CANADA

Report of the
National Advisory Board
on Science and Technology

INDUSTRY COMMITTEE

Presented to the
Prime Minister of Canada

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Industry Committee Report

February 1988

The views expressed in this paper are those of the authors and do not necessarily correspond to the views or policies of the Government of Canada.

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Introduction

The Mandate

The Prime Minister, in a March 4, 1987 address at the University of Waterloo, stated that:

> Science and technology . . . are vital to promoting our national sovereignty and our well-being as a people.
>
> This is an enormous Canadian challenge - the need to meet the new international competition and to prepare and strengthen our competitive advantage around science and technology.
>
> [It is necessary] to develop and apply science and technology to productivity and industrial innovation, to boost the competitiveness of our manufacturing and service sectors, to create new industrial opportunities and to infuse a greater technological edge into our traditional resources sector.

With these words - and the earlier creation of the National Advisory Board on Science and Technology (NABST) - the Prime Minister established the national leadership that has been missing for this important issue in Canada.

The Prime Minister asked the NABST Industry Committee to consider three questions:

a) What can Canadian industry do to increase its rate of industrial innovation and investment in new technologies to increase the national effort in science and technology (S&T)?

b) What approaches could be taken to enhance the effectiveness of industry-university-government collaboration?

c) What measures are needed to minimize social and economic disruption and enhance the benefits of technological change, recognizing the accelerating pace of technological change and the key role of Canadian workers to Canada's economic and social goals?

Section 1 of this report focuses on the first two questions; Section 2 examines the third. The Industry Committee divided into two groups to deal with these sections separately.

Section One

ADVANCING THE COMMITMENT AND CAPABILITY FOR INDUSTRY-DRIVEN SCIENCE AND TECHNOLOGY

1.1 Background

This section addresses the first two questions that the Prime Minister posed to the Industry Committee in February 1987. It reflects the further thinking and the priorities set by the NABST Industry Committee in June of last year. These priorities are:

a) achieving consensus on key areas, on strategies for addressing them and on the appropriate role for all partners in implementing these strategies; and

b) encouraging government action to facilitate and support industry-established pre-competitive applied or developmental research that could strengthen existing industries.

The participation of a wider representation of sectors and trade associations through the Industry Consensus Committee greatly assisted the Industry Committee in dealing with the Prime Minister's two questions. Its advice influenced how the response to the first two questions was framed.

1.2 The Challenge

The NABST Industry Committee recognizes the urgency of advancing the capability of Canadian industry to develop and apply science and technology (S&T). Industry initiatives in science and new technologies in other countries have seriously eroded the capacity of established industries to support economic growth in Canada. Canada must find ways to develop and apply new technology to build new industries, as well as to improve productivity and expand the markets of its established industries. Mobilizing a national will to strive for a more competitive international position in S&T is critical.

The NABST Industry Committee developed a mission, goal and objectives to respond to the questions the Prime Minister posed to the committee.

Mission: To develop new ways of achieving sustained economic growth based on our existing economic strengths in order to maintain and enhance the system of social justice expected by Canadians.

Goal: To sustain and enhance Canada's economic growth within a changing global economy, by making Canada a more knowledge- and technology-intensive nation with an entrepreneurial culture.

Objective 1: To increase the rate of diffusion and adoption of new technology in established industries and to enhance the effectiveness of its application because Canada's established industries are important

for sustaining our existing economic base and for developing many of our new technology industries.

Objective 2: **To increase the rate of formation, rate of growth** and size of **research and development (R&D) intensive industries whose products are based on new technology** because the merging of science and technology is leading to the development of new industries and changes in established service-based industries that are changing the economic status of nations, their competitive ranking and creating new ways to sustain economic growth.

1.3 Canada's Weak Science and Technology Position

Canada starts from a comparatively weak position in meeting the science and technology (S&T) challenge. Canada spends less on research and development (R&D) as a percentage of Gross Domestic Product than all but a handful of the Organization for Economic Cooperation and Development (OECD) countries. (Appendix A presents a full picture of Canada's S&T position.) The Canadian industry research base is particularly small and, with a few exceptions, falls seriously below the levels of spending in the other major industrialized countries.

Canada's R&D position can be summarized briefly:

- low government spending on R&D;
- low industry spending on R&D;
- low government support for industry-based R&D; and
- an emphasis on government support to government labs and basic research in universities, creating surrogates for an inadequate industrial research base.

Table 1 compares Canada with seven other countries on measures of S&T competitiveness.

The limited industrial base for new technology, especially science-based technology, is highly vulnerable. Much of the country's S&T is performed by small- and medium-sized firms that must put their entire companies at risk with each new major technological investment. A positive policy environment for this part of our economy is very different from one for many other parts of the economy; these firms require specific strategies.

The traditional resource and manufacturing components of the economy present another picture. Companies in these industries have historically spent much less on R&D, but many of these companies are now going through technological transformations. Automotive, steel and forest product industries will continue to be critical to exports and income-generation in this country for many years. Their competitive survival depends on technology diffusion and many firms are seeking advanced international capabilities and strategic relationships. These industries have become important buyers of technology and provide an attractive market for innovative firms in this country. The Industry Committee found the technological needs of the traditional resource and manufacturing industries

differ substantially from the high technology sectors. Targeted strategies are required for them as well.

Table 1
Canada's Science and Technology Performance

Measure of Science and Technology Competitiveness	Canada's Rank Among Eight Comparative Countries*
Gross R&D expenditures as % 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
Domestic patents granted per 100,000 inhabitants	2nd Lowest
International patents granted (by population)	Lowest
Advanced degrees awarded (by population)	Middle
Scientists and engineers in labour force (by population)	Lowest
Number of technology-intensive industries with positive trade balance	Lowest

* Canada, U.S., Germany, France, Sweden, U.K., Netherlands, Japan
Source: see Exhibits 1-11 in Appendix A

Industry R&D is concentrated in a small part of Canadian business. As discussed in Appendix A, only six Canadian industries qualify as R&D intensive by statistical standards:

- engineering and scientific services;
- aircraft and parts;
- telecommunications equipment;
- other electronic equipment;
- computer services; and
- electronic parts and components.

These industries represented only 4.5 per cent of Canada's total industrial sales in 1985 (by companies performing R&D), but they accounted for 46.5 per cent of Canada's total industry funded R&D. These industries also claim a disproportionate share of the R&D growth. R&D expenditures in these six industries grew by 324 per cent since 1978; R&D expenditures in the other industries increased by only 179 per cent (See Figure 1).

This growth was crucial to the technological advancement of the economy. However, much of the technological effort concentrated on development. The industrial R&D effort in the country remains precariously weak in longer term applied research. In fact, few companies have any significant longer term applied research capabilities. As Canada faces intensifying industrial competition, it falls far short of the concerted efforts in other countries. They are building stronger applied research capabilities and accelerating the transformation of research results into marketable commodities. Canada's weakness is serious today; it could be disastrous for the competitiveness of the economy in the years to come.

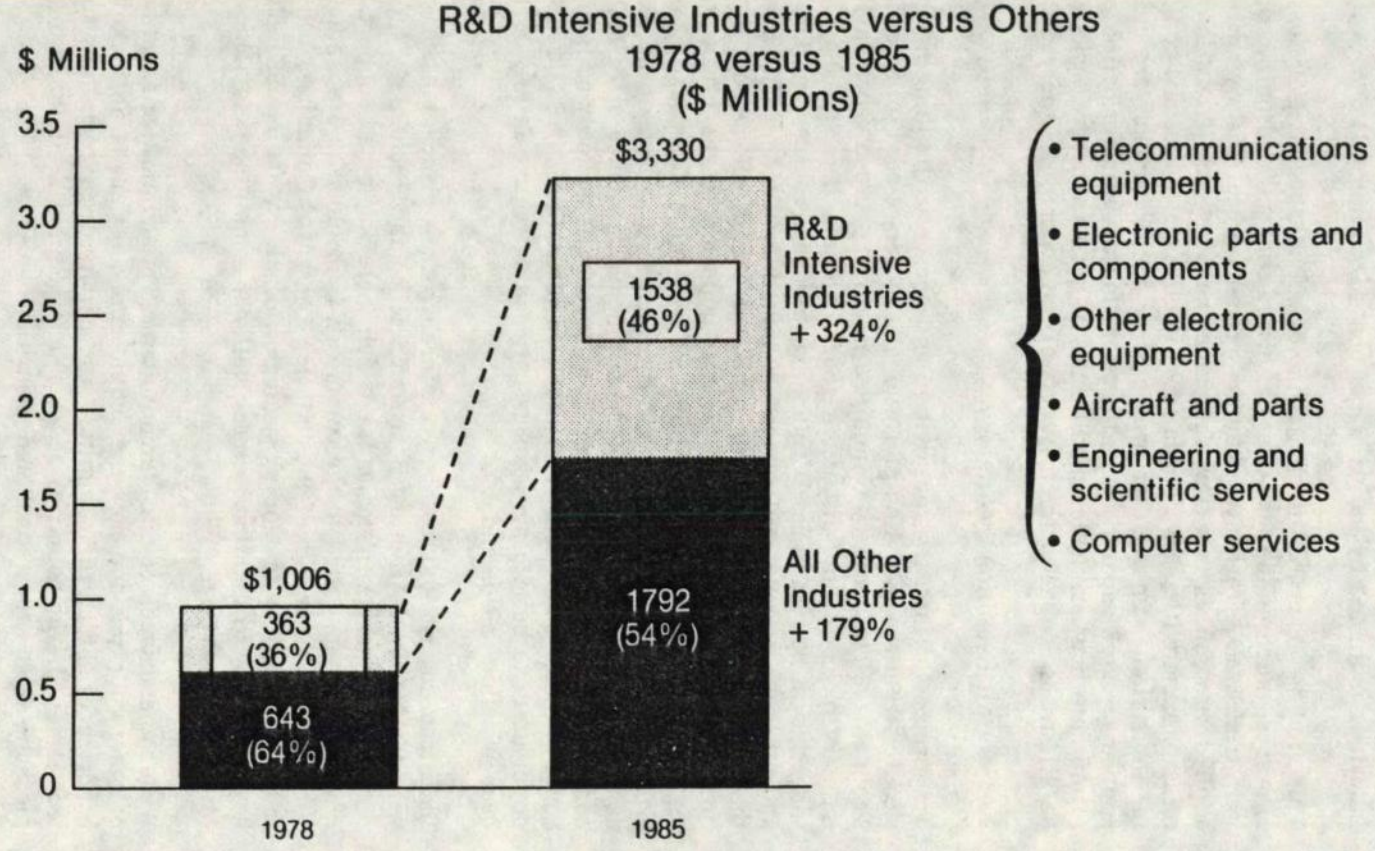
1.4 An Evolutionary Strategy

The process of industry consultation and consensus-building has progressed steadily from the inception of National Advisory Board on Science and Technology. The Industry Committee involved a broad representation of Canadian industry in its ongoing discussion. (See Appendix B for a list.) These groups suggested initiatives in R&D financing, human resources, marketing, procurement and other areas - many of which we have drawn upon.[1] This committee believes the consultative process and approach that is being developed, limited as it is due to circumstances at this stage, is as important as the advice we are tendering. The adversarial relationships between business and government in Canada are counterproductive and dysfunctional in developing S&T strategies. Key competitor nations are showing the strategic importance of formal and informal consensus-building mechanisms. Our approach is not only counterproductive, it could also cast a competitive gridlock on the nation. NABST represents a unique opportunity to build a new consensus reaching regime in this country and has been working to this end.

Industries contributed to this work through their associations. In consultation with the National Advisory Board on Science and Technology Industry Committee, they tried to define strategies for which there was broad support. (A summary of the strategies suggested to the committee is included in Appendix C, Analysis of Responses by Members of the Industry Consensus Committee.) Involving different industry groups in developing strategies to achieve the NABST objectives could go a long way to building a strong national commitment to achieve the Prime Minister's vision.

With the assistance of outside consultants,[2] the committee examined S&T policies of other countries and how they could apply to Canada. In looking at experiences abroad the committee was alert to discovering how successful technology-driven countries developed joint private-public sector consensus mechanisms to set national S&T priorities.

Figure 1
Total Intramural Industry R&D Expenditures



Source: Statistics Canada, *Science Statistics*, Volume 11, No. 5, April 1987
Note that total intramural industry R&D expenditures include funding from all sources, including government.

A consensus mechanism can be considered a partnership between the private sector and government to develop a shared vision of national S&T goals. All parties must agree and commit to national S&T strategies based on those goals. Such a mechanism should be able to establish how the nation's private and public resources can be used to transform our industrial R&D base to meet the objectives set out in this report. This process could help focus our publicly funded R&D resources on enhancing the development of a strong entrepreneurial industrial R&D capability. A nation with 3 per cent of the population of the developed world must optimize the use of its limited resources if it is to build an industrial R&D capability competitive with other developed nations. A much more clearly defined private and public sector consensus on S&T priorities in Canada is required before we can hope to achieve such an optimization.

An essential outcome of our review of what other countries are doing and our industry discussions to this point has been the identification of the guiding principles for any effective consensus mechanism for setting a national science and technology vision and policy. These principles are not just those that we see as critical to the continuation of the consensus development that has taken place up to now through NABST, but they are consistent with the lessons and experiences of those other countries that have advanced their international competitiveness through effective consensus making.

Principles for a Canadian Science and Technology Consensus Mechanism

- Governments, industry, labour and the academic community must trust each other.
- There must be national leadership with a clearly defined vision of a technologically advanced and competitive Canadian economy.
- National S&T priorities must be industry-driven.
- All important and relevant political structures, provincial and federal, must be involved and committed to the success of the effort.
- Industry and government must participate at the most senior levels.
- All strategies must be developed with bottom up participation of companies and research organizations and take into account the need to build consensus among all those groups.
- S&T policy should be linked implicitly with policies to enhance social harmony and social justice in the country.
- Resources allocated to S&T should be seen as an investment and not an expense.

The key to developing a consensus-building capability in Canada is clarifying the roles of the individuals involved in S&T. Business, government, universities and labour are active players in the S&T agenda of this country. For some, their roles have emerged through a history of experience and adaptation. Others assumed roles derived from collectively held expectations and unexamined assumptions. All these players in S&T found that the current pressures of technological change, industrial adjustment and economic survival focused attention on two central policy questions: is the role of each player appropriately defined and are we adequately funding the right things?

1.5 Clarifying the Roles of Key Players in Science and Technology

Any national approach to S&T must ensure as much as possible that resource allocation decisions are made with a fairly clear set of institutional expectations. For business, government, universities and labour, current roles and expectations developed over time and now guide the missions and performance of the players. But it is increasingly important to resolve whether they are the right roles. 'Right' means whether they are using to best advantage Canada's scarce S&T resources. Are they reflecting the experience and lessons of countries that are S&T leaders? And are they the right roles in terms of where financial resources get allocated to advance the economic growth and competitive strengths of this society?

Canada evolved through mixed public-private involvement in economic development. Crown agencies played an important part in industrial development and some Crown Corporations such as Polysar, AECL and the provincial hydro organizations are research leaders in their fields. Private sector firms such as Northern Telecom, Pratt & Whitney, Alcan and Gandalf all established internationally recognized competitive advantages through their S&T efforts. But as emphasized earlier in this report, the combined efforts of our industries in S&T are not adequate to assure our future prosperity.

Looking back, Canada's limited R&D activity has been a public policy concern for many years. The Science Council was created in the 1960s to give visibility and prominence to the role of science in our society; Lamontagne raised serious concerns about Canada's limited S&T efforts in the early 1970s; and governments have taken many measures since then to give new priority to S&T in their organizations and programs. Although these helped increase R&D in Canada, we consistently lost ground to our leading competitors in S&T. This failure was caused by a slow transition to an R&D culture with an attendant lack of national commitment in industry and government to close the S&T gap.

1.6 The Creation of Surrogates for Industrial Research

In many instances, government and universities redressed the limited level of private sector research by carrying out the research themselves, becoming surrogates for industrial research. The federal government, through its departments and agencies, is the predominant research organization in the country. In some resource sectors, fragmented industrial structures provided the rationale for a coordinated research effort on the part of government. In the emerging technology sectors, the sheer lack of a corporate base or presence also reinforced a rationale for establishing government labs. Moreover, the relatively large scale of government research over time creates an inertia and bias toward doing more and more in-house research.

Universities have sought increasing levels of industry-related R&D funding to help offset the financial squeeze they are facing. New efforts focus on doing contract research, establishing university-industry centres for research and casting proposals for university research funding in terms of its benefits for industrial competitiveness.

Despite all these efforts, the level of industrial R&D in Canada remains significantly below that of our key competitor nations. As Appendix A indicates, neither the resource orientation nor the branch plant nature of the country sufficiently explain this relatively weak effort. Both government and universities sought expanded research roles to help fill the industrial research gap. As government and universities carried out S&T for industry-related purposes, however, roles blurred and the guiding expectations for what each institution did best became confused.

1.7 The Lessons from Abroad on Appropriate Roles

The committee studied S&T policy lessons from the United States, Sweden, Germany, France, the United Kingdom, the European Economic Community (EEC) and Japan. It found some fairly clear role expectations which are consistent across most of these jurisdictions. Although not obviating the need for effective cooperation and coordination among all institutions, each country identified and built its strategies around the special strengths of its key players. The committee offers four observations on S&T roles in other countries:

a) Industry abroad is seen as the driving force in the development of competitive S&T. The commercial market place is too far removed from non-industrial players; research resources expended outside of industry for competitive ends are, in most cases, used less effectively. Public resources for industry-related R&D in most of the countries are allocated as much as possible for use by the private sector. The extreme in this regard is, of course, Japan. But the United States clearly follows this direction and the Europeans are increasingly moving this way as well. For example, industry in the United States receives 52 per cent of federal government R&D funding versus 18 per cent in Canada.

b) Universities are looked to for basic research and their vital function of developing graduates. In the United States, universities receive 60 per cent of federal government funding for basic research.

c) Governments themselves play a key policy coordination role and a more targeted applied research role. The primary policy concern is with economic growth. The priorities appear to be helping build an essential industry-research scale in key emerging technologies. Often this means lengthening the research horizons of industry. (The Japanese experience in very large-scale integrated (VLSI) microelectronic technology is a classic example of industry and government identifying the critical long-term applied research problems facing industry and attacking them jointly.) Governments also find ways to accelerate and intensify the transfer of technology toward commercial ends. Europe, Japan and the United States have all launched major S&T projects with industry. Better linkages are encouraged between industry and universities and cooperative pre-competitive research is being sponsored between companies.

   Government in-house research is becoming more and more mission-oriented. Much more than half the spending in United States government labs is on

development work, with more than 80 per cent on applied R&D. Japan is even more commercially driven. Moreover, all the major OECD countries are intensifying efforts to link government research organizations with private sector clients. They are also increasingly using industry guidance and direction to shape the research programs of these organizations.

d) Although relatively well-defined institutional roles exist in most of the countries studied, all are endeavouring to build flexibility into their systems. They are asking questions about what their institutions do best. They are also seeking ways to integrate organizations more effectively and use these linkages as important competitive tools. The overriding objective for all is to allocate S&T resources in the most effective ways. The roles that have emerged recognize institutional differences and unique strengths.

1.8 Recommended Roles for Science and Technology Players in Canada

These questions about roles are especially relevant for Canada. The experiences of other countries suggest the acute need for clarifying Canadian roles. The committee suggests the following are appropriate roles for key players in Canada:

Industry: There can be no surrogate for industry research. National resource allocation decisions must seek to increase applied R&D in industry.

Universities: Expectations of what the universities can do in the field of commercially related research need to be dampened. Although coordination between industry and universities will need to be continually strengthened, the driving force should be based in industry for applied R&D. Universities should continue to be pre-eminent in basic research.

Government: Government research, except that dedicated to clearly defined public missions like environmental protection, setting standards and defence, must increasingly be tied to an industrial client base. It must be driven by market needs and specific long-term national missions. Why government does research and when it is truly useful must be critically assessed. The resource allocation bias should be toward industry for both existing and possible new resources.

1.9 The Goal: Increasing Research and Development as a Percentage of Gross Domestic Product

Enhancing our fragile industrial R&D base requires a commitment by industry and government. They must raise our level of activity to compete with comparable nations producing tradeable goods and services. Given our present economic culture and the mechanisms other countries use to support longer term, high-risk, industrial R&D, the government must make a significantly greater investment in R&D. This is in addition to providing appropriate climate-setting mechanisms to enhance private sector R&D spending. Such investment must be done in a manner that leads to a stronger corporate commitment and investment

in building an industrial R&D base in Canada. Although our country periodically sets R&D expenditure targets, for many reasons it fails to achieve them. If our industrial base is to compete in today's global economy, Canada must be prepared to substantially increase its present R&D expenditures as a percentage of GDP within 10 years. If we want to double R&D expenditures as a percentage of GDP, the additional investment in today's dollars would total about $8-9 billion. To achieve this increase requires a combined effort of industry and government. It is difficult for government to increase its support for research if there is not an industrial base committed to significant R&D activity. The failure of many of our established manufacturing and resource industries to do R&D at the same level as their competitors in other countries - such as the United States - is serious. For those firms in Canada that make a substantial commitment to R&D, government assistance must be comparable to that available in other countries - which it is not today.

RECOMMENDATION

To set an achievable target of R&D as a percentage of GDP without the combined commitment of industry and government is meaningless. The committee believes it would be valuable if the government of Canada, in consultation with industry, could set a realistic target for our expenditures on R&D as a percentage of GDP. At a minimum we should try to achieve levels comparable to our competitors.

1.10 The Need for More Industry-Driven Research and Development

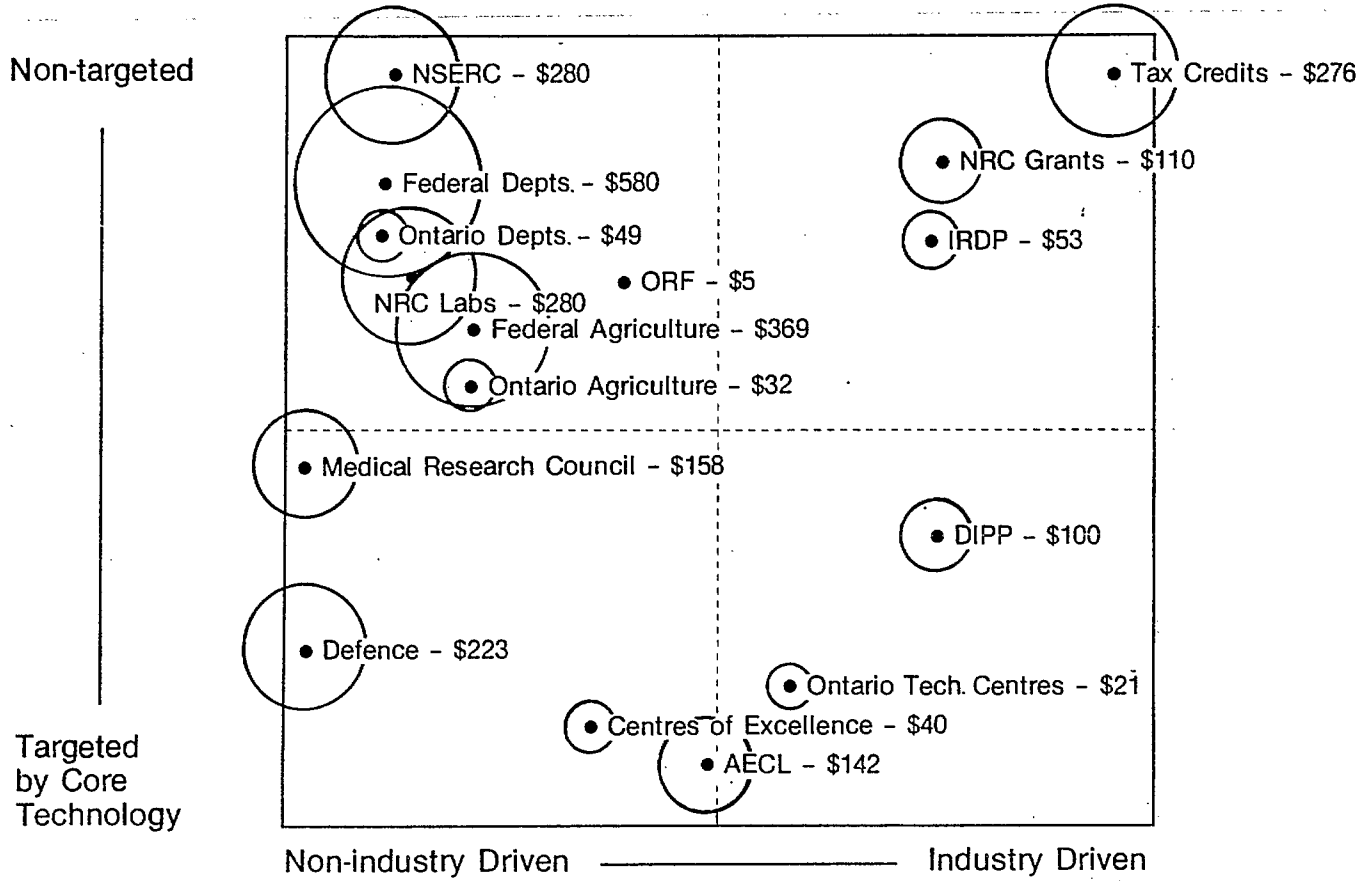
There is a need now to shift some of the resources allocated by government for in-house R&D to industry-based R&D. This need is especially urgent because so much government R&D is skewed toward non-targeted and non-industry driven activities (see Figure 2). While Canadian R&D activity is low by practically all measures, the amount of R&D performed in government labs is about average compared with the other OECD countries (see Exhibit 4 in Appendix A). Our proposed policy direction for reducing the level of in-house government research is quite consistent with the economic imperative of increasing the level of industrial R&D in Canada.

RECOMMENDATION

The federal government should shift 10 per cent of its in-house expenditures on S&T to industry-driven R&D during the next three years. This should be achieved by cutting the administrative overhead in science and related activity expenditures and by eliminating in-house government research, which is not clearly mission-driven. This should absolutely not be a 10 per cent cut across the board but rather a selective pruning of unnecessary non-mission driven activities.

The creation of a strong industrial R&D base from our present weak base is a formidable challenge. The objectives set out at the beginning of this report clearly indicate what must be done. If our existing industry base is not prepared to commit its resources to establishing new R&D capabilities and strengthening existing capabilities, then reallocating government R&D resources to industrial

Figure 2
Distribution of Ontario and Federal Government R&D, 1986-87



Note: The area of the circle represents R&D expenditures in millions, as reported by Statistics Canada, 1986-87.

