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13

R&D POLICIES, PLANNING
AND PROGRAMMING

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TABLE OF CONTENTS

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INTRODUCTION

For several years, successive federal administrations have recognized the importance of R&D to the strength of the Canadian economy and to the quality of life of Canadians. They have adopted policies and put into effect programmes to stimulate and encourage R&D. Despite these initiatives, the level of R&D in Canada, expressed as a percentage of G.N.P., continues to be one of the lowest among OECD countries.

The Ministry of State for Science and Technology therefore initiated in the spring of 1980 a review of ways and means of increasing the contribution which R&D could make to the economic and social development of Canada. It was assisted by, and consulted extensively with, the departments funded through the economic development envelope as well as the Department of the Environment. These departments account for 80% of federal R&D expenditures and 66% of all federal scientific activities*. They perform R&D in the following sectors: agriculture and food, fisheries, oceans, forestry, minerals, earth sciences, energy, transportation, environment, communications/ information, space, manufacturing and construction.

This background paper brings together the contributions made by the departments, identifies the main factors or issues which affect the level and quality of Canada's R&D effort, and analyzes their implications for the federal government's R&D policies, planning and programming.

I. BACKGROUND

A. General Comments

The information received from departments shows that they engage in a wide range of R&D and related

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* Total federal expenditures on science and technology include both research and development (R&D) and related scientific activities (RSA) such as data collection and analysis.

activities in support of their mandates. The focus of this paper, however, is not on departmental programmes, but on the broad priorities, organization and objectives of the federal government's R&D activities.

Some of the key elements of a national R&D policy are already in place. The government has set a target for national R&D expenditures equal to 1.5% of G.N.P. It has not set a specific date for reaching that target nor has it indicated the size of the contribution which it expects each of the principal R&D performing sectors to make towards the attainment of the target. It has proposed that the share of the federal government in the national R&D effort both as a funder and performer should fall and that industry's share should increase. It recognizes the importance of university research. Its support for R&D should aim at establishing appropriate research capabilities in each region.

B. Federal Government Involvement in R&D

Government involvement in R&D is normally justified on the following grounds:

(a) the benefits of the R&D accrue to society and can be captured only with difficulty, if at all, by the performer of the R&D (externalities);

(b) there are economies of scale to be achieved by having the R&D performed by the government rather than by a large number of small units (economies of scale);

(c) the functions which the R&D supports are not divisible, e.g. defence (indivisibilities); and

(d) the risks or costs associated with the R&D are too large for the private sector alone to assume.

Government programmes (other than those in support of university research) justified in terms of the first three reasons are in this paper called mission-oriented R&D; those justified in terms of the fourth are described as programmes in support of industrial R&D.

There is agreement among departments on the respective roles of government, industry and universities in the performance of R&D.

R&D is required by the federal government to support policy formulation, and operational and regulatory responsibilities; it is performed by industry to support the development of new or improved products and processes. University research is closely related to training highly qualified manpower and to the general advancement of knowledge.

There is also agreement on the types of research which each of these main performers should do. Government R&D is for the most part applied but includes some basic research. Industrial R&D is almost all applied and associated with the development of specific products or processes. Universities concentrate on basic research. In practice, this neat assignment of roles and associated types of research is difficult to maintain and is in reality considerably more complex.

The R&D activities of departments are for the most part mission-oriented. They originate with, and remain rooted in, the mandates of departments e.g. the management of natural resources such as forestry; the compilation of basic information such as weather forecasts, hydrographic charts, and geological surveys, and its distribution to the public; the setting and monitoring of standards and regulations for certain activities such as the transportation of hazardous substances, the control of automobile emissions and the discharge of toxic substances into the environment; the negotiation of international treaties and agreements covering such areas as the protection of Canadian resources from foreign pests, diseases and pollutants, improved access to foreign markets of Canadian products and the equitable sharing of common resources such as the oceans, the atmosphere and the electromagnetic spectrum. Some of these R&D activities can involve the department in acting as a research arm for industry (e.g. agriculture).

The missions which departments support through their R&D programmes tend to be narrowly rather than broadly defined and closely related to their specific mandates. The R&D associated with these mandates is part of a larger package of activities designed to facilitate economic activity in the private sector

through the provision of essential services and information and by helping to ensure the sound management of natural resources.

However, a large, and probably growing, part of federal R&D activities extends beyond departmental missions to the support and promotion of industrial R&D by sharing the risks (and costs) with industry. A large number of departments undertake or finance R&D for this reason, although in highly varying degrees. Some consider it to be part of their mandate to support industrial R&D and have taken it on as a major responsibility. This is certainly so for the Department of Communications in the case of space and communications and, to some lesser extent, Energy, Mines and Resources in the case of energy, Agriculture Canada in the case of food, Transport in the case of certain areas of transportation, and Fisheries and Oceans in the case of oceans. Other departments are moving in the same direction.

