% Growth Rate 1980-88)



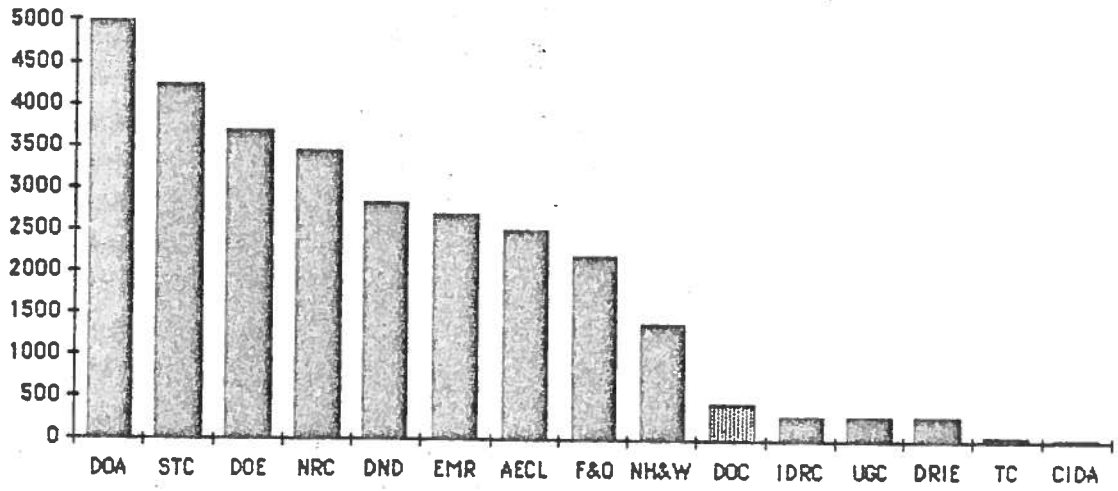
Source: Statistics Canada, Catalogue 88-204

Overall employment in S&T activities in the federal government has remained fairly stable from 1979 to 1987 at around 34,000 person years. Over 80 percent of the R&D personnel in the natural sciences and engineering S&T activities (24,000 person years) are accounted for by five organizations: Agriculture Canada, Atomic Energy of Canada, the Natural Research Council, Energy, Mines and Resources, and National Defence.

In terms of federal personnel engaged in S&T activities, DOC was one of the smallest departments in 1987-88 with 417 person years or 1% of total S&T personnel.

Graph 4.12

Federal Personnel Engaged in S&T Activities by Department/Agency, 1987-88



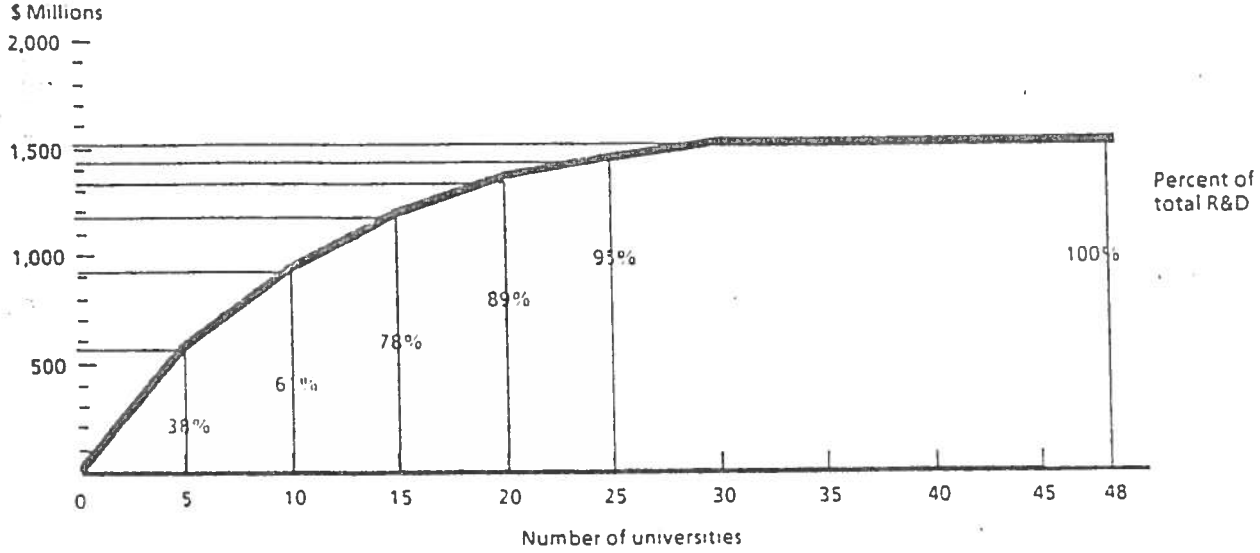
Source: Statistics Canada, Catalogue 88-204

