TELECOMMUNICATIONS RESEARCH AND DEVELOPMENT

Department of Communications
Communications Development & Planning
Bev Mahoney
May 1990

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

* Canada's R&D performance ranks near the bottom when compared to other major industrialized countries.

* On a per capita basis, Canada is doing less than half the R&D of Japan, West Germany, Sweden, and the United States.

* The federal government's share of R&D financing has declined steadily from 43% fifteen years ago to 39% now. During the same period, the private sector has increased its share from 29% of all spending to 42%.

* Industry's share of the national R&D effort is less than that of other industrialized nations, including the U.S., Japan, Germany, and the U.K.

* We have few major firms which perform industrial R&D.

* Canada employs fewer engineers and scientists on a per capita basis than most industrialized nations.

* Canada has had a trade deficit in communications equipment, a previous area of strength, for the past two years.

* Japan and East Asia's newly industrialized countries have increased their market share in telecommunications.

* Canada ranks 15th among 22 developed countries in innovative forward orientation and 14th in outward orientation, a poor showing for success in global markets.

* Although Canada's overall R&D effort is weak, an exception can be found in the telecommunications sector.

* Telecommunications equipment manufacturers are Canada's leading performers of industrial R&D, accounting for 17% of total industrial R&D in 1989.

* Northern Telecom's R&D commitment seems to have paid off: 80% of Northern Telecom's revenue comes from products that didn't exist five years ago.

* Canadian companies account for about 5% ($.85 Billion) of the total worldwide telecommunications R&D expenditures, compared to 40% for U.S. companies.

* Northern Telecom is the fifth largest telecommunications equipment maker in the world in terms of world market share, with 10% of total sales on the global market.

* In a global economy, many companies have recognized the need for strategic alliances and co-operative research and development.

* We need to shift Canada's business economic and political mindset towards investment in long-term innovation and technology.

* Fuelled by trade liberalization and the need to recover the high cost of R&D, many Canadian companies are operating in a global market.

* Spending more money on R&D is a necessary but not sufficient condition for increased competitiveness and economic growth.

* A strategy needs to be developed to transform effective R&D into high quality products. R&D needs to be commercialized for economic success.

1. OVERVIEW OF R&D SPENDING

1.1 Importance of R&D

Throughout the 1980s, the consensus grew among government and industry that increased investment in R&D was a key to our global competitiveness.

Before his election in 1984, Brian Mulroney promised to increase Canada's R&D spending from 1.32 percent to 2.5 percent of gross domestic product. But that target is as far off today as it was then. In a speech at the University of Waterloo in 1987, Prime Minister Brian Mulroney promised to put "science and technology on the top of the national agenda". As part of its drive to make science a focus of the nation's attention, Prime Minister Mulroney set up a National Advisory Board on Science and Technology in 1987.

The federal government has repeatedly come under fire for talking a good line on research and development, while cutting funds for organizations such as the NRC and continuing tax measures and high interest rate policy that discourage scientific investment by industry.

Roy Woodbridge, President of the Canadian Advanced Technology Association, notes: "We've gone through a decade of pretty positive economic growth, yet if you look at all our global science and technology indicators, we haven't improved any of them. There is a growing sense that the window of opportunity for Canada to become a substantial player in the emerging world economy is closing. There is a growing concern within the technology community in this country."

Fraser Mustard, President of the Canadian Institute for Advanced Research said the "situation for Canada at the moment is deeply, deeply serious. Canada's industry base in applied research is virtually non-existent. Canada has one of the weakest industrial capacities in R&D when compared with other developed nations."

The fear voiced strongly by the private sector, is that Canada won't have the footing to compete with the rest of the world for much longer if it doesn't exploit new opportunities through the commercial application of technology, stimulate science-based innovation, and promote industry-driven R&D.

The Science Council of Canada has noted that 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. Information technologies are such strategic technologies. Information technologies are the infrastructure on which the future competitive success of a variety of sectors depends. Telecommunications R&D is a strategic factor in determining Canada's economic performance.

This report assembles available information about Canadian activities in R&D and assesses the current situation for telecommunications R&D.

1.2 International Comparison of R&D

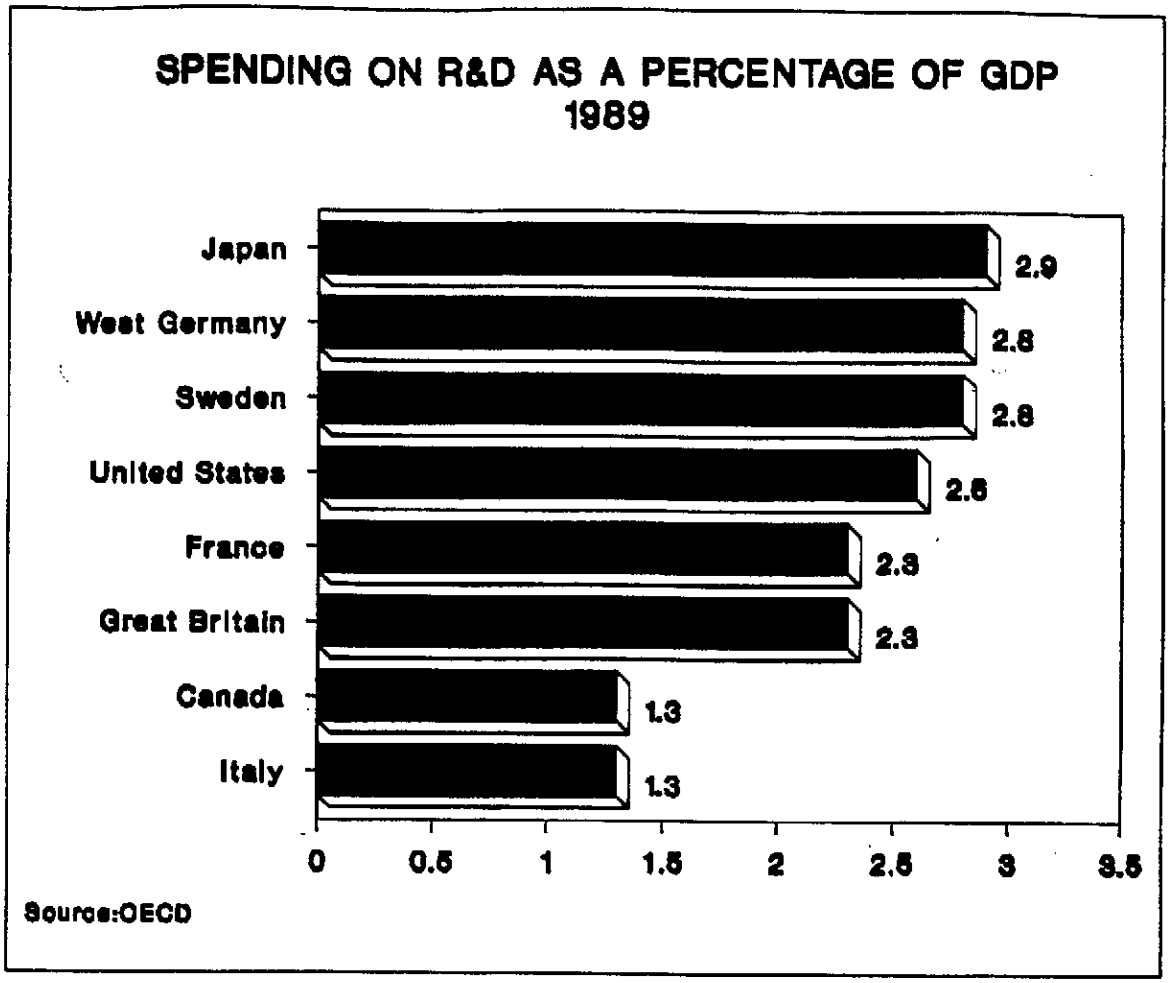
Canada has not kept pace with other industrialized countries in maintaining the technological base and leadership fundamental to economic viability. When compared with the United States, Japan, West Germany, Italy, Netherlands, Sweden and Britain by the Organization for Economic Cooperation and Development (OECD), Canada ranks near the bottom in most R&D indicators.

CANADA'S PERFORMANCE IN RESEARCH AND DEVELOPMENT

Measure of Competitiveness	How Canada Ranks
Gross R&D expenditures as a percent of GDP	Lowest
Industry funded R&D/GDP	Lowest
Government funded R&D/GDP	2nd Lowest
Government performed R&D/GDP	Middle
Higher education R&D/GDP	2nd Lowest
Scientists and engineers in labour force (by population)	Lowest
Advanced degrees awarded (by population)	Middle
International patents granted	Lowest
Number of technology intensive industries with positive trade balances	Lowest

SOURCE: "From Paradox to Paradigm: The Evolution of Science and Technology in Canada", Journal of the American Academy of Arts and Sciences, Fall 1988.