The mandate of the Department of Industry, Trade and Commerce clearly encompasses the support of industrial R&D. It shares the risks and costs of R&D across a wide range of sectors. Its approach differs from the purely sectoral departments in two respects: its programmes are from the outset project rather than sector-oriented and it does not have an R&D capacity of its own.

The National Research Council holds a somewhat special place. It has several roles to play. It supports and performs basic research. It assists departments in their mission-oriented R&D. It helps industry through its own laboratories and test facilities. It also has programmes to finance industrial R&D. These programmes are not unlike IT&C's in that they do not have a prior sector bias built into them. However, they are influenced by the NRC's intra-mural research programmes and capabilities.

Departments agree that one of the roles of universities is to train manpower. Shortages of certain types of research personnel have started to appear and threaten to become more acute. Departments attribute this situation to the poor prospects for careers in research. They agree on the importance of basic research. At the same time, they tend to question the relevance of university research to the problems of concern to them. This attitude arises in part from

the essentially discipline orientation of university research and the essentially mission orientation of departmental research. Nevertheless, departments wish to work more closely with universities and some maintain close links with them. The new strategic grants programmes of the granting councils are seen as a first step towards concentrating more university resources in areas of national interest.

In addition to the support of departmental missions and university research and the assumption of part of the risks and costs of industrial R&D, departments undertake or finance R&D for a variety of other reasons: the research is important and would not otherwise be done; the research is being neglected because the respective responsibilities of the federal and provincial governments are not clear; there is a regional need for it. Thus, the federal government often finances R&D on a residual basis. In so doing, it may be deterring other performers from financing themselves the R&D which they require. Accordingly, and notwithstanding the initial justification for federal involvement, it may be desirable in some cases to ensure that the federal government does not become permanently engaged and that arrangements are made for its eventual withdrawal.

C. Factors Inhibiting R&D

In general, departments were of the view that the principal factor inhibiting a better R&D performance by Canada has been a failure on the part of most sectors to recognize the importance of research and development and hence, the absence of a strong commitment to R&D.

In the case of the resource-based sectors and the environment, for instance, there has been insufficient recognition that natural and environmental resources have to be effectively husbanded and managed if they are to continue to provide a basis for economic development and that resource management has an important R&D component. This is obviously so in the case of fisheries and forestry, but it is also true of other areas.

The result has been an under-funding or a lack of continuity in the funding of R&D in these sectors leading to planning difficulties, ill-defined goals, organizational weaknesses and problems in securing co-operation among sectors. A further consequence

has been a rather strong tendency to concentrate on short-term, immediate problems and to neglect longer term and potentially much more serious ones. This lack of appreciation of the importance of R&D in assuring an adequate resource and service base has had its main effect on mission-oriented R&D carried out by departments.

In the case of industrial R&D, a similar lack of commitment was noted. The main reasons for the industry's poor performance are the smallness of the Canadian market, the large number of small firms and foreign ownership. These factors, structural in character, cannot be dealt with simply by placing more public funds in industrial R&D. The general economic climate and the general economic policies of the government were also important determinants of R&D levels.

Impediments to university research were discussed only in passing, if at all.

Inhibiting factors which cut across all sectors include lack of trained personnel, lack of clarity in the definition of federal and provincial responsibilities, and the increasing amount of time having to be spent by scientists on matters other than R&D.

D. R&D Policy Instruments

The manner in which the R&D policy instruments at the disposal of the government are used, and the extent of their use, are very much a function of the role which the government plays in the performance of R&D.

Mission-oriented R&D, almost by definition, is performed in-house. Certain policy instruments may be used to support and supplement the government's intra-mural research capacity, but in practice account for only a small proportion of all the mission-oriented R&D performed.

In contrast, the range of available policy instruments and their use is much greater when the objective is to establish or to develop industrial R&D capacity. For instance, in the case of space and communications, an

attempt is made not only to assist in the R&D itself, but also to create an industrial capacity able to support on its own a sustained R&D effort. Stress is placed on the joint planning and programming of both R&D policy and industrial policy not only through the R&D stage but also through the demonstration, product development and marketing stages. Government procurement and international co-operation become important policy instruments. (The various policy instruments will be discussed in more detail later in this paper).

Given the differences in their roles, departments do not view all the policy instruments in the same light. For instance, those departments which assume part of the risks associated with industrial R&D are more inclined to use contracting-out in a positive and aggressive way to develop and establish new industrial R&D capacity. They do not see it primarily as a means of carrying out in the private sector R&D needed by the government for its own internal purposes. They would like to extend the use of contracting-out quite significantly. Departments whose R&D programmes are essentially mission-oriented see contracting-out as a helpful tool but one which, if they are pressed to use it indiscriminately, can detract from the effectiveness and efficiency of their research programmes.