4.4 University Research

Support for university R&D is concentrated in the largest universities. Graph 4.13 shows that five universities account for close to 40% of the R&D activity in 1985 and 15 universities for almost 80%.

Graph 4.13

Cumulative Distribution of R&D Expenditures by Canadian Universities, 1985



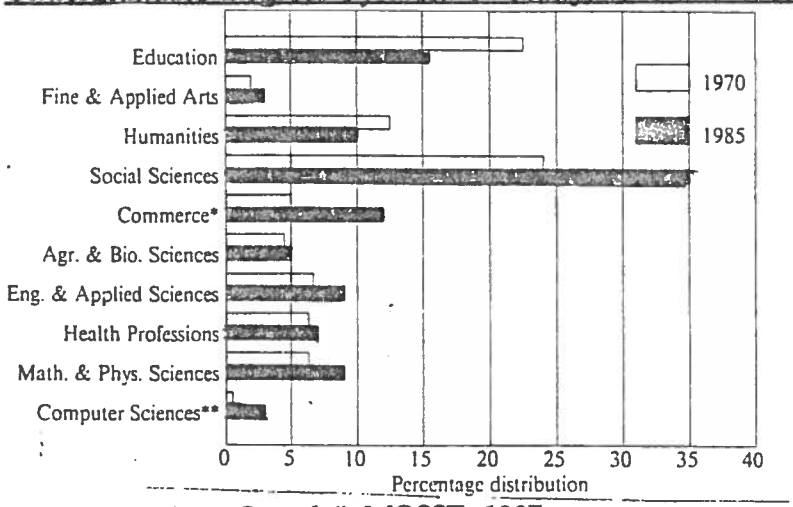
Source: Statistics Canada, Catalogue 88-203, December 1987

Source: Statistics Canada, Catalogue 88-203, December 1987

One of the key competitive challenges Canada faces is developing its human resources - highly qualified personnel with the skills needed by the country. About 70 percent of undergraduate degrees are awarded in the social sciences, humanities, education and in the fine and applied arts. The natural sciences and engineering gained little ground as a share of undergraduate degrees awarded from 1970 to 1985.

Graph 4.14

Undergraduate Degrees by Field of Study, 1970 and 1985



Source: "University Research in Canada", MOSST, 1987
(Statistics Canada Data)

At the graduate level less than one-third of all degrees awarded in 1984 were in natural sciences and engineering compared to 37% in 1970. As shown in Table 4.15, all sub-fields of natural sciences and engineering, except the health professions, declined in their share of total graduate degrees awarded. By comparison, the social sciences and humanities experienced absolute growth rates double those of the natural sciences and engineering.

Table 4.15

Graduate Degrees Awarded by Field of Study

	1970 % of total	1984
Natural Sciences and Engineering	37.1	30.0
Engineering/Applied Sciences	12.1	11.0
Mathematics/Physical Sciences	13.5	8.2
Agriculture/Bio Sciences	7.6	5.5
Health Professions	3.8	5.2
Social Sciences and Humanities	62.8	68.0

Source: "University Research in Canada", MOSST, 1987. (Statistics Canada Data).

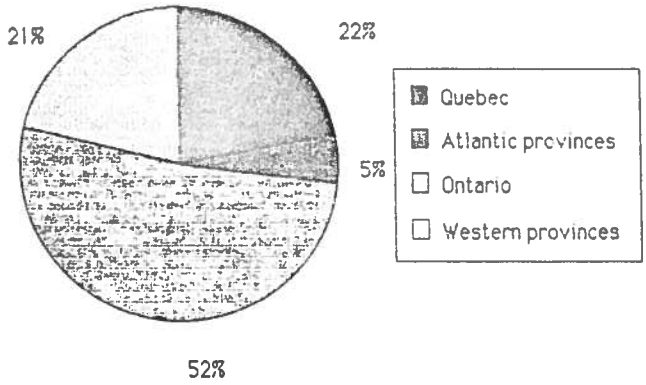
It is also important to note that foreign students, who may leave the Canadian labour market on graduation, received about 20 percent of all Masters and Doctorate degrees combined in the 1980-85 period. Degrees awarded to foreign students were highest at the PhD. level in engineering/applied sciences (40%) and computer sciences and mathematics (35%).