Source: Canada Consulting and Telesis analysis for the Premier's Council in Ontario based on Statistics Canada data and hundreds of interviews with government departments and industry

R&D will have little or no effect. The base of firms that understand the importance of S&T for their future growth is small; we must, however, concentrate on these firms. Any strategies for enhancing industrial R&D must give high priority to mechanisms that encourage the growth of these firms. Established industries that recognize the importance of building or enhancing their R&D capability for future economic growth should also be a key focus of any initial strategies. Government funds to support industrially based R&D should be targeted to firms that create new technology for world markets or that effectively use new technologies to maintain or improve the quality of their products and services, and increase their productivity. If industry does not allocate increasing resources to R&D, then there is little reason to increase government support for R&D in Canada. Moreover, the government must focus its increasing allocation of public resources to industrial R&D on programs that assist companies and industries that are making significant commitments to S&T based innovation and productivity improvement.

1.11 Government Funding for Industrial Research and Development Must be Comparable to Other Countries

The recommendation to shift federal in-house S&T expenditures does not diminish the importance to Canada of expanding total expenditures on S&T. Canada's level of government support for industrial R&D falls seriously short of our key competitors. Tax support is the strength of our policy approach, but we are not competitive in total government assistance to industrial R&D when compared with the United States, the United Kingdom, France and Germany (see Table 2). Together, tax and non-tax assistance measures fund up to 40 per cent of industrial R&D in these countries (see Exhibit 21 in Appendix A).

Table 2
Tax and Non-Tax Government Support for Industrial Research and Development as a Percentage of Research and Development Performed in Industry

Country	Non-Tax Support	Tax Support	Total Support
United States	33%	7%	40%
United Kingdom	29%	8%	37%
France	22%	7%	29%
Germany	18%	6%	24%
Canada	**12%**	**8%**	**20%**

Source: see Appendix A, Exhibit 20

The conclusion to be taken from our competitors is two-fold. The government commitment must be primarily to industry-driven R&D, and it must compensate for the high degree of non-tax support given to foreign competitors. Canada will need to look at both tax and non-tax means of making up this competitive disadvantage.

RECOMMENDATION

The proportion of Canadian industrial R&D paid for by government must be increased from 20 per cent to 25 per cent over the next five years. In other words, if industrial R&D doubled in five years, the government support to industrial R&D would increase by 125 per cent. This would bring Canada's industrial R&D support only to the level of Germany and still far below the United States and the United Kingdom.

Reaching the 25 per cent target could be done in many ways. The tax credit for R&D could be increased and the definition of qualifying expenditures broadened. Pre-competitive research in industry could be directly supported by grants and similar funding. Prototype R&D funding related to government procurement could be expanded - especially to balance, albeit in a small way, the massive U.S. spending in defence-related R&D in industry.

No single mechanism will suffice. Tax credits, for example, are efficient and fair in administration, but they would not be able to support much of the longer term, high-risk research of importance to industry. (Possible mechanisms for increasing government support to industrial R&D are discussed later in this paper.)

Provincial governments must also recognize that they need to increase their commitments to industrial R&D. Most provinces, like the federal government, also spend the bulk of their R&D internally. A commitment by each province to increase its spending on industrial R&D by 25 per cent more than the rate of increase in private sector R&D funding would complement the greater federal commitment to industrial R&D recommended above. It would also assist Canadian industry in recovering some of its international competitive disadvantage in government support for industrial R&D.

1.12 Realigning Government Research

The committee's recommendation to shift a proportion of government in-house R&D expenditure to industry is a decisive first step in advancing Canada's industrial R&D capability. At the same time, it shifts government into a role that is appropriate for the recognized scarcity of S&T resources in this country. As part of this role, government in-house industrial related research must become mission-oriented and driven by industry.

RECOMMENDATION

The federal government must align its industrial related research to an almost total mission orientation with specific industrial clients over the next three years.

The committee recognizes that its recommendations require a major change in the commitment of industry to advance its R&D capability. Government labs are an important Canadian resource. Too often they are cast as a capability in search of a client. They cannot work to their full effect unless there is a dedicated and determined industrial capability that sets the expectations and standards for performance. Without an expanded industry commitment and capability, the prospects are limited. Continuing government investment in S&T would yield an unsatisfactory return to the public.

As the government begins to realign its industrial related research to a mission orientation, some existing activities could be shut down and S&T workers displaced. Canada must be careful not to lose the services of these valuable people; adjustment mechanisms must be put in place to assist them to move to areas of growing R&D activity - especially in industry.

There is a pressing need for action. The next section sets out a strategic framework for advancing the commitment and capability for industry-driven S&T and for making the most of the unique strengths of all the key players.

1.13 Strategies for Achieving Greater Industrial Research and Development

The committee proposed a target of doubling R&D expenditures in Canada as a percentage of GDP and increasing government assistance to industry to 25 per cent of every dollar spent. These objectives could be achieved in many ways. Based on discussions with industry groups and individual companies, the NABST Industry Committee formed a strategic framework for viewing the S&T priorities of industry. It has seven components:

- financing company R&D;
- risk-sharing in product development and marketing;
- encouraging procurement opportunities;
- sustaining pre-competitive research;
- building human resources;
- diffusing new technologies; and
- increasing S&T awareness.

Government and industry have opportunities to work together more closely in each of these seven areas. Moreover, if S&T funds now spent internally are put to work in industry with a commitment to S&T, each of these seven areas hold major opportunities for new or expanded initiatives. Based on discussions with industry, the committee identified specific programs that could implement the strategies and meet the needs expressed by Canadian industry. It does not recommend that each initiative be taken immediately; rather, this represents an

agenda from which the government could choose several ideas for early execution.

1.13.1 Financing Company Research and Development

Comparisons among OECD countries of total government assistance to industrial R&D find Canada at the low end of the scale. Taking non-tax support (e.g., grants, R&D contracts including defence) and tax support together, about 20 per cent of all R&D performed in Canadian industries is financed by government (federal and provincial).

This is only half the support in the United States, where 40 per cent of all industrial R&D is financed by government. In the United Kingdom government support is 37 per cent, in France 29 per cent and in Germany 24 per cent. Canada's R&D tax incentives are at least as generous as each of these countries, but our non-tax support is much lower. Expressed as a percentage of GDP, government assistance to industrial R&D in Canada looks even smaller; Canada's government assistance is only one-sixth of the U.S. rate and one-quarter to one-third of what industry receives in the United Kingdom, Germany and France. Given the high level of non-tax support for R&D in these countries and their already high levels of industry-funded R&D, Canada's tax support would have to be much higher than theirs, rather than comparable, to create a more level playing field.

The NABST Industry Committee generally prefers R&D investment tax credits (ITCs) to grants, consistent with OECD finding that the R&D tax credit is the most favoured government funding mechanism among its member countries. The industry associations that met with the Industry Committee also preferred ITCs. R&D tax credits involve the least government intervention and administration. They also allow maximum market influence on private spending decisions. At the same time, the committee recognizes that there is a role for grants and other mechanisms that can help provide investment capital for R&D spenders. Longer term applied research cannot be easily financed by tax credits; it usually needs direct government assistance. In most other countries a mix of tax and non-tax assistance is available, although in all cases the research priorities are industry-driven.

Proposed Tax Reform

The principles of a more equitable tax system and lower tax rates in the 1987 White Paper on Tax Reform are generally well-supported by industry. However, three aspects of the proposed tax reform, when examined in the context of government support for industrial R&D, do not reinforce the Prime Minister's stated goal of strengthening our competitive advantages around S&T:

a) The tax credit for R&D costs would stay at current levels (excluding R&D buildings), but the use of ITCs would be restricted to 50 per cent of the federal tax payable.[3] For most industries, this limit will have no effect. The penalty would be severe for Canada's R&D intensive industries, however, and they account for about half of the country's industrial R&D. There would be

an annual cash flow reduction of about $85 million (based on 1985 spending) equivalent to almost 1 per cent of their revenues or 20-25 per cent of their after-tax earnings.[4]

b) Building and rental costs would be ineligible for R&D tax credits, in response to perceived abuse in claiming buildings for R&D. Since it still remains necessary to provide facilities for R&D, companies will find it more difficult to justify sufficient building capital (versus other capital spending opportunities) to ensure optimal provision of internationally competitive R&D facilities in the future. (Examples include the special facilities required for biotechnology, materials and semiconductor R&D.) The annual cost of this measure (for industries not already restricted by the ITC cap) is estimated at $10-15 million.

c) The federal sales tax portion of the proposed marketing company rules apparently give a cost advantage to those companies which market goods in Canada but do not manufacture them here. This rule could encourage some foreign-based multinationals to establish franchise operations to sell their goods in Canada rather than invest in manufacturing and R&D operations here.

Revenue Canada Activities

Revenue Canada is striving to ensure fair application of rules for claiming R&D credits, but many R&D intensive companies are concerned. Among actions cited by industry as adverse to R&D are:

a) Revenue Canada's Information Circular 86-4 of August 29, 1986. Industry considers this a more rigorous definition of what activities qualify as R&D. The emphasis on criteria of scientific advancement and uncertainty show a bias for research and against development. Given that the largest part of Canada's industrial R&D activities are for the development of applications using new technology, the new definition is seen as unfairly restrictive. Company estimates of reduction of expenditures qualifying as R&D because of the new definition range from 15 to 25 per cent.[5]

b) The lengthy audit procedure when a company claims a tax credit delays ITC refunds for some companies by one and a half to two years. For small companies, this can create major cash flow problems.

c) The audit procedure also requires an in-depth explanation of a company's R&D activities. This can place an extraordinary demand on a company's R&D professionals, diverting significant time and effort away from R&D work itself and reducing that company's R&D competitiveness.

RECOMMENDATION

The government should not implement the white paper recommendations on R&D taxation, specifically:

a) **R&D tax credits should continue to be allowed to reduce a company's federal tax without being capped.**

b) **Unused R&D tax credits should have an unlimited carry-over period and should continue to be partially refundable to a 20 per cent maximum.**

c) **Deductions for qualifying R&D expenditures on buildings and equipment, for both capital write-offs and ITCs, should be retained, with consideration given to determining appropriate time frames for write-offs.**

In addition, the government should move to improve the usefulness of the existing tax incentives, specifically:

a) **Interpretation of eligibility for R&D tax credits should be widened to include expenditures on industrial development of new products and technology.**

b) **The R&D tax credit claiming and audit procedure should be streamlined to find ways to get refunds to claimants more quickly.**

c) **The Prime Minister should make a special appeal to the provinces to stop taxing the R&D ITCs.**

Grants

Grants are particularly useful for smaller companies and for large, long-term and risky development initiatives. Government grants can play a major role in encouraging industry to undertake important yet uncertain R&D projects instead of sticking with safe, short-term investments with less potential for major benefits for the Canadian economy.

Investment Capital

Limited availability of capital is a major barrier facing Canada's threshold new technology companies as they strive to compete effectively in the global arena of world-scale competition.

RECOMMENDATION

Technology-directed investment programs should be enhanced. This will stimulate the flow of individual and corporate investment capital to Canadian companies attempting to take advantage of technology-related opportunities.

One possibility is a specially certified innovation share that would provide a substantial tax write-off for investors. Such a program could be modelled on the highly successful Quebec Stock Savings Plan (QSSP) which encouraged the flow of investment capital to developing and medium-sized firms in that province.

1.13.2 Sharing Risks in Product Development and Marketing

In most of its high technology industries, Canada is faced with structural weaknesses that suggest that government should view its role only in terms of assistance to R&D. Of equal or greater importance to many small- and medium-sized Canadian technology-driven firms is that the cost of developing a prototype and final design, and marketing a product can be 10-20 times the cost of the product's original R&D.

In today's high technology market a company must launch its product in all major countries simultaneously. No firm can expect to build sales at home for one to two years before tackling export markets. In one to two years, foreign markets will be full of competitors' products.

This problem is more severe for Canada than other countries because we have so few technology-driven, world-scale, multinational firms indigenous to our country. Indigenous firms direct their R&D, marketing and strategy for their core products from a Canadian base. They may or may not be Canadian. Northern Telecom is an indigenous company, but so is Pratt & Whitney Canada, the U.S. multinational. Many other successful industrialized countries have this technologically advanced, world-scale, indigenous core, even countries as small as Sweden, Switzerland and the Netherlands.

Canada does have dozens of small- to medium-sized new technology companies with $10-$200 million in sales, but they are, or soon will be, competing with much larger competitors in other countries. Globally, a multinational with $200 million in sales is still a very small company. The Canadian high technology challenge is developing many true Canadian world-scale multinationals from this group of threshold technology companies. We will have difficulty sustaining a competitive position in advanced technology without such a core of large firms. There are too many businesses where success depends on global scale in manufacturing, marketing, advertising, product service, applications engineering, R&D or other competitive factors.

Moreover, only large multinationals with some product line diversity can withstand the inevitable new product missteps that occur in fast changing technology businesses. If Hitachi, General Electric or Philips blunders in one business, the whole company is not threatened. In most Canadian small- to medium-sized new technology firms, each new product generation is a "bet the company" proposition. If the product fails, the company fails with it despite the company's strengths.

The high cost of final product development and marketing, the need for simultaneous entry of world markets and the "bet the company" problem mean that R&D incentives only begin to solve the disadvantages of small scale for most Canadian high technology firms. The government should consider sharing the risk of high technology products through all phases of their development.

Sweden, Japan and Ontario (to start next year) all developed special conditionally reimbursable loan funds to aid such companies. The loans are for up to 50 per

cent of total project financing (including R&D prototypes and marketing) on new advanced technology products. The loans bear above-market rates of interest (to discourage firms only seeking cheap financing) if the project succeeds, but are forgiven if the project fails. In Canada, such a risk-sharing loan fund would enable medium-sized technology firms to make more of the faster 'bets' on new products and ensure that global marketing is done properly. It would extend the incentive value of current R&D assistance by helping to assure that research ideas become fully backed products. In Sweden, the fund operated in the black after its initial capitalization.

RECOMMENDATION

The federal government should establish a product risk-sharing, conditionally reimbursable loan fund to assist threshold technology firms with new product development, launch and marketing.

The committee's industry consultations suggested several other ways to help threshold Canadian technology companies with their final product development and marketing. The government could develop a prototype financing program to assist Canadian technology firms in placing early versions of their products in the hands of customers. Such financing accelerates the product development cycle and speeds customer feedback on new product designs and features. Japan's prototype financing was very effective for its computer industry.

RECOMMENDATION

Low-cost prototype financing should be made available to accelerate the placing of new high technology products with key customers.

Another type of marketing assistance would be creating industry-managed marketing information networks. These would assemble market information abroad and funnel it back to small and medium high technology firms in Canada. Such networks are effective in other countries when they are industry-managed and industry pays a substantial portion of the costs. These networks could be an area of fruitful government-industry cooperation in Canada.

RECOMMENDATION

The federal government, working with the private sector, should establish industry-managed marketing information networks using the latest available electronic technology.

1.13.3 Encouraging Procurement Opportunities

Many of Canada's industrial competitors use the power of government procurement to develop advanced technology industries. In France, for example, high-speed trains, military and civilian aerospace, nuclear power generation and offshore oil equipment export products were originally developed for French government purchases. The United States, through its massive defence purchasing, supports a wide range of technologically advanced companies. Many

U.S. defence contracts have an R&D override clause that allows contractors to charge 1 to 2 per cent of the contract for R&D related to the contract but not actually for the same products. The U.S. Defense Department also contracts directly for R&D with U.S. firms.

Canada has not used the procurement lever very effectively. Research found that federal contracts, despite proclaimed policy, often do not favour Canadian firms and that federal procurement officials are ignorant of the competitive dynamics of the industries involved and thus make poor decisions. Canadian firms are often consigned to subcontractor status to foreign firms. This may seem beneficial for these Canadian firms, but procurement benefits are sharply reduced because the Canadian firm does not interact with end-users and therefore does not increase its understanding of their needs. Many small Canadian firms are stuck in the role of being original equipment suppliers and need help in breaking out. The policy questions in this area are summarized well by the NABST Government Procurement Committee.

Canadian procurement procedures do not view procurement as a series of enabling steps that assist Canadian firms in developing world competitive technology - this is the root problem. Typically, Canadian procurement creates specifications internally and then asks for bids on well-defined product criteria. This approach usually leads to buying off-the-shelf technology from foreign companies. Canadian firms are then forced to scramble to be component suppliers under some offset arrangement. Consequently, very few government purchases ever lead to major new Canadian products.

Procurement would be more effective if the government invited Canadian firms to get involved in defining the needs of the government and experimenting with new ways of meeting those needs. This can be done through enabling R&D contracts and procurement of designs and prototypes. Once a product is ready to go out for a full bid, onde or more Canadian firms should be able to meet the technological requirements and possibly have a working prototype with unique features not yet on the market.

To make enabling and nurturing procurement serve effectively, the government must also:

a) emphasize buying in scale from one source (e.g., one large contract for a system rather than many small ones);

b) make long-term commitments for products to allow Canadian firms to reach an efficient production scale and recover their R&D costs; and

c) make long-term procurement plans identifying opportunities well ahead of time.

The incentives for taking risks on procurement from Canadian firms must also be increased relative to the current overriding imperative of the federal government to buy as cheaply as possible and mostly off-the-shelf. Making a major change in

procurement practice probably requires a new initiative to overcome the natural conservatism of the current purchasing system.

RECOMMENDATION

The government should introduce a new council on procurement with prominent individuals from the private sector to support enabling-technology development. This council would conduct its own analysis and target areas of Canadian technological strength where government purchasing could play a major role in fostering the development of world-class Canadian products. If these areas were carefully chosen in consultation with industry, free trade problems could be somewhat minimized by selecting areas of legitimate Canadian strength which would not attract significant American interest. The council would be an independent voice in government for the long-term view of using procurement to support emerging Canadian industry.

The government should also place more research contracts with industry rather than government labs. Research contracted to industry is more likely to result in commercial spin-offs and other benefits (See the discussion of U.S. defence R&D in Appendix A).

1.13.4 Sustaining Pre-Competitive Research

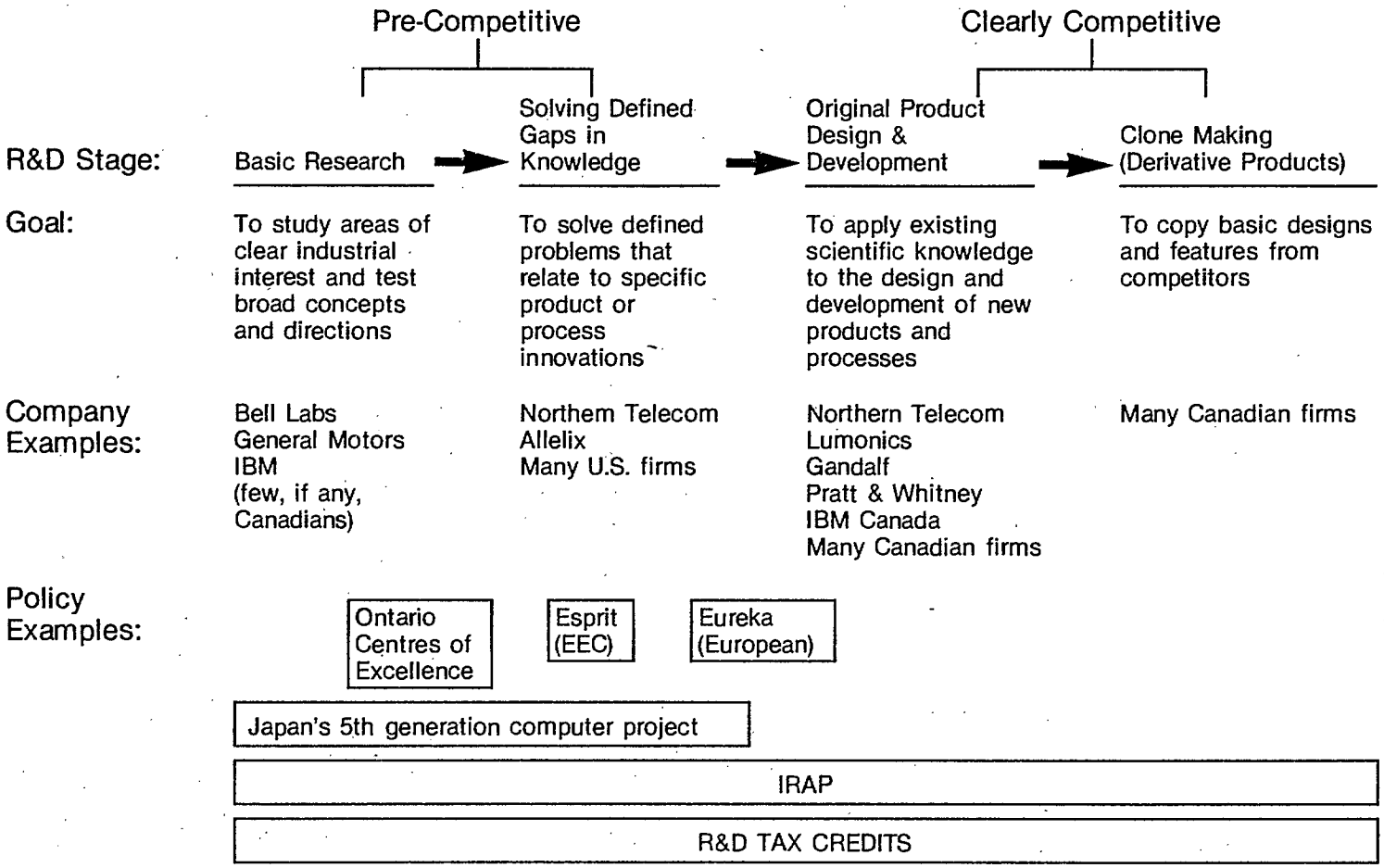
Most Canadian companies have technology horizons that do not extend beyond immediate product development. Figure 3 describes four stages of industrial R&D that are performed in world industry. In practice, Canadian firms engage mainly in competitive R&D at the product design and development stage. Few Canadian firms engage in more basic pre-competitive research. Pre-competitive research can be fairly broad in scope or clearly focused on filling gaps in basic knowledge for specific products and process innovations. Northern Telecom does work in the latter category. In the United States, Bell Labs do both broad and more focused research.

There is a need in Canada to encourage more firms to move to at least Northern Telecom's level of R&D. The need is present in metals, plastics, software, product design tools and other areas. Such pre-competitive research can best be done in Canada jointly in industry consortia that draw upon university and government laboratory support. The government should increase its joint funding with industry of such longer term pre-competitive research. The committee's industry consultations suggest that at least three vehicles could be used.

In the first place, government should assist industry consortia that voluntarily form for such purposes. Precarn, the pre-competitive research network in artificial intelligence, is an example of what such consortia can look like in Canada. Given the long-term, high-risk nature of such research, the federal government should match industry funding in such consortium efforts.

Another vehicle could be centres of excellence, like those in Ontario, involving university research and long-term, industry-based, applied research. Each centre should be in an area of existing Canadian research and industrial prowess, and

Figure 3
The Chain of Industrial R&D



Source: Developed by Telesis and Canada Consulting

seek to cement the university-industry bonds in such fields. The centres must be industry-driven, but offer some research independence to attract top scientists in world-class laboratories such as the Bell Labs and IBM.

A third opportunity would be a program like Esprit in Europe. Esprit is funded by the European Economic Community (EEC), but the European information processing industry directs the pre-competitive research enabling them to compete with U.S. and Japanese firms. Industry-defined areas of research urgency and competitive proposals were received in each. The EEC matches industry funding up to 50 per cent of total project costs. All proposals must be sponsored by two or more companies in two or more EEC countries, plus universities and other laboratories as desired. This requirement greatly increased the rate of technological exchange among European firms and countries. Esprit has the virtues of being technology-focused and industry-directed, with high leveraging of government funds. Canada could consider a similar program in several fields of broad interest to industry.

RECOMMENDATION

Canada should launch at least three major industry-initiated pre-competitive research programs before the end of 1988. This is feasible and badly needed.

1.13.5 Building Human Resources

In all the committee's consultations with industry, concern was expressed over the acute need to complement the development of Canada's industrial R&D base with the growth of technical and scientific personnel. The two are intimately dependent on each other. We can put in place the most powerful R&D incentives in the world, but they will not be effective if we do not have skilled people to do the work. On the other hand, there is no point educating our youth for employment in a knowledge-intensive economy if we have not built the advanced industrial base to create skilled employment opportunities for them.

The federal government must provide national leadership on this issue and initiatives must be taken throughout the system to improve elementary, secondary and university education. Emphasis must be placed on better mastery of fundamental reading, mathematical and scientific skills. Specific solutions must be worked out at the provincial and even school district level. Some solutions will require additional funding, but others can be achieved with new teaching methods, higher standards and curriculum changes without demanding more resources.

The federal role should be to set national targets, provide a continued spur to provincial efforts and, where appropriate, fund innovation and create incentives to break out of the rigidities of the current system. For example, the Government of Canada could set a national target of bringing the high school completion rate to more than 80 per cent in four years. As part of this, any school district that increased its real high school completion rate by 20 per cent and held the new rate for two years might receive special federal incentive

grants to enable the offering of special services. These grants would offer incentive and visibility to a critical national effort.
Efforts must also be made to enhance the quality and effectiveness of post-secondary programs, especially in the areas of S&T. There are areas of technological capability critical to our industrial base in resource sectors and traditional manufacturing where we have lost our past excellence. There are also areas of future technological importance where we have not yet established an adequate base. A separate NABST committee is making recommendations on the needs of our universities and the Industry Committee recognizes the importance of their efforts for Canadian industry.

A concern in post-secondary education deserving prompt attention is the relative absence of S&T courses from the curricula of business programs in our colleges and universities. If our future business leaders are to be comfortable managing in rapidly changing technological environments, they must master some technological basics today.

RECOMMENDATION

Programs in S&T should be developed and incorporated as part of the regular curriculum at post-secondary business schools.

Another area of critical importance for adequate human resources is the development of first-class training and retraining programs, coupled with a learning-for-life philosophy. Industry in Canada is spending rapidly increasing amounts of money on training; the federal and provincial government must be prepared to support the training mobilizations already under way in the automotive, aerospace, steel and other sectors. Committee comments and recommendations for training, responding to the Prime Minister's third question, are in the next section.