Other differences among departments relate to the relative emphasis which they place on the creation of an economic climate which will foster industrial R&D compared to the importance which they attach to specific policy instruments. In the case of some, the accent is definitely on the general climate; in the case of others, the emphasis is on specific instruments; and in the case of a third group stress is placed on general policy (e.g. pricing) and specific instruments.

E. Technological Trends

While each department of government concentrates its R&D activities in those sectors for which it is responsible, there are certain areas of research in which they have a common interest.

Considerable importance is attached to production and process efficiency. This concern reflects in part the increasing difficulties of access to some of our natural resources (forests are farther away, minerals are deeper underground) and hence the need for better,

less costly methods of getting to them and processing them. More broadly, this emphasis reflects the current efforts to strengthen Canada's manufacturing base. This can be accomplished only if Canada is competitive in productivity and cost. Technology advances which have a wide range of industrial applications and which give other countries an advantage, e.g. increased use of automation, deployment of computer control and robotics, must be matched by Canadian industry.

Concern over the environment is also widespread among departments. It is their view that, unless the accumulation of harmful and hazardous by-products and side effects from the production and processing of raw resources are effectively controlled, production will be endangered either by the destruction of the natural resource on which the production is based (e.g. soil fertility) or by the unacceptability to the public of the production processes themselves (e.g. certain mining operations). They recognize that the requirements for improving process quality can be expensive and that compromises are often necessary. A balance must be struck between long-term adverse effects and short-term economic gains. The harmful effects of pesticides on life forms other than those which they are intended to destroy needs to be reduced, and means must be found for the safe disposal of toxic and nuclear waste materials and for the reduction of atmospheric emissions from ore smelting and coal burning that give rise to acid rain.

Data systems as tools for dealing with the increased complexity and scope of information are another area of general interest. Highly organized systems are required with capabilitites for the collection, assessment, updating, dissemination, and presentation of information in the most usable form. New techniques of remote sensing for the acquisition of global data are currently being explored in many sectors. Remote sensing has been made possible by advances in satellite technology and can be used for crop assessment, forestry, weather forecasting, ice and sea conditions, and mineral deposits. Data content and subject matter are of course specific to sectors and can help in the establishment or modification of codes, standards, and regulations.

In addition to product and process improvement, environmental considerations and data collection which

have a pervasive long-term effect on the technologies being used and developed in almost all sectors, there are at least two sectors which were singled out, in which the rate of technological change is very rapid and in which there is a virtually constant flow of new opportunities. They are space and communications. They can be characterized as technology driven. There are other areas with similar characteristics, e.g. biotechnology.

Finally, there is one sector - energy - in which all departments have a significant interest. Their interest is twofold: in conservation which offers possibilities for substantial economies in almost every sector and in finding new improved sources of energy.

F. Federal-Provincial and Regional Considerations

Provincial research activities vary from region to region and from sector to sector. Generally, the provincial research and development effort reflects the wealth of the province (Ontario, Quebec, Alberta and British Columbia have the largest research organizations) and is directed at the most significant problems and opportunities facing a particular province. For example, Quebec, Ontario and British Columbia have substantial programmes in forestry. In some cases such as fisheries, where the federal government has the responsibility for the management of the resource, provincial governments are demanding a larger role in decision-making. In others, where the responsibility lies with the provinces - for instance, forestry - they look to the federal government for leadership and assistance in order to avoid duplication and achieve economies of scale, to supplement their own resources, to establish a common knowledge base for the establishment of regulations and to develop new technologies.

In addition to carrying out through sector-oriented departments R&D of interest to the provinces, the federal government has also funded, through other departments such as IT&C and DREE, research in which a provincial government has indicated a particular interest or in an industry which requires R&D support for its continued viability.

It is becoming increasingly important to develop common objectives and funding strategies for the R&D

at both the federal level and the federal-provincial level.

Research in some sectors is highly regionalized. Often this is a reflection of the nature of the sector, such as fisheries and oceans where the R&D is concentrated along the coasts. By contrast, in the field of transport, the main emphasis is on road-related R&D except in Ontario which is involved in some urban transit R&D. Industrial research capability is largely concentrated in Ontario and Quebec.

In general, provincial and regional priorities in the resource sectors vary with the economic importance of the resource concerned, or the problems encountered in developing and exploiting it. In other sectors, such as communications, and the industrial area, factors such as size and concentration of population, and general wealth go far to determine the provincial government's concerns.

Federal-provincial consultations are valuable where they exist, and needed where they do not. Existing federal-provincial co-operation makes possible the more efficient use of the resources of both levels of government. Consultative arrangements ensure minimal overlap in areas such as the environment where both the federal and provincial governments have an interest. There is a need for more and better consultation in areas such as oceans where provinces wish to exercise greater influence over decisions made by the federal government, and in areas such as minerals where federal research serves not only federal needs, but is also useful to provinces in managing their resources.

II FACTORS

This review of the federal government's R&D policies and programmes shows a significant degree of agreement on the importance of R&D and on the various factors which have made it difficult to raise the quantity and the quality of R&D carried out in Canada.