4.5 Regional Distribution of R&D

Canada's R&D efforts are not distributed evenly across the country. Ontario accounts for about half of all R&D expenditures in Canada. Much of Ontario's dominance is due to the high concentration of federal scientific establishments in the province and the strong manufacturing presence in Ontario.

Graph 4.16

Expenditures on R&D by Region, 1985

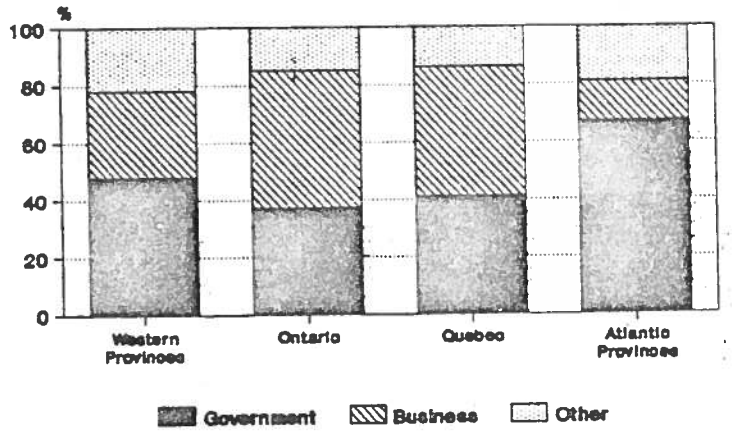


Source: Statistics Canada, Catalogue 88-001, Vol. 11, No. 8

Graph 4.17 summarizes the estimated expenditures on R&D by performing regions and funding sources in 1985. Within the Atlantic provinces, the federal government is responsible for the largest share (65%) of these provinces' total expenditures. In both Ontario and Quebec, the business sector was the biggest funder of R&D (representing almost half of each province's expenditures). In the Western provinces, industry funded 30% and 48% was funded by federal and provincial governments