A broad Canadian problem is the low proportion of scientists and engineers in the labour force (see Table 3). A more specific concern identified by industry is that small- and medium-sized firms do not have adequate technical staff to absorb new technology or effectively interact with the existing technical capability in university and government laboratories. A program that assisted and encouraged such firms in hiring new research and engineering personnel could be very effective. When small and medium manufacturing firms (less than $50 million in sales) need to hire incremental research, development and engineering personnel, the salary costs could be subsidized by 50 per cent in their first year, 25 per cent in their second and not at all thereafter. Germany, Quebec and Ontario (at its Automotive Parts Technology Centre) all tried similar programs with success. They can be especially effective in speeding the diffusion of new technology to small firms. Incidentally, Germany manages its program through the tax system thereby minimizing administration effort.

RECOMMENDATION

A new and broadly based R&D personnel subsidy program, like those described above, should be established. Funding should be comparable to efforts in other

countries to encourage the hiring of new technical personnel in small- and medium-sized manufacturing businesses. Ideally, incentives would subsidize incremental personnel for up to two years in all qualifying firms with a minimum of paperwork. This will require a concomitant effort to encourage more small- and medium-sized companies to improve their technical capability and make all firms aware of the program.

Table 3
Total Research Scientists and Engineers
(per thousand labour force, 1983)

Country	Research Scientists and Engineers
Japan	7.4
United States	6.4
Germany	4.8
France	3.9
Sweden	3.9
Netherlands	3.7
Canada	2.7

Source: OECD Recent Results, 1979-86. The OECD notes that the Japanese data are likely overestimated. No data are available for the United Kingdom.

1.13.6 Diffusing New Technologies

The NABST Industry Committee strongly supports the principles for enabling better technology diffusion that were presented in the March 1987 MOSST InnovAction S&T strategy paper. The vital importance of rapid technology diffusion and adoption by Canadian industry is underscored by the observation that 98 per cent of all technology is developed outside Canada.

Both the Technology Inflow Program (TIP) and the Technology Outreach Program (TOP) can play major roles in identifying important new technologies and in finding means to help Canadian firms install these technologies. Industry could be more active in the transfer process by developing formal information networks, possibly by sector.

A further option for accelerating technology diffusion could be the development of licensing mechanisms, supported by government and industry, with a mission to identify important new technologies abroad, negotiate licensing arrangements and find Canadian users.

RECOMMENDATION

Increased emphasis must be given to programs that accelerate technology diffusion, especially in traditional industries.

1.13.7 Increasing Science and Technology Awareness

The NABST Industry Committee applauds the government's stated intentions to promote a science-oriented culture. It also urges the government to continue increasing its support for the wide range of programs keeping Canadians aware and supportive of our progress in S&T, including the Youth Science Foundation, the Conseil de developpement du loisir scientifique and the federal Public Awareness Program.

1.14 The Need for Enhanced Consensus-Building in Science and Technology

In the longer term, the committee is concerned that Canada does not yet have a consensus mechanism for setting S&T policy equal to those in other countries. NABST was a step forward in consultation, putting the Prime Minister, industry, labour, academics and others all at the same table. However, the newly created Department of Industry, Science and Technology (DIST) throws into question the role of NABST and also opens the longer term question of how best can industry, government, academics, labour and other interests sit down and articulate a national S&T strategy?

1.14.1 Lessons From Other Countries

Many other countries have the kind of consensus mechanism the committee is concerned with. In Japan, S&T priorities are generally set by a national committee chaired by the Prime Minister; national committees for different technologies develop specific objectives and strategies with strong industry direction.

In Sweden and Germany, S&T consensus-setting is more informal but still very real. Companies sit down with government and universities to articulate priorities together. The roles for implementation are very clearly defined.

Esprit, the EEC's $10 billion (half government, half industry) pre-competitive research program on information processing is a unique model. It has broad research allocation by the Council of Ministers, priorities set by industry only and implementation in a government-administered framework.

All of these models can be applied in some way to the Canadian context. From the Japanese model, the committee takes the view that direct prime ministerial

involvement can be a critical consensus-builder. From the Swedish and German models, the committee found that implementation roles should be defined after priorities are set. The mission for national laboratories in Germany closely follow the country's industrial priorities. From the EEC and Japan, the committee adopts the concept of industry setting all the priorities, except for pure research and specific programs in the national interest (e.g., space, defence, standards).

1.14.2 Building a Canadian Consensus

NABST was successful in building the early stages of a broadened national consensus mechanism for S&T policy. There is urgency in building on this momentum. NABST currently fills the role of providing the Prime Minister with broad outside advice, but the responsibility for developing specific strategies and allocating S&T funding among different alternatives is still mainly within the government. In Japan, Sweden, Germany and many other successful technology-driven economies, industry has a much greater role in determining how government S&T funds are spent; joint industry-government R&D strategies are typical. Canada must move in this direction. Final decisions for allocating government funds will always be a ministerial responsibility. Development of national strategies, however, both at the broad level and within sectors, must be done by consensus involving industry, academics, labour, provincial governments and other groups.

Obviously individual companies know best what is required for competitive success in their specific markets. The first requirement of any national S&T policy is to support companies in their own identified R&D priorities. But in the longer term, the high-risk research necessary for future industrial competitiveness increasingly needs government funding assistance and joint public-private sector development of strategies. In more fragmented industries where many smaller firms have limited resources, there may also be a need for government-assisted shorter term R&D. This too would be based on jointly developed strategies. If true joint strategies are developed with industry, the consensus process will increase both government and industry commitments to R&D. An effective consensus machinery would spur private sector spending on S&T above present growth trends.

NABST can be a base for building a broader consensus process and moving toward effective development of joint strategies. The committee believes NABST should continue to have a broad advisory role to the Prime Minister on S&T policy. NABST can review specific policies as requested; bring industry, academic and public S&T concerns to government attention; and make recommendations on the broad allocation of S&T funds.

NABST in its present configuration cannot do the whole job. The process of industry consensus-building on S&T priorities must be extended to the sector levels as it is in Japan, Germany, Sweden and other successful technology-driven economies. The Industry Committee would like to see sectoral committees formed under NABST with the mandate to develop sectoral S&T strategies on a consensus basis with government and academics. Sectoral committees could be organized by traditional industrial categories like aerospace or steel. They could

also be based on common technological interests, for example an advanced materials group, with interested firms from metal, aerospace, automotive and other industrial sectors participating. Each of these sector consensus groups must have senior corporate, academic and labour representation. They should also be linked to DIST.

In addition, a suitable secretariat must be established to support this broadened consensus process. This new secretariat should not only serve the consensus machinery, but also develop world-class analysis of S&T issues in Canada and a keen understanding of what major S&T developments are taking place abroad. This secretariat, if successful, would have the added benefit of stimulating high-quality data gathering and analysis in government departments on S&T issues. In other countries, competition in research and analysis of national problems is considered healthy and essential to a complete understanding of the issues.

A broadened consensus mechanism to develop joint industry-government strategies in S&T is an absolute imperative for Canada. Even the United States can no longer afford the luxury of ad hoc S&T strategies. Canada, with one-tenth the U.S. population and a smaller industrial R&D capability (even proportionally), can hardly afford to continue its equally ad hoc arrangements.

One warning is that any broadened consensus mechanism put in place by government must be strong enough to overcome the interdepartmental struggles that can balkanize the federal allocation of S&T resources. The committee wants to see the evolution of a consensus process that can identify a national vision on S&T policy that transcends current conflicts among competing interests of industry, government, academics and others. This requires an atmosphere of trust among all players. Frankly, it also requires an element of peer pressure. When all groups concerned with S&T in Canada realize that a national program is being developed that has broad and powerful support from many constituencies, even the most recalcitrant among them will likely feel compelled to get on board in the national interest.

RECOMMENDATION

The Prime Minister should broaden the consensus process already begun under NABST by establishing sectoral S&T consultation committees. They should be under a general committee concerned with a strategy that is effectively linked to DIST; this committee should be composed of senior members of business, government, labour and academics. NABST should still be responsible for policy advice to the Prime Minister and recommendations on the broad allocation of S&T resources. The sectoral committees would be asked to develop joint industry-government sectoral strategies within the broad general strategies. This broadened consensus process would require a secretariat capable of world-class S&T analysis to support both broad policy recommendations from NABST and specific strategies in the sector groups.

The evolution of the NABST consensus process described above is the only way the committee believes true industrial direction of S&T priorities can be achieved in Canada. Building informal mechanisms that are successful in more homogeneous

economies like Germany or Sweden would not be easy nor likely to succeed in Canada. The committee believes NABST should be seen as only the first phase of broad consultations. The next phase must go more directly to the heart of Canada's central S&T question: how can we create a system where all S&T players are consulted, but the competitive needs of industry set the basic priorities?

Section Two

TECHNOLOGICAL ADVANCE AND SOCIAL CHANGE

2.1 Background

A dynamic and prosperous Canadian future depends on science and technology and its associated social and economic changes. Recognizing this, the Prime Minister asked the NABST Industry Committee:

> What measures are needed to minimize the social and economic disruption and enhance the benefits of technological change, recognizing the accelerating pace of technological change and the key role of Canadian workers to Canada's economic and social goals?

To address this question, the Industry Committee formed the Social Adjustment Sub-Committee with industry, trade union, academic and government representatives.

2.1.1 A Framework for Change

> There is no alternative to technological advance: it's a matter of survival. In reality it can be a mixed blessing, since it carries the potential to create both winners and losers. But with vision, planning and careful attention to the human side of the change equation, the new technologies can be harnessed to generate prosperity and jobs.
>
> Keith Newton and Gordon Betcherman
> Economic Council of Canada, July 1987

Although the rates of social and technological change increase at an ever-growing pace, the new constant becomes the capacity of Canadians to manage change. Society's consciousness should be the context for its work and consumption; its technology, only content - tools that create products and services for people. The further application of technology encompasses the physical artifacts themselves and the knowledge to develop, operate, improve and direct them. Technology in and by itself does nothing. It is the human knowledge and direction given to it that determines its function, production and use.

The Economic Council of Canada, the OECD and many other groups conclude that economic advancement depends on technological change. It is the key to improvements in productivity, global competitiveness and employment. Rapid adoption of new technologies is therefore vital to future prosperity. Canada must pursue strategies that promote S&T developments, application and diffusion. Technological advance, however, is rarely smooth and painless. By nature, change can be disruptive and its effects are unevenly felt by different regions, industries and individuals.

These effects must be identified and studied to maximize the benefits of change and minimize the costs. Many observers contend that we are in a wave of technological change that is unparalleled in its rapidity and magnitude. This throws the problems of coping with and adjusting to change into sharper focus. Where will jobs be created, where will they be lost? How do individuals adjust? Do social institutions need to change?

2.1.2 The Industry Committee Response

The committee considered the following when studying the Prime Minister's question:

a) evidence and lessons from past technological changes and how society adjusted to them;

b) the nature of the technological changes and the apparent relationships between economic growth and social changes;

c) the opportunities for new activities that these changes will produce; and

d) the mechanisms that allow for social adjustment, while still maintaining individual self-reliance and adaptability, and minimizing social disruption.

2.2 Past Experience

Throughout the history of civilization, people have been developing and applying technologies. This was most intensive during the last 200 years, less than 0.3 per cent of the time man has existed on this planet; we have limited experience with handling major technological change in an increasingly interdependent global society. What we learned from the changes caused by the Industrial Revolution is that in the longer term these changes lead to substantial improvement in the quality of life for societies that can garner the full benefits. For example, the better social and economic conditions resulting from the Industrial Revolution were the main reasons for the increase in life expectancy from 1840 to 1960 in England and Wales; it was not better medical care. The most dominant factor was improved human nutrition that resulted from this socio-economic change.

2.2.1 The Mechanization of Agricultural Production

The changes in agriculture over the past 100 years illustrate the socio-economic changes induced by technology. In 1820 more than 70 per cent of the labour force worked on farms. In 1980 only 3 per cent worked on farms and 70 per cent of the work force had moved through manufacturing and into services and information industries. Agriculture did not disappear with its decrease in employment, it became more productive. In 1850 one farmer provided for about four other people. New labour-saving technologies, agricultural methods, management and organizational systems meant that a farmer in 1982 provided for nearly 80 other people. It is interesting to note that although few people are employed in agriculture directly, highly efficient agricultural production is still an important source of income for countries like Canada.

Agriculture shows how increased productivity displaces labour but still maintains an income-generating activity. Although direct employment in agriculture is small, the indirect employment generated by this activity is probably four times that number. These concomitant new jobs or activities are in the service and processing sectors directly related to the primary agriculture industry. Other industries that create tradeable goods and services likely also generate employment in the service sector that is directly equal to or greater than these industries' direct employment. One only has to look at the automobile industry to see the extent of the service sector linkage relationship. The relationship between enhanced economic growth and the expansion of employment in what are often classified as social and personal services is less clear.

2.2.2 Productivity That is Important for Economic Growth Depends on People

Since 1929 more than three-quarters of the increase in productivity and most of the growth in national income can be attributed to growth in on-the-job knowledge, reallocation of labour and the increase in the quality of labour through education, training and improved health. Over the same period, the amount of machine capital per worker contributed less to enhanced productivity.

The U.S. National Academy of Sciences in *Technology and Employment* (1987), stated:

> Technological change is an essential component of a dynamic expanding economy. Recent and prospective levels of technological change will not produce significant increases in total unemployment, although individuals will face painful and costly adjustments. The modern U.S. economy, in which international trade plays an increasingly important role, must generate advanced technologies rapidly in both the manufacturing and non-manufacturing sectors if growth in U.S. employment and wages is to be maintained. Rather than producing mass unemployment, technological change will make its maximum contribution by higher living standards, wages and employment levels if appropriate public and private policies are adopted to support the adjustment to new technologies.

This is one view of what technological change will encompass; others are uncertain that additional employment will be generated. What is clearly recognized, however, is that adjustment will be a critical element of the process of technological change.

In the past, nations recognized the economic and social importance of investing in education and transferred resources to it. This created the infrastructure necessary for an educated skilled population. Most developed nations, as their wealth increased, also transferred resources to activities believed to enhance the quality of human life, such as health care and social services. As individual disposable income increased, leisure and recreational activities expanded, as well as other activities that contribute to the quality of life. The service sectors

depend on the income of a nation for stability and growth. Nations with low per capita wealth spend less on health care, education, recreation and leisure activities.

2.2.3 Adjusting to Technological Change

The transition from an agrarian to an industrial economy was turbulent. People were not always recognized as the core of economic growth. Broad backs, not broad minds, were the cogs in this industrial wheel.

Examination of the socio-economic changes during the Industrial Revolution showed that many individuals suffered profoundly from the disruptions produced by these changes. However, from the disruptions came new programs of public education, health care, social security, transportation and communications. This led to improved standards of social justice and the quality of life to which developed nations have become accustomed. Today's challenge, as we move into another period of major technological change, is changing without the profound social and economic disruptions that occurred in the past.

The Economic Council of Canada clearly sets out this challenge for Canadians in their June 1987 report, *Innovation and Jobs in Canada:*

> Together, the rapid adoption of the new technologies and the development of human resources can bring economic progress and more and better jobs. At the moment, however, Canadians must face up to some uncomfortable facts:
>
> a) Canada's industry continues to lag behind that of other countries in adopting the new technologies that are essential to its future prosperity. Thus Canadians have a lot of catching up to do.
>
> b) Technological change is never smooth and balanced; it creates both winners and losers and Canada must do a better job of helping the losers to cope.
>
> c) The pace of change in the global economy will remain rapid and it may even accelerate; so the next round of innovation will have more profound employment consequences than previously.

Minimizing the disruption of technological change requires minimizing the risk of that change for individual citizens. Meaningful activity and income must be assured so Canadians can create new enterprise, develop new ideas and change as old jobs disappear and new activities emerge. We must actively mould change or passively accept the consequences.

2.2.4 Conclusions and Objectives

A review of foreign and Canadian information leads us to the following conclusions.

a) The application of S&T to the sectors of our economy that produce tradeable goods and services will increase Canada's income. But these sectors, with efficient application of new technologies, will generate little, if any, direct job growth.

b) Better industrial relations, improved work-place innovations and a well-educated, skilled labour force are the key to developing and applying new technologies in our industries that produce tradeable goods and services.

c) All of the evidence from developed countries indicates that employment over the last 100 years has shown a remarkable shift from more than 50 per cent employment in the agricultural, resource-based and manufacturing industries to more than 50 per cent employment in the service industries. This trend will likely continue.

d) The major increase in employment in recent years was in social and personal services, with many social services such as education, health care and family services being largely supported by public monies. The projections indicate that the greatest job growth will be in new activities in the personal and social services sectors, many of which have yet to be defined. This indicates that the need for government support will continue and must be flexible in recognition of the changing environment. The recent national daycare initiatives show how the government is responding to new and emerging conditions.

e) Effective policies for renewed economic growth and labour market adjustment have to take the above points into account.

2.2.5 Summary Conclusion

On the basis of evidence from our own country and other developed nations, the following points must be emphasized:

a) the industries producing tradeable goods and services are vital to our future economic growth;

b) the ongoing development and application of science and of technology to our resource-based industries, established manufacturing, and new industries, is key to their producing tradeable goods and services;

c) this economic sector, however, is not a direct prime generator of new jobs;

d) it is the income generated through these activities that allows for expansion in the service sectors, particularly in the personal and social services sectors; and

e) this income generation also creates new jobs and a better quality of life for Canadians.

Although, there are many definitions of the service sector, this report puts them into two categories. The first includes service industries, such as finance, transportation, communications and legal services, that are directly linked to the industries that produce tradeable goods and services. The second category includes social and personal services, such as education, health, leisure and recreation services. The scope and quality of these services is related to the wealth of a nation. The expenditure on health expressed as a percentage of the GDP correlates directly with the per capita wealth of a nation. It is difficult to increase the growth of this service sector if the industries producing tradeable goods and services do not sustain and enhance our national income.

2.3 Other Nations and Technological Change

In 1986 the Royal Commission on Economic Union and Development Prospects for Canada stated in the *Economics of Industrial Policy and Strategy:*

> Countries which appear to have been most successful in adjusting to changing economic opportunities have focused a substantial part of their adjustment policies on easing the adjustment costs of labour rather than capital, through generous and widely available institutional and on-the-job retraining schemes, relocation allowances, early retirement schemes, sophisticated labour force analysis and forecasting techniques to yield more useful information on present and future labour market opportunities, and have frequently conditioned receipt of unemployment benefits on participation in these schemes. The closer integration of social and economic policies in facilitating more rapid economic adjustment would seem an important priority in Canada.

Looking at the full scope of adjustment to the rigours of a new era, it is clear that we are not dealing with an isolated problem; we are dealing with a complex and broad socio-economic change. Our goal is nothing less than preparing Canadians to become one of the most literate, innovative, entrepreneurial and technologically knowledgeable populations in the world. To do this within our system of social justice we should look not only to the past, but also to the present and the experience of other countries.

Many of Canada's competitors in the global market place recognize the power of people in a knowledge-based age. The global economy is rapidly moving to where international market position is determined by national brain power and the capacity to translate this knowledge into strategic thinking and planning. We are moving into the knowledge-based era, in which S&T leadership is a key determinant of national economic performance.

Most developed countries and a growing number of developing countries recognize this fact. The primary focus of their industrial development emphasizes the human contribution to economic growth.

2.3.1 Japan

In an April 22, 1987 speech, *Productivity - Our Weakest Link*, our Prime Minister said, "The Japanese believe that of the factors that affect productivity, people - their motivation, security and reward - are the most important. They spare no effort or investment to produce generations of talented, sensitive and responsive managers. Improved management development is a constant objective."
As shown recently, this emphasis continues. Former Prime Minister Nakasone called for the commitment of $20 billion ($10 billion to be provided by Japan) to a "world project on human frontiers."

The "Japanese technological miracle" is often cited - but their success and that of others cannot be explained by studying technology alone. A fuller understanding of the Japanese context shows that their success was no technological miracle, but rather a result of deliberate strategic directions. Technology and its priorities, uses and development always occur within the social context. The dynamics of technological, cultural, economic, political and social change emerge interdependent, entwined and united. The technopolis project started several years ago is a reminder of their capacity to find solutions to complex socio-economic problems.

2.3.2 The United States

Joining S&T policy on the other side of the competitiveness coin must be education policy. The Americans fully recognized this symbiosis with the three strategic pillars of the 1987 Trade, Employment and Productivity Act. These are:

- human resource development;
- R&D; and
- protection of intellectual capital.

In the United States, individual states historically have the constitutional responsibility for education. They are pulling together as a nation, however, through a number of Presidential Education Advisory committees and the establishment of the much-resisted federal Department of Education.

The private sector shares in this concern for human resource development. Illustrating this, in 1986 the Carnegie Foundation for the Advancement of Teaching announced in *Corporate Classrooms* that spending on training in business and industry was "fast approaching the total annual expenditures of all of America's four-year and graduate colleges and universities." A year later, Statistics Canada announced that about 75 per cent of industrial establishments in Canada did not provide any training. The contrast between the two countries is significant because it is the application of scientific ideas through industry-driven technologies that increases the spin-offs of further industrial development.

However, even with increased government and private sector recognition of the importance of education and training, there are concerns that the United States may not be able to handle the institutional changes being produced by the impact of S&T in the new global dynamics. There is also evidence of the problems they are having in coping with the necessary socio-economic adjustment.

2.3.3 Federal Republic of Germany

In *Towards Solving Canada's Human Resource Paradox* (1981), the Honourable Frank Oberle cited the importance of the work place-training interaction in the Federal Republic of Germany.

There is a fundamental recognition of the link between training and economic performance. Germany emphasizes vocational training and cooperation between labour, government and private business with a dual system of on-the-job training and part-time studies in a vocational school. Employers attach prime importance to the role of entry-level training in establishing work habits, developing responsibility and leadership, and improving cooperation in the work force. In addition, both federal and state governments resisted introducing programs specific to certain companies or job categories.

Three laws set the training agenda: the Vocational Training Act (1969), Employment Promotion Act (1969) and the Works Constitution Act of (1972). The Federal Institute of Vocational Training represents the social partnership between the major players on matters of legislation, training standards and issues. The Federal Employment Institute is responsible for vocational counselling, training and employment placement.

Students have a wide range of vocational schools, technical schools and combination apprenticeship-school programs to choose from. Adults wishing to upgrade their skills have a range of extension and trade schools available. Government restricted its direct involvement in training, preferring to leave it to the private sector, but stuck to strategies that promote, accredit and assist financially workers who train.

As in Canada, the primary responsibility for education legislation and administration of the school and university systems rests with the country's 11 Lander (provinces). Intergovernmental cooperation, however, was embodied in the Federal Government-Lander Commission for Education Planning and Research Promotion. The commission includes seven representatives of federal government (eleven votes) and one representative from each of the eleven Lander (a total of eleven votes). In 1973 the commission drafted a joint plan for the coordinated development of the entire educational system through to 1985.

2.3.4 Sweden

Although Sweden's economy deteriorated in the late 1970s, its recent economic scorecard is impressive. With an unemployment rate of only 2.7 per cent and an inflation rate of 3.3 per cent (below the 3.7 European average), Sweden enjoys

one of the highest standards of living in Europe and maintains a comfortable surplus on the current account of its balance of payments. In the March 7, 1987 assessment of Sweden's economy in the *Economist*, their success was attributed to the following:

> Unlike socialist governments elsewhere, the Social Democratic Party, which has ruled Sweden for 49 of the past 55 years, has generally been happy to allow industry to play by the rules of the market. Many government activities have enhanced rather than choked growth by helping to make markets work better. Sweden has used a capitalist engine to maximize output, and its public sector to redistribute the wealth thus created through taxes and transfers.

Pivotal to this, government's role in Sweden is broadly accepted as helping workers adjust to market focus.

There are five policies that contributed to Sweden's present position. These are:

a) **labour market information** - including a strong local vocational and educational guidance service;

b) **geographic mobility** - the wage policy of solidarity and the desire to facilitate structural changes that permit Swedish industry to retain its competitive ability have placed both geographic and vocational mobility demands on employees;

c) **labour market training**;

d) **measures to create employment** - major projects are undertaken to counteract unemployment caused by the structural transformation of business or seasonal employment. Employees can take extended leaves to care for children and aging or invalid family members.

e) **investment reserves** - during boom periods companies are encouraged to set aside part of their profits in counter-cyclical investment reserves, which are tax-exempt. During a recession, companies can apply to the cabinet or the National Labour Market Board for permission to take funds from their investment reserves. The reserve can also be used for new developments.

Although the broad guidelines for labour-market policy are set by the government and Parliament, the main body for shaping and implementing these policies is the National Labour Market Board (labour, management and government). Funded by Parliament, the tripartite board has regional offices and supervises 24 County Labour Market boards and the 220 local offices of Employment Services, all with local tripartite representation.

The *Economist* pointed out in an article earlier this year that the labour market policy of Sweden gives it one of the most skilled and mobile labour forces in the developed world.

2.3.5 Korea

In the 1960s, the strategy of South Korean industrial development emphasized people. They placed priority on S&T education, the building of related infrastructure and importing technology. Built on this human resource base, their industrial development strategy for the 1980s emphasizes high-level science and engineering, the enhancement of productivity in their R&D efforts and investment in strategic technologies. Their expenditures on R&D this year will surpass 2 per cent of GDP.

As wage levels rise to keep pace with educational levels, new countries wait in the wings to take up low wage production. The speed of the technological revolution and the problems with managing the people-side of the Korean changes led to profound social upheaval. It is not clear how they will deal with the continuing socio-economic adjustment they face. Will their approach lead to new national prosperity or increased unrest?

2.3.6 Summary

The most basic message from these and other countries is that the success of a country in capturing new opportunities and wealth depends on its vision and the commitment of its population to that vision. It is the human factor that will eventually determine whether Canada can compete effectively in the world being produced by the present S&T revolution.

2.3.7 Objectives

Past and the present experience of Canada and other countries leads to the following objectives. They can be used as a framework for developing policies and strategies to "minimize social and economic disruption and enhance the benefits of technology change" and are:

a) to ensure an effective and efficient application of S&T that will enhance economic growth by generating income to maintain and improve social justice and opportunities for Canadians;

b) to provide a framework and climate for adjustment to technological change that maintains individual self-reliance and adaptability and minimizes social disruption, while providing greater opportunities for an integrated, more cohesive society; and

c) to establish and apply social and economic indicators to measure how well we are achieving the above objectives.