It also shows that there is no common approach by departments to R&D. This state of affairs is not altogether surprising or, for that matter, unhealthy, but acknowledgement of its existence is important and

perhaps even essential to the formulation of federal R&D policy. The differences arise from the various roles which the federal programmes play in the national R&D effort and from the relative emphasis given to one or another of the roles by departments. The roles have an impact on the interface between the government and other performers of R&D, on the choice of policy instruments and on other aspects of R&D policy.

A. The Roles of the Federal Government in R&D

1. Mission-Oriented R&D

As noted earlier, a large part of the R&D performed or funded by the federal government is directly in support of departmental missions. These missions have been defined so as to exclude programmes specifically designed to develop R&D capacity in the private sector. The R&D associated with them provides departments with information, products, or services that enhance their ability to conduct their resource management, operational, regulatory, service, and other functions. The R&D is thus, or should be, fully integrated with these missions. To the extent that the missions underpin or facilitate the operations of the private sector, the R&D is also or should be, responsive to the needs of the private sector.

2. General Support of Industrial R&D

The government has a number of general programmes designed to support and encourage industrial R&D by assuming part of the risks and costs associated with it. They range from tax incentives to programmes such as EDP, DIP, and IRAP which provide support in response to R&D initiatives by industry. Because of their responsive nature, these programmes are more likely to finance product and process improvements for which there is a fairly well assured market and in respect of which the risks are not high rather than entirely new products and processes. These programmes are strongly supported by industry, have a good record of success and should be encouraged as a valuable element in strengthening industrial R&D activities in Canada.

3. Focussed Support for Industrial R&D

The background section mentioned that several departments have R&D programmes designed to establish an

industrial R&D capacity in the sectors for which they have responsibility or to strengthen it if it already exists. Perhaps the best known example of programmes of this kind are those of the Department of Communications in support of the space and communications industries. The Department of Energy, Mines and Resources has some relatively large programmes related to the development of new sources of energy. Other departments have similar programmes, but on a smaller scale. The Department of Industry, Trade and Commerce has not had, as a rule, sector-oriented R&D programmes. However, an important recent change has been the establishment of an electronics programme within EDP.

4. Support of University Research

The federal government also has a role to play in the support of university research. Its three aims are:

(a) to support fundamental research in order to advance knowledge and to maintain the flexibility required to adapt to changing demands;

(b) to institute concerted research programmes in areas of national concern; and

(c) to support and develop research trained manpower.

Most of the financial support is provided to universities through the granting councils and in the case of the natural sciences and engineering mainly through the National Sciences and Engineering Research Council. But departments also finance university research through grants, subventions and contracts. Their purpose is not so much to support university research as to use the universities' research capacity to further their missions or to help ensure a better supply of the kind of trained manpower which they need.

B. Co-ordination and Management of R&D

1. Internal Co-ordination

Given the variety of roles which many departments play in support of R&D and the number of policy instruments which they use, the co-ordination of federal R&D activities is essential to ensure consistency in policies and programmes.

In the case of mission-oriented R&D, the necessary co-ordination can be expected to be achieved through normal interdepartmental mechanisms, including inter-departmental committees, and through the annual planning and budgetary processes. Nevertheless, there are some important areas where there is an urgent need for co-ordination among a number of departments which have remained impervious to these processes.

An interdepartmental committee on industrial innovation might be useful in permitting a regular exchange of information on existing and proposed R&D policies and programmes. It is unlikely, however, to provide the leadership and co-ordination required to establish a strong R&D capacity in industry. This is specially true of sector-oriented programmes. Such undertakings require a concerted long-term effort by all interested parties, both inside and outside the government, and the use of a wide range of policy instruments. Inter-departmental committees are not well suited to working in this way. The industrial development mandates extend beyond the mandate of any single member department and, in the absence of some very strong directive from government, neither the committee nor any of its members are able or, if able, find it easy to take responsibility for the broader objective.

The experience with the space programme which works through an interdepartmental committee is relevant in this regard. While the space programme has achieved a significant degree of success, its planning, co-ordinating and administrative weaknesses are becoming more apparent and less tolerable. It consists of separately funded and separately administered departmental programmes. The technical support for the programme is widely dispersed and not accountable to a single authority. As a consequence, long-term planning is difficult, the overall purpose of the programme is at times subordinated to the objectives of individual departments, uncertainties are created, commitments are unduly limited and collaboration with industry and universities is much more difficult to achieve and maintain.

2. External Co-ordination and Consultation

The relations between the federal and provincial governments are in an almost continuous state of change and, as a consequence, the R&D interface between the two levels of government often needs to be

adjusted. In a number of sectors, including the resource sectors, the environment and the oceans, lack of clarity in this interface is hampering the effectiveness of R&D activities. There is ample scope for overlapping activities, on the one hand, and missed opportunities, on the other. These are underlined by the increasing interest which provincial governments are taking in R&D in itself and in the R&D activities of the federal government.