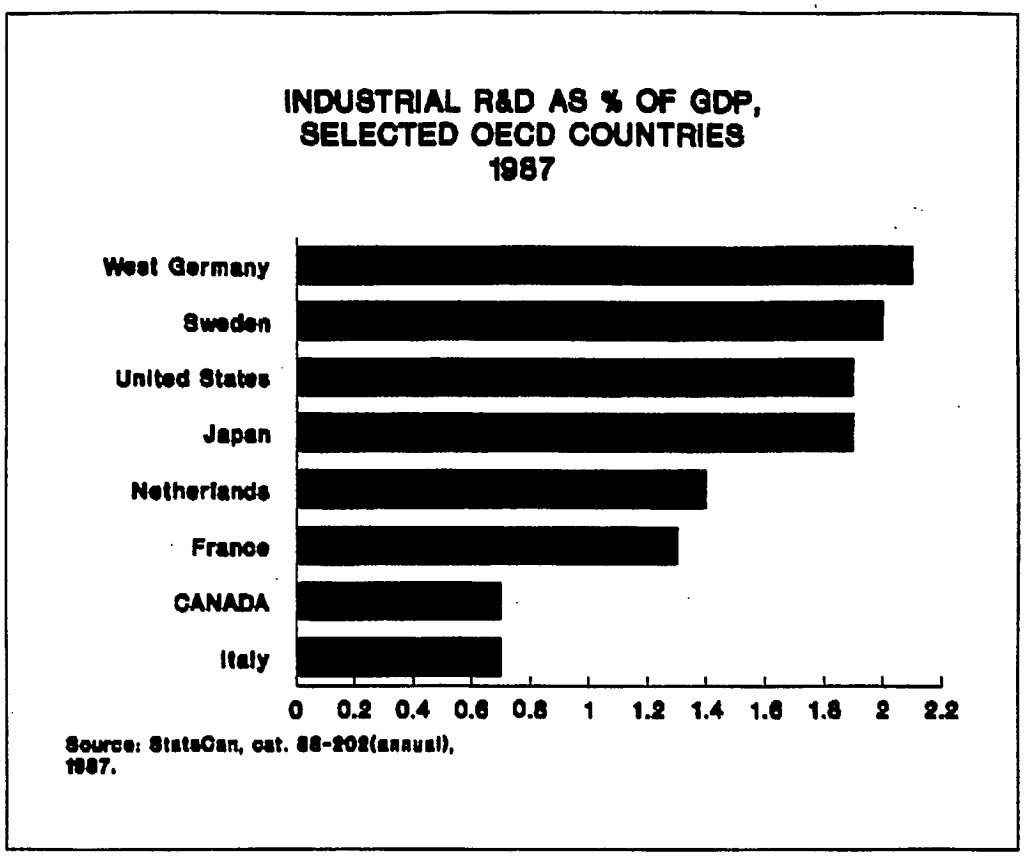
On a per capita basis, Canada is doing less than half the R&D of major competing countries. Japan, West Germany, Sweden and the United States, for example, spend almost three percent of their gross domestic product on R&D, compared to 1.3 percent for Canada.



The spending of 2.5 percent of GDP on research and development was endorsed by members of federal and provincial advisory councils on science and technology at a Halifax conference. But there seems to be a lack of consensus or focus on an optimum target for R&D. It is apparent that without R&D as an input, economic success cannot be generated.

Meanwhile other developed countries are increasing their spending and the gap is widening. Ontario's minister of industry, trade and technology, Monte Kwinter, declared: "When we are competing against countries like Japan, which has announced that it plans to increase its research and development funding to 4.5 percent of the GDP by the year 2000, it is clear that the federal government must send out a signal - and it's not doing that."

The government's contribution to the total R&D effort in Canada which amounts to 0.6 percent of the GDP compares favourably with government spending of 0.5 to 0.7 percent in other industrialized countries. What is not in line is the contribution by the private sector. Overall, the private sector's share of the national R&D effort is less than that of other industrialized nations, as shown below.



Part of the reason for this situation is that Canada has had an industrial infrastructure that did not require much R&D, because the country has always relied very heavily on the exploitation of its abundant natural resources for wealth creation. As well, Canada has a high proportion of foreign-owned branch plants, many of which do their research on their home ground.

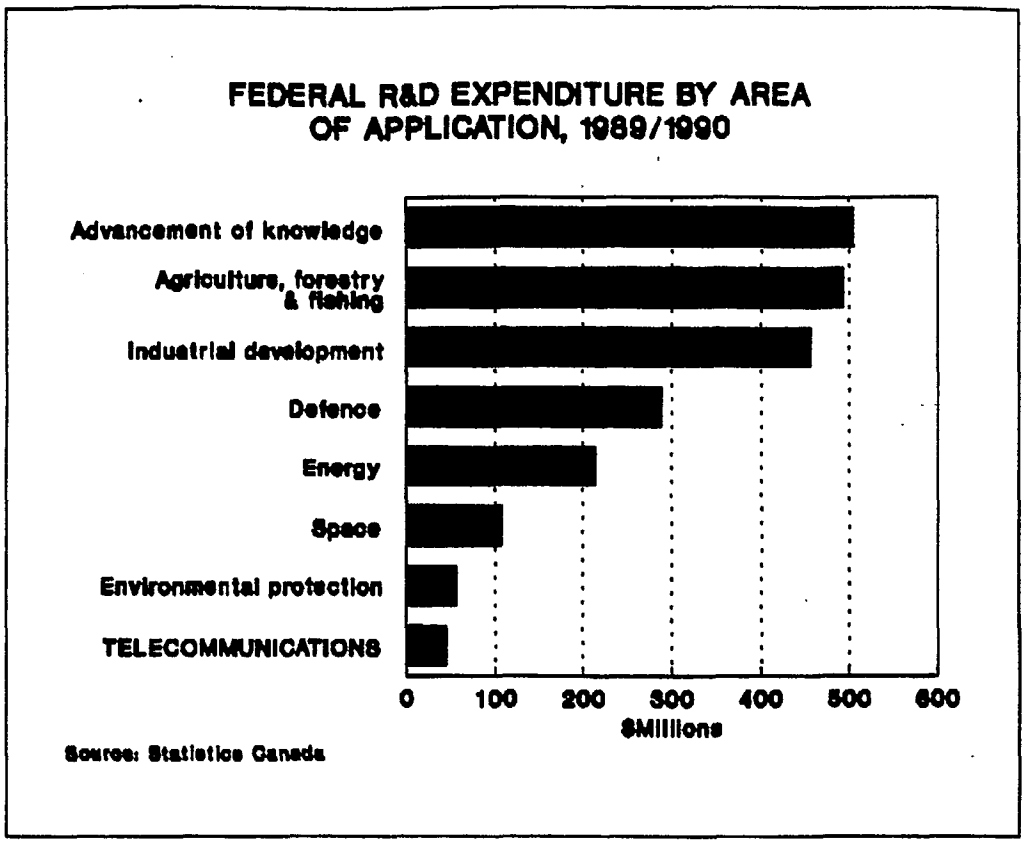
As well, the R&D support from the private sector needs to be more widely based. The vast majority of Canadian companies do no R&D at all. In 1987, 50 percent of all R&D spending was accounted for by just 25 companies.

A lack of skilled scientists and engineers threatens the ability of Canadian industry to compete in the world, said science minister William Winegard. Canada has 90 scientists and researchers for every 100,000 people, compared with 280 per 100,000 in the United

States. In fact, our situation looks to be worsening. In 1972, doctoral degrees in natural sciences and engineering accounted for over 60% of all PhDs granted by Canadian universities, but by 1988, the figure had declined to 50%. High-tech leaders are also calling for government and industry to invest more in training and upgrading the current work force. Canada devotes approximately one-third the time to in-service training of its major industrial competitors.

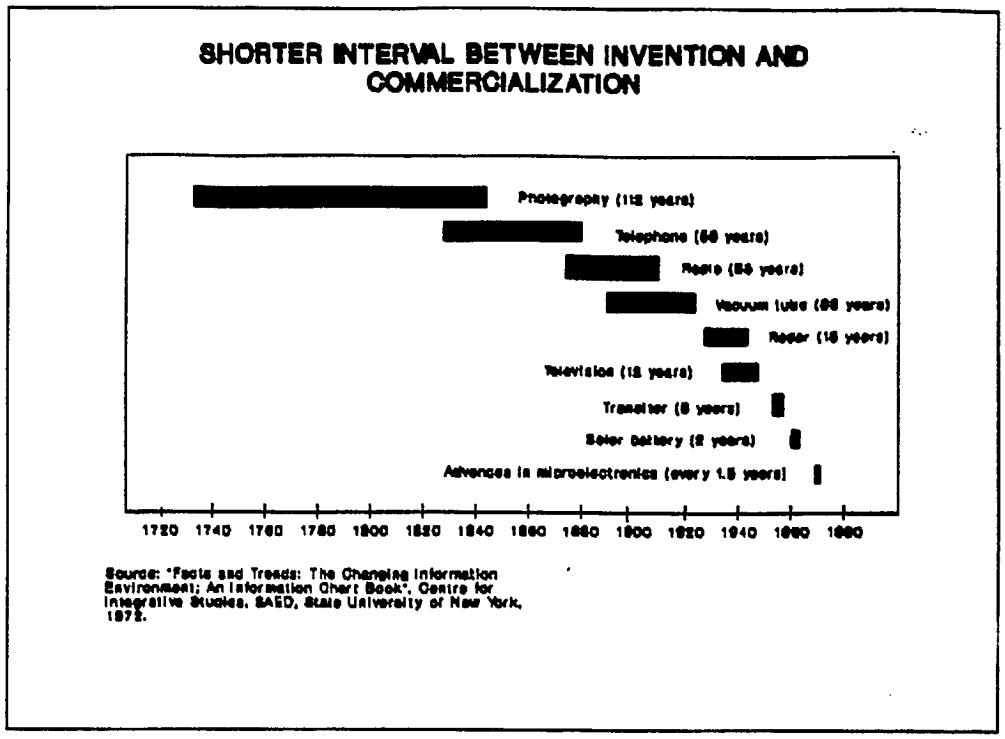
In a 1989 World Competitiveness report published by the International Management Development Institute and the World Economic Forum, Canada ranks fourth among the world's developed countries - surpassed only by Japan, Switzerland and the United States. Canada's rankings are relatively high in the areas of human resources, natural endowments, market dynamics, and industrial efficiency. Despite its strong performance this year, Canada has a long way to go in some key areas. For example, Canada ranks 15th in innovative forward orientation. Insufficient investment in research and development is cited as a major factor in the poor showing. Outward orientation is another Canadian weak spot - with a ranking of 14th. According to a Globe & Mail article by Pierre Lortie, success in global markets is neither a constant preoccupation nor a priority among Canadian businesses.