2.4 Opportunities for the Future and the Canadian Scene

The following conclusions about the effects of technological change in Canada can be surmised:

a) The historical record to date does not indicate major, lasting or pervasive unemployment caused by introducing new technologies. However, it is still too early to tell whether the employment generation of technological change will outweigh its adverse effects on employment.

b) Canadian business to date has shown an impressive capacity to create jobs.

c) Although the evidence is limited and fragmented, Canadian data show little adverse effect on income distribution resulting from technological change.

There are disquieting signs, however, which leave little room for complacency.

Historical analysis and future projections show that the effect of technological change is uneven. Although the effects may be beneficial in general, there will inevitably be winners and losers.

In the absence of appropriate policy initiatives, some individuals face painful and costly adjustments; concern must be expressed about the quality of the emerging job structure, particularly for women and older workers. There are clear signs that those with educational deficiencies are at a serious disadvantage in enjoying the employment benefits of the new technologies.

The future raises additional concerns. The pace of change will remain rapid and become more pervasive. Research suggests that the next round of innovation will be qualitatively different from what has gone before. The adjustment will be more profound. Thus it is important for Canada to accept that an innovative economy and adjustment support go hand in hand; one cannot exist without the other.

What is the rationale for this position?

a) From the standpoint of macroeconomic stability, the unevenness of technological effects poses a potential problem for Canada with its thinly spread population and diverse regions. Rapid development in one industry or region may cause inflationary bottlenecks at the very moment that labour displacements elsewhere are swelling the ranks of the unemployed. In addition, there is wide variation in the structure and dynamics of the regional economies across Canada. If rigidities persist, the growth of output and incomes is inhibited. There are sound efficiency arguments, therefore, for the policies and programs that enhance labour mobility through labour-market adjustment.

b) The equity argument is also compelling in a country such as Canada. Change is threatening. It involves dislocation and imposes its adjustment costs irregularly. It is entirely appropriate in an advanced and democratic society,

therefore, that all individuals are equipped to share the fruits of technological progress. It also seems logical that if policies and programs are designed to lessen the pain of transition, people's acceptance of the new technologies will be enhanced. In this respect the equity and efficiency rationales for adjustment policy are complementary.

c) Unemployment adversely affects individuals. Although not fully understood, there is increasing evidence that unemployment affects health, as shown by increased mortality rates among the unemployed. Also individuals who become separated from the social interaction in the work place and from the personal esteem provided by a job quickly lose their confidence and ability to re-enter the work force.

Many issues can readily be identified. Those mentioned here are not a comprehensive list.

In a technological environment characterized by breathtaking change, no single study, however insightful, is definitive; events will inevitably overtake it. The committee emphasizes, therefore, that technological advance is a process of **continual (though uneven) change that demands, accordingly, continual attention.** Although the nature and the pace of change may alter, certain key issues are likely to remain important in the next decade. These constitute the committee's present focus.

2.4.1 The Pattern of Job Creation

It is not possible to predict precisely the kinds of jobs that will be created in the sectors that will emerge in the present revolution in S&T. There are a number of indicators, however, of the kind of changes that will take place.

To look at this more closely, it is useful to divide the labour market in to three sectors.

a) tradeable goods and services;

b) services that are directly linked to first category (e.g., finance, law, transportation, accounting, communications); and

c) personal and social services (e.g., leisure and recreation, education, retail and health).

The linkage of the first two sectors to the last sector is only indirect. However, the success the first two sectors have in generating income for a nation influences the level of expenditure in the third category. For example, the amount of money nations spend on health care correlates closely with their per capita wealth. The same holds true for education. When economic growth slows, the service sectors in the third category find their resources constrained until economic growth resumes.

Even though the activities of the industries in tradeable goods and services are essential to economic growth, all evidence indicates that they will not be a major source of new employment. They will, however, require a well-educated, skilled, adaptable work force that is competitive with industries in other countries. As these industries change focus and apply new technologies, they require education and training programs geared to their changing circumstances to enable their work force to adjust.

Education and training programs directed to the tradeable goods and services sector are important in facilitating labour adjustment to new technologies in industry. Even so, such programs will not solve labour adjustment in relation to new opportunities in the service sector. Recent evidence indicates that most new-job creation will continue to be in the personal and social services sector. However, the importance of the income-generating sectors must continue to be emphasized.

As more and more women become key members of the labour force, the need for high quality daycare for children will increase. This is a point clearly recognized in the recent government announcement of new national child care initiatives. As the population lives longer and an increasing proportion of the population is older, there will be substantial growth in the services directed to the needs of older citizens. This will include growth in the informal care sector and the expansion of professional care services. The importance of the development of the informal care sector is underlined by the estimates in the United Kingdom, that if the informal care sector for the elderly is reduced by 5 per cent, medical and social services will be swamped.

How we prepare people for roles in the personal and social services sector and the mechanisms for financing these services will have a significant impact on both the quality of the jobs and the capacity of individuals to take up new careers in this sector.

Any program designed to fulfil the goal of efficient labour-market adjustment must be broad enough to embrace the areas of new opportunity. Education and training programs should therefore prepare individuals for developing new careers in this emerging sector. In the minds of many, the social and personal services jobs are considered low skilled. But the requirements for careers in the field of human interaction are both complex and demanding. Furthermore, the jobs in this sector provide the satisfaction that comes from helping other human beings and interacting with them.

These prevailing work-place realities call for programs for labour-market adjustment that meet the needs of industries in the tradeable goods and services sectors, for highly skilled adaptable personnel and expanding jobs in the service sectors, particularly those related to personal and social service needs.

Because individuals of all ages may have to move into new areas of work, it is essential that there be a coordinated approach that involves all sectors of the changing labour market.

2.4.2 Employment and Technological Change

The most recent projections for Canada are guardedly optimistic about the net employment effects of technological change to 1995. They emphasize the unevenness of the effects and their potential adjustment costs. Improved estimates of the direction and magnitude of the effects, and thus of the potential adjustment cost, depend on developments in our data and analysis systems.

Recent evidence from Ontario indicates that the average employee will likely change jobs or careers eight times during his or her working life. Since we no longer can expect one job for life, labour market policies appropriate for an industrial period are strained and often inappropriate for the new economic society.

For example, pension plans restrict mobility when they are designed for permanent employment in one company and are not portable. Pension plans that do not continue when employees leave work to provide informal care for aging relatives in a time of need penalize these citizens when they are older. (These individuals are usually women.) The training, unemployment insurance and other labour-market programs must be geared to a dynamically changing situation and targeted to a philosophy of adjustment to new employment rather than unemployment.

The Industry Committee agrees with the Newfoundland Royal Commission on Employment and Unemployment in *Building on Our Strengths* when it says that the role for "the reconstituted Unemployment Insurance system" should be "to provide a financial bridge between permanent jobs, and through periods of absence from work due to sickness, accidents, and maternity leave." This proposition is tied directly to a new income-security program. The Industry Committee was impressed with the vision and understanding in this report and suggests that the advice of the Royal Commission be examined. In particular the commission recommends that "the government of Newfoundland and Labrador should enter into negotiations with the government of Canada for the implementation of a new income-security system along the lines suggested in the report, possibly using Newfoundland as a pilot project for Canada as a whole."

2.4.3 Incomes

Do the new technologies polarize skills and earnings? Are we witnessing the emergence of a "new feudalism" of 'techno-nobles' and 'techno-peasants', with a concomitant erosion of the middle class?

The latest Canadian evidence on this topic shows only slight evidence of the declining middle class. There is enough evidence of inter-industry employment shifts to support concerns about the quality of the emerging job structure. Canada's technological adjustment process may also be a year or two behind that of the United States, where a number of analysts report evidence of a declining middle class. Careful updating is therefore required on this issue too.

It is clear that the income-transfer mechanisms of the market place should work effectively for the service sectors that relate directly to the income-generating sector. There remains uncertainty that income transfer to the personal and social service sector may not be equitable under strictly market conditions. Policies are necessary to ensure that the growth of the service industry is not blunted by the limits of market mechanisms.

2.4.4 Education

The seedbed of scientific knowledge in Canada is within the minds and imaginations of our students. However, when viewed comparatively we have a long way to go to develop our full potential. In Canada there are 2.7 researchers and scientists per 1000 population. In Japan the number is 7.4, 6.4 in the United States, 4.8 in West Germany, 3.9 in France and Sweden, and 3.7 in Finland and the Netherlands. Canada needs to put much greater emphasis on the development of highly qualified personnel.

In addition, an adaptable and skilled labour force is a necessary ingredient for the realization of the greatest possible gains from the rapid and effective application of new technologies. This brings into sharp focus the fundamental role played by the educational system, especially skills-training, in producing the types of workers and managers required in a high technology world.

Furthermore, the unevenness of the direct employment impacts of technological change is apparent in educational attainment. Workers who have some university education benefit, but those with only a secondary or primary school education are adversely affected. The United Nations Scientific and Cultural Organization (UNESCO) in *Adult Illiteracy in Canada* identified one in every five Canadians as functionally illiterate. These individuals are greatly handicapped in adjusting to change and severely limited in their capacity to contribute to the skilled work force that is necessary in Canada. A March 30, 1987 editorial in the *Globe and Mail* entitled "Our Hidden Shame" underscored Canada's deplorable position.

> [It] called us to account on behalf of the 1 million adult Canadians who can not read or write at all, and the 4 million who can not read or write adequately to function in our society. They are . . . our country's hidden shame . . .
>
> They are also, if we care to deal with this in the context of the national interest, a considerable burden on the economy, one that has been estimated at over a billion dollars a year.
>
> . . . 60 per cent of the illiterate population is out of work. They can neither find nor hold a job . . .
>
> . . . despite the efforts of such admirable institutions as Frontier College, Canada is believed to be running far behind Britain and the U.S. in dealing with illiteracy, perhaps because we have not fully appreciated its dimensions or its costs. We who can read and write have no excuse for inaction.

We must ask ourselves why a developed nation that has prided itself on its public education programs allowed itself to get into this position.

Although the Canadian Jobs Strategy does have some adult basic education allowances in the various programs, the adult basic education focus of the previous Basic Training and Skills Development (BTSD) program has blurred. Even there, the funding of adult basic education continued to decline in recent years. Perhaps an alternate route for effectively mounting a national campaign to eradicate functional illiteracy would be through the voluntary sector. In 1981-82, Employment and Immigration Canada spent $73.1 million; in 1982-83, $78.8 million; in 1983-84, $85.3 million; in 1984-85, $86.2 million; and in 1985-86, $89.9 million. Given the level of funding of the BTSD program, the voluntary sector would be capable of great strides toward a fully literate Canadian society.

The committee commends the Prime Minister for his recent initiatives through the Secretary of State to establish a Literacy Secretariat and the voluntary sector Literacy Council.

It is important that the Prime Minister continue his leadership and enlist the commitment and support of the provincial premiers to correct this problem which has been a collective failure of our society.

There must be progress on several fronts. The ability to learn will be the premium skill of the future as workers and managers face the need for periodic reschooling and retraining. This means that for many people, deficiencies in literacy must be corrected so that such 'retooling' can occur.

A two-pronged attack is necessary. School retention rates and average educational attainment levels must be raised. Many adult workers need continuous learning, remedial education programs and vocational training. Strategies need to be developed to ensure our educational institutions adapt effectively to the emerging needs of our society.

2.4.5 Training

A training system that contributes to the development of a skilled and adaptable work force is essential for both efficiency and equity reasons. It is necessary for realizing the gains in productivity and growth that potentially reside in the development and application of new technologies. The training system must also be a fundamental tool in facilitating the continuous adaptations that workers must make in a high technology world.

Technological change raises many challenges for continuous learning. Training must keep up with the new technologies and the skill requirements which they create. In this regard, Canadian companies under-invest in industry-based training programs that develop the skills to make technology work to its maximum. Public training schemes do not seem well-focused on occupations that are assuming greater importance in S&T. Training must also respond to the needs of individuals who face the prospect of skills obsolescence. One-career work

lives are becoming increasingly uncommon and workers must have the opportunity to participate in recurrent education throughout life. An institutional framework is required to facilitate the inevitable work transitions of an S&T labour market.

Job creation must be an important element of training and adjustment. Temporary job creation will be important in the short-term. However, a broad employment strategy is needed to ensure the development of meaningful and more productive activities in the longer term.

The broadly based movement toward a learning society requires a universal mechanism for continuous learning. The committee feels this mechanism should be paid educational leave. A number of members pointed to this mechanism as the most equitable and efficient way to raise the level of training by all employers in Canada. The present wage bidding for well-skilled employees and the transitional pains of industrial restructuring would be diminished if all employers were training. The recent past chairman of the Science Council of Canada was the federal government representative on the National Advisory Panel for Skill Development. In its report *Learning for Life*, the panel proposed that employees earn time off for educational leave in the same way they accumulate statutory sick leave and vacation time. Rather than unproductive increased vacation time and recently legislated reduced hours-worked of a number of European countries, this would be a productive use of increased down time.

2.4.6 Demographic Changes and Immigration

The composition and the population of the Canadian labour force exacerbates the adverse effects of technology-associated change in Canada. The population is aging. The proportion of the population under 20 declined from a peak of 42.1 per cent in 1966 to 28.9 per cent in 1986. On the other hand, according to the Institute for Research on Public Policy (January 1987), the proportion of the population over 65 increased from 7.7 per cent in 1966 to 10.7 per cent in 1986. With 1.6 fertility rates across Canada (1.4 in Quebec), what will the future hold?

In examining demographic projections, there is no doubt that increased life expectancy and the changing age distribution of the population will affect labour markets and our personal and social services sectors. These include leisure and recreational activities, informal care and professional care. It is absolutely essential to have humane and effective services for older people and that informal care predominate. The care of older people controlled by medicine is inappropriate and expensive. The nature of the changes that are taking place call for an integration of the formal and informal care sectors.

The aging of the population brings with it concerns about social costs, especially for pensions, social services and health care. With lower ratios of the working population to the dependant population, it is questionable whether the productivity gain from innovation will yield a sufficiently large generation of income to sustain adequate and equitable living standards for all. As the youth segment of the population shrinks in proportion to the older population, what proportion of the older labour force will have to remain active? Social adjustments in a time of rapid change may be further complicated by

immigration. At the moment immigration tends to intensify the bias in the age-structure of the population and the work force.

2.4.7 Women

How is technological change affecting female employment? Is technological change eroding the number of jobs available to women? Is it eroding the quality of female employment? Some earlier predictions of very high unemployment for female clerical workers in 1985 did not materialize. Does this mean we can be complacent about the future?

More recent evidence shows that women are holding a proportional share of the new jobs that are being created in the high technology sector. However, there are some serious concerns over the quality of the emerging female job structure.

a) In the high technology sector, female employment concentrates in industries that employ high proportions of clerical workers. The traditional tendency toward the "ghettoization" of women in clerical occupations is continuing.

b) Part-time work is increasing and almost three-quarters of it is done by women. This trend includes an element of increasing involuntary part-time work and much of that affects women. A growing number of women who are accepting part-time work would prefer to be employed full-time.

c) Even though women have made some inroads into non-traditional occupations, they are still significantly under-represented in enrolment in certain studies, such as engineering, sciences, business management and entrepreneurship. These will figure prominently in technological advance. They are also grossly under-represented at senior management levels. Better vocational guidance services are required.

d) Single-parent families headed by women are at the low end of the economic scale. The number of single-parent families as a percentage of all families was 16.6 per cent in 1981. More than 50 per cent of these single-parent families had low incomes compared with 10 per cent of two-parent families. This could adversely affect the future development of children caught in these circumstances.

2.4.8 Special Groups

Will the new technologies further exacerbate the traditional problems faced by young people in making the transition from school to work? With rapid skill obsolescence in the work place, what is the optimal educational preparation? Are computer literacy and programming skills the key for future job entry? Should we be providing specialized skills for specific occupations or should the education system emphasize general problem-solving skills that create a versatile and flexible work force?

What are the prospects for older workers facing the trauma of retraining late in their careers? How does someone who has worked a lifetime in manufacturing

begin working in the expanding services sectors that relate to a changed set of interpersonal and caring skills? How can the new technologies be brought within the reach of our native peoples? For all the people in these groups who are likely to have difficulty adjusting the common characteristic is low levels of educational attainment. This is a critical concern in light of recent evidence concerning the close link between education level and the probability of technological threats to employment.

2.4.9 Industrial Relations

Technological change is creating a number of issues in the area of industrial relations. The new technologies appear to be contributing to some of the difficulties in the collective bargaining system.

a) Technological change is threatening union membership levels by accelerating employment shifts away from traditionally unionized occupations.

b) Some evidence suggests that the balance of bargaining power is shifting toward managers in high technology settings.

c) There appears to be insufficient negotiation over technology-related issues of mutual concern to labour and management.

These developments are cause for concern in a country where collective bargaining represents a cornerstone of industrial relations policy in unionized companies. There were attempts in some Canadian jurisdictions to use labour legislation to encourage collective bargaining over technological change. Since research does suggest that technological change is most effectively implemented in societies where all the affected parties are involved, developing more effective bargaining approaches seems an important policy objective.

2.4.10 Organizational Change and Work-place Innovation

Organizations change as technologies change. Not only do new technologies alter the skills that an organization requires, but they also create pressures for new ways of designing jobs and structuring the decision-making process. The key is involving employees. Traditional hierarchical relationships, repetitive assembly-line tasks and centralized control do not provide the best organizational context for making the most of the new technologies. The Japanese success is attributed as much to organizational changes as to the adoption of advanced technology.

In Canada some companies have been very innovative in redesigning jobs, organizational structures and decision-making processes. Canada has been praised for some of its imaginative ways of organizing the work place with new machinery. The Shell Chemical plant in Sarnia and the GE Bromont plant are often cited. Most Canadian firms, however, appear to stay with traditional practices. Certainly organizational change poses considerable challenges to managers and to workers and their unions. Nonetheless, innovations in work-place design and structure represent a key to success in established industries introducing new technology or new industries producing new technology.

2.4.11 Data, Research and Monitoring

A major obstacle to a better understanding of the social effects of technological change is the absence of a unified data set dealing with technological change questions. This data set must be regularly and consistently updated and refined. Canada badly needs a data set that is readily accessible and widely disseminated. Existing data sets are often ill-suited to the analysis of technological change effects; they are fragmented and uncoordinated. Rather than a quick snapshot of Canadian technological and social conditions, we need a continuing, moving picture of the progress of diffusion and its human resource management effects.

The fragmented monitoring of human resource development in this country also suggests the need for the maintaining data sets that monitor Canadian involvement in education and training. Particularly needed are data on what Statistics Canada calls the New Majority: the adult, part-time learner.

The importance of the social sciences in Canada as referred to in the Macdonald Royal Commission report is relevant to our current discussion. It is imperative that the role of the social sciences and Social Sciences and Humanities Council (SSHRC) be emphasized within the context of structural change in Canada. It is inappropriate to expect that the social sciences will get private sector support for much of their research.

2.4.12 Policy Coordination

Current efforts to establish a national S&T policy framework must explicitly recognize the need to cut across vertically defined ministerial mandates to coordinate policies and programs relating to labour-market change and social impacts. There is clearly a need for enhanced federal-provincial coordination. Horizontal industrial arrangements may also be necessary to link the relevant activities of diverse agencies.

2.5 In Conclusion: Technological Advance and Social Change

There are two choices for minimizing social and economic disruption and enhancing the benefits of technological change for Canadians.

a) We can assume that within free economic and labour markets, that the adjustments that are required will eventually happen through the normal operation of the market. This may eventually lead to a richer society and interesting work for all Canadians. However, this transition will not be victimless. This is a non-managed approach.

b) The second approach, and that preferred by the committee, is based on learning from past experience. Although markets eventually lead to suitable adjustments, they are uneven and at times erratic in their effects. This adversely affects individuals in society. Minimizing disruptions for individuals requires policies and programs for the management of change.

The committee believes that based on past events, the significance of the technological changes and the goals of individuals in our society, we should maintain and enhance our labour market programs designed to facilitate the management of the change.

The management of change requires the informed participation of all sectors in our society. New forms of cooperation are required at both the macro and micro levels. Governments must plan and work with other governments, as should management with labour, schools with employers, government departments with other government departments and the mix repeats again at all levels of society. Basic to this cooperation should be the belief that the full development of Canadian social and economic strengths depends on the well-being and full participation of each and every Canadian in our social and economic life.

The following example illustrates this new cooperation. An individual whose job is no longer required in an industry could be kept on in the industry for a period of time. The individual should be paid through government programs to take part in retraining and contribute to some local community projects of interest to him or her, the business or the community.

With time, this individual should find new work opportunities and transfer to his or her new institutional base. In this approach, the individual's adjustment does not require sudden separation from normal work contact and activities, which help maintain individual confidence, sense of worth and self-reliance. These characteristics are important for those seeking new jobs. In this example, the role of the business, community, government and labour are all important ingredients of successful adjustment.

In Canada there have been a number of clear and far-sighted proposals to facilitate labour-market adjustment. The Industrial Labour Adjustment Program has been praised in Canada and abroad for its range of assistance to downsizing industry. Although the Canadian Jobs Strategy needs work, its rhetoric and individual components, if positioned within a positive orientation, could also be a great help. An essential component of many labour adjustment programs is joint labour-management-government planning and administration of programs.

The complexities of Canada's geographic and political structure make it difficult to coordinate the smooth integration of policies and programs for labour-market adjustment in the different parts of the country. The myriad of policies, programs and jurisdictions often makes the understanding of what is available elusive for many individual Canadians and businesses. We also need programs that can effectively take into account not only the need for highly skilled and trained personnel for the tradeable goods and service sectors, but also to facilitate individuals taking on new careers in the expanding service sector. This creates a strong need for better coordination among programs nationally and locally.

Achieving the effective participation of management and labour is difficult because of the lack of a unified national organization representing employers and the fact that labour is split into organized and non-organized labour. Countries

that do not have Canada's unique characteristics were able to create tripartite national groups (labour, management and government). In countries like Sweden, such groups develop and operate national labour market adjustment programs. At this stage in Canada's evolution, however desirable such an arrangement might be, it would be difficult if not impossible to implement.

Proposals

a) There is a base within Canada that could be used to facilitate the evolution of a more coordinated and integrated national approach for labour-market adjustment. The federal Cabinet Committee for Social Development (CCSD), chaired by the Honourable Jake Epp, is an instrument that could coordinate labour-market adjustment across all federal departments. It is highly appropriate that the Minister of Health and Welfare chair this group because of the effects of social and economic change on the health status and function of individual Canadians. A valuable indication of how well we 'manage' the changes is the change in the health status of vulnerable groups. In the spirit of cooperative federalism, it would seem appropriate to create a Council of Ministers from the different provinces concerned with labour-market adjustment, including the education upside adjustment. This council should be chaired by the Chairman of CCSD to facilitate national coordination of provincial and federal programs.

b) The Canadian Labour Market and Productivity Centre, which represents both business and labour leadership in Canada, could be used as a base for private sector interaction with the government group concerned with coordinated national programs in labour-market adjustment. The government group should be used to build a network of involvement that includes labour and management and filters down to the level of the individual firm. This network might be community-based in the 287 Canadian federal electoral districts. If a Member of Parliament also serves on the community labour-market adjustment board for the region that he or she represents, all communities would be represented in Parliament.

2.6 RECOMMENDATIONS

The Industry Committee of NABST believes that there are steps that the Government of Canada can take now to facilitate the development of truly national labour-market adjustment programs. **We recommend** the following steps **be considered:**

2.6.1 National Coordination and Action

a) **As a first major step towards a truly national labour-adjustment policy, we propose that the Prime Minister ask the Cabinet Committee for Social Development (CCSD) to establish a close working relationship with similar provincial ministers to address the following specific recommendations. To assist in their discussions, we believe that the federal government should provide the necessary information, analysis and staff support for these deliberations.**

b) In further developing and expanding the following programs for labour-market adjustment, they must be based on trust and partnership among government, management and labour. The federal government should provide the leadership to develop this trust and partnership. One mechanism would be to implement a labour-market adjustment council similar to NABST to periodically bring to CCSD, NABST and the Prime Minister the status of labour-market adjustment in Canada and to provide advice for further development.

2.6.2 Monitoring the Change

It is important to maintain and develop a continuing research analysis of the issues and problems associated with labour-market adjustment during periods of major technological change. To determine how well individuals in Canada are able to adjust to the changes wrought by technology, the federal government should ask Statistics Canada, in collaboration with the appropriate federal and provincial departments and agencies, to establish a national data base that portrays the changes taking place in the labour markets of our society as a consequence of technological change. This should be a continuing assessment that has the same status as our economic indicators. Coincident with this development is the need to strengthen social sciences research in Canada, as well as the role of SSHRC, so we have the work force and capability to do basic research.

2.6.3 Labour Adjustment

a) The use of unemployment insurance funds to keep job-loss threatened individuals in contact with other members of the work force through their place of work, retraining programs and community-based programs in recurring periods of transition should be given consideration. (This does not mean Unemployment Insurance funds should be used for retraining.)

b) Labour adjustment could be supported at the firm level with the establishment of a *technology and labour adjustment fund* for providing a full range of adjustment measures related to technological change and productivity enhancement. The fund might be established with a ceiling based on number of employees by allowing 25 per cent of pre-tax net profits to be maintained in a designated account. The entitlement to establish such a pre-tax account and disburse monies from it for the prescribed purposes would require joint labour-management trusteeship.

2.6.4 Training and Education

a) To ensure that all employers train and that all employees have access to continuous learning opportunities, the federal government should consider establishing an industry-based national system of paid education and leave. Similar to vacation and sick leave, time off and support could be earned for educational purposes. The proposals put forward in March 1983 to the ministers of Employment and Immigration and Labour in *Learning for Life*

should be examined in terms of the possibility of establishing a national system of paid educational leave.

b) A national council for learning for the work-place should be established as a focus for the national coordination of education and training policies, programs and standards. It should be targeted to not only preparing individuals to handle new technology in their industries, but also to facilitate their changing careers to the new and expanding opportunities in the growing service sectors.

c) Since the poorly educated and functionally illiterate individual is at the greatest disadvantage in making adjustments and in being able to contribute to the nation's economic growth, it is essential that the federal government maintain its leadership to see that this problem is corrected with the utmost urgency. There is no excuse for a nation with the resources of Canada to tolerate the level of functional illiteracy that now exists.

d) Given all of the indications of the transition to a knowledge-based economy and the importance of knowledge and its application to the income-generating sectors of the economy, it is essential that the federal government work with the provinces to develop a strategy for training and developing highly qualified or highly knowledge-intensive human resources in Canada.