Graph 4.17

The Regional Performance of R&D by Funding Sectors, 1985

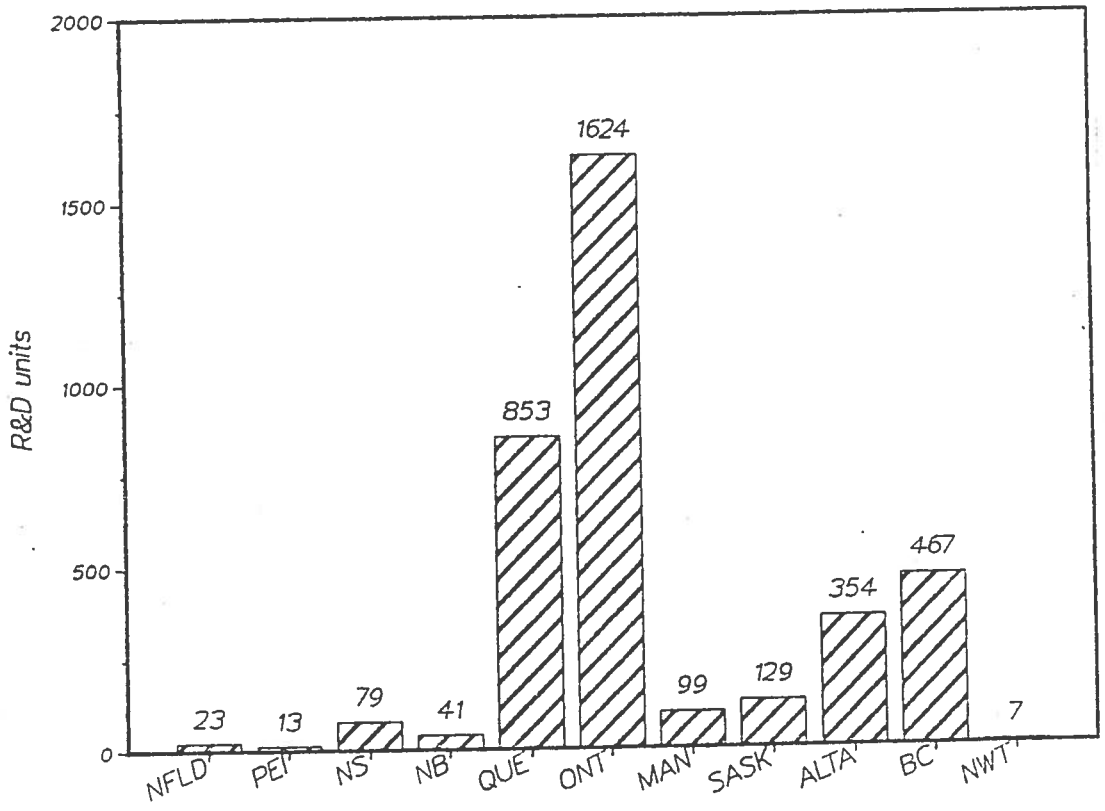


Source: Statistics Canada, Catalogue 88-001, Vol. 11, No. 8

Industrial R&D activities are heavily concentrated in Ontario and Quebec, with 67% of R&D facilities being located in one or the other of these two provinces. Most of the remaining units are in Alberta or British Columbia.

Graph 4.18

Industrial R&D Units by Province,1986
(total number of R&D units = 3,678)

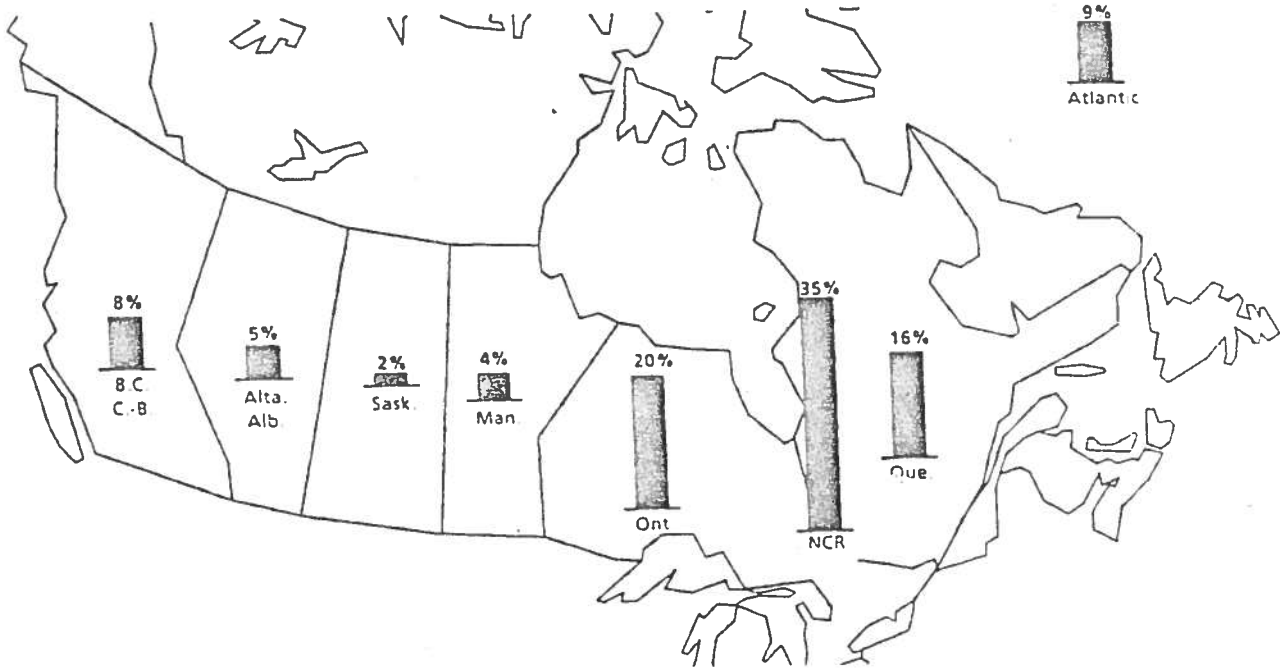


Source: Statistics Canada, Catalogue 88-202

The largest share of federal R&D funds is spent in the National Capital Region (NCR). Ontario (less expenditures in the NCR) is the second largest recipient of federal science funds (20%) and Quebec is third (16%), as shown in Graph 4.19.