Canada commits more of its R&D budget to pure research than most other industrialized countries according to Minister of Science William Winegard. Federal R&D expenditures for 1989-90 show advancement of knowledge receives a large portion of the total.



Canada's share of the world's scientific publications is higher than what one might expect from the scale of our R&D effort and size of our population or economy. According to Pierre Lortie, Chairman of the Committee on Federal Science and Technology Expenditures, in effect, we are subsidizing the large economies that are better equipped to make the best use of the advancement of knowledge. This suggests that Canada has the capability to produce knowledge but needs to capitalize on this capability (ie. more development and commercialization) for our own economic development.

According to Denzil Doyle, one of the most common misconceptions in the technology exploitation business is that only applied research results in products or services. It is important to remember that there is not a natural progression from pure to applied science, to breadboarding, to engineering prototype and so on. A carefully thought out strategy of exploiting the by-products of pure research can result in a shortened innovation chain. In fact, the time lag between invention and commercialization is shrinking at an accelerating rate in nearly every field.

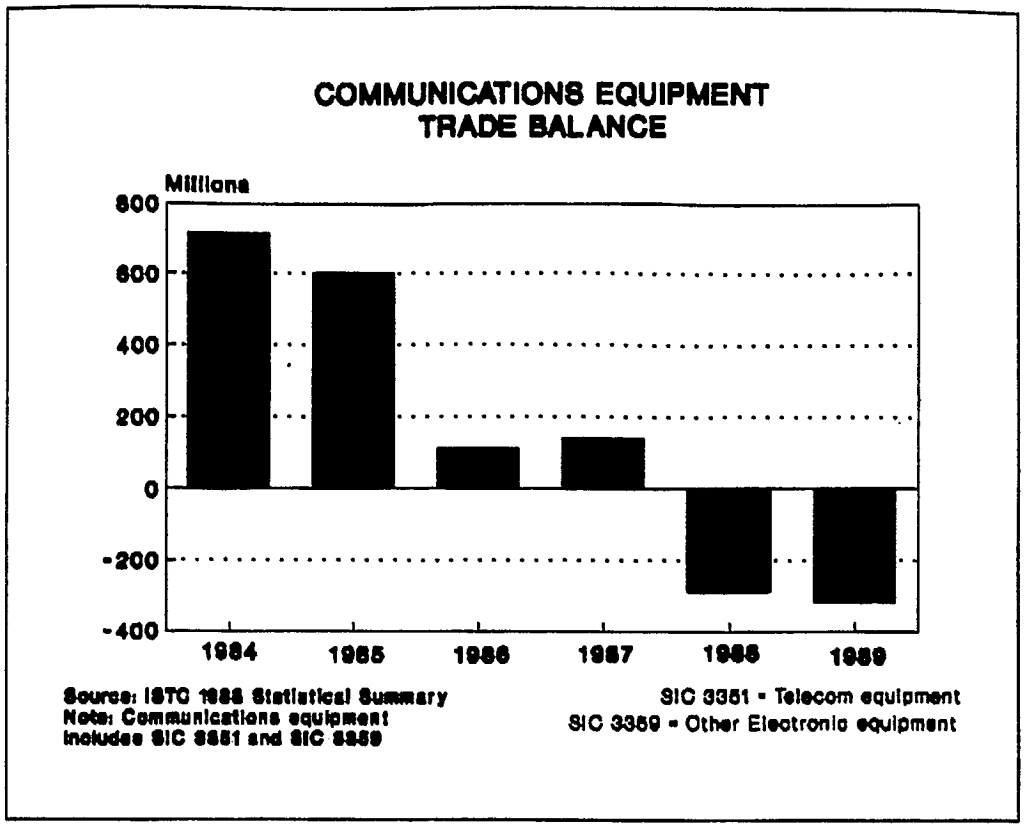


Notice that advances in microelectronics are occurring every one and a half years. This has a significant impact on communications and information product life cycles.

1.3 International Trade in Telecommunications

There are signs that our position among the high-tech nations of the world may be slipping. Canada's high-tech trade deficit has grown from $4.6 billion in 1980 to $7.2 billion in 1987, an increase of 56 percent. A major reason for this deficit is Canada's heavy reliance on imported computers.

For the past two years, Canada has run a telecommunications trade deficit. A trade deficit in telecommunications, one of Canada's key high-tech export industries is worrisome - not least because a large share of the industrial R&D done in Canada is directed at telecommunications. It should be noted that Canada's trade in telecommunications equipment is still in surplus and the overall deficit is a result of weaker performance in electronic components.



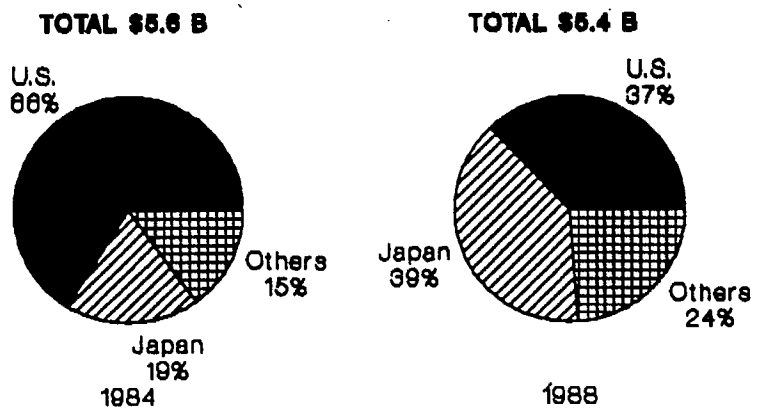
During the past two decades, we have suffered a substantial erosion of our competitiveness in world markets. Between 1971 and 1986, the Japanese share of technology-intensive imports into the U.S. market expanded to 35% from 28%. In the same period, the combined market share of South Korea, Taiwan, Hong Kong, Singapore and Malaysia increased to 20% from 7%. Meanwhile, Canada's share declined to 9.4% from 22.8 percent. Our market share eroded in all high-tech sectors, and was most pronounced in automatic data processing and telecommunications equipment. Given Canada's access to the U.S. market, our declining performance should be of concern.

The pattern of international trade in telecommunications equipment during the past decade has undergone substantial change. East Asia's newly industrialized countries (NICs) emerged as very competitive suppliers on the world market. The simpler and more standardized an item of equipment, the more the production moved towards countries of the Far East. NICs possess a comparative advantage in products that are of relatively low technology content and are amenable to mass production. As well, telecommunications liberalization in the U.S. and other markets has given NICs the opportunity to increase exports to the industrialized countries.

In contrast, the more sophisticated products now require efforts in R&D that far exceed those that were required before. The U.S., Canada, and the major European countries have a comparative advantage in the production and marketing of equipment having a high technology content and service follow-up. Japan belongs to this group but also appears to have some advantages in selling mass-produced products abroad. This has forced the large producers of sophisticated products to spread high R&D costs over a broader market base. This has led to an intense struggle for market entry into foreign markets according to the March 1989 issue of Telecommunications Policy.

The increases in demand have predominantly affected customer premises equipment (CPE) and hardly at all the other types such as central office switching equipment. CPE products are simple and technologically undemanding and if they have high technology content can be mass produced. According to the comparative advantage argument, it is not surprising to see that NICs have been able to increase their share of world trade in telecommunications. Japan and the NICs substantially increased their share of Canada's imports, as they did in the U.S.

CANADA'S TELECOMMUNICATIONS EQUIPMENT IMPORTS BY COUNTRY/REGION



Source: Statistics Canada, Cat. 66-007
Note: SIC 3351 only.

Japan's rise in share of Canada's imports between 1984 and 1988 is almost totally due to facsimile machines. As the product breakdown of Canada's imports indicates, facsimile accounts for 30% of total imports and the dominant supplier is Japan.