APPENDIX A

CANADA'S WEAK SCIENCE AND TECHNOLOGY POSITION

A.1 Summary

By any measure, Canada's S&T performance is below the level required to sustain living standards at the level of the leading industrial countries. Canada spends less on R&D as a percentage of GDP than all but a handful of OECD countries (Exhibit 1). At 1.4 per cent of GDP, Canada's rate is about half the U.S. and Japanese rates of spending and well below the rates of Germany, Sweden, Switzerland, the U.K., France and the Netherlands.

This under-performance occurs in almost all areas of S&T support. This appendix presents some S&T comparisons between Canada and seven leading competitive countries that have living standards at least 69 per cent of the Canadian level (Table 1). This group's high living standards and economic diversity make comparisons relevant. Exhibits 1-26 present the comparisons graphically.

All of these countries, except the U.S. and the U.K., saw their GDP per capita grow much faster than Canada's in the last 20 years. The United States, Japan, Sweden and Germany are now generating more wealth per person by this measure than Canada.

A.2 Canada's S&T Spending is Low

Different S&T comparisons between Canada and these seven countries find Canada coming in last in many categories. Both industry and government R&D funding in Canada is below international competitive standards. Industry-funded R&D, at 0.57 per cent of GDP in Canada, is little more than half the level of the next lowest country, the Netherlands (Exhibit 2).

Government spending on R&D only exacerbates Canada's problem. Government-funded R&D in Canada is only 0.76 per cent of GDP, which is lower than all the comparison countries except Japan (Exhibit 3). Canada does not lag as seriously here as in industrial R&D, but governments in Canada are still funding R&D to a much lesser degree than their counterparts in most competitive countries. For example, Canadian government funding of R&D is only 59 per cent of the U.S. rate.

The case is sometimes made that comparisons of government-performed R&D put Canada in a better light. To some extent this is true, since government-performed R&D in Canada is 0.39 per cent of GDP, which is higher than the U.S., Germany, Japan and Sweden. Only France and the U.K., with their large state research apparatuses, are significantly greater government R&D performers than Canada (Exhibit 4). But such comparisons are less relevant when it comes to measuring the comparative contribution of national R&D efforts to industrial competitors. The technological fruits of national laboratories transfer only slowly and fitfully to industry in most cases, if they transfer at all. Case studies for

the Ontario Premier's Council have confirmed this finding for Canada's national laboratories. University research often has similar limitations.

Table 1
Seven Countries Selected for Comparison with Canada
(ranked by 1986 GDP per capita relative to Canada)

United States	120%
Japan	113%
Sweden	110%
Germany	102%
Canada	100%
France	89%
Netherlands	82%
United Kingdom	69%

Source: Ontario Premier's Council Office

Canada's funding of university R&D is also at the low end of our comparison countries. Canada spends only 0.3 per cent of GDP on university research versus significantly higher rates in Sweden, Japan and the Netherlands and marginally higher rates in Germany and the U.S.; France and the U.K. spend at the same rates as Canada (Exhibit 5).

A.3 The Effects of Low R&D Spending

Comparisons of R&D expenditures compare R&D inputs; comparisons of Canada's performance in realizing the fruits of its R&D efforts are harder to measure. No indicators are perfect, but those most readily available again indicate weak Canadian performance. In terms of the number of domestic patents granted to residents per 100,000 inhabitants (Exhibit 6) and the number of international patents granted to Canadians per 100,000 inhabitants (Exhibit 7), Canada scores very poorly. Only 8 per cent of all patent filings in Canada are made by Canadians (Exhibit 8). As one might expect, low resources devoted to R&D correlate with proportionately fewer scientists and engineers in the work force. Despite relatively high rates of technical graduates, Canada has only 2.7 research scientists and engineers per 1000 people in the labour force, which is well below the comparison countries and only one-third the rate of the highest country, Japan (Exhibit 10).

Table 2
Canada's S&T Performance

Measure of S&T Competitiveness	Canada's Rank Among Eight Comparative Countries*
Gross R&D expenditures as % of GDP (Exhibit 1)	Lowest
Industry-funded R&D/GDP (Exhibit 2)	Lowest
Government-funded R&D/GDP (Exhibit 3)	2nd Lowest
Government-performed R&D/GDP (Exhibit 4)	Middle
Higher education R&D/GDP (Exhibit 5)	2nd Lowest
Domestic patents granted per 100,000 inhabitants (Exhibit 6)	2nd Lowest
International patents granted by population (Exhibit 7)	Lowest
Advanced degrees awarded by population (Exhibit 9)	Middle
Scientists and engineers in labour force by population (Exhibit 10)	Lowest
Number of technology-intensive industries with positive trade balance (Exhibit 11)	Lowest

* Canada, U.S., Germany, France, Sweden, U.K., Netherlands, Japan
Source: Exhibits 1-11

The most relevant measure of Canadian performance in R&D may be the international performance of Canada's advanced technology industries. The OECD completed a characterization of manufacturing industries according to their R&D intensity. After grouping industries into high-, medium- and low-intensity R&D, the OECD determined that Canada was the only one of our comparison countries to have a negative trade balance in both medium- and high-intensity R&D industries in 1970-84 (Exhibit 11). In medium-intensity R&D industries, the Canadian trade balance has turned positive since 1981, mainly because of an improving automotive trade situation.

The OECD analysis actually understates the problem. To the extent that Canada remained competitive in medium-intensity R&D industries in recent years, it was mainly because of a significant devaluation of the Canadian dollar - equivalent to a national wage cut relative to workers in other countries. Even this wage cut could not halt the deterioration of Canada's trade position in many high-intensity R&D sectors. In computer hardware and office machinery, for example, the trade deficit grew from about $1 billion in 1979 to more than $3 billion in 1984.[1] In computer software, the trade deficit stands at $2-3 billion and is growing by 20-30 per cent a year.[2]

The Canadian resource sectors, such as forest products and agriculture, and basic manufacturing industries, such as steel and automobiles, will continue to be critical to exports and income-generation in this country for many years to come. Their survival will depend to a considerable extent on how well they can apply new technologies to improve productivity and product quality. We must also recognize that as the markets for high technology products grow, Canada needs to foster a critical mass of world-wide technology-oriented exporting companies that can relate to and augment our established industries. We do not have anything like that group of companies today. Unless we create a critical mass of knowledge-intensive businesses, Canadians could be condemned to ever-increasing devaluations (i.e., wage cuts) as we try to compete with less developed countries. At present, these countries must export on the basis of lower labour costs since they lack the technological capability that Japan, West Germany, Sweden, the U.S. and other countries have in their corporate sectors.

A.4 Canada's Underdeveloped Industrial R&D

Industrial R&D is where Canada's international weakness is most apparent. Several facets of Canada's economic structure act to depress the level of industrial R&D spending. Resource-based industries are a critical part of Canada's economy, but are relatively low R&D spenders. The high level of foreign ownership of Canada's industries also contributes to our low industrial R&D spending, as foreign-controlled companies generally spend a much lower percentage of their Canadian sales on R&D in Canada than do Canadian-controlled companies (Exhibits 12 and 13).

Nevertheless, structural peculiarities of the Canadian economy, such as high resource sector concentration and high foreign ownership, do not explain Canada's low R&D performance. Reasons vary by sector and do not fit easy patterns. For example, Canada often seriously lags the U.S. in R&D spending even by resource sectors, such as pulp and paper. Canada also lags U.S. R&D spending by 50 per cent in an almost 100 per cent Canadian-owned sector such as ferrous metals (Exhibit 14). Statistics Canada data give a similar profile (Exhibit 17). On the other hand, Canada's low spending relative to the U.S. in R&D in automobiles, chemicals and drugs is very much a function of foreign ownership in those sectors.

Canada's firms outspend their U.S. counterparts by a factor of 2.5:1 in telecommunications and 3.7:1 in aerospace. In telecommunications, this is

attributed to Northern Telecom's aggressive pursuit of international leadership in this technology; most of its R&D spending is in Canada, but its sales are spread around the world. In aerospace, Canadian-based firms like Pratt & Whitney Canada are forced to spend more of their own funds on R&D to make up for the much greater U.S. defence R&D subsidy for their competitors.

In summary, Canada's resource bias and its high degree of foreign ownership contribute to low R&D performance, but the problems go much further. Even in sectors with high relative R&D performance, like aerospace, Canadian companies may be spending at significant levels in part to make up for higher levels of government-funded R&D for their foreign competitors.

A.5 Concentration of R&D Spending

Canada's industrial R&D expenditures have increased dramatically; 1981 spending was up by 66 per cent in 1986, to $3.5 billion (Exhibit 15). However, that spending is concentrated in relatively few companies and industry sectors. Based on *Financial Post* survey data, the top four spenders, Bell Canada Enterprises, Atomic Energy of Canada, IBM Canada and Pratt & Whitney, account for almost 30 per cent of Canada's total industrial R&D; the top 15 spenders account for about half the total (Exhibit 16). Statistics Canada data gives a similar profile (Exhibit 17).

Analysis of 29 industries in Canada shows that only six groups would be considered research-intensive, where expenditures on R&D are high, expressed as a percentage of sales. They are:

- engineering and scientific services;
- aircraft and parts;
- telecommunications equipment;
- other electronic equipment;
- computer services; and
- electronic parts and components.

Other industries may include companies that spend a lot on R&D, such as drugs and chemicals, but the ratio of their R&D expenditures to sales are lower than the above industries, perhaps because of the influence of foreign-controlled companies who do relatively little R&D in Canada.

The six groups listed above accounted for only 4.5 per cent of Canada's total industrial sales in 1985 (by companies who perform R&D), but 46.5 per cent of Canada's total industry-funded R&D (Exhibit 18). It is important to point out that the creation and growth of R&D intensive industries is, with a few exceptions, a recent development in Canada. Since 1978 the industries in the six R&D intensive groups increased their R&D expenditures by 324 per cent, while all other industries increased R&D expenditures by 179 per cent (Exhibit 19).

A.6 The Structural Weakness in Canadian High Technology

Canada has only a few large, world-scale, indigenous R&D intensive firms. Indigenous firms direct their R&D, marketing and strategy for their core products from a Canadian base. They may or may not be Canadian. Northern Telecom is an indigenous company, but so is the American multinational Pratt & Whitney Canada. Many other successful industrialized countries have this technologically advanced indigenous core. Even nations as small as Sweden, Switzerland and the Netherlands achieved it.

Canada does have dozens of small- to medium-sized new technology companies with $10-$200 million in sales, but invariably they are, or soon will be, competing against much larger competitors in other countries. The Canadian R&D challenge is not only to increase R&D performance across all industries, but also to help develop many truly Canadian, world-scale multinationals out of this group of threshold technology companies. We will have difficulty keeping competitive in new technology without such a core of large firms. There are simply too many businesses where global scale in manufacturing, marketing, advertising, product service, applications engineering, R&D or other competitive factors decide ultimate success.

Moreover, only large multinational companies with some product diversity can withstand the inevitable new product missteps that occur in fast-changing technology businesses. If Hitachi, General Electric or Philips make a major mistake in one business, it does not threaten the whole company. In most Canadian small- and medium-sized new technology firms, each new product is a "bet the company" proposition. Large firms have the scale to conduct diversified ongoing R&D programs to minimize this vulnerability.

A.7 The Low Level of Support for Industrial R&D

International comparisons of total government assistance to industrial R&D find Canada wanting. Taking non-tax support (e.g., grants, R&D contracts) and tax support together, about 20 per cent of all R&D performed in Canadian industry is financed by government (federal and provincial). This is only half of the level of support in the U.S., where 40 per cent of all industrial R&D is financed by government (Exhibit 20). In the U.K. it is 37 per cent, in France 29 per cent and in Germany 24 per cent.

Canada's R&D tax incentives are at least as generous as each of these countries, but our level of non-tax support is much lower. Expressed as a percentage of GDP, government assistance to industrial R&D in Canada looks even more paltry; Canada's government assistance is only one-sixth the U.S., rate and one-quarter to one-third what industry receives in the U.K., Germany and France (Exhibit 21). One could argue that given the high level of non-tax support for R&D in these countries and their already high levels of industry-funded R&D, Canada's tax level of support should be much higher than theirs.

The government proposed in its White Paper on Tax Reform that the investment tax credit for R&D should be limited. We already made a submission on the very

negative consequences such as a limit would have for R&D intensive companies, costing them $85 million in cash flow a year (based on 1985 data) increasing to $120 million in 1992. The leading R&D companies in the country would lose R&D tax incentives equal to about 1 per cent of sales or 20-25 per cent of their after-tax earnings. Since we have already explained the many potential negative consequences of this measure, we will not repeat them here. We will reiterate the conclusion of our brief to Mr. Wilson that given the very low level of non-tax government support for industrial R&D in Canada, it would be very damaging to cap R&D tax credits to industry.

A.8 The Competitive Disadvantage Imposed by U.S. Defence R&D

Differences in government non-tax support for industrial R&D cause very real competitive difficulties for Canadian firms competing against U.S. or European corporations. For example, much of the non-tax support for R&D in the U.S. comes from the Department of Defense. Many U.S. companies have large percentages of their total R&D paid for by the U.S. Department of Defense - in some cases 90 per cent (Exhibit 22). Three examples illustrate the nature of the problem:

a) Canadian aerospace firms receive 50 per cent of all their R&D dollars from government sources - U.S. competitors average 75 per cent of R&D paid for by government.[3]

b) Northern Telecom's key competitor in the United States is AT&T. Bell-Northern Research, a research and development affiliate of Northern Telecom, has less than 1 per cent of its R&D directly paid for by government (i.e., non-tax support).[4] At AT&T about 5 per cent ($125 million) of all research is paid for directly by the U.S. Department of Defense.[5] AT&T also receives additional government R&D contracts and grants from other federal agencies.

c) Lumonics is the third largest laser company in the world. It has been effectively shut out of defence research. The U.S. government is spending more than $200 million a year on many types of laser research. Lumonics' two main competitors in the U.S., which are 2-3 times Lumonics' size, are each receiving from the U.S. government direct research monies well in excess of U.S. $10 million. Lumonics' entire R&D effort is CDN$10 million.[6]

U.S. defence spending assists U.S. firms in at least three identifiable ways:

a) some civilian products come directly out of defence R&D, although most estimates are that less than 20 per cent of all defence R&D has such direct civilian benefits.[7]

b) Defence R&D provides a base level of R&D funding for many companies, giving them funding stability and assisting them in achieving economies of scale in research.

c) An estimated 3-5 per cent of U.S. researchers change jobs every year, resulting in significant technology diffusion from defence projects to civilian activities through labour mobility.[8]

Canadian firms, which receive significantly less public non-tax R&D support than their U.S. competitors, will find it increasingly difficult to stay competitive.

A.9 Where Government Spends

The federal government currently spends most of its $4.1 billion S&T budget internally (only $2.6 billion of which is R&D).[9] Fully 75 per cent of it is spent by federal departments and only 25 per cent is given to the granting agencies (Exhibit 23). Most of the S&T money given to the National Research Council and government departments, except for DRIE, is spent internally (Exhibit 24). And of the 33,000 federal government employees engaged in S&T activities, 42 per cent, or about 13,900, are actually in administrative and *not* technical positions (Exhibit 25).

Two other important observations can be drawn about Canadian government funding of R&D:

- very little is industry-directed; and
- rarely are specific technologies targeted.

Exhibit 26 illustrates the situation. Most Canadian government R&D is conducted without much regard for industrial priorities and without a clear sense of targeting key technologies. The committee questions both these tendencies. Experience in other countries and Canada amply demonstrates that to be commercially relevant, research priorities need to be as industry-driven as possible. Moreover, a small country with very limited R&D resources, like Canada, cannot afford to distribute its research funding broadly without directing it toward its most critical technological needs.

The committee believes that not only is the absolute level of Canadian R&D much too low and causing our economic competitiveness to suffer, but also our ability to allocate what money we do spend in an efficient manner is constrained by a fundamental lack of understanding about how to develop priorities on a consultative basis. This stems from a confusion in Canada about the proper role of each of the players in S&T: industry, universities, government laboratories and science ministries.

Notes

1. Statistics Canada.

2. Telesis and Canada Consulting estimates from DRIE data, prepared for the Ontario Premier's Council.

3. Telesis and Canada Consulting for Ontario Premier's Council based on company interviews and U.S. Department of Defense data.

4. Telesis and Canada Consulting analysis based on data from Northern Telecom.

5. Telesis and Canada Consulting analysis based on data from *Business Week* and U.S. Department of Defense.

6. Telesis and Canada Consulting interviews and analysis for the Ontario Premier's Council.

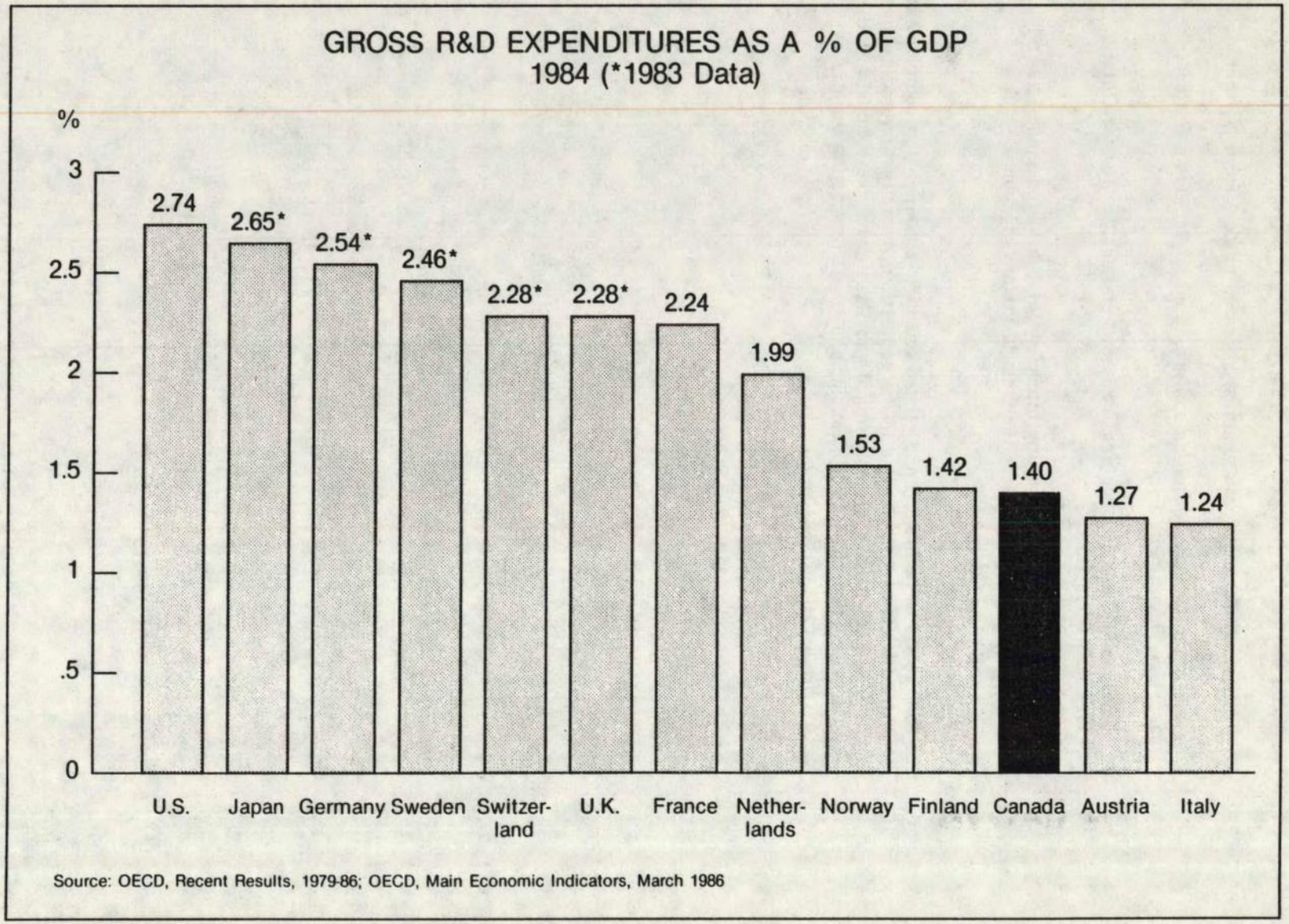
7. Telesis and Canada Consulting interviews of U.S. defence analysts and reviews of the literature for the Ontario Premier's Council.

8. Ibid.

9. S&T refers to both R&D and related scientific activities that complement and extend R&D by contributing to the generation, dissemination and application of S&T knowledge such as technical and statistical surveys, special studies and museum services. It does *not* include laboratory testing services as overhead costs of R&D.

EXHIBIT 1

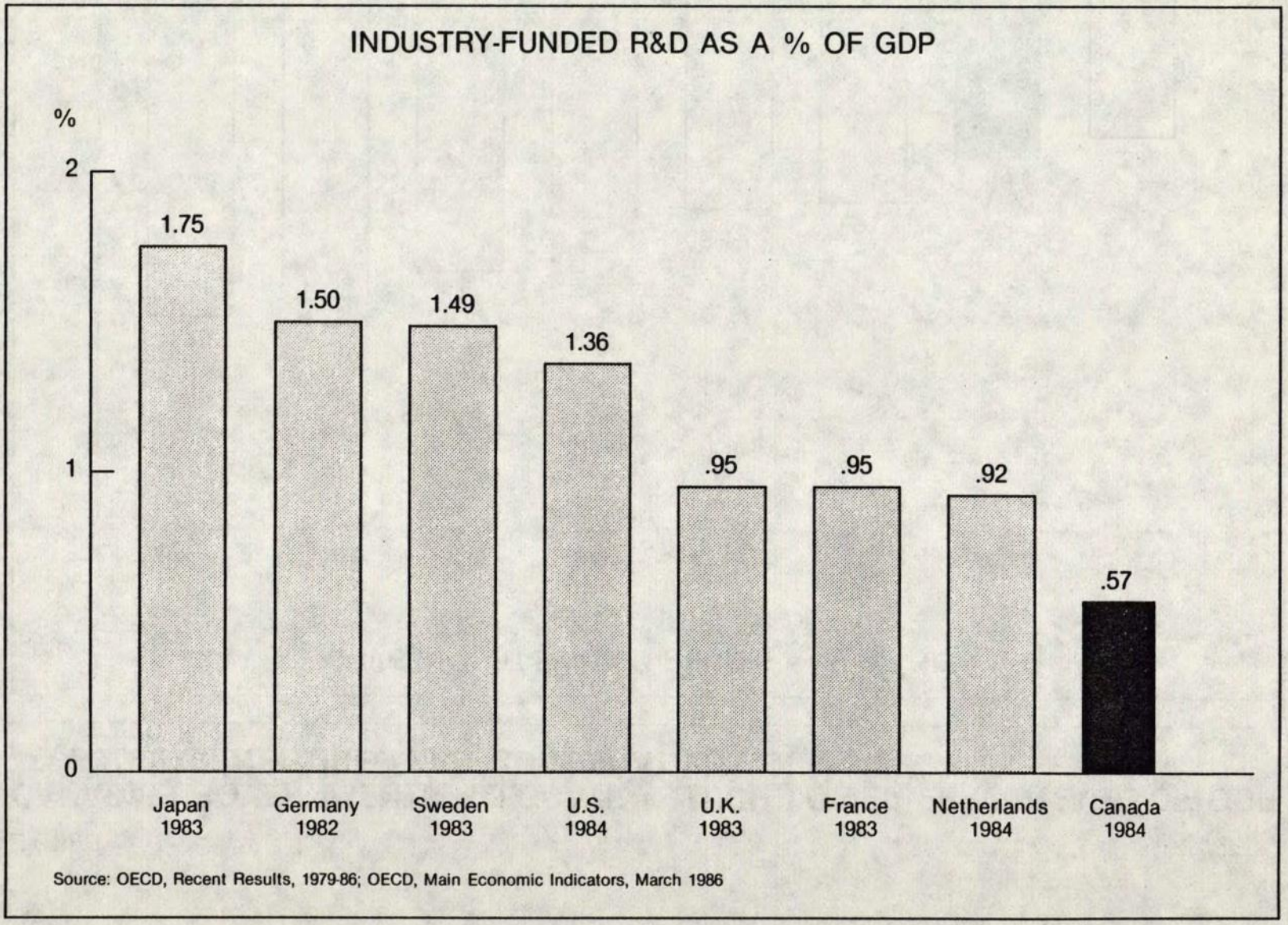
CANADA HAS A MUCH LOWER RATIO OF R&D EXPENDITURE TO GDP THAN MANY OTHER DEVELOPED COUNTRIES



Source: OECD, Recent Results, 1979-86; OECD, Main Economic Indicators, March 1986