Graph 4.19

Regional Distribution of Federal R&D Activities, 1985-1986



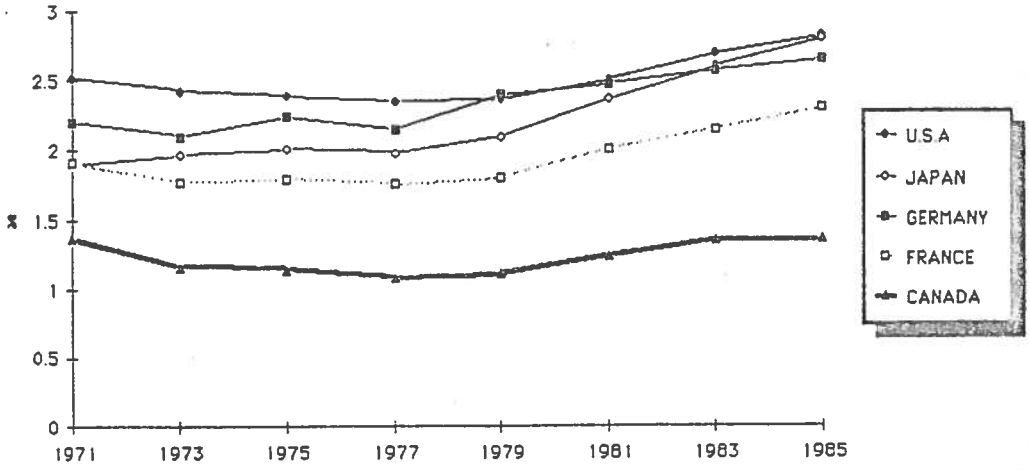
Source: Statistics Canada, Catalogue 88-204

4.6 International Comparisons

International comparisons of national R&D efforts are often made by comparing total gross expenditures on R&D (GERD) as a ratio of Gross Domestic Product (GDP), thereby compensating for the different sizes of national economies. At 1.4% of GDP, Canada's relative R&D effort trails far behind that of the more industrialized OECD countries.

Graph 4.20

Total Expenditures on R&D as a Percent pf GDP for Selected OECD Countries, 1871-1985

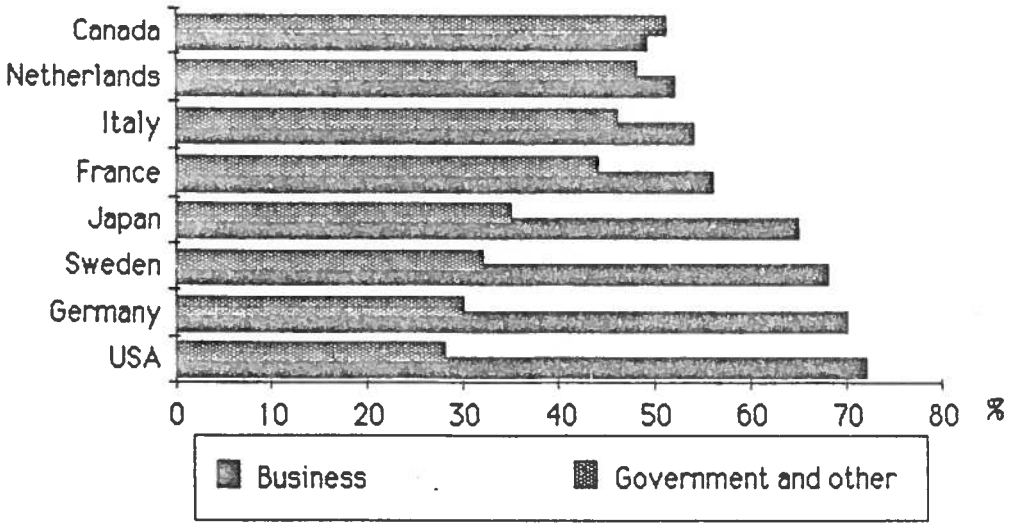


Source: Statistics Canada, Catalogue 88-201

Canada's business enterprises' share of R&D expenditures is low in comparison to other countries such as the USA, Japan, Germany and Sweden.