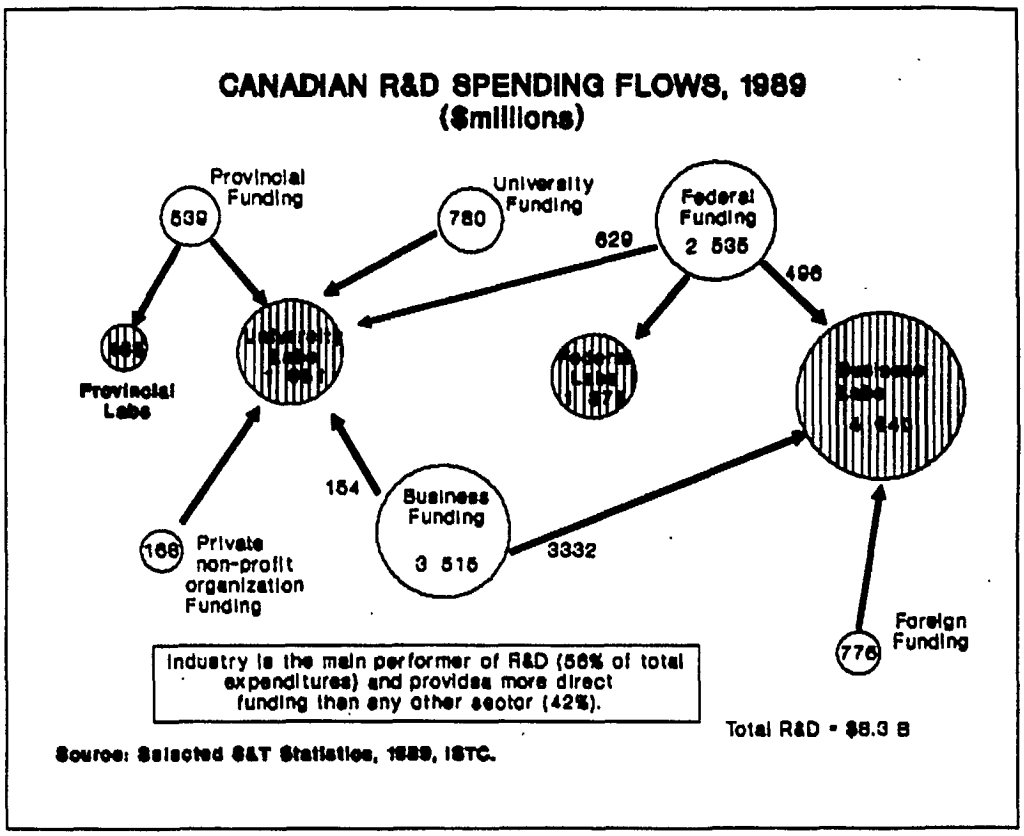
CANADA'S IMPORTS OF TELECOMMUNICATIONS EQUIPMENT BY PRODUCT CATEGORIES, 1988

Category	Supplier Countries $'000	Japan	U.S.	NICs	Other
Facsimile	163,118	95%	5%	-	-
Telephone sets	96,425	23%	18%	54%	5%
Modems	83,199	1%	84%	6%	9%
Telephone answering machines	38,636	15%	9%	66%	10%
Central office switching systems	29,659	17%	65%	5%	13%
Other parts, etc.	128,984	18%	62%	8%	12%
Total	540,021	39%	37%	18%	6%

SOURCE: Information Technologies Industry Performance, Statistical Summary, 1988, ISTC

1.4 Industrial Research and Development

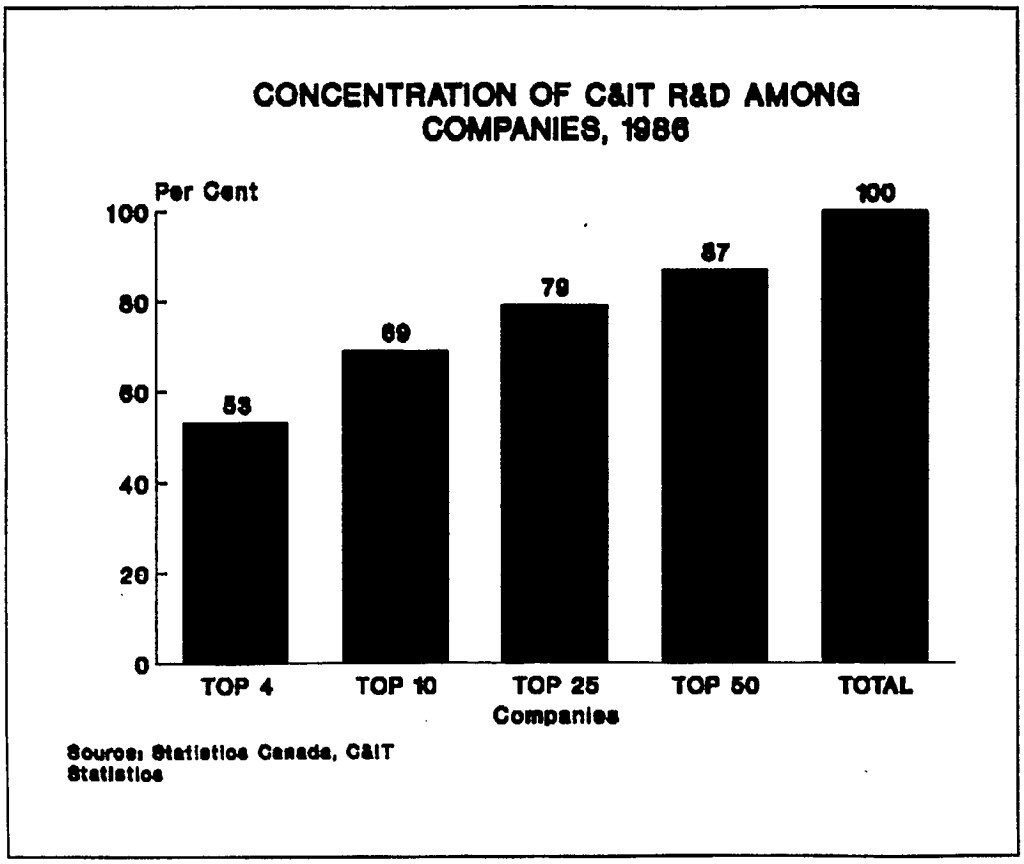
As noted in section 1.2, Canada's industrial R&D effort is less than that of other major industrialized nations. However, the business sector is the biggest performing and funding sector of R&D in Canada. Most R&D activity within the business sector is funded by the companies doing the work. In 1989, direct federal funding to business amounted to $496 million, lower than the $776 million from foreign sources.



Statistics Canada figures show that the federal government's share in financing research and development has declined steadily from 43% 15 years ago to 30% now. During the same period, the private sector has increased its share from 29% of all spending to 42%

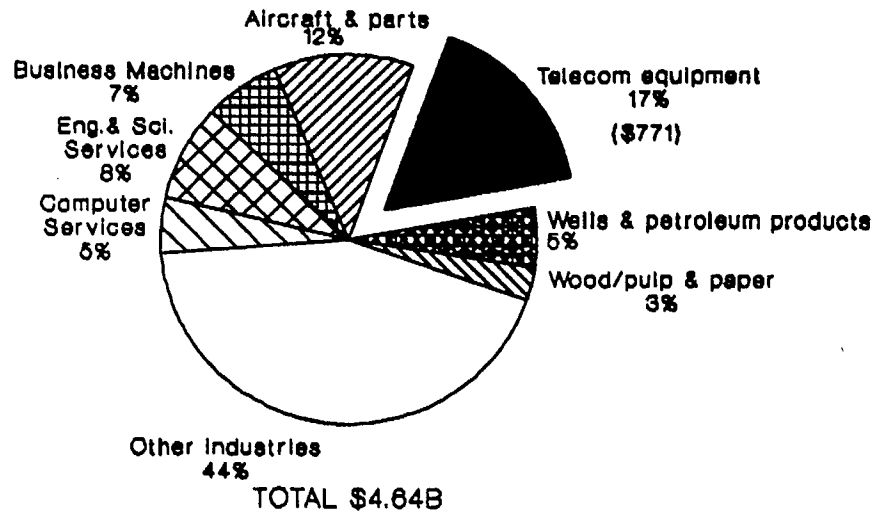
The federal government is spending a smaller percentage of its budget on science and technology this fiscal year than it was at the beginning of the 1980s, according to Statistics Canada. For 1989-1990, the government plans to spend $5.1 billion, or 3.5% of the total federal budget on science and technology, compared to 3.9% of the total in 1980-81.

Most industrial R&D in Canada is performed by a small number of firms. Such concentration is true for communications and information technology (C&IT) companies as well. In 1986, the top 4 companies accounted for over half of the R&D performed and the top 10 companies for almost 70%. Such concentration of R&D can have dramatic effects on expenditures. The decisions of a few firms can significantly alter overall R&D expenditures.



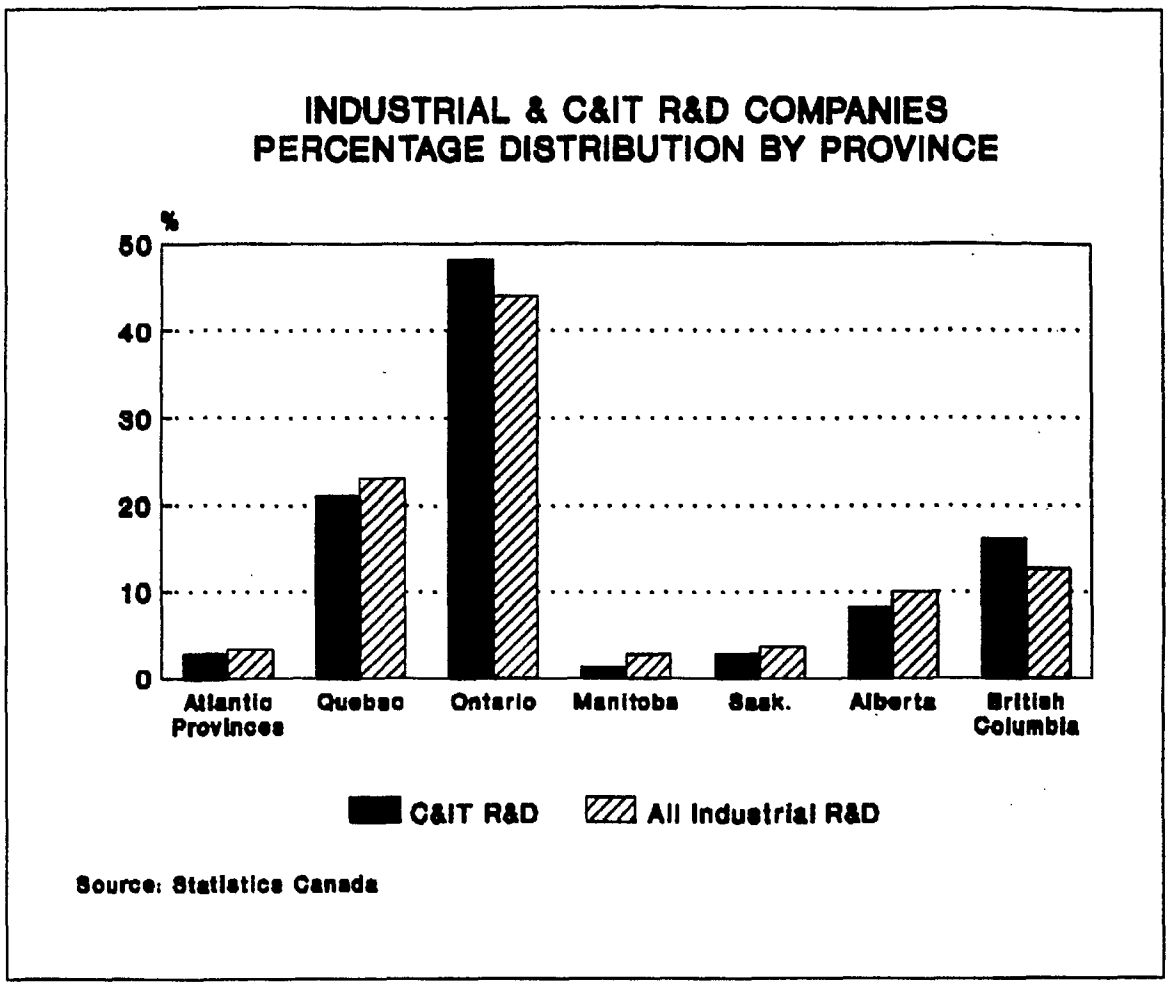
Canada's research and development expenditures are also concentrated within a few industries. Manufacturers of telecommunications equipment are the major performers of industrial R&D, accounting for 17% of total industrial R&D in 1989. The R&D effort in high-tech industries is better than in most other Canadian industrial sectors.