EXHIBIT 2

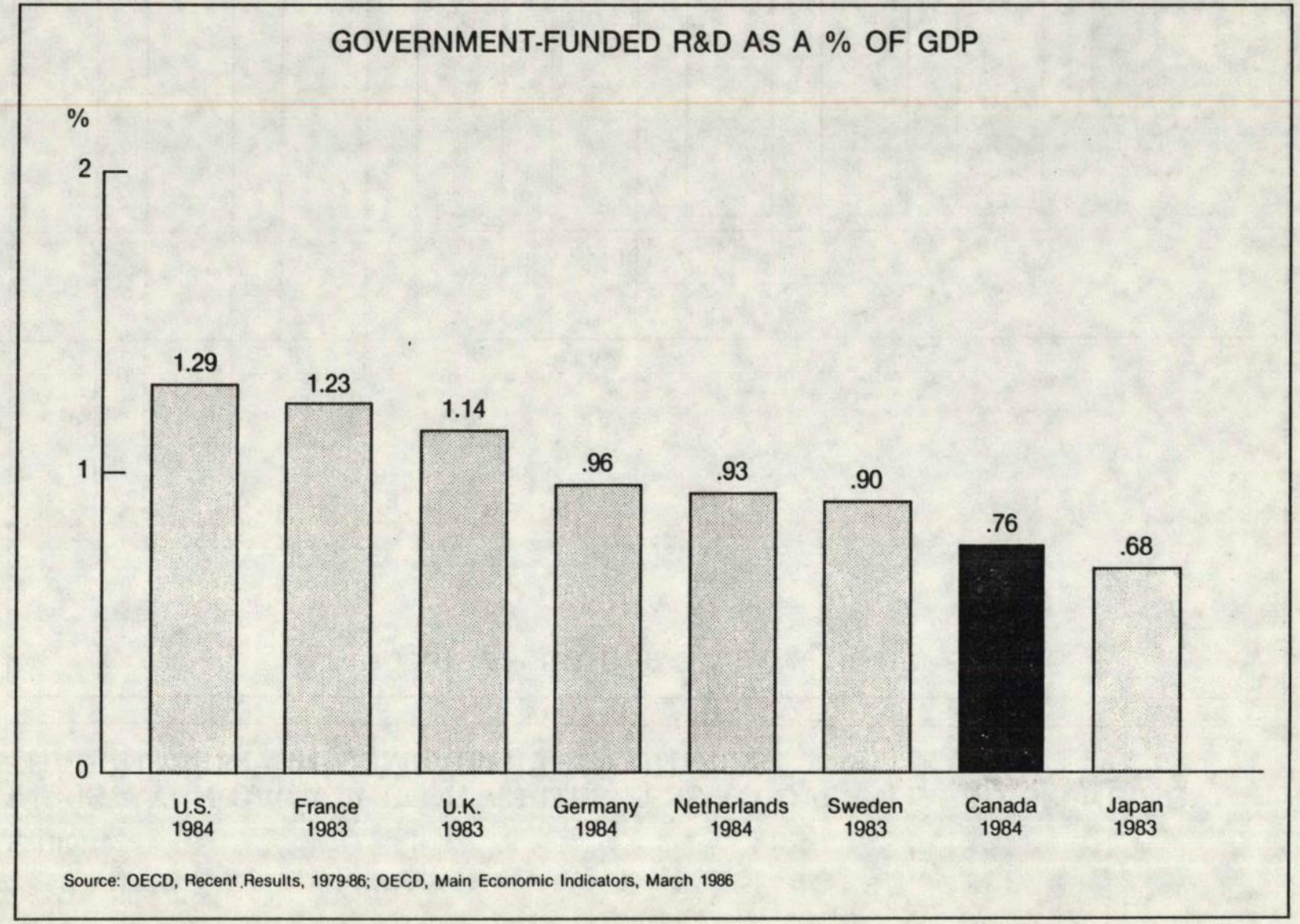
INDUSTRY IN CANADA CONTRIBUTES LESS TO OVERALL R&D SPENDING THAN INDUSTRY IN COMPARATIVE COUNTRIES



Source: OECD, Recent Results, 1979-86; OECD, Main Economic Indicators, March 1986

EXHIBIT 3

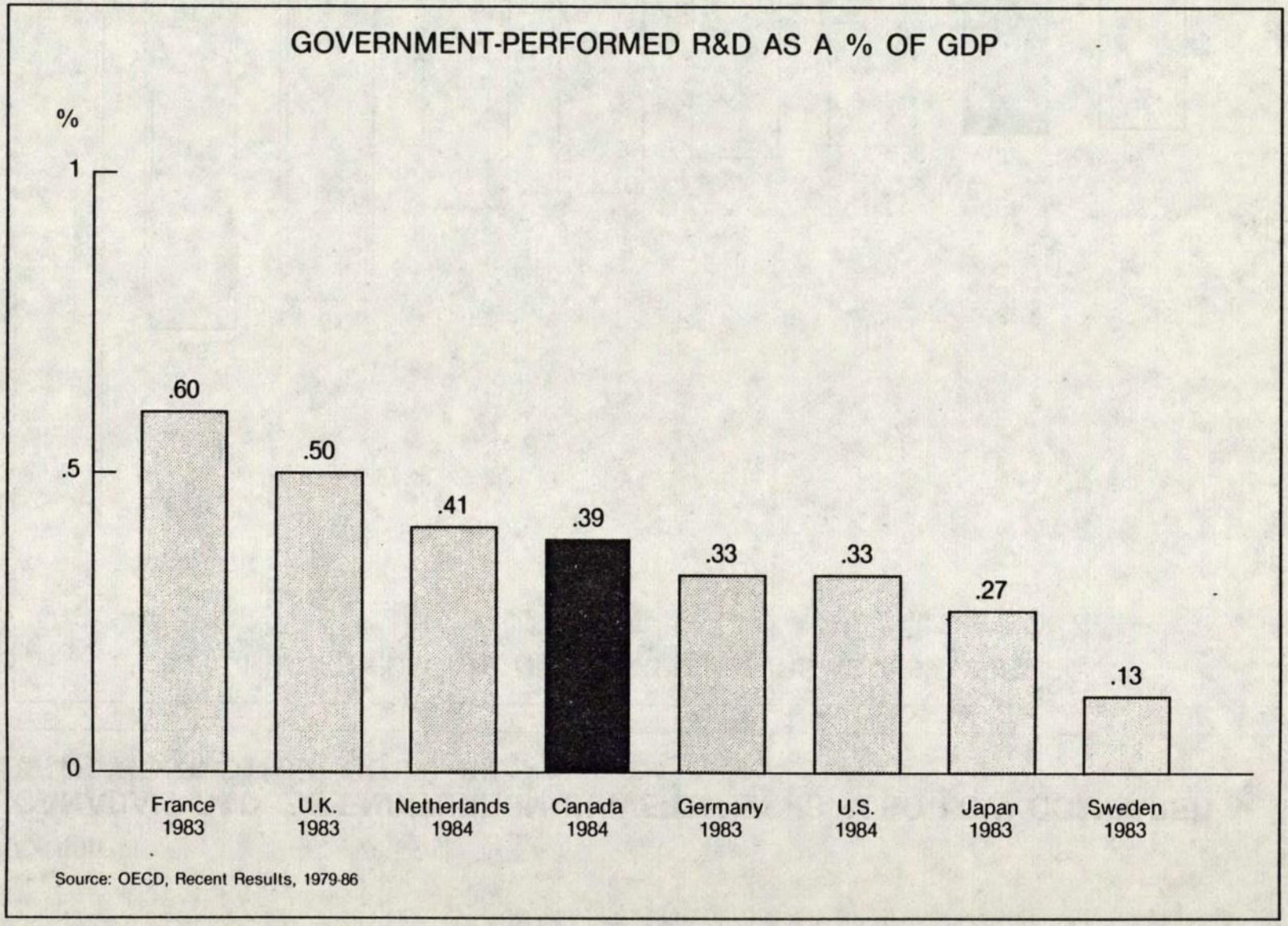
CANADA'S GOVERNMENTS ALLOCATE A MUCH LOWER PERCENTAGE OF GDP TO R&D EXPENDITURE THAN COMPARATIVE COUNTRIES



Source: OECD, Recent Results, 1979-86; OECD, Main Economic Indicators, March 1986

EXHIBIT 4

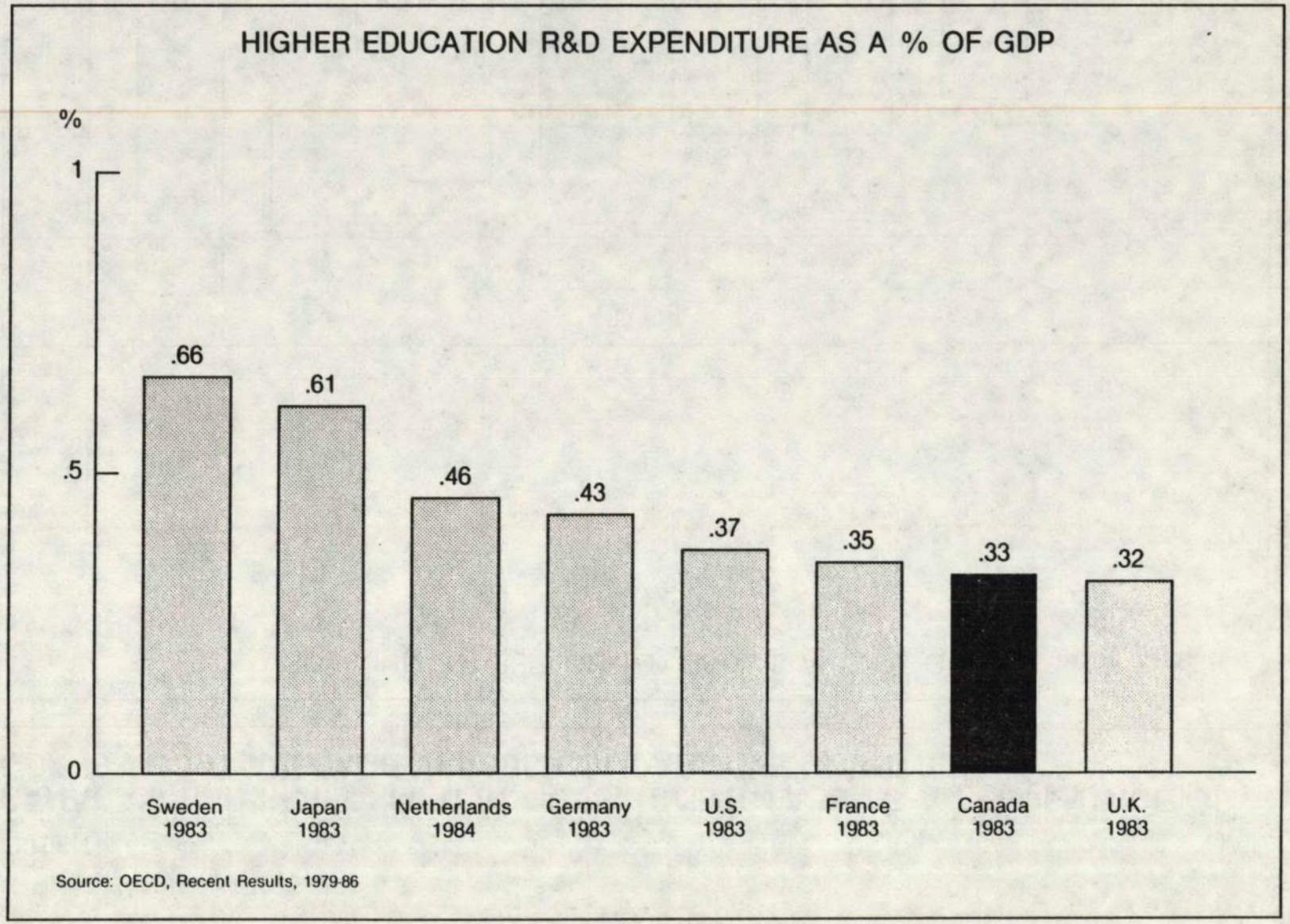
CANADA'S R&D PERFORMED IN GOVERNMENT LABS AS A PERCENTAGE OF GDP IS ABOUT AVERAGE VERSUS COMPARATIVE COUNTRIES



Source: OECD, Recent Results, 1979-86

EXHIBIT 5

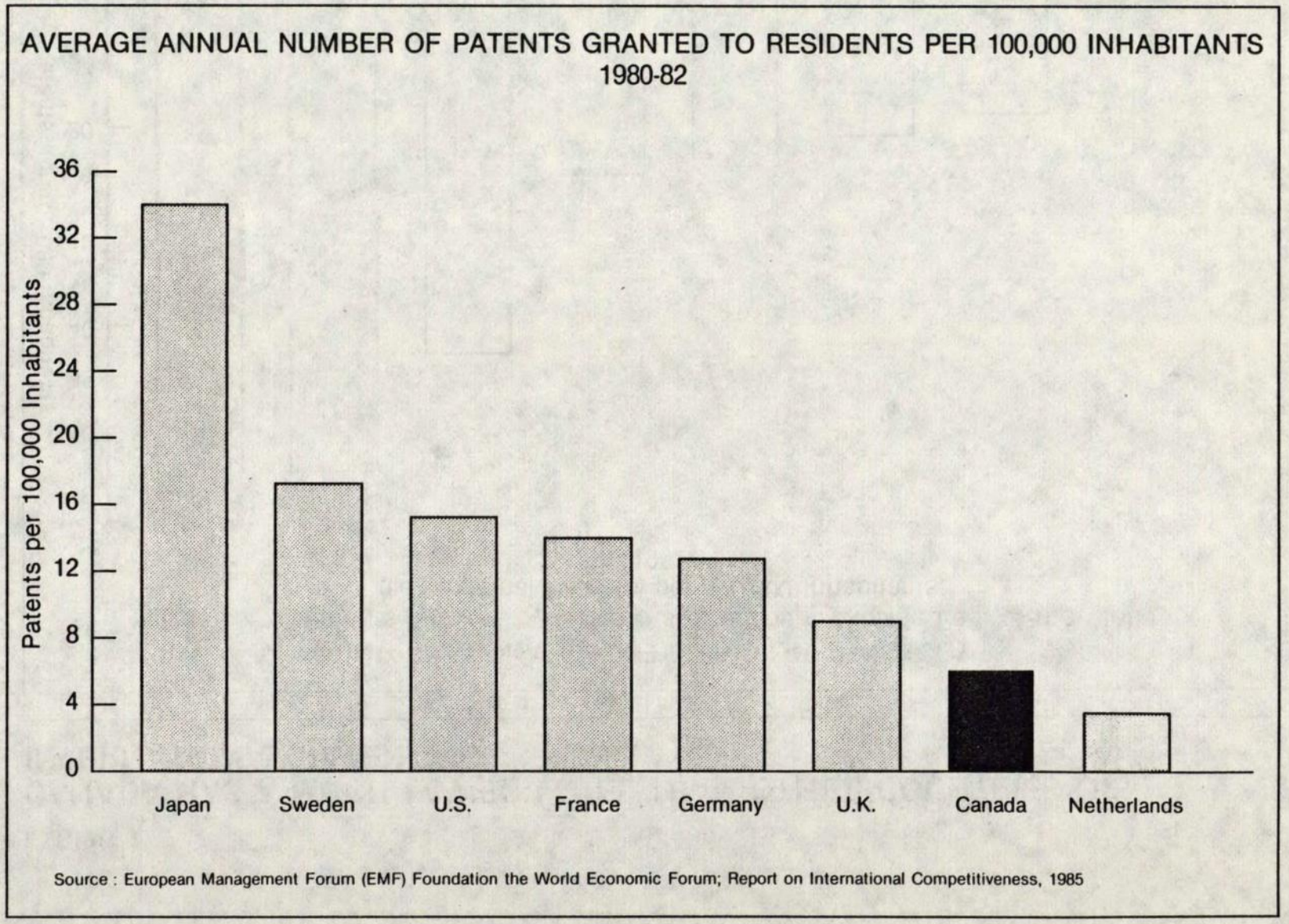
CANADA'S R&D EXPENDITURE IN UNIVERSITIES IS ALSO LOW COMPARED WITH MOST OTHER COUNTRIES



Source: OECD, Recent Results, 1979-86

EXHIBIT 6

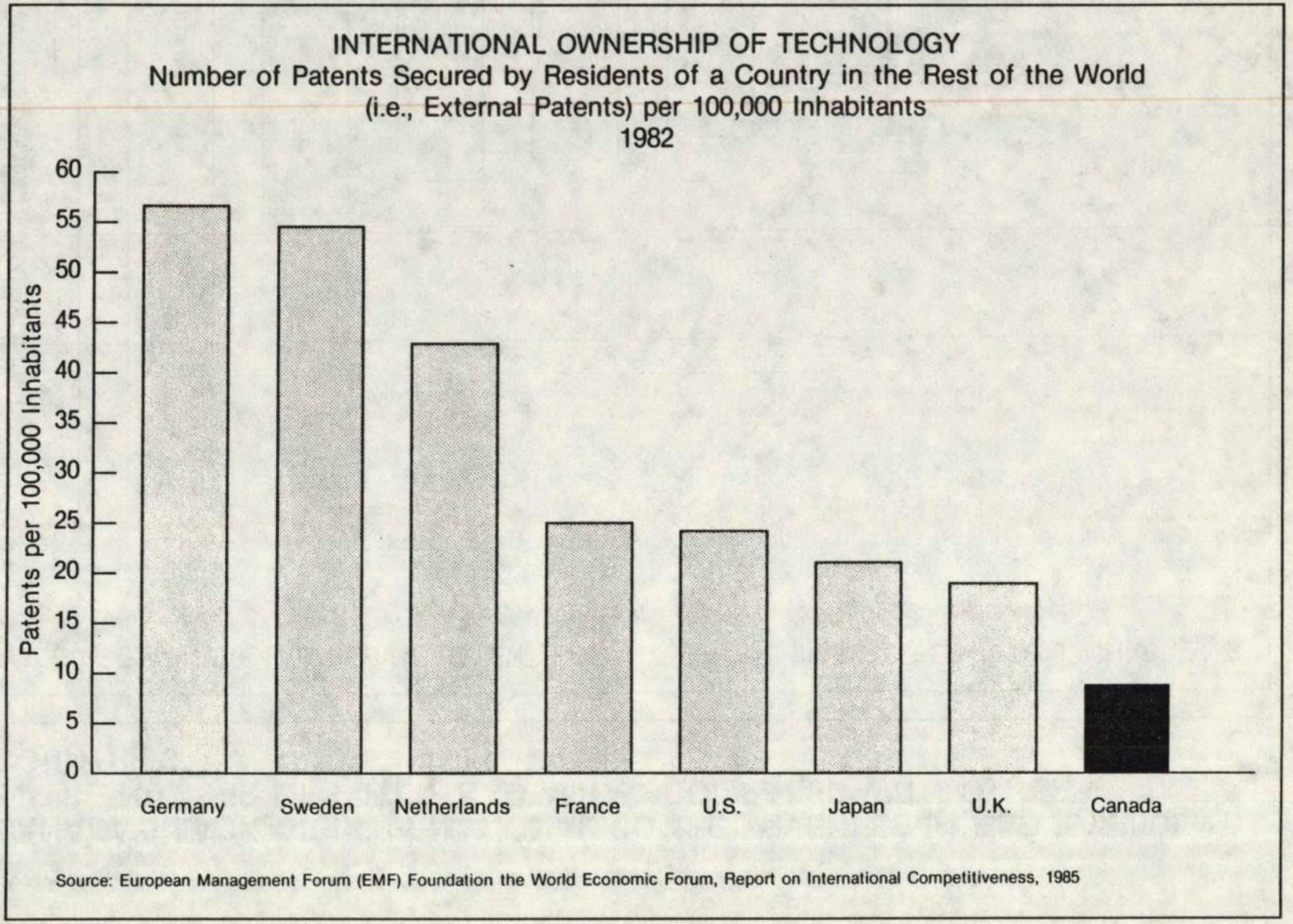
CANADA'S LACK OF INTERNATIONAL COMPETITIVENESS IN R&D IS EVIDENT IN THE NUMBER OF PATENTS GRANTED COMPARED WITH OTHER COUNTRIES



Source : European Management Forum (EMF) Foundation the World Economic Forum; Report on International Competitiveness, 1985

EXHIBIT 7

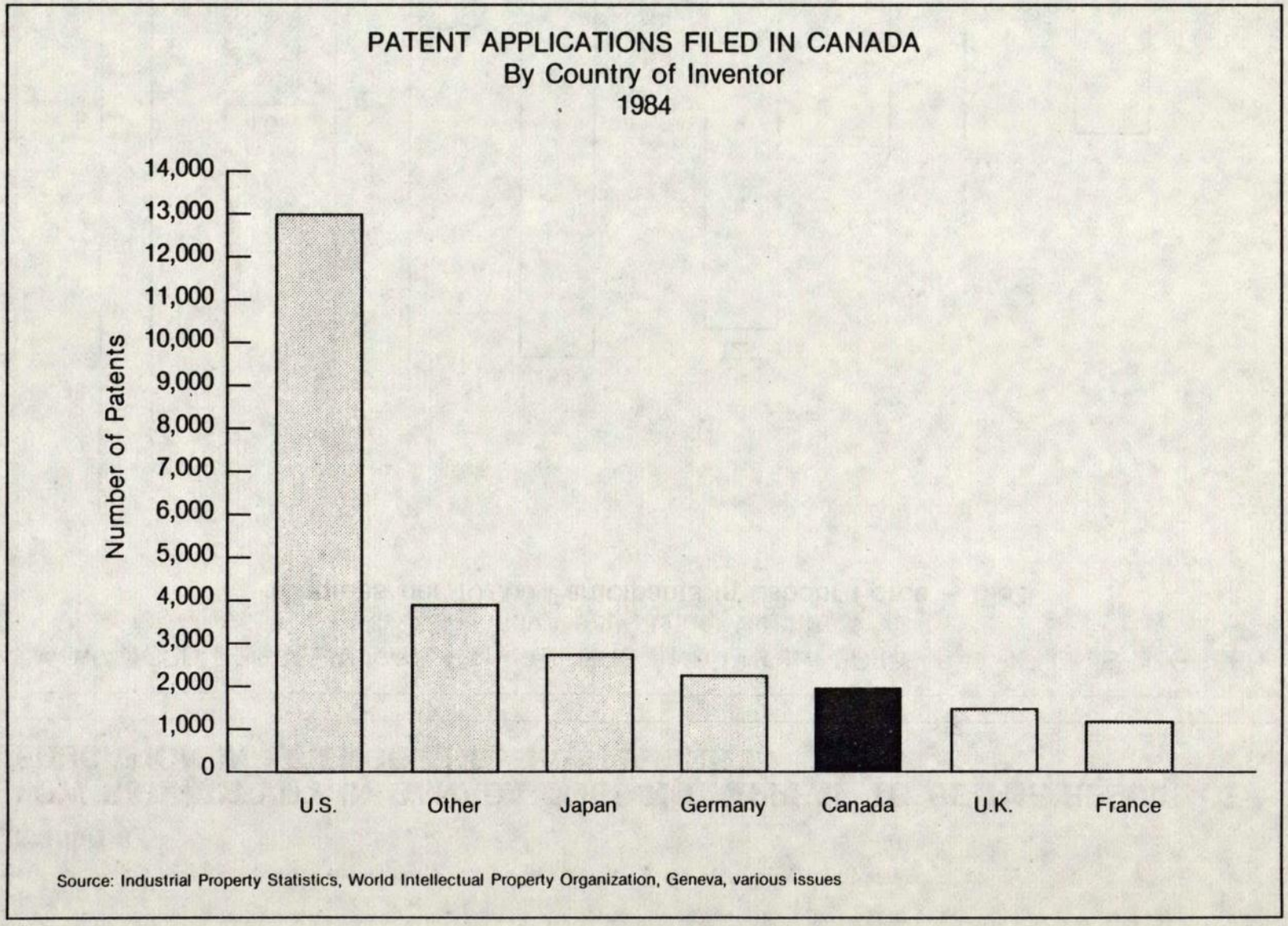
CANADA HAS A MUCH LOWER LEVEL THAN OTHER COUNTRIES OF INTERNATIONAL PATENTING



Source: European Management Forum (EMF) Foundation the World Economic Forum, Report on International Competitiveness, 1985

EXHIBIT 8

HALF THE PATENTS FILED IN CANADA IN 1984 WERE BY AMERICAN INVENTORS — ONLY 8% BY CANADIANS



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

EXHIBIT 9

LOW R&D ACTIVITY IN CANADA DOES NOT APPEAR TO BE THE RESULT OF EDUCATION IN SCIENCE AND ENGINEERING

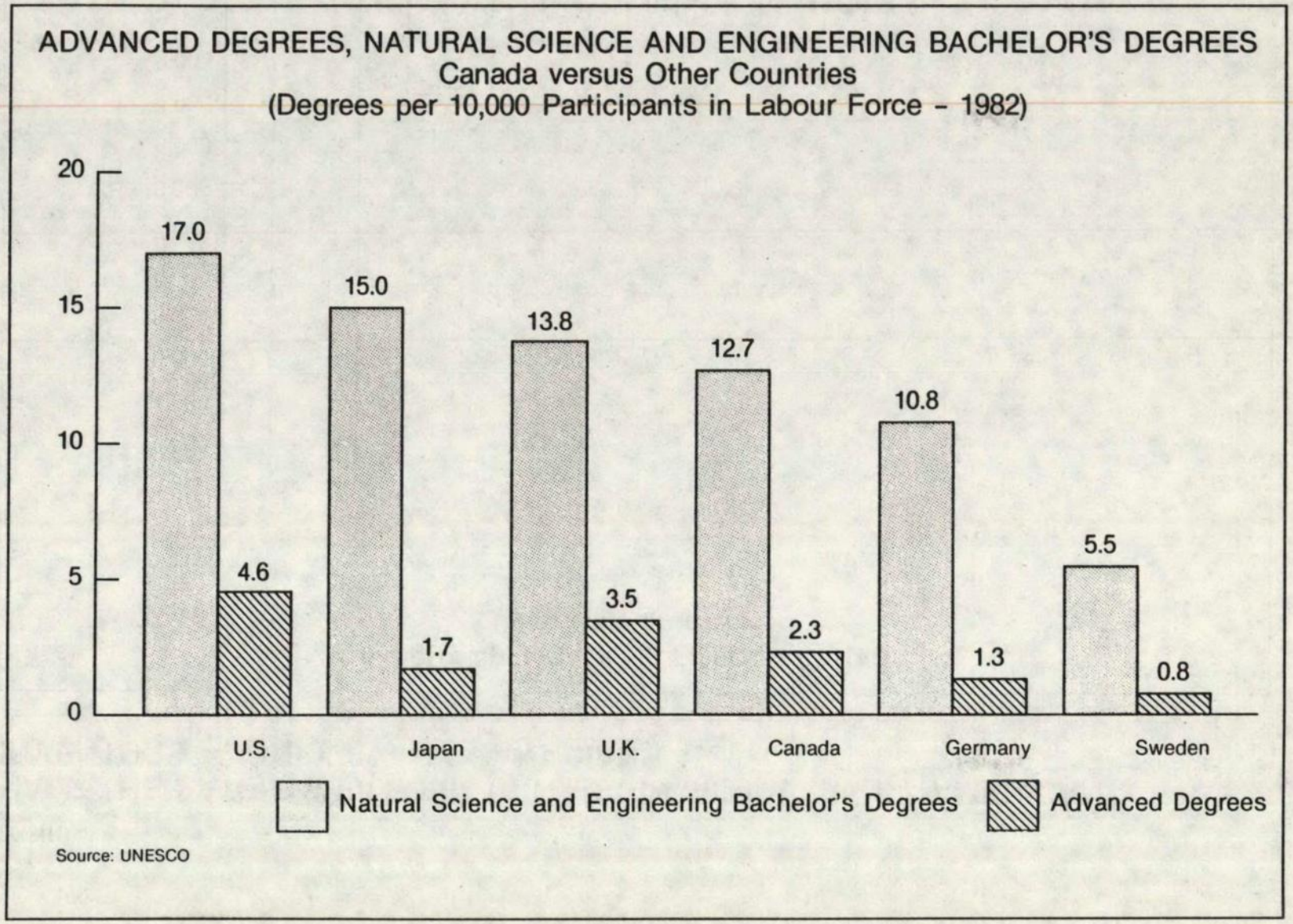


EXHIBIT 10

HOWEVER, CANADA HAS FAR FEWER RESEARCH SCIENTISTS AND ENGINEERS IN THE LABOUR FORCE THAN OTHER COUNTRIES

TOTAL RESEARCH SCIENTISTS AND ENGINEERS
Per Thousand Labour Force, 1983

Country	Research Scientists and Engineers
Japan	7.4
United States	6.4
Germany	4.8
France	3.9
Sweden	3.9
Netherlands	3.7
Canada	2.7

Source: OECD, Recent Results, 1979-86. The OECD notes that the Japanese data are likely over-estimated. No data are available for the U.K.