We can ill afford to let the situation continue. A concerted effort is needed to resolve it. In order to increase both the national and regional benefits, the objectives and activities of the provincial and federal governments must be supportive and complementary. In the case of mission-oriented research, an effort is needed to clarify the respective responsibilities of the federal and provincial governments and ensure that the federal government does not engage in research simply to fill gaps left by others. In the case of programmes in support of industrial R&D, the objective should be in the direction of engaging in collaborative programmes in areas of mutual or national interest.

There is a need, as well, to improve the effectiveness of the contribution which university research can make to governmental and national R&D objectives, particularly industrial development. Greater efforts should be made to ensure that university training and research activities are more closely related to the needs of industry. Closer relationships between university and government researchers would benefit both groups.

NSERC's strategic grants programme moves in these directions, but it may not be enough. Further progress could be made if the universites were invited to collaborate in specific programmes and tasks, whether in support of mission-oriented or industrial R&D.

3. Management

Doubling the country's R&D expenditures in real terms will require a concerted national effort led by the federal government. This responsibility can only be discharged effectively if the total federal effort is well co-ordinated, managed and supported. The sheer magnitude of the task and the number of

organizations involved suggest that new management responsibilities and structures may be necessary.

As more and more emphasis is placed on industrial development objectives for R&D, it is possible that the traditional mandates of departments will become barriers to enhancing the effectiveness of government R&D activities. Complex technologies and their pervasive effects will demand the attention of more than one department or will require departments to expand their mandates and activities. Inter-departmental committees, lead departments, expanded mandates, and special agencies are among the approaches taken to solve these problems. There is unlikely to be a single solution as each sector's needs will undoubtedly be different. It is, however, important to recognize that the existing arrangements for management and co-ordination may no longer meet the needs of some sectors.

More generally, there is a need to manage actively the federal government's R&D programme if the commitment to raise the level of R&D is to be met. Consistent strategies need to be developed and implemented. Federal expenditures on R&D need to be allocated according to an agreed track for the federal share. Effective consultation with the other funders and performers must be established in order to develop a concerted national effort. The matter deserves further consideration.

C. Stability of Federal Funding

For the federal government to provide the leadership necessary to raise the nation's R&D effort, it is indispensable that it make a long-term financial commitment. It is virtually impossible to plan and conduct research programmes that require several years to produce results when the funding commitments are uncertain from the outset. Similarly, technology development and industrial development are long-term endeavours demanding continuity of purpose and funding. Industry cannot be expected to increase its commitment to R&D if the technology risks are compounded by the real financial risks associated with uncertainty in related government programmes.

The frequent erosion of the federal R&D funding by ad hoc demands of operational programmes seriously inhibits R&D activities. While it is perhaps understandable and natural to seek to resolve short-term problems at the expense of longer term considerations, any serious attempt to enhance the effectiveness of R&D must ensure that federal funds allocated for R&D purposes are protected from erosion by other demands. Otherwise the credibility of the federal commitment will be reduced and this in turn will have a bearing on the action of others.

D. Characteristics of Canadian Industrial Structure

In developing policies, plans and programmes for R&D activities intended to enhance the industrial capabilities of the country, the Canadian industrial structure must be taken into account. The manufacturing sector is small relative to the economy as a whole and its R&D intensity is on the low side. Canadian industry is dominated by foreign-owned multinational corporations which, by and large, perform their R&D "at home". These are major impediments to increasing Canada's R&D efforts.

Many of the R&D intensive sectors are characterized by a large number of small firms distributed across the country. These companies do not have sufficient sales margins or experienced staff to finance or conduct R&D, and usually must purchase their technology needs. Many of the companies are in potentially high growth areas and need encouragement to initiate the appropriate R&D activities. Yet compared to other governments, the Canadian government does not finance a large share of the R&D in manufacturing. In the United States, for instance, 37.2% of the funds come from the government, in France 25.4%, in the U.K. 20.9%, in Germany 17.9%, in Sweden 15.9% and in Canada 11.2% (1975 figures).

Finally, it may be noted that in many sectors, fragmentation of the domestic market makes it difficult for industries to invest in R&D. More effective use of legislation, regulation, and government procurement could help in stabilizing and aggregating the domestic market. Aggressive pursuit of the international market will also be necessary if Canada is to produce more world-class competitive industries.

E. International Considerations

Except in a few areas (notably in Canada's space programme), there has been no systematic policy to promote and facilitate Canadian participation in international intergovernmental programmes on science and technology. A major barrier has been the high initial cost of identifying potential partners and of laying the groundwork for joint planning and execution of programmes. Departments and agencies have been unable to finance those activities during the prolonged period of budgetary restraint.

On the industrial side, success in reaching the R&D expenditure target will depend very much on the extent to which multinational enterprises operating in Canada will undertake R&D in this country. Future policy will have to address ways and means of bringing this about.