INDUSTRIAL R&D SPENDING IN CANADA
(estimated, 1989)
(actual dollars, 000,000)



Source: Statistics Canada, Catalogue 88-202

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 firms are in Alberta or British Columbia. All other provinces have a minor share of total industrial R&D activity.

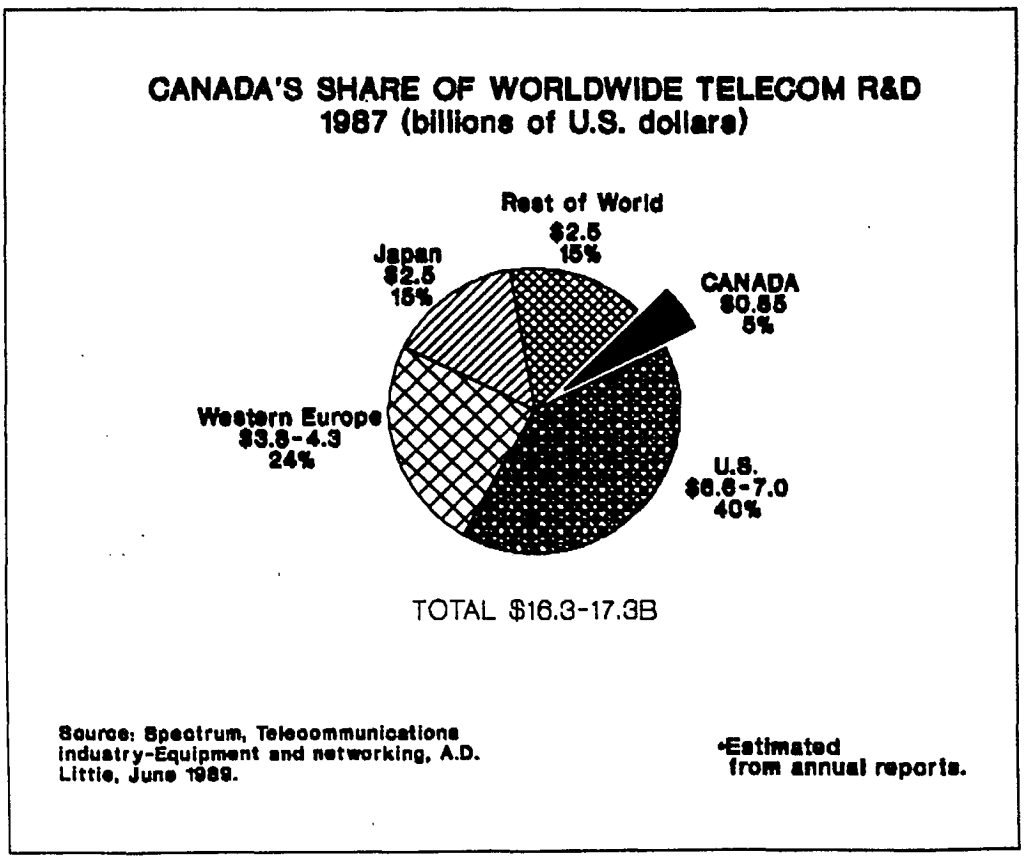


2. TELECOMMUNICATIONS R&D

2.1 Worldwide Telecom R&D Expenditures

Markets for telecommunications equipment are international, and a strong trend toward more open competition is emerging as many countries relax trade barriers and ease regulatory restraints. At the same time, both carriers and end users are becoming more demanding and more discriminating. To maintain or increase market share, telecommunications suppliers must offer a steady stream of new and improved products and services that reflect the latest technologies.

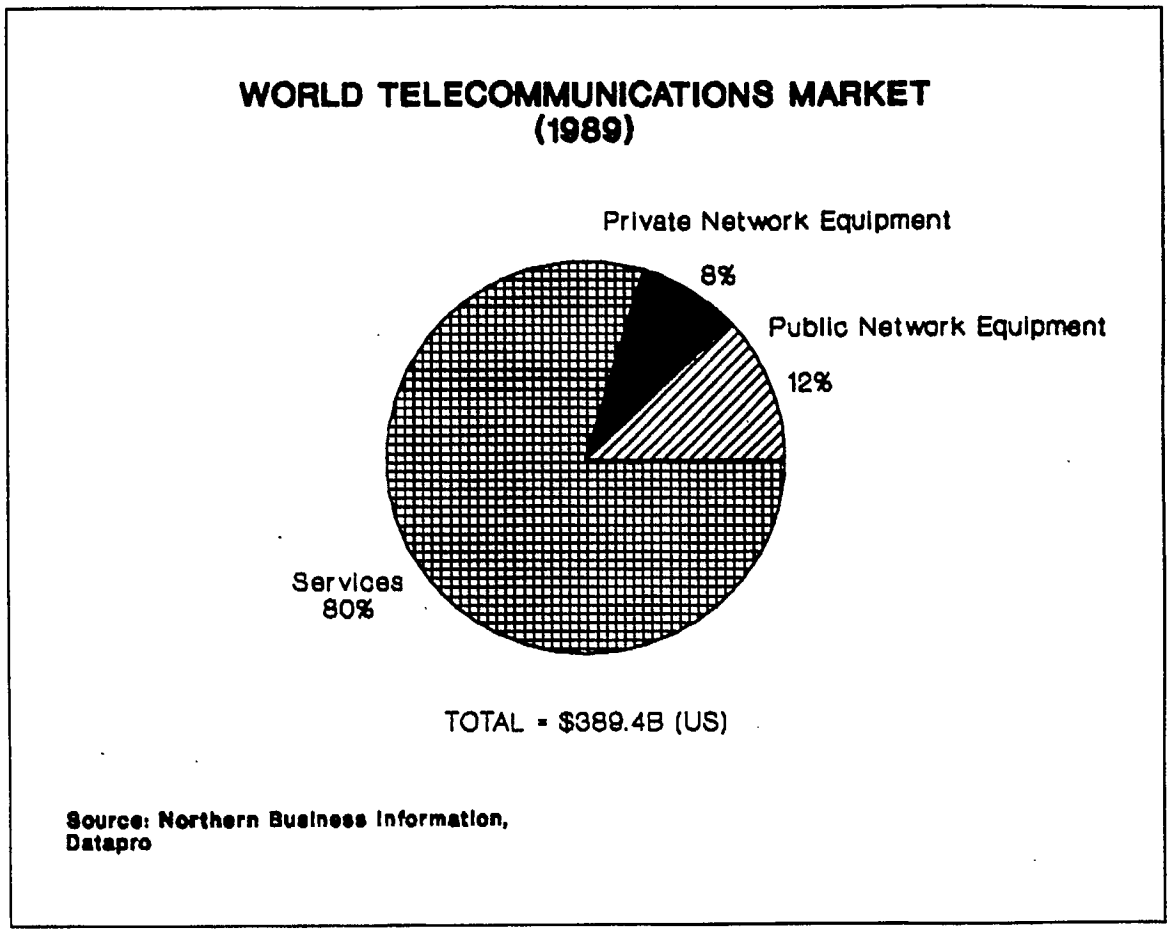
Arthur D. Little estimates that R&D expenditures for the worldwide telecommunications industry totalled $16-18 billion in 1987, with $10-11 billion spent on product development by equipment manufacturers, and slightly more than $6 billion spent by telephone companies and other communications carriers on products and services. Of the total, U.S. companies spent an estimated $6.6-7 billion, or about 40%. It is estimated that Canadian companies account for about 5% of the total.



2.2 World Telecommunications Market

In 1989, the world telecommunications market was estimated to be worth $389 billion. The market for services accounted for $310.5 billion or 80% of the total market. According to Northern Business Information estimates, the market for telecommunications services is five times larger than the equipment market and growing at about 10 per cent a year.