EXHIBIT 11

CANADA'S LOW R&D EXPENDITURES, ESPECIALLY IN THE PRIVATE SECTOR, ARE REFLECTED IN A NEGATIVE TRADE BALANCE IN R&D INTENSIVE INDUSTRIES

TRADE BALANCE OF MANUFACTURING INDUSTRIES ACCORDING TO THEIR R&D INTENSITY*
1970-84

	High Intensity	Medium Intensity	Low Intensity
Japan	Positive	Positive	Positive
United States	Positive	Positive	Negative
Germany	Positive	Positive	Negative
France	Positive	Positive	Negative
United Kingdom	Positive	Positive	Negative
Netherlands	Negative	Positive	Positive
Sweden	Negative	Positive	Positive
Canada	Negative	Negative**	Positive

* R&D intensity is measured by R&D expenditure/output. High-intensity industries have more than 10% measure; medium intensity is 1-10%; and low intensity is less than 1%.
** Positive from 1981

Source: OECD Science and Technology Indicators, 1986

EXHIBIT 12

THE HIGH LEVEL OF FOREIGN OWNERSHIP CONTRIBUTES TO CANADA'S LOW OVERALL INDUSTRIAL R&D

R&D EXPENDITURES BY COUNTRY OF CONTROL FOR FIRMS IN CANADA
% of Sales

	1977	1979	1981	1982	1983	1984
Canadian-controlled	1.0%	0.9%	1.1%	1.4%	1.4%	1.6%
Foreign-controlled	0.7%	0.7%	0.9%	1.0%	0.9%	1.0%
Total	0.8%	0.8%	1.0%	1.2%	1.2%	1.2%

Source: Statistics Canada

EXHIBIT 13

CANADIAN-OWNED FIRMS DEVOTE A MUCH HIGHER PERCENTAGE OF SALES TO R&D THAN FOREIGN-OWNED FIRMS IN ALL OF CANADA'S R&D INTENSIVE INDUSTRIES

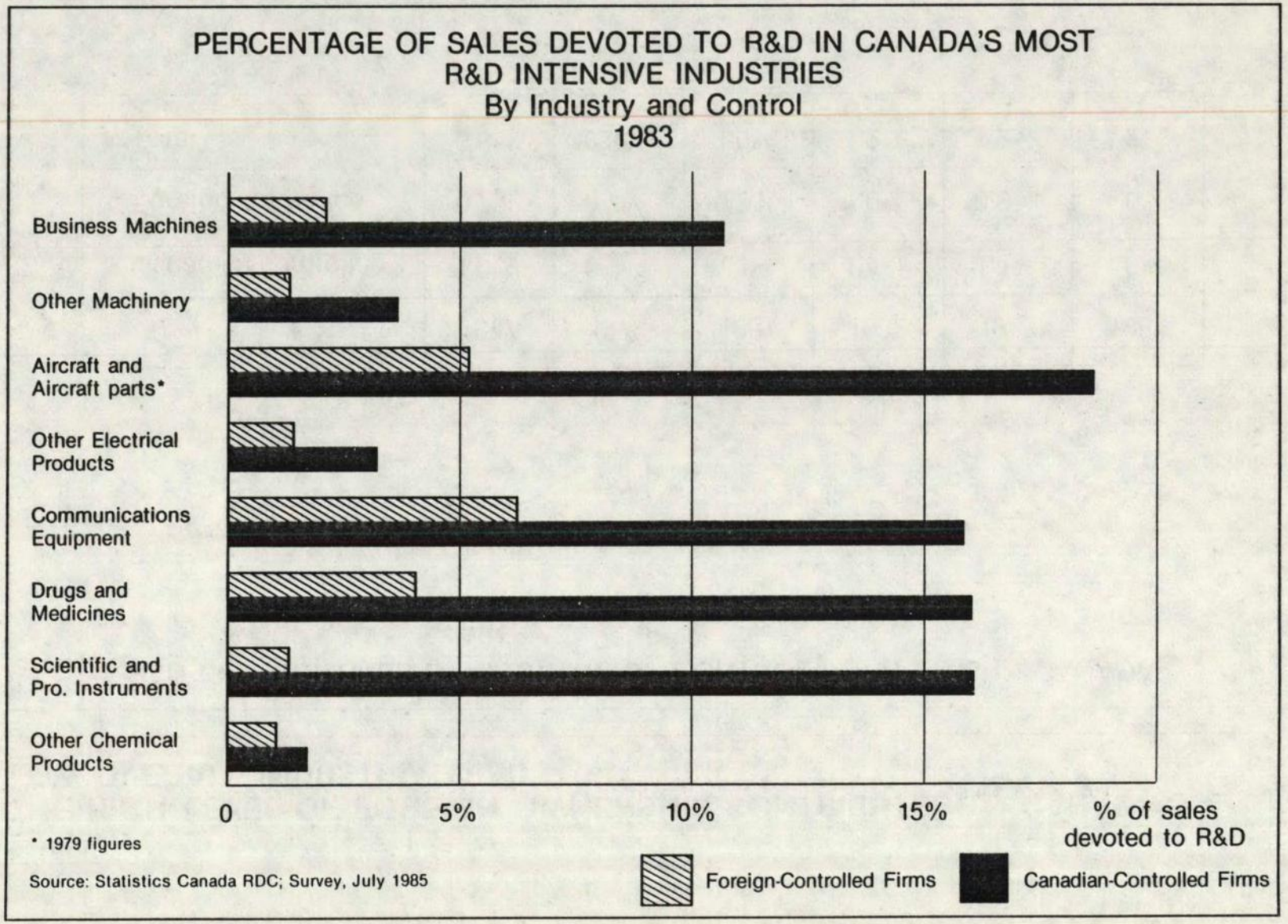
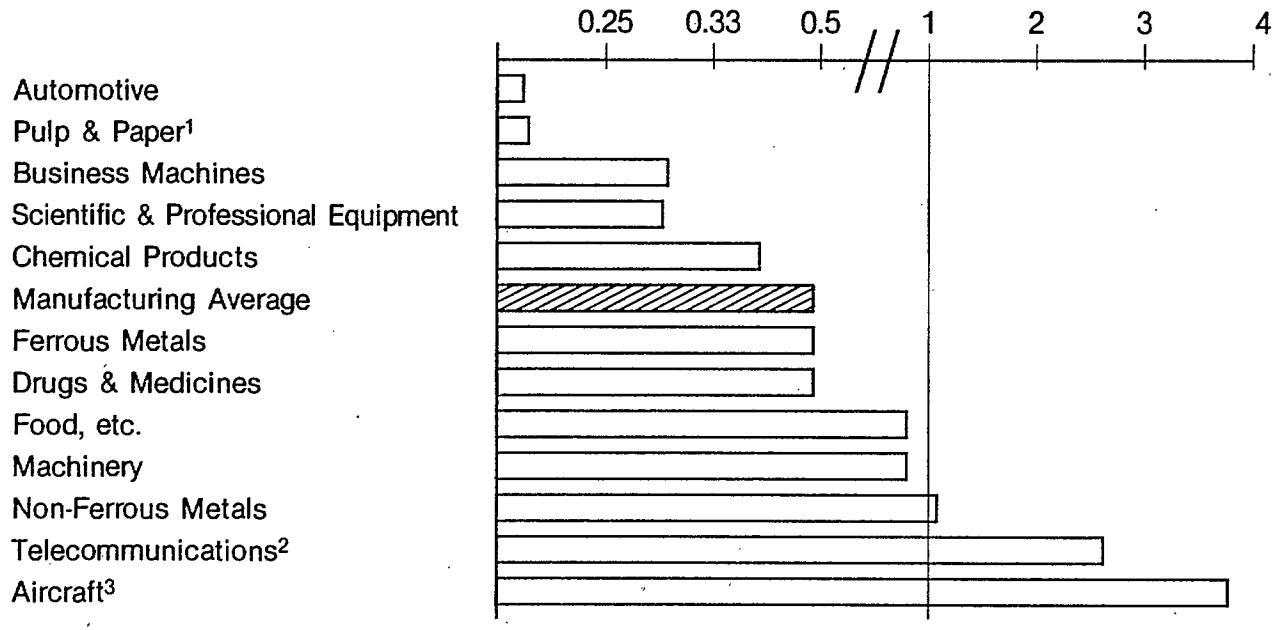


EXHIBIT 14

IN MANY SECTORS CANADIAN COMPANIES SPEND SUBSTANTIALLY LESS ON R&D AS A PERCENTAGE OF SALES THAN THEIR U.S. COUNTERPARTS



1 Pulp and paper companies in Canada contribute to a central research institute, reducing their internal expenditures.
2 The much higher Canadian rate of expenditure also reflects corporate structure differences. Many U.S. telecommunications firms have service revenues in their base, reducing R&D as a percentage of sales. Northern Telecom does not have this problem as it is kept separate from Bell Canada in these statistics.
3 U.S. aircraft firms receive a much higher proportion of their R&D funds from the government than Canadian firms, which explains the much higher rate of company spending in Canada.

Source: Canada Consulting and Telesis
Analysis based on Statistics Canada and U.S. Commerce Dept. data

EXHIBIT 15

CANADIAN INDUSTRY HAS INCREASED ITS LEVEL OF R&D OVER THE PAST SIX YEARS

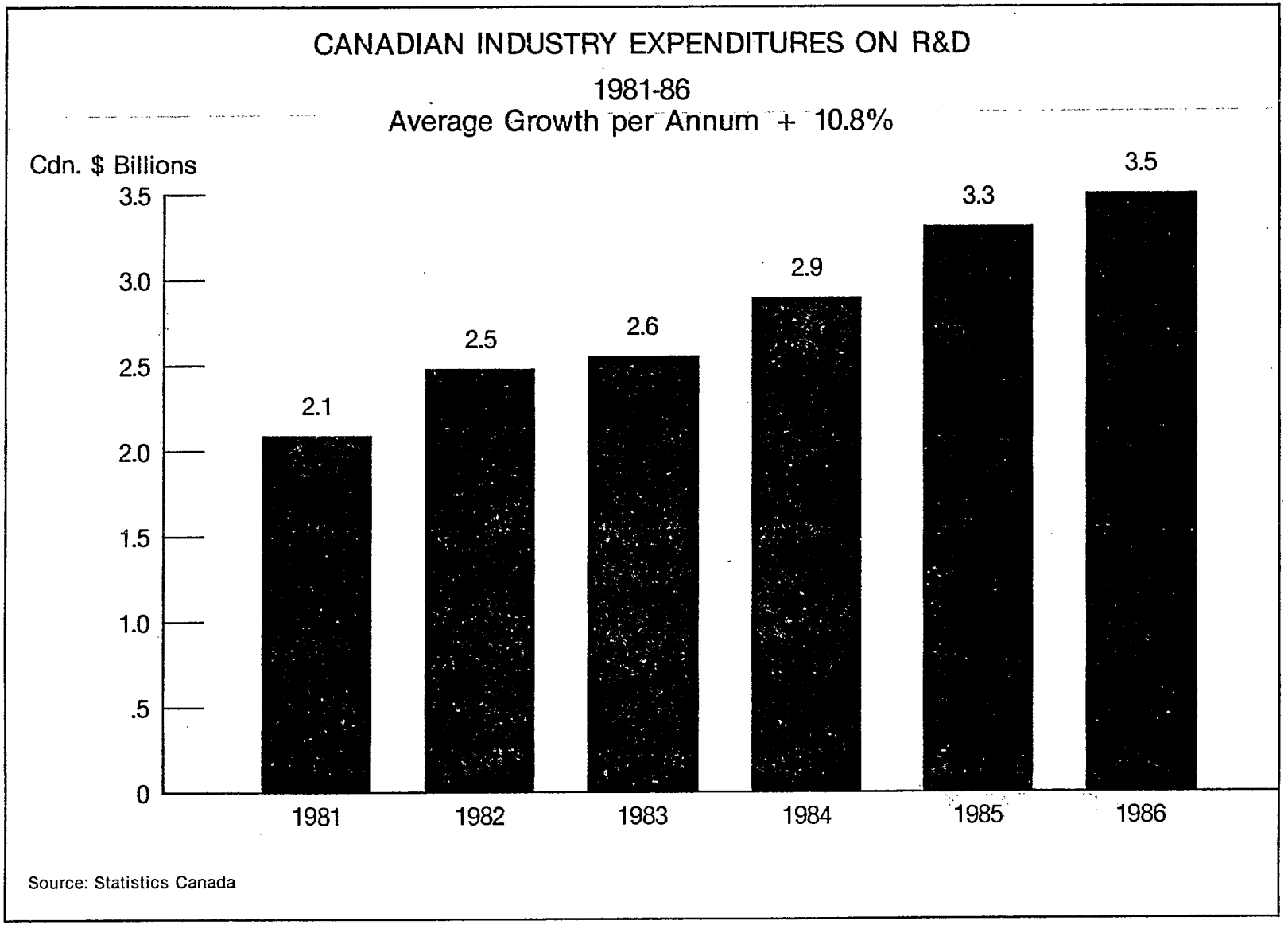


EXHIBIT 16

INVESTMENT BY CANADA'S FIFTEEN LARGEST R&D SPENDERS IS GREATER THAN $1.5 BILLION — ABOUT HALF OF TOTAL INDUSTRY R&D

INDUSTRY-FUNDED AND PERFORMED R&D UNDERTAKEN IN CANADA

($ Millions)

	Projected 1987	1986	1985	1984	Ownership of Company
Bell Canada Enterprises	$687	$630	$606	$473	Canadian-owned
Atomic Energy of Canada	172	173	187	190	Crown corporation
Pratt & Whitney	149	128	134	100	Foreign-owned
IBM Canada	138	108	89	68	Foreign-owned
Ontario Hydro	99	92	80	72	Crown corporation
Alcan Aluminum	61	56	62	n/a	Canadian-owned
Imperial Oil	60	65	70	70	Foreign-owned
Canada Development	n/a	n/a	79	75	Canadian-owned
Hydro Quebec	60	64	75	n/a	Crown corporation
Mitel	n/a	56	52	53	Canadian-owned
CAE Industries	50	55	49	27	Canadian-owned
de Havilland Aircraft	n/a	49*	41	48	Canadian-owned
Boeing of Canada	43	57	40	n/a	Foreign-owned
Allied Signal Canada	36	26	27	n/a	Foreign-owned
Canadair	34	33	20	20	Foreign-owned**

* Projected
** Crown Corporation up to 1986

Source: The *Financial Post*. Note that the numbers are provided by companies responding to the *Financial Post*'s survey, and that there are likely variations in some companies' interpretation of how to report their data (e.g., gross R&D spending vs. net of government grants).

EXHIBIT 17

INDUSTRIAL SPENDING ON R&D IN CANADA IS VERY CONCENTRATED IN A SMALL NUMBER OF FIRMS

INDUSTRIAL CONCENTRATION OF R&D IN CANADA

R&D Spenders	1975 % of Total Industry-Funded R&D	1985 % of Total Industry-Funded R&D
Top 10	35%	38%
Top 25	51%	52%
Top 50	64%	63%
Top 100	76%	74%

Source: Statistics Canada

EXHIBIT 18

R&D INTENSIVE INDUSTRIES ACCOUNT FOR 4.5% OF CANADA'S TOTAL INDUSTRIAL SALES BY R&D PERFORMERS, BUT ARE RESPONSIBLE FOR 46.5% OF CANADA'S TOTAL INDUSTRY-FUNDED R&D

CURRENT R&D EXPENDITURES AND SALES BY INDUSTRY

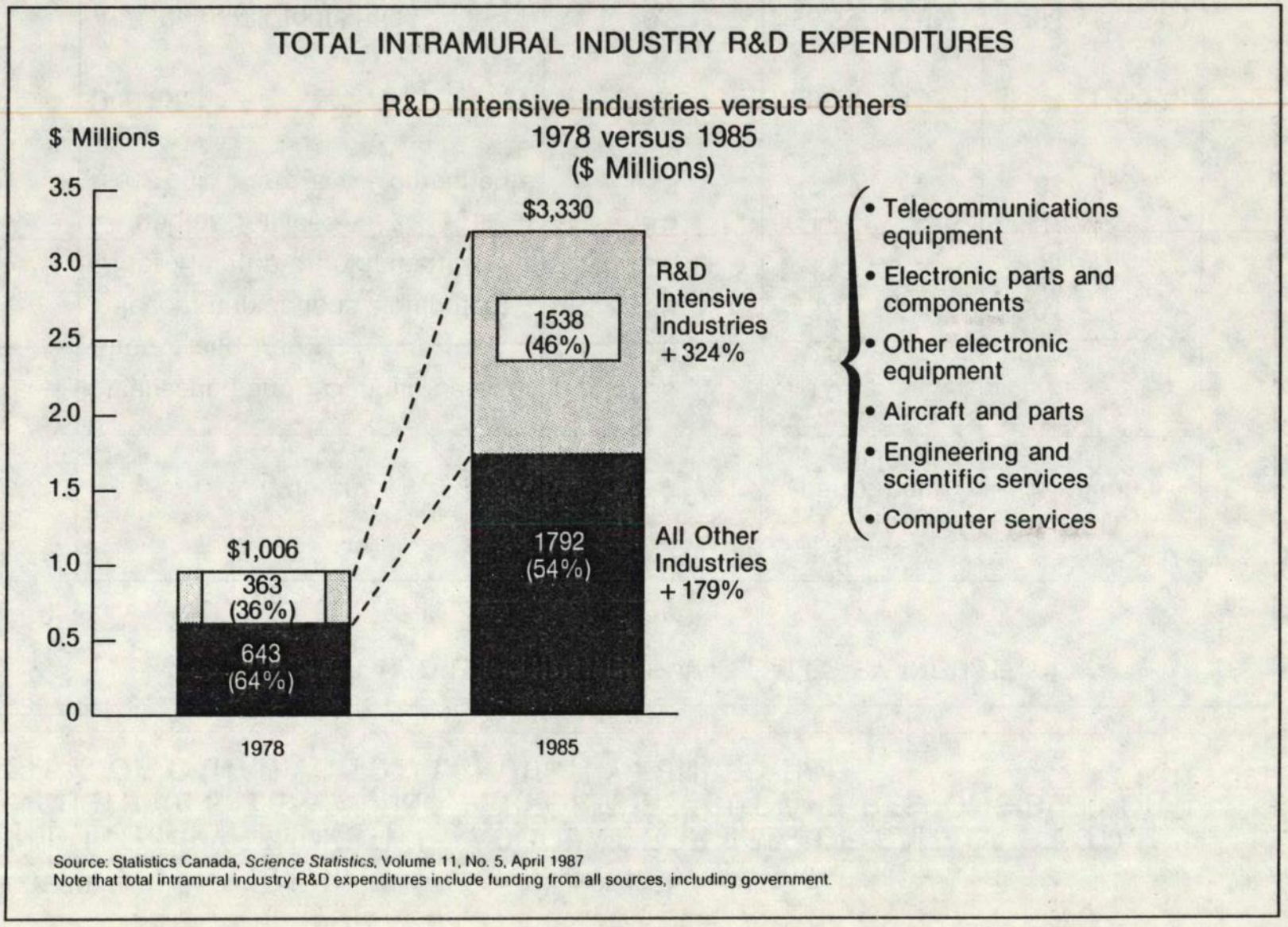
1985

Industry	R&D/Sales (%)	Sales by R&D performers ($ Billions)		R&D ($ Millions)	
Engineering and Scientific Services	17.6	1.0		178	
Aircraft and Parts	15.8	2.0		312	
Telecommunications Equipment	14.3	3.5		504	
Other Electronic Equipment	14.3	1.1		153	
Computer Services	8.5	1.1		94	
Electronic Parts and Components	8.3	0.7		63	
Sub-total	14.0	9.3	(4.5%)	1,304	(46.5%)
All Others (23 Industries)	0.8	196.5	(95.5%)	1,498	(53.5%)
Total	1.3	205.8		2,802	

Source: Statistics Canada 88-202, Industrial Research and Development Statistics 1985

EXHIBIT 19

THE GROWTH IN R&D SPENDING IN R&D INTENSIVE INDUSTRIES HAS SIGNIFICANTLY OUTPACED ALL OTHER INDUSTRIES



Source: Statistics Canada, *Science Statistics*, Volume 11, No. 5, April 1987
Note that total intramural industry R&D expenditures include funding from all sources, including government.

EXHIBIT 20

CANADA'S OVERALL LEVEL OF GOVERNMENT SUPPORT FOR INDUSTRIAL R&D IS MUCH LOWER THAN KEY COMPETITORS

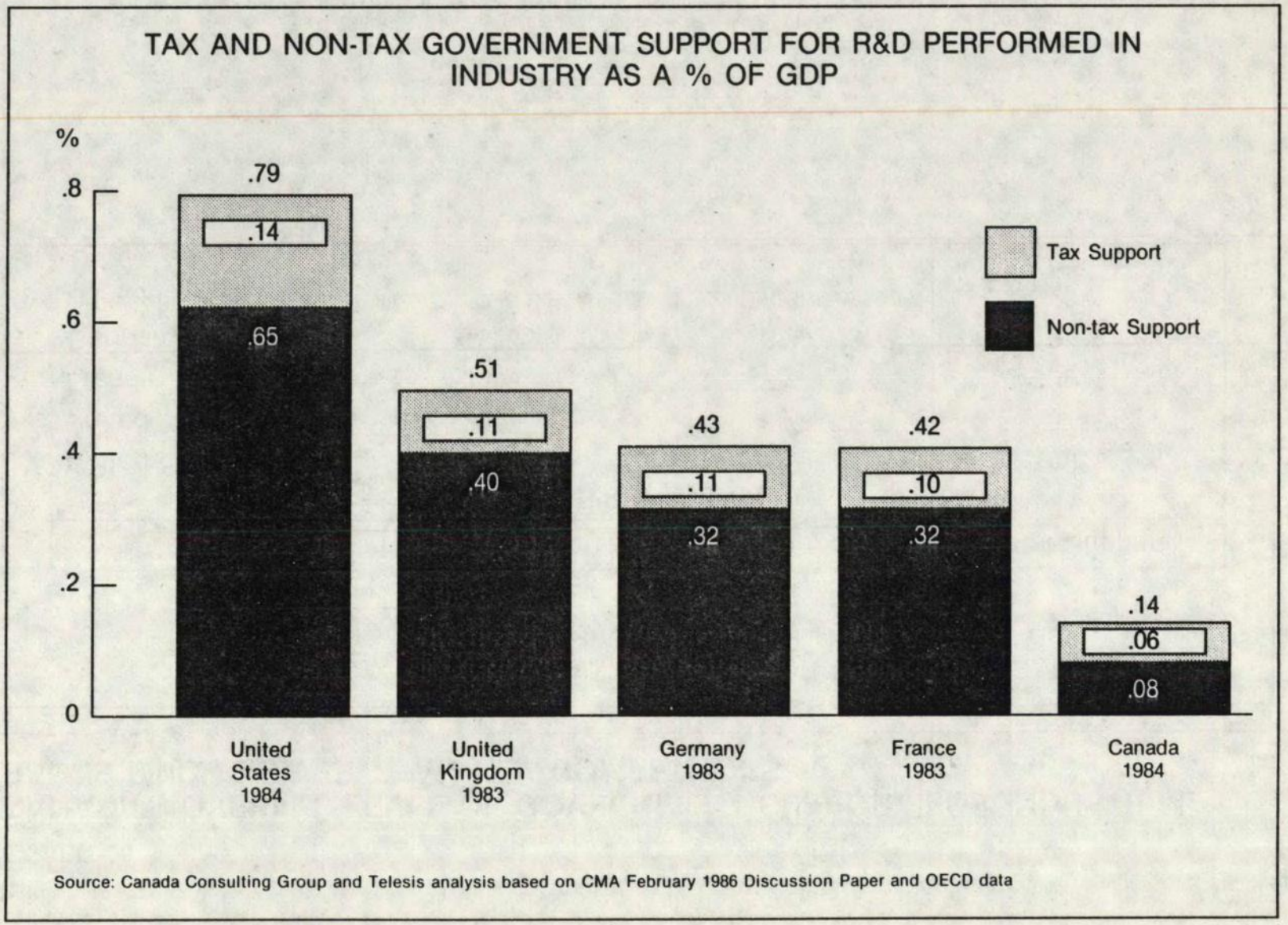
TAX AND NON-TAX GOVERNMENT SUPPORT FOR INDUSTRIAL R&D AS A % OF R&D PERFORMED IN INDUSTRY

Country	Non-Tax Support	Tax Support	Total Support
United States	33%	7%	40%
United Kingdom	29%	8%	37%
France	22%	7%	29%
Germany	18%	6%	24%
Canada	12%	8%	20%

Source: Canadian Manufacturers Association, February 1986 Discussion Paper. Percentages for non-tax support of industrial R&D in competing countries were obtained from OECD Science and Technology Indicators, 1984, Tables 2.29 and 3.24, which provide percentages based on 1979 information. The dollar amount of Canadian government non-tax support of industrial R&D and the dollar amount of R&D performed in Canadian industry are available for 1984 from Statistics Canada, Science and Technology Indicators 1984, Table 3.1. The dollar amount of Canadian tax support for industrial R&D for 1982 is available from Macdonald Royal Commission data in Volume II of the Commission Report, Table 8-8. Figures for tax support for other countries are calculated using the amount of 1982 Canadian tax support and ratios that define the relative generosity of R&D tax incentives in Canada and other countries. They were developed by McFetridge and Warda (Canadian R&D Incentives: Their Adequacy and Impact, Canadian Tax Paper, No. 70, Table 5.4). Although the McFetridge and Warda ratios were developed on the basis of tax incentives for R&D support that are different from the incentives available today, the changes in the R&D tax incentives were designed to improve the utilization of the tax incentives and not the level of the incentive. As a result, the estimates in the table can still be considered a useful proxy of the level of R&D tax support provided by various countries today.