The international side of Canada's research and development activities needs to be explored. A preliminary appraisal suggests that:

(a) international collaboration is important if a number of our problems are to be addressed simultaneously;

(b) in the light of experience, the most fruitful programmes occur at the agency-to-agency or programme-to-programme level in cases where the joint effort is of an important size and of medium to long term duration;

(c) in the short-term, the creation of a central fund to finance exploratory exchanges would significantly assist in establishing the necessary mutual understanding between agencies in Canada and abroad upon which could be built practical programmes of cooperation; and

(d) there is a need to ensure that international collaboration is systematically considered as a potential means of attaining programme objectives.

In any areas where it would be to Canada's advantage to make a concentrated effort to develop an R&D capacity such as in the energy, space, communications and information, transportation and oceans sectors, the

need to pursue opportunities selectively for international collaboration will be particularly important.

F. Policy Instruments

Over the years, a number of instruments and procedures have been developed for putting into effect the government's policy to strengthen industrial R&D. The relevance and effectiveness of these instruments depend very much on the role which they are intended to support and the sector to which they are applied. Some of these instruments are well established and accepted and do not cause any problems. Others, however, are not always well used, used at all or used extensively even though they are considered to have a significant potential to stimulate R&D, especially industrial R&D. These are the instruments which are discussed briefly below, including suggestions that have been put forward for changes from time to time.

It might be noted, in passing, that the wide variety of policy instruments used by the government often give rise to demands for simpler and more readily understood programmes. The plea must be listened to. At the same time, it must be recognized that the multiplicity of instruments provides elements of flexibility and adaptability which allow many projects which otherwise would have to be abandoned to proceed.

1. Contracting-in Policy

A contracting-in policy would allow government laboratories to perform research on behalf of Canadian industry and thus give industry access to specialized equipment and services. It would also constitute an efficient and effective method for providing new and small companies with R&D capabilities they could not otherwise afford. At the same time, it would help invigorate the government's R&D capability and increase the likelihood that federal R&D proposals would take into account industry's interests. Such a policy, if adopted, should operate on a cost-recovery basis. The Technical Information Services has some elements of contracting-in.

2. Government Procurement

Government procurement to stimulate R&D is a policy instrument that should be used to the fullest extent possible consistent with our international obligations. There needs to be better consultation

with Canadian industry, sufficiently in advance of the procurement of technological products and services to allow, where appropriate, modification of requirements to match more closely industrial capability and to give industry adequate lead-time to gear up for production. Policy guidelines for the payment of premium costs to encourage the development of Canadian sources to replace imports could also be worthwhile. An appropriate "Buy Canadian" Act or policy would encourage departments to seek out and develop indigenous competitive sources for their procurement needs. Consideration could also be given to extending the procurement policies to include Crown Corporations and Agencies.

3. Contracting-out

Contracting-out has proven to be an effective policy instrument for increasing the share of Canada's R&D performed by industry, but its effectiveness can be diminished if the procedures for its use are too cumbersome or inflexible, or if decisions are delayed too long. It could be extended to embrace large long-term development projects in order to give it more continuity and thereby enable industry to hire qualified staff on a permanent basis. It could also be used to encourage joint industry/government projects, particularly in high-risk situations where market acceptance of new products and services is uncertain.

4. Demonstration Activities

There is a need to provide better support for those activities which must follow R&D work to apply the results successfully and to reap the subsequent economic and social benefits. For example, prototype demonstration projects, field trials, and similar activities are often required to establish markets. Examples of what can be done are the fibre optics technology in Manitoba, the vertical axis wind turbine in Quebec and the Straflow tidal turbine at Annapolis Royal. Government support is often essential in international marketing ventures. Thus, when considering ways and means for increasing the effectiveness of industrial R&D, consideration should be given to the extension of many of the instruments used to support R&D to cover the essential activities that allow R&D results to be taken through the product development and marketing phases. In some cases, the government will have to take the initiative for creating a market demand.

5. Government Regulation

The government could, in certain circumstances, include industrial development as a consideration when exercising its regulatory functions. The setting of technical standards and specifications offers one possible way of successfully using regulations to encourage the commercial exploitation of indigenous R&D.

6. Enlisting University Research

The research capabilities of universities would appear to be under-utilized mainly as a result of inadequate funding. While respecting the basic integrity of the universities as teaching institutions, a greater effort is needed to ensure that their research and teaching activities are more relevant to the needs of industry and the country generally.

Grants and contributions have been used successfully in getting universities and research institutes to perform R&D related to specific federal missions (e.g. the environmental area) and to develop relevant research expertise. Increased funding of universities and institutes is important to ensure the availability of trained professionals in specific areas. The funding of large-scale industrial research activities at universities is not, however, favoured.