Of the $79 billion spent on equipment, telephone companies spent almost $47 billion on hardware for their public networks, but the annual rate of growth in this market has slowed to 7 per cent. Private businesses made up the other $32 billion of equipment purchases and are increasing their spending by a rate of 15 per cent a year.



Not surprisingly, the world's major telecommunications equipment makers hope to expand by developing new services in the lucrative services segment of the global telecommunications market.

2.3 World Leaders in Telecommunications

R&D is absolutely essential for telecommunications industries to remain competitive. The following data indicates the R&D expenditures for some of the world's leading telecommunications equipment manufacturers.

R&D EXPENDITURES OF LEADING TELECOM EQUIPMENT MANUFACTURERS, 1988

COMPANY	TOTAL SALES ($B)	TELECOM EQUIPMENT SALES ($B)	R&D EXPEND. ($M)	R&D EXPEND % OF SALES
AT&T (U.S.A.)*	35.2	11.4	2572	7.3
ALCATEL (France)	13.1	10.6	1290	9.8
NEC (Japan)	22.9	6.1	2009	8.8
SIEMENS (W.Germ)	33.5	5.7	3665	10.9
NORTHERN TELECOM (Can.)	5.4	5.4	711	13.1
GPT (U.K.)	2.1	2.1	175	8.3
ERICSSON (Sweden)	5.1	4.5	577	11.3

* AT&T is both a carrier and an equipment manufacturer.

Source: Spectrum, Telecommunications Industry - Equipment & networking, June 1989.

Northern Telecom, part of the BCE group of companies, spent $711 million on R&D in 1988, representing 13 percent of revenues. According to Computing Canada, this R&D commitment seems to have paid off: 80 percent of Northern Telecom's revenue comes from products that didn't exist five years ago.

Northern is truly a global player and has R&D facilities throughout the world. In Verdun, France, Northern is a partner in a plant that makes Meridian SL1 PBX switches and a R&D lab is located outside Paris. Northern is also part owner of a plant in Turkey, where a good portion of the 2,000 member workforce is in R&D. The Galway, Ireland plant produces PBXs and other products for markets in Europe and the Middle East. There's a major research facility outside London. And Northern has manufacturing and some R&D in Australia, Malaysia and the People's Republic of China.

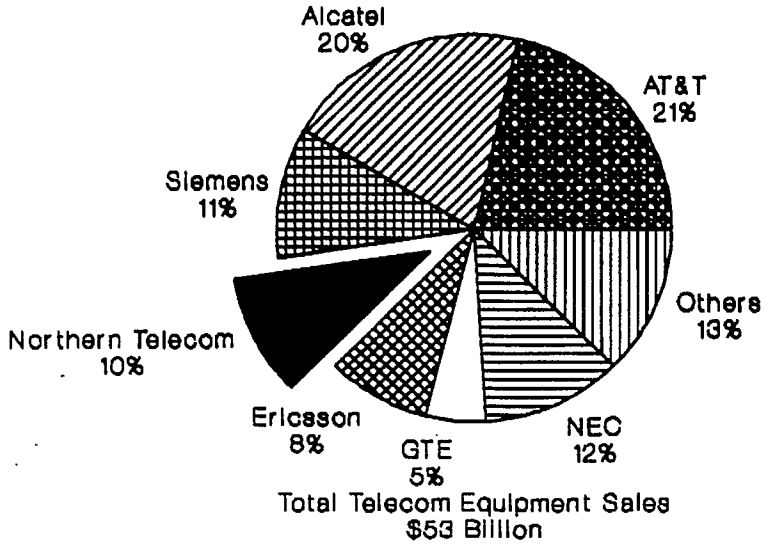
From 1979 to 1989, Northern increased its R&D spending from 7 percent to 13 percent of revenues - or $17.6 million U.S. to $730 million U.S. Paul Stern, president of Northern Telecom, states: "The rise in our absolute dollar investment in R&D reflects the

corporation's continuing commitment to the development of products and systems that satisfy the needs of our global customer base."

Northern Telecom is the fifth largest telecommunications equipment maker in the world, ranked by 1988 telecommunications sales. In terms of world market share, Northern Telecom has 10% of total sales on the global market. Charles Baker, vice-president of market development says: "Northern's goal is to become the leading telecom supplier in the world by the year 2000." That means Northern Telecom must capture a leadership position in the dominant services segment of the market.

According to a June 22, 1989 article in Computing Canada, Northern Telecom has less than one percent of its R&D paid through government. Its primary competitor, AT&T, has five percent of its R&D paid by government.

WORLD MARKET SHARE FOR TELECOMMUNICATIONS EQUIPMENT MAKERS, 1988



Source: Datamation (June 15, 1989), Telecommunications Market (Nortel,1989)

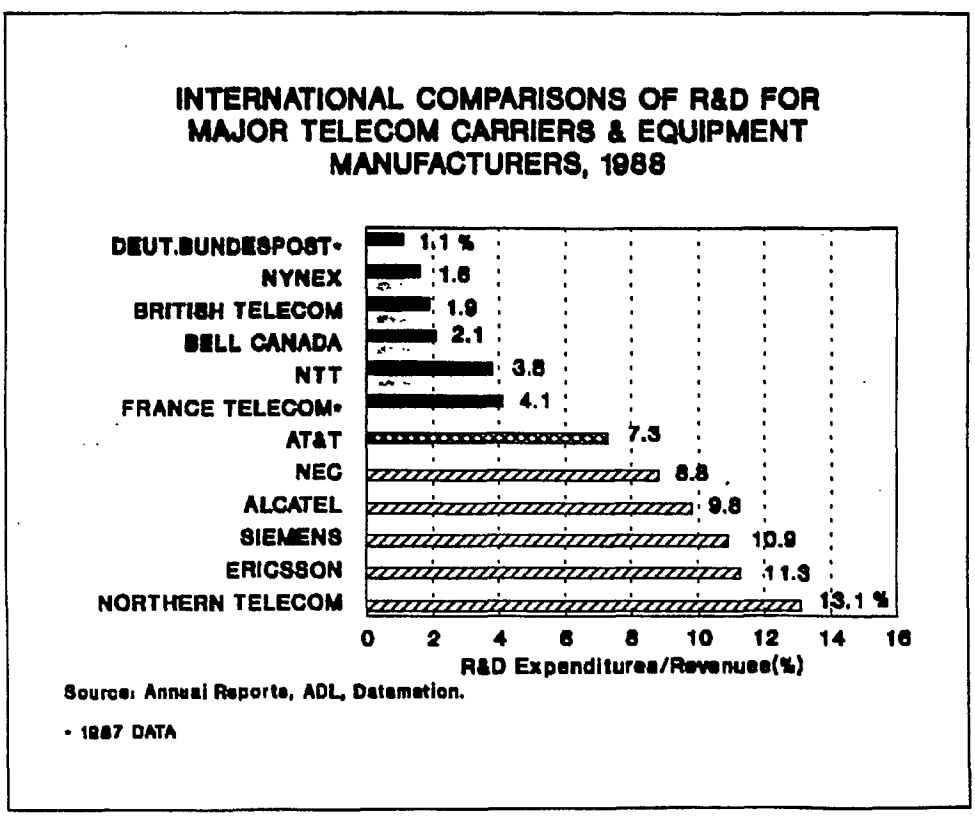
A recent report on telecommunications in the May 29, 1990 Globe and Mail notes that suppliers agree that a manufacturer must have about 15 per cent of the current equipment market to continue profit growth, which leaves room for only six switch makers. There are now 10.

2.4 R&D Intensities of Leading Telecom Companies

R&D expenditures as a percentage of revenues vary between telecommunications carriers and telecommunications equipment manufacturers. This is a complex area which is currently being examined.

The following data on R&D expenditure intensities of certain major telecommunications carriers (Deutsche Bundespost, NYNEX, British Telecom, Bell Canada, NTT and France Telecom) indicate a range of R&D expenditures from 1% to 4% of revenues. AT&T which is both a carrier and an equipment manufacturer spends 7.3% of its revenues on R&D.

The major equipment manufacturers (Alcatel, NEC, Siemens, Ericsson, Northern Telecom) have R&D expenditures a percent of revenues ranging from 7.7% to 13.1 % for Northern Telecom. This demonstrates that the equipment manufacturers are the major players in telecommunications research and development.



2.5 Canada's Telecom R&D

Although Canada's overall R&D effort is weak, an exception can be found in the telecommunications sector. According to Bell Canada, "The Canadian telecommunications industry was forced, simply by virtue of being disconnected from AT&T to embark on aggressive R&D." Others note that Canada's geography meant we had to be good at communications.