EXHIBIT 21

EXPRESSED AS A PER CENT OF GDP, GOVERNMENT SUPPORT FOR INDUSTRIAL R&D IN CANADA IS ONLY 1/6 THE U.S. AND 1/4-1/3 OF THE U.K., GERMANY AND FRANCE



Source: Canada Consulting Group and Telesis analysis based on CMA February 1986 Discussion Paper and OECD data

EXHIBIT 22

LEADING U.S. DEFENCE R&D CONTRACTORS RECEIVE ABOUT HALF ALL THEIR R&D FROM THEIR DEFENCE WORK

TOP TEN U.S. DEFENCE R&D CONTRACTORS
(CDN $ Millions)

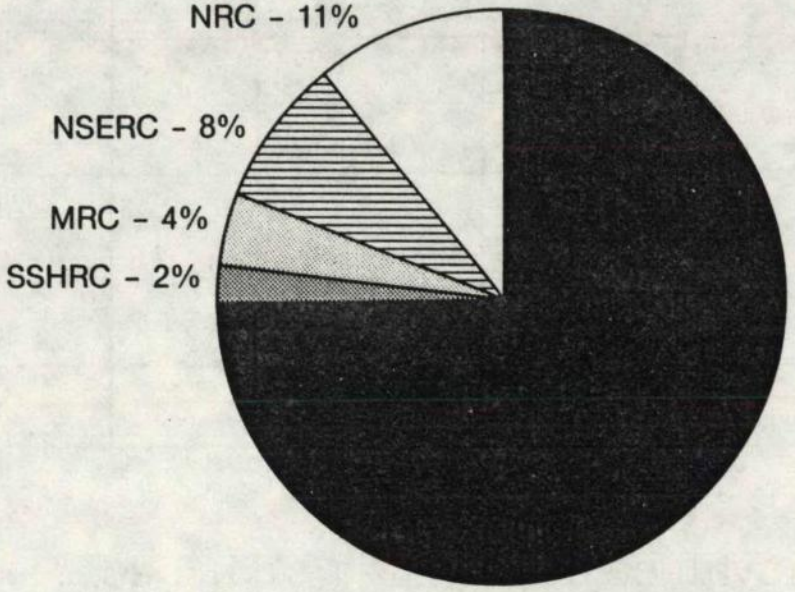
		R&D of Own Funding	Defence R&D as % of Total R&D
Lockheed Missiles & Space	$2,048	$678	75%
Martin Marietta	1,788	302	86%
McDonnell Douglas	1,281	697	65%
General Electric	1,275	1,794	42%
Grumman	1,256	109	92%
Rockwell International	857	563	60%
Boeing	835	1,045	44%
TRW	740	221	77%
Bell Boeing, Joint Venture	711	N/A	N/A
IBM	683	5,486	11%
Hughes Aircraft	558	N/A	N/A
United Technologies	552	1,177	32%
Total	$12,584	$12,072	48% (8 Firms)

Source: Telesis and Canada Consulting based on data from U.S. Department of Defense and *Business Week* 1987, U.S. R&D Survey

EXHIBIT 23

FEDERAL GOVERNMENT DEPARTMENTS ACCOUNT FOR 75% OF FEDERAL S&T EXPENDITURE, WITH ONLY 25% GOING TO THE NATIONAL RESEARCH COUNCIL AND PURE GRANTING AGENCIES

DISTRIBUTION OF FEDERAL S&T EXPENDITURE
1987
$4.1 Billion



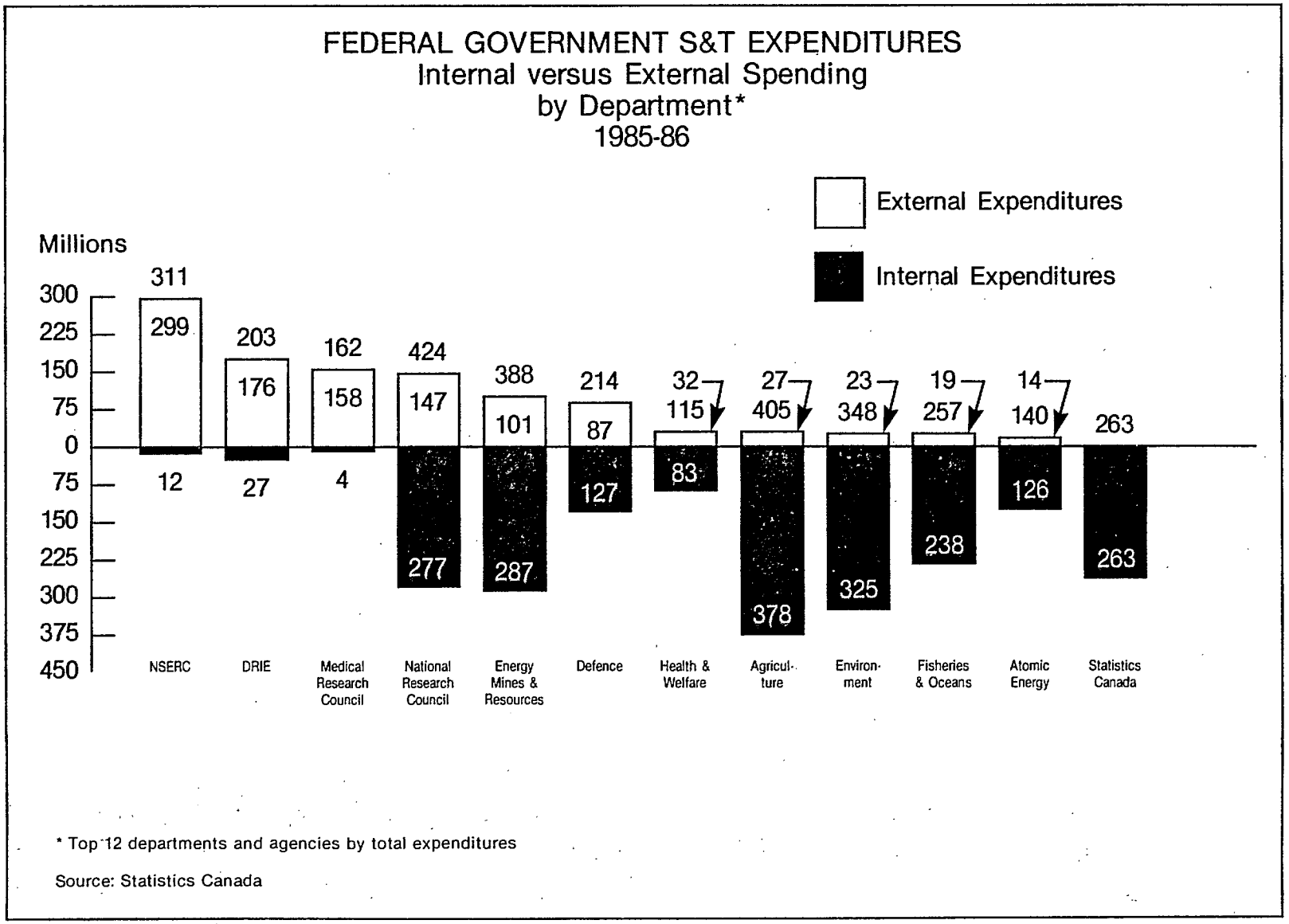
GRANTING AGENCIES

NRC	National Research Council (one-third granting, two-thirds own labs)
NSERC	Natural Science & Engineering Research Council
MRC	Medical Research Council
SSHRC	Social Sciences & Humanities Research Council

Source: Statistics Canada

EXHIBIT 24

THE PRINCIPAL FEDERAL GOVERNMENT DEPARTMENTS AND AGENCIES SPEND THE MAJORITY OF THEIR S&T EXPENDITURES INTERNALLY



* Top 12 departments and agencies by total expenditures

Source: Statistics Canada

EXHIBIT 25

MORE THAN 40% OF THE FEDERAL GOVERNMENT PERSONNEL ENGAGED IN S&T ACTIVITIES ARE ACTUALLY EXECUTIVE AND ADMINISTRATIVE PERSONNEL

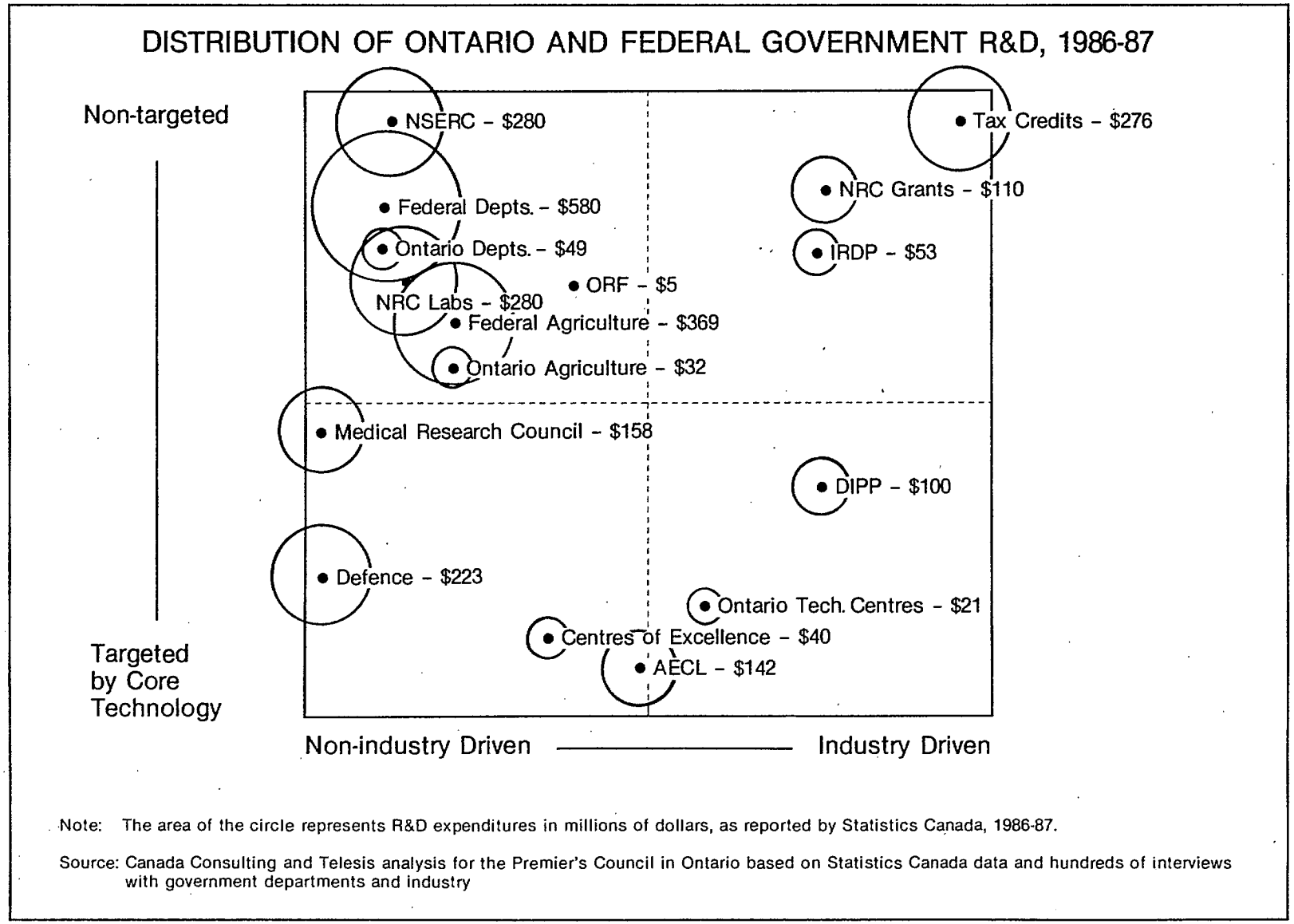
FEDERAL PERSONNEL ENGAGED IN SCIENTIFIC & TECHNICAL ACTIVITIES
By Category

Category of Personnel	Internal Research & Development		Administration of External Programs		Total	
	#	%	#	%	#	%
Executive & Administrative	13,856	42	964	67	14,820	43
Scientific & Technical	19,137	58	478	33	19,615	57
Total	32,993	100	1,442	100	34,435	100

Source: Statistics Canada

EXHIBIT 26

DISTRIBUTION OF GOVERNMENT R&D IS HEAVILY SKEWED TOWARD NON-TARGETED AND NON-INDUSTRY DRIVEN ACTIVITIES



Note: The area of the circle represents R&D expenditures in millions of dollars, as reported by Statistics Canada, 1986-87.

Source: Canada Consulting and Telesis analysis for the Premier's Council in Ontario based on Statistics Canada data and hundreds of interviews with government departments and industry

APPENDIX B

NABST INDUSTRY CONSENSUS COMMITTEE

B.1 Participants in the Consensus Committee

The NABST Industry Committee drew heavily on information and advice provided through the Industry Consensus Committee. It gave the Industry Committee an excellent perception of S&T related issues from the perspective of a broad and diverse representation of Canadian industry.

In preparing its recommendations, the Industry Committee considered in depth the input from the Industry Consensus Committee. It must be recognized, however, that this report's recommendations are the collective opinion and responsibility of the NABST Industry Committee, and not the Industry Consensus Committee.

Industry Associations and Companies Participating in the NABST Industry Consensus Committee

Aerospace Industry Association of Canada
Automotive Parts Manufacturers Association
Business Council on National Issues
Canadian Advanced Technology Association
Canadian Association of Data and Professional Service Associations
Canadian Chemical Producers Association
Canadian Manufacturers' Association
Canadian Shoe Manufacturers Association
Canadian Steel Industry Research Association
Canadian Textile Institute
Electrical and Electronic Manufacturers Association of Canada
Information Technology Association of Canada
Mining Association of Canada
Mining Industry Technology Council
Society of the Plastics Industry

Alcan
Allelix
Noranda
Northern Telecom
Woodbridge Foam
Xerox Canada

APPENDIX C

ANALYSIS OF RESPONSES BY MEMBERS OF THE INDUSTRY CONSENSUS COMMITTEE

C.1 Introduction

The *immediate objective* of this analysis is to examine the material contributed by the associations and organize their comments and proposals into a clear format for discussion. No assessment of merit was made and only the considerations of time, space and organization of the material limited the inclusion of all comments and proposals.

The contributions were diverse and reflected particular industry characteristics and special concerns. Nevertheless, a significant degree of unanimity emerged on current practices and proposals toward stimulating technological development and change in Canadian industry.

C.1.1 List of Responding Associations

The following industry associations responded:

Aerospace Industries Association of Canada
The Mining Association of Canada
Canadian Association of Data and Professional Service Organizations
The Canadian Steel Industry Research Association
A.B.I. Biotech Inc.
The Canadian Chemical Producers Association
Information Technology Association of Canada
The Canadian Manufacturers' Association
Mining Industry Technology Council of Canada
Electrical and Electronic Manufacturers Association of Canada
Canadian Textiles Institute
The Institute for Research in Construction
The Society of the Plastics Industry of Canada *and* the Canadian Plastics Institute
Canadian Advanced Technology Association

C.1.2 Principal Finding

The principal finding is that activities at the industry level that are designed to promote technological development are essential to the well-being of the member companies. These activities are organized variously in the central industry association, as subcomponents of the association or as separate entities.

C.2 The First Question

What can Canadian industry do to increase its rate of industrial innovation and investment in new technologies, to increase the national effort?

C.2.1 The Industry

As previously concluded, the principal finding is that a strong, central, technology-related research and facilitating body is the keystone of technological progress in industry. Following are some of the more important technology-related activities that such a body can perform on behalf of its member companies:

- identifying future strategic and critical technologies;
- identifying technologies at home and abroad which can be shared within the industry;
- facilitating the sharing of information resulting from members companies' productivity programs;
- identifying joint Canada-U.S. and NATO development-sharing programs and other international opportunities;
- facilitating or participating in shared research into new fields of engineering and production technology;
- contributing to government policy and decision-making processes;
- monitoring the structure of the industry so as to adapt to change;
- assisting and encouraging government laboratory and agency heads to transfer technical information;
- identifying research and technology priorities and needs within the industry;
- providing a forum for technology interchange;
- promoting and facilitating the formation of cooperative research task groups;
- guiding and encouraging research in universities and colleges toward the industry's needs;
- encouraging members either independently or collectively to sponsor research at universities;
- advising universities and colleges on curriculum development;
- encouraging universities to establish updating, upgrading and retraining programs;
- designing supplier development programs;
- organizing professional development seminars in cooperation with universities and colleges;
- providing liaison with other associations at home and abroad for the exchange of technology;
- promoting the establishment and use of S&T centres in universities;
- promoting a culture of technology; and
- addressing the issues of the development and utilization of the industry's labour force, including labour-adjustment problems.

C.2.2 The Company

Individual companies could also carry out some of the above activities. The division of responsibilities differ between industries depending on, for example, particular industry characteristics or the role assigned to the central body. Some important features and activities of companies involved in increasing innovation and investment in new technologies include:

- a high degree of awareness and commitment to R&D by chief executive officers and boards of directors;
- skilled managers knowledgeable in the firm's technology, the management of change and new forms of work organization;
- developing a technology-aware work force (a culture of technology) with diverse technical skills and, at all levels, promoting and supporting continuous training and retraining;
- maximum investment in up-to-date equipment;
- participation in joint R&D initiatives (with other companies, universities and government laboratories);
- sponsoring university research;
- ongoing liaison with university and government laboratories; and
- development of comprehensive plans for the introduction of technological changes.

C.3 The Second Question

What approaches could be taken to enhance the effectiveness of industry-university-government collaboration?

C.3.1 The Role of Government

This question evoked most response. In general, the appropriate role of government is perceived to be to support, facilitate, enable and broadly focus the technological R&D efforts of industry and universities. Government should resist direct involvement by implicitly selecting winners and losers in the decision-making processes of the private sector. For this reason, investment tax credits are generally favoured over grants.

It is proposed in principle that government should:

a) support company (industry) and university R&D and reduce the activity level of government laboratories because of their perceived lack of relevance; and

b) promote a national culture of technology, that is, an awareness of national achievements and requirements.

Some of the associations proposed degrees of abandonment of government research laboratories in favour of industry-university initiatives. They favoured development of S&T centres at universities, with private and public support. Government would maintain a coordinating role. One large association stated that companies looked first to in-house R&D, then to collaboration with universities and only rarely to government laboratories.

Several responses stressed that a major government role is creating and maintaining a stable economic environment with clear and consistent policies.

Specific government activities proposed include:

- developing effective labour-market policies that emphasize easily administered training and educational programs to enhance the development of highly qualified employees, as well as to facilitate labour adjustment. Cooperative university-industry programs were especially commended;
- facilitating the opening of new international markets;
- facilitating technology transfers nationally and internationally;
- facilitating research into new applications of Canadian and foreign technologies; and
- facilitating joint domestic and international R&D ventures.

C.3.2 Government Finance

Respondents generally preferred R&D investment tax credits (ITCs) to grants. They felt that the regulations are more certain and equitably applicable, and government is less tempted to involve itself in industry decisions.

The point was made that the success of S&T policy depends ultimately on the ability of companies to buy new equipment and create new products. Government tax policy should encourage investment in new technology, but current tax reform proposals concerning capital cost allowances would make new purchases more expensive.

Several responses advocated more financial support to company, consortium or company-university research and proportionately less to government laboratories.

Investment Tax Credits

In general, respondents agreed that R&D ITCs:

a) should be at least as generous (in scope and rate) as those of our principal competitor nations;

b) should be treated independently of general business tax credits;

c) should include development expenses as well as pure research expenses; and

d) should have stable and consistent policy and regulation.

One respondent quoted an OECD report that states that the R&D tax credit is most favoured by member nations. It involves the least amount of government intervention, requires minimal additional administration and allows maximum market influence on private spending decisions.

Respondents stated that the effectiveness of this incentive is inhibited because:

a) ITCs are taxed both federally and provincially;

b) the eligibility of R&D costs are too limited;

c) the administration and justification procedures are unnecessarily costly and complicated; and

d) the apparent objective (new knowledge) is too narrow and not entirely compatible with the broader objectives of industry.

It is proposed that R&D ITCs be treated independently of general business tax credits and that:

a) ITCs be allowed to reduce a taxpayer's federal tax without any restrictions or limitations;

b) any unused ITCs have an unlimited 'carry-over' period and should continue to be partially refundable to a 20 per cent maximum;

c) the ability to deduct qualifying R&D expenditures on buildings and equipment, both from a capital write-off and ITC position, should be retained;

d) provincial governments should relinquish taxing federal R&D incentives or alternatively provide some offsetting benefits for R&D performers in their provinces; and

e) the interpretation of eligibility for R&D tax credits be widened to include expenditures on industrial development of new products and technology.

Procurement

Unlike those of Canada's major competitors, our government does not contract for products so that new industrial capabilities develop. Government contracts are often too competitive with no allowance for substantial development costs. It is proposed that:

a) a new public program be implemented to support enabling-technology development;

b) defence and other government purchases be used to build greater technical capability, particularly in design; and

c) technological research contracts be awarded to industry rather than to government laboratories, where there is more likelihood of commercial development.

Government procurement is proposed as a major tool for technology development. The risk of new product failure can be compensated for by associated technology development.

Grants

Grants are particularly appropriate for smaller companies, and for large, long-term and risky development initiatives. However, financing R&D by grants has become less attractive since the 1985 federal budget when tax credits for work funded by grants became taxable. The use of R&D grants as a regional development tool diluted the principal objective. Grants are considered complementary and subordinate to ITCs. Concern is expressed over the uncertainty, time delays and program distortions of current grants programs.

Investment Capital

Measures are needed to attract individual and corporate investor participation in technology-related enterprise. Large amounts of investment capital will be required by the Canadian companies stimulated by technological opportunity. The current lifetime exemption of $500,000 of capital gains is a positive step, but is not directly focused at the higher risk, developing, wealth-generating enterprises that need funds.

It is proposed that a specially certified innovation share be allowed that would provide a substantial tax write-off for investors.

C.3.3 Human Resource Development

Many expressed concern over the declining ability of universities to provide leadership on many technical issues. Insufficient funding of post-graduate development through the federal Natural Sciences and Engineering Research Council (NSERC) was cited as one reason for this deterioration. University staff cannot remain at the forefront of specific industrial problems, given the increasing rate of change and the burdens of other responsibilities.

The total educational system - primary through post-graduate levels - requires a strategic plan that will allow future reshaping and evaluation.

It is recommended that:

a) in cooperation with the provincial ministers of education, a strategy for education and skilled manpower development be determined;

b) a strategic planning approach to educational reform be implemented;

c) an accelerated turnover of 2 per cent per year of existing faculty be created and 1 per cent per year new faculty be hired in strategic areas. Capital expenditure should be increased in key areas. Faculty salaries should be brought closer to industry levels in competitive areas such as business and engineering;

d) new resources be allocated in staff, equipment and space to engineering and computer science faculties and industrial experience be introduced into university courses;

e) a five-year plan of renewal be instituted for universities to provide adaptability and move to a market-influenced system with funding by individuals, business and industries; and

f) uniform high school graduation standards be established and technological illiteracy be reduced with required science content in schools and universities.

C.3.4 Government-Industry-University Interaction

The response and recommendations of the Research and Development Committee of the Electrical and Electronic Manufacturers Association of Canada (*Survival*, March 1987, p.26) is included in its entirety as an eloquent summation of the whole or parts of other points of view expressed.

> The human technical resources of Canada must be fully marshalled to effect rapid growth in secondary industry. To this end, interaction and transfer must take place linking government bodies, universities and industry.
>
> For the electrical and electronic industries, which perform more than one-quarter of Canada's industrial research and development, the transfer of technology is recognized to be of such difficulty that research and development must be done as intimately as possible with the manufacturing function. Industries, both in Canada and in the United States, which have corporate R&D centres have recognized this and are increasingly performing their research and development in the manufacturing facilities.
>
> Corporate R&D centres have some difficulty transferring technology to the manufacturing operation. Government laboratories are even less effective, not only because of their physical remoteness, but because of the organizational distance that isolates their activity from its applications. The likelihood of government laboratories becoming more useful to industry is remote since technology is moving in a direction that favours integrated activity.
>
> The importance of the university community in technology development cannot be overstressed. The technical personnel in the universities represent a large potential resource for future development. In Canada, almost a quarter of all persons involved in research and development are in universities. They do not spend all of their time in research and development because teaching and training are also a part of their responsibilities.
>
> Universities train personnel not only for the research and development activities of industry, but for all other technical and professional roles. It is therefore of great concern that, in

spite of this importance to Canada, the interface between industry and the universities is poor.

There should also be a great deal of encouragement for policies and programs that encourage the interchange of personnel between university-industry-government laboratories. A new program for industry with specific financial incentives for becoming involved with universities at the working level would be an appropriate incentive. Such a program might support industrial staff seconded to universities, equipment donations by industry to universities, and matching grants.

What is most critically needed beyond that is a strong recognition in federal policies of the nature and function of research and development in industry. Industry must develop products, processes and technology to meet market needs. That activity is based on the knowledge generated by curiosity-driven research but is radically different from it in motivation, direction and approach.

Recommendation: The staffs of government research laboratories should be encouraged to spend periods of time working in industry through a system of mutually rewarding incentives.

Recommendation: To encourage university researchers to work with industry they must get full credit for this during performance evaluation at their university.

NOTES

1. Although the committee drew heavily on the suggestions of these groups in its consultations, sole responsibility for the recommendations in this document rests with the NABST Industry Committee.

2. The Canada Consulting Group and Telesis assisted us in this international review drawing on their work for the Premier's Council in Ontario. They also helped prepare Section 1 and Appendix A. Consultant John Drew helped frame the labour adjustment context in Section 2 and prepared the analysis of the Industry Consensus Committee member submissions in Appendix C.

3. In the new tax legislation, this amount has since been changed to 75 per cent.

4. Based on Telesis and Canada Consulting Group interviews and analysis on behalf of NABST.

5. Based on Telesis and Canada Consulting Group interviews on behalf of NABST with major R&D spending companies.

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