7. Tax Incentives

The R&D tax incentives are intended to encourage profitable companies to undertake more R&D. The available evidence suggests that they have been successful and the companies which benefit most are often those which are, or promise to be, internationally competitive. The incentives are of limited or no use to smaller or newer companies because they may not generate the income against which the tax credit can be taken.

8. Technology Transfer

The government has given considerable attention to the transfer of technology from government laboratories to the private sector. In 1978, the successful NRC programme, PILP, was extended to five other departments with a total funding of $2 million. This was

welcomed by all and proven successful. However, funding of the programme, named COPI, has been inadequate. There are several other technology transfer mechanisms, but none is as well developed as PILP/COPI. Past and present funding restrictions could continue to hinder technology transfer efforts.

9. Creation of New Institutions

In the past, the federal government has, on occasion, responded to industrial opportunity in a high-risk area by creating a new institution, usually a Crown Corporation, to be the focus for the development of a new technological competence. AECL, in the nuclear energy field, is a good example. The same route is now being followed for the development of alternative energy technologies.

10. Conclusions

From this brief review of the major policy instruments at its disposal, it appears that the federal government has selected a wide variety of them. It is also clear that some of them could be used more effectively and more extensively.

III. THE 1.5% TARGET, THE FEDERAL SHARE AND THE ALLOCATION OF FUNDS

A. Financial Implications of the 1.5% Target and the Federal Government's Share

The government repeated, in the Speech from the Throne, its policy objective of raising R&D expenditures in Canada to 1.5% of G.N.P.[1] To reach the target by 1985 means that in real terms national expenditures on R&D would have to be about double the $2.5 billion spent in 1979. Such a target, while quite challenging, is not impossible to reach.

In several OECD countries, for example, the Scandinavian countries, national governments finance about one-third of the national R&D effort, and industry about one half. In Canada, this norm, if applied, would result in a reduction of the federal share of the national effort from 38.9% in 1979 to 33.3% by the target date, and industry's share would increase from

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(1) Gross expenditures on Research and Development (GERD) as a percentage of G.N.P. is an indicator used by most countries to determine their level of R&D expenditures.

35.8% to 50%. If the provinces were to finance 7% of the total, the overall government share would be 40%.

To attain both the target and this distribution of the national effort by 1985, federal government expenditures would have to increase by 8% in real terms, and industry expenditures by 17% annually. For the provinces' share of the total to increase, their expenditures would have to rise at an average annual rate of more than 9%. These rates would be 17%, 27% and 19% respectively if allowance is made for inflation.

The relative growth rates and the relative shares of each of the main funders of R&D, together with their financial implications are set out in the table below.

FUNDER	1979		1985		Nominal Growth	Real Growth
	$M	(%)	$M	(%)	%	%
Federal	973.4	(38.9)	2520.8	(33.3)	17	8
Provincial	173.5	(6.9)	496.8	(6.6)	19	9
Industry	895.3	(35.8)	3781.3	(50.0)	27	17
University	348.5	(13.9)	576.7	(7.6)	9	0
Other	108.9	(4.4)	186.9	(2.5)	9	0
TOTAL	2499.6		7562.5		20	10

B. Long-Term Planning

Adoption of an expenditure track for the federal share of the national target would do much to remove some of the major problems noted in the two preceding sections. It would provide the assurances of funding so necessary to long-term planning and offer to ministers a much improved basis for judging competing proposals by allowing them to compare the main thrusts and directions rather than have to examine a multitude of separate items.

Planning would also permit better and more meaningful consultations to take place with the provinces, with industry and with the universities. Indeed the planning could be a joint endeavour. This already takes

place to some extent in the case of mission-oriented R&D, but means of doing so in the case of industrial and university research are considerably less well developed.

C. The Relative Importance to be Given to the R&D Roles of the Federal Government

1. Mission-Oriented R&D

Roughly 50% of federal R&D expenditures in 1979 were, it is believed, mission-oriented. The main justification for giving a high priority to mission-oriented R&D is that it serves an essential purpose and that unless financed by government the R&D will not be done at all or will not be done as well by others. The principal and often repeated criticism of this approach is that the proportion of mission-oriented R&D is already too high, that the R&D is neither responsive nor relevant to the needs of industry, and that it does little to raise the level of industrial R&D.

These two points of view, on the surface irreconcilable, are more definitional than real. Mission-oriented R&D is not intended to provide direct support to industrial R&D. This is not the same as saying that it is not of fundamental importance to the private sector. In addition to maintaining the scientific capacity required by the federal government for the formulation of public policy, its purpose is to support government services such as aid to navigation, weather forecasting and resource management and regulation, all of which facilitate private sector activity; and to meet in whole or in part the R&D needs of sectors which because of their inherent structure are unable to perform all the R&D that they require. It is essential to the economic health of such industries as forestry, mining and fisheries. There is also evidence to suggest that the economic cost of neglecting mission-oriented R&D is substantial while the return on it is high.

Against this background, it is difficult to maintain that mission-oriented R&D performed by or for government departments is not responsive to real or immediate economic needs or that it is not integrated into the production process.

The policy instruments that can be used to promote mission-oriented R&D are fairly limited. Most mission-oriented R&D must be intramural. It offers limited opportunities for contracting-out. The possibilities for technological transfer are somewhat greater, especially in those cases where the government is acting as the research arm of an industry (agriculture) or part of an industry (small mining companies). The potential for co-operation with the provinces is significant because mission-oriented R&D tends to be in areas of interest to them; the same is true of the universities. For this reason, mission-oriented R&D lends itself rather readily to building regional research capacities, but this should be done in such a way that the provinces contribute to the creation of some part of that capacity. Mission-oriented R&D creates a demand for equipment and the opportunity, through procurement policy, to support industrial R&D.

2. General Support Measures for Industrial R&D

There are, as already noted, three major structural weaknesses which impede industrial R&D in Canada: foreign ownership, the large number of small firms and the smallness of the Canadian market. The resolution of these problems rests as much in the domain of industrial as of R&D policy. It is doubtful that the R&D target can be reached unless the impact of foreign ownership on the amount of industrial R&D carried out in Canada is reversed. This is the background against which proposals intended to support industrial R&D should be assessed.

The measure most often advocated is a 25% R&D tax credit to replace the existing arrangements. At the moment only small businesses receive a 25% tax credit; for other businesses, the credit is 10% (20% if located in the Gaspé or the Atlantic Provinces) plus a write-off of 50% (additional to the long-standing 100% write-off) on R&D expenditures over and above those made in a base period. The main advantages of this approach are that it reflects the preferences of the business community; that it involves no direct intervention by the government; that it is easily integrated into the rest of the innovation process; and that a general measure of this kind is required given the low level of R&D in Canada and the obstacles that must be overcome in order to raise it.

The counter-arguments have by now become familiar. A first is the windfall gain that accrues to firms that are already performing R&D (the use of a base period for the additional 50% write-off was intended to meet this point); a second is that the measure will not induce a large increase in R&D (but the CMA, on the basis of a survey of its members, believes that an increase of 10% in R&D expenditures would take place); a third is that companies with no taxable income could not claim the credit (a refundable tax credit is the solution most often considered). It is also argued that R&D is but one element in the total innovation process and that tax credits should therefore be extended to other phases of the process and in particular to pre-production design and engineering expenses. This measure would be far more expensive than a tax credit related to expenditures on R&D alone.

The other main sources of general support for industrial R&D are those programmes, such as EDP, DIPP and IRAP which are designed to be responsive to projects submitted by the private sector. Generally speaking, these programmes operate on a project-by-project basis, not on a sector basis.

The principal advantages of general measures are their flexibility in terms of sectors, the integration of R&D with other parts of the innovative process, their concentration on small and medium-sized firms (which are often unable to claim the tax incentives), their heavy reliance on the private sector for the initiation of projects with direct government intervention thus being kept to a minimum, and the use and reinforcement of existing industrial R&D capacities. Evaluation of some of the programmes shows that the returns are high and materialize quickly.

But it should also be recognized that these programmes are not readily responsive to regional needs or to co-operation with other performers of R&D; they do not easily allow the concentration of resources either over time or in a particular sector, even though some concentration may be desirable; they do not encourage longer-term planning; they tend towards the low risk incremental type of R&D rather than towards new products and processes; and the limits placed on the amount of R&D that can be financed per project can be inhibiting.

The programmes take essentially the form of grants and contributions, but contracts are also used as, for instance, the NRC's PILP programme.

3. Sector-Oriented Programmes for Industrial R&D

Sector-oriented programmes are designed to stimulate and support the development of technological capabilities in certain selected industrial sectors through the co-ordinated application of appropriate federal policy instruments. The R&D programmes are usually associated and integrated with other programmes in support of the production process.

A number of the departments have programmes of this kind, but their size and scope as well as the range of instruments used varies enormously. In the case of the larger programmes (e.g. space), almost every instrument at the disposal of the government is used and the co-operation of all the main performers of R&D and of all the main potential users is actively sought. This is done at both the national and international levels. The R&D capacities within the government are used in such a way as to complement those in industry and have even been put at the disposal of industry pending the development of its own independent capacity. Procurement is often used as an important policy instrument. Support might extend to demonstration projects and other pre-production activities. Grants, contracts and loans may all be used.

The principal advantages of this approach to the support of industrial R&D are that it lends itself to longer-term planning and programming. It allows for a greater concentration of resources over time and by sectors. It is recognized that in certain industries, specially high technology industries, R&D is an essential element of commercial and industrial success, and that there is a need to encourage, support and organize such R&D, especially in Canada where industrial R&D is weak. The possibilities of federal-provincial co-operation are significant.

The major objection to this approach is that it involves a higher degree of risk. It is often