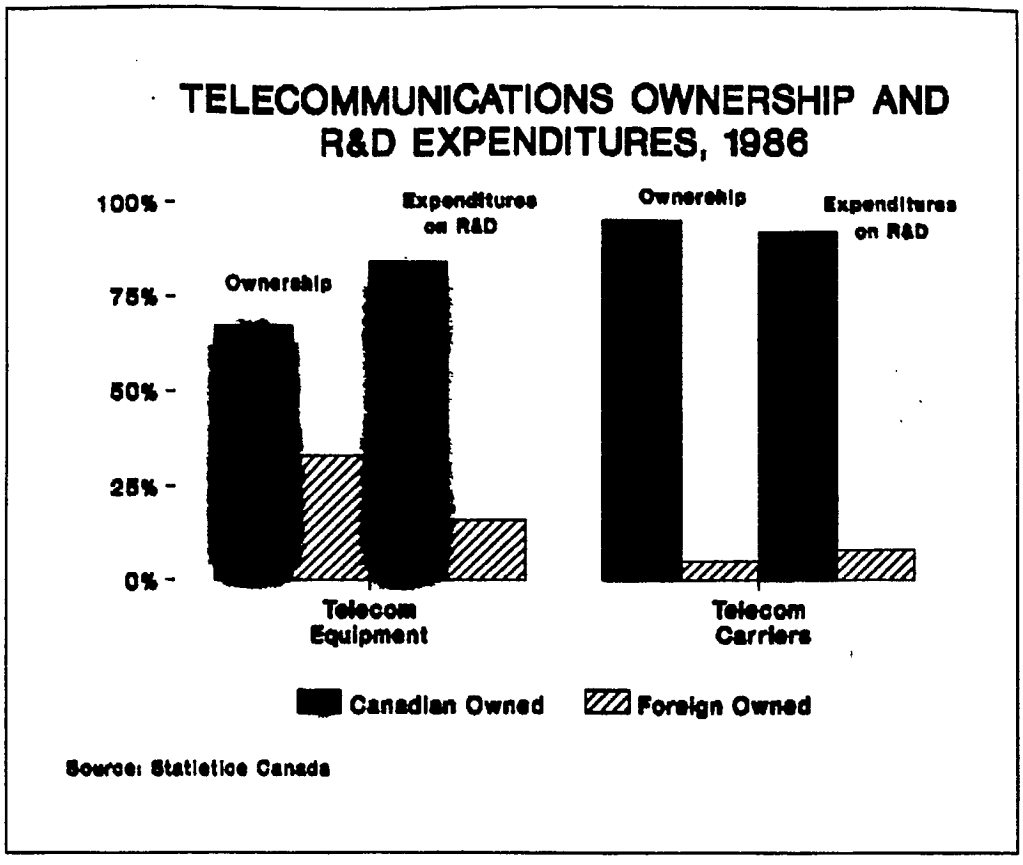
The expenditures of Bell Canada Enterprises (BCE) illustrate the importance of R&D for telecommunications industries. BCE is by far Canada's largest R&D spender accounting for almost $1 billion.

KEY CANADIAN PERFORMERS OF COMMUNICATIONS AND COMPUTER R&D, 1988

Bell Canada Enterprises	$998 M
IBM Canada	$181 M
DOC Research Program	$ 50 M
Mitel	$ 34 M
B.C. Telephone	$ 32 M
Gandalf Technologies	$ 16 M
Spar Aerospace	$ 11 M

Jean Monty, president of Bell Canada noted that in 1988, the three members of the Bell telecommunications family (Northern Telecom, Bell Northern Research and Bell Canada) invested one out of every eight R&D dollars spent in Canada - that was one billion dollars for BCE and seven for the rest of the country.

In general, telecommunications in Canada is dominated by Canadian controlled firms. About 70% of telecommunications equipment manufacturers are Canadian owned and 95% of telecommunications carriers are Canadian. In addition, Canadian owned firms account for the majority of R&D expenditures as noted below.



2.6 Key Areas of R&D in Telecom

Current R&D in the public telephone network could transform it into a flexible medium for all forms of communications and information delivery. Following are some of the key areas where R&D is underway in the telecommunications industry, as described by A.D. Little in July 1989.

Fibre-optic research is directed towards bringing the cost of fibre down so that it roughly equals the cost of copper wire. Fibre-to-the-home is in intense development, in particular studying the use of a bus architecture rather than a star. The bus system is less costly because it permits a large number of subscribers to share some of the most expensive optoelectronic components and reduces the amount of fibre required. Fibre to the home could provide telephone companies the opportunity to compete with the existing cable television systems if allowed.

The rapid penetration of personal computers in the office and workstations in labs and factories has created a booming market for local area networks (LANs). LANs proved to be more attractive than PBXs for nonvoice intrapremises communications on the basis of both cost and functionality. Major R&D projects focus on the applications software (trying

to encourage software firms to enter in joint development arrangements with LAN suppliers, eg Microsoft working with 3Com) and to develop software products specifically for LAN systems.

R&D in fast packet switching aims to reduce and to achieve three important design objectives, namely: minimum delay, minimum connection time, and maximum bandwidth for transmission speed.

R&D in intelligent network (IN) components is of great interest. A large amount of R&D is needed for the development of functional services such as real-time authorization code verification and calling number identification. Public network operators feel IN will provide a means to new revenue producing services with relatively small incremental investments. Of particular importance, IN must be in place before widespread introduction of ISDN (Integrated Services Data Network) is possible.

R&D efforts are also underway in mobile communications, electronic and electro-optic component, networking and applications software.

3. STRATEGIC ALLIANCES IN TELECOMMUNICATIONS R&D

3.1 Purpose of Alliances

Strategic alliances allow companies to leverage their competitive strengths through co-operative efforts. The need to form strategic alliances is being driven by the high cost of technology development and commercialization, coupled with the recognition that many products may have life spans of less than two years. In addition, a single company often doesn't have the financial or technological resources needed to develop completely new generations of complex products. As well, trade liberalization is causing firms to reassess their current methods of market penetration and positioning. To deal with these pressures, firms are developing alliances to pool ideas and resources, keep pace with market changes, reduce risks, develop new markets, and maintain flexibility.

For large firms, alliances provide a means of sharing costs and risks in the development of expensive, technology-intensive products. Moreover, large firms are increasingly entering into alliances with small firms to exploit their entrepreneurial capabilities and market niches. For small and medium-sized firms, alliances, especially with larger firms, are becoming important sources of finance and are providing the opportunity to become more active players in the global economy. According to a recent Investment Canada newsletter, alliances are rapidly becoming the preferred route for small and medium-sized firms to go international.

3.2 Examples of Alliances

To deal with today's intensely competitive marketplace, high-tech companies are forming partnerships or are involved in takeovers or mergers with rivals.

R&D collaboration is seen by many as a way to achieve critical mass in the research function. According to the report "1992 Implications of a Single European Market", over 40% of the EC and EFTA firms surveyed expect to participate in joint R&D projects under EUREKA, ESPRIT, RACE. etc. The purpose of RACE is to maintain the EC's existing competitive edge in the telecom sector, which will represent 7% of Community GDP by the end of the century compared to roughly 2% now. RACE's general goal is to enable the Community to replace existing digital telephone systems with integrated broadband communications (IBC) based on ISDN, or integrated services digital networks. For more details see the report "International R&D Collaborative Programs," March 1990 by DOC.

In 1988, Europe's largest electronics firm signed a joint venture with the largest computer manufacturer in the world to sell telecommunications equipment. Under the deal, West Germany's Siemens AG bought much of Rolm Corp., a 1984 purchase by IBM, to become the global leader of sales of private branch exchanges or PBXs, ahead of Northern Telecom.

Britain's two leading electronics giants, General Electric Co. (GEC) and Plessey Co. (PLC) were in a battle to acquire each other. GEC joined forces with West German electronics giant Siemens AG to purchase Plessey.

In 1987, Northern Telecom, which has only a fraction of its sales outside North America, bought one quarter of U.K. based STC PLC for $730 million.

A few years ago, British Telecom bought the majority shares of troubled Mitel Corp. of Kanata. In 1988, Plessey bought Kanata-based defence manufacturer Leigh Instruments Ltd.

A commitment to co-operative research and development is essential for the survival of Canada itself, said Dr. Fraser Mustard, head of the Canadian Institute for Advanced Research. We need to shift Canada's business, economic and political mindset towards investment in long-term innovation and technology.

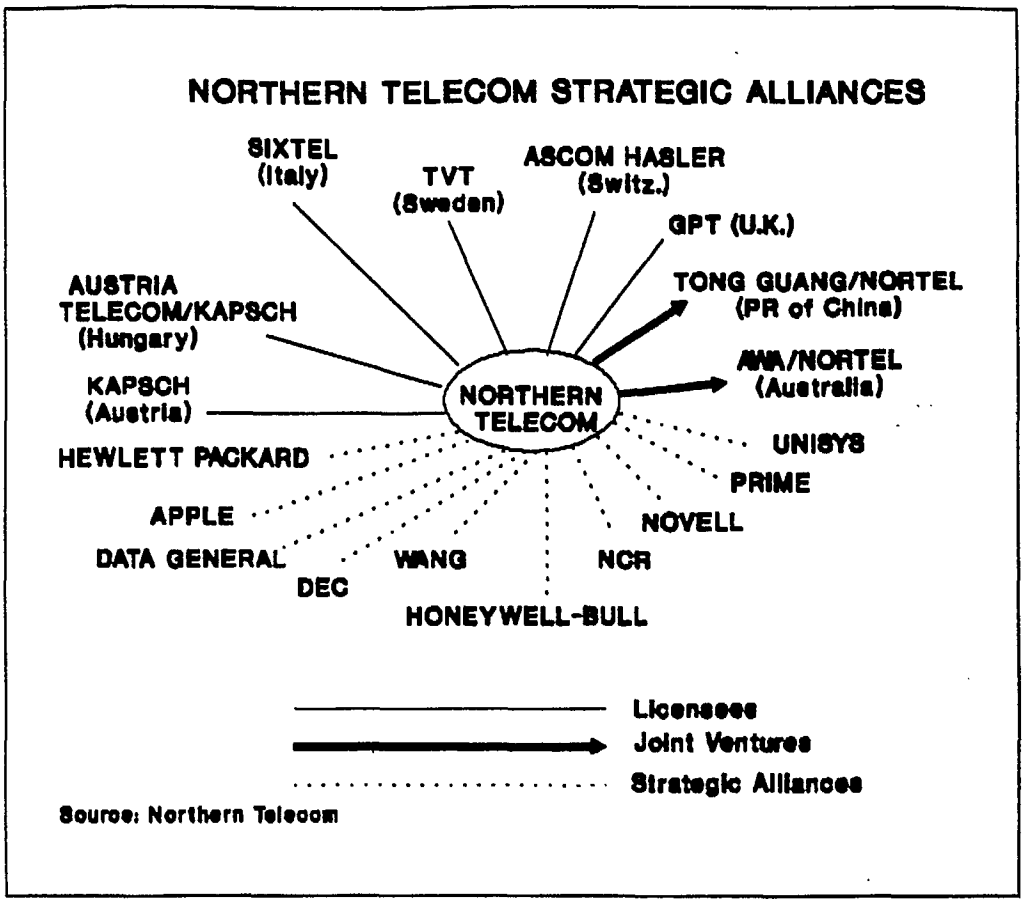
3.3 Global Markets

As we move toward the year 2000, it will be virtually impossible to isolate domestic and global markets. Nations will depend more and more on one another's markets. The Canada-U.S. free trade agreement, the formation by 1992 of a single trading bloc in Europe, and the ongoing international GATT negotiations have all gradually opened up new markets.