Graph 4.21

Share of GERD by Sector, 1984



Source: Statistics Canada, Catalogue 88-203, December 1987

Two other useful indicators of R&D effort are GERD per capita and number of researchers per 1000 labour force. Judged by these indicators, Canada is in a relatively weak position compared to many other OECD countries as shown in Table 4.22.

Table 4.22

International Comparisons of GERD Per Capita and Number of Researchers, 1985

Country	GERD per Capita (U.S. $)	Researchers per 1000 Labour Force
U.S.	420	6.7
Sweden	361	4.4
Japan	324	7.9
FRG	318	5.0
France	284	4.2
Norway	244	4.7
U.K.	239	n.a.
Netherlands	236	3.7
Canada	214	3.0
Finland	163	3.7 (1983)
Italy	125	2.7

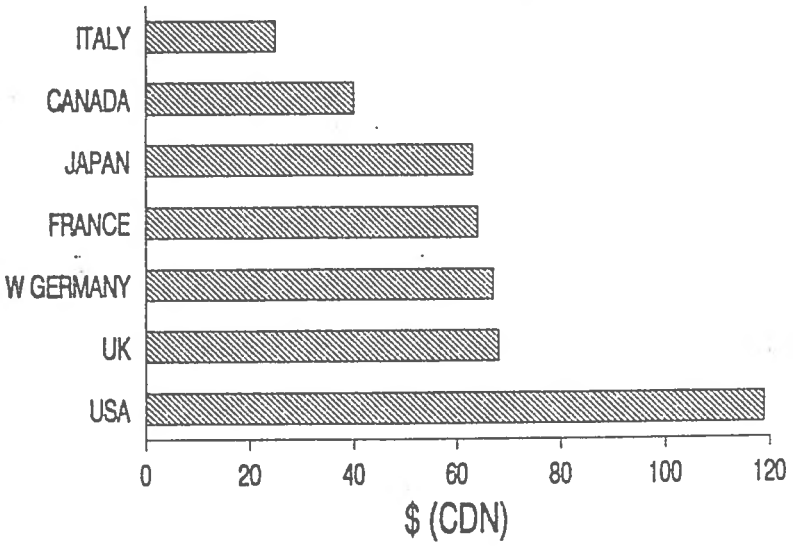
Source: OECD

The OECD categorizes government R&D expenditures by socio-economic objectives. Over 60% of the USA government's R&D expenditures in 1984 were in defence compared to 58% for the UK, over a third for France, and 8% for Canada. The Canadian government R&D objective receiving the most support was "advancement of knowledge" - largely due to the activities of the three university granting councils. Canada also strongly supported R&D for agriculture, forestry and fishing (22% of total government R&D expenditures).

Canada is recognized worldwide for its achievements in telecommunications. However, even in an area of strength such as information technology, Canada's efforts in terms of GERD per capita are low in comparison to the U.S., Western Europe and Japan.

Graph 4.23

C&IT R&D Expenditures Per Capita, 1985



Source: "Information Technology", U.K., Trade and Industry Committee, November 1988, and Statistics Canada.

Even the public sector's share of R&D in information technology does not compare well with contributions from other countries, as shown below.

Table 4.24

Public Sector Spending on IT R&D

Country	Public Sector Portion of IT R&D
France	25.7%
Norway	23.9%
U.S.	23.5%
Ireland	23.0%
Italy	16.6%
Denmark	10.9%
Sweden	10.6%
Canada	7.4%

4.7 Conclusion

To sum up our findings:

* The business sector is the largest performing and funding sector of R&D.
* Most industrial R&D in Canada is performed by a small number of firms.
* Manufacturers of communications equipment account for 19% of total industrial R&D.
* R&D activities are particularly crucial for IT industries.
* While other countries are significantly increasing their expenditures on information technology R&D, Canada's R&D priorities are weighted towards more traditional industries such as agriculture, fisheries and energy.
* From 1980-1988, the real average annual growth rate for federal S&T was 3.4%. The Department of Communication's R&D base declined 9%.
* At the graduate level, less than one-third of all degrees awarded in 1984 were in natural sciences and engineering.
* About half of all R&D expenditures in Canada are spent in Ontario. Quebec accounts for another 22% of total R&D expenditures.
* Canada's R&D efforts pale in comparison with other nations.

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