Steadily rising capital intensiveness, ever-shorter product life cycles, and the ease with which new technology can be copied requires that markets must be ready, or must be created, to recover the cost of R&D and production within a very short time frame.

The relatively small size of the Canadian market demands that high-tech companies look for customers beyond its borders. Roy Woodbridge, president of the Canadian Advanced Technology Association says the Canadian market is simply not big enough to produce the sales to fund the amount of research and development needed to survive in this fast-paced sector. A number of Canadian companies are aggressively pursuing foreign markets.

- Northern Telecom is competing successfully in the U.S. against companies twice its size. A year ago it became the first foreign supplier of public telephone exchanges to Japan's Nippon Telegraph and Telephone Corp. It has a joint venture in China, has been doing business in Turkey since 1967 and recently gained entrance to Hungary through a joint venture with Austria Telecommunications GmbH.



- Newbridge Network Corp. of Kanata operates in North America, Europe and Asia.

- Earlier this year Gandalf Technologies signed a co-marketing and product development agreement with West German electronics giant Siemens AG and is pursuing similar strategic alliances in France and Britain.

4. EFFECTIVENESS OF R&D

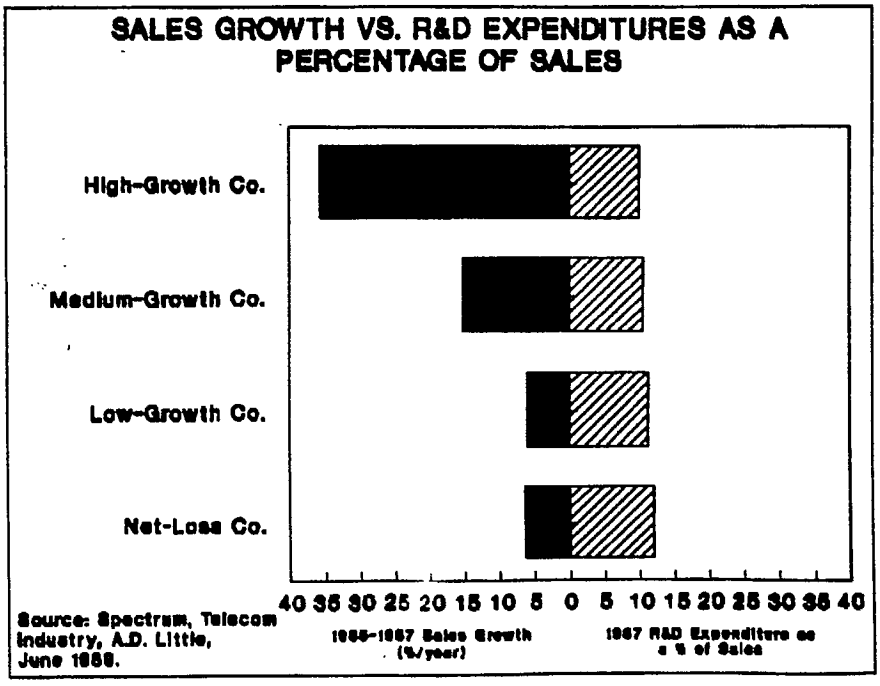
4.1 Relationship between R&D and Growth

R&D is important in the innovation process, but spending more money on R&D would not be a sufficient condition for increased competitiveness and economic growth.

Technology by itself does not create wealth. Only the products and services that are created by technology can be sold. Unfortunately, many people assume that more and more R&D will automatically create wealth. The fact is that the only output from R&D is knowledge, and unless that knowledge leads to some form of innovation, it will not lead to products and services.

Ernie Welling, director, communications of the Electrical and Electronics Manufacturers Association of Canada states that without a payoff in new and improved products, the R&D can only benefit someone else's economy. Denzil Doyle, president of Doyletech Corp., notes that even if we were to double or triple our R&D spending, we do not have many of the other important tools which are required to exploit the R&D and turn ourselves into a modern trading nation.

Levels of R&D expenditures alone do not directly correlate with success in the marketplace. Most telecommunications companies spend 10-11% of sales on R&D, almost without regard to their current growth performance or profitability. In fact, the data show that low-growth companies and companies losing money tend to spend slightly more on R&D as a percentage of sales than do high-growth companies.



However, the way R&D expenditures are reported may be confusing the relationship between R&D spending and success. Different companies vary in what they include in R&D costs, thus it is difficult to make any valid comparisons on the success of various companies' R&D activity.

Arthur D. Little Inc. stated that effective R&D depends more on how it is managed and marketed than on the amount spent. More important than increasing R&D expenditures is choosing the right products and technologies for the market at the right time, to develop the chosen products successfully, and to bring the products to market effectively and in a timely manner.

This view is also supported by Robert Reich in an October 1989 article in Scientific American. According to Robert Reich, there is no reason to suppose that more U.S. spending on research and development will result in commercial success. The fruits of research and development - new data, insights, inventions, prototypes - are easily disseminated across national borders. Increasingly the winners in the competitive race are the companies and the nations that transform R&D quickly into high quality products and into processes for designing, manufacturing, marketing and distributing such products.

This discussion indicates that a strategy which includes research, development, a highly trained labour force, and commercialization of new technologies is vital for economic success.

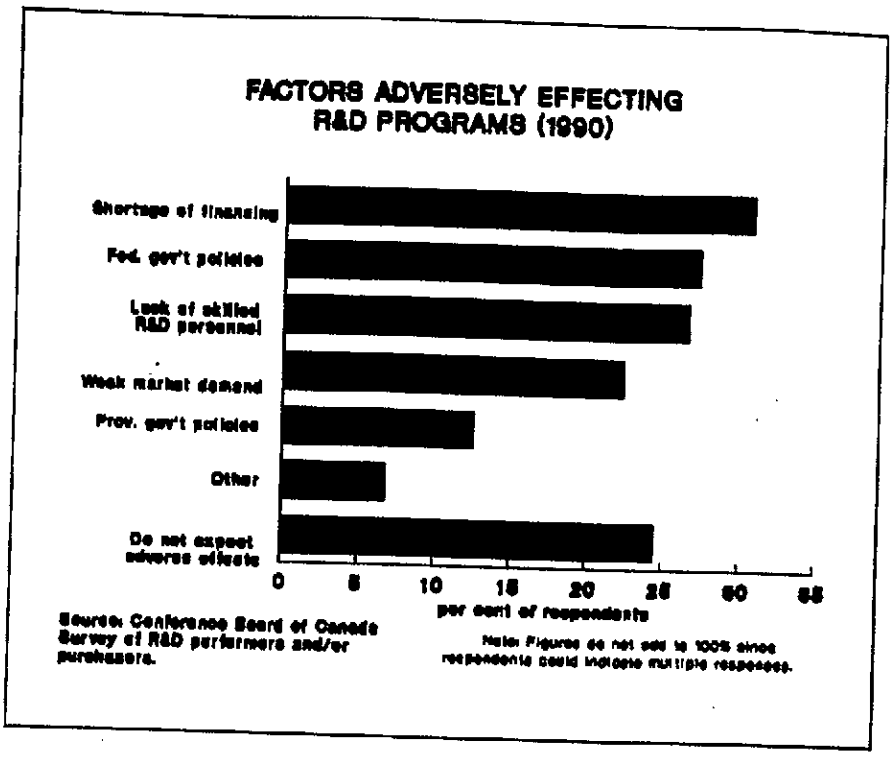
4.2 Impediments to R&D

A survey on corporate R&D attitudes and spending intentions conducted by the Conference Board of Canada indicated that the top three impediments to R&D programs were "shortage of financing", "federal government policies" and a "lack of skilled R&D personnel."

Shortage of financing was the most significant adverse effect, with 31% of respondents citing it as a problem. The main concern over R&D financing was in the service sector and among small companies. The major cause of this lack of financing was due to inadequate internal budget allocation within the company.

The second most adverse effect was federal government policies at 27%. Small and medium firms were the most critical of government policies.

Lack of skilled personnel was ranked third by 26% of respondents. Manufacturing companies considered this lack of skilled personnel as a very serious problem, with the greatest effect on medium sized companies.


FACTORS ADVERSELY EFFECTING
R&D PROGRAMS (1990)
Shortage of financing
Fed. gov't policies
Lack of skilled R&D personnel
Weak market demand
Prov. gov't policies
Other
Do not expect adverse effects
0
5
10
15
20
25
30
35
per cent of respondents
Source: Conference Board of Canada Survey of R&D performers and/or purchasers.
Note: Figures do not add to 100% since respondents could indicate multiple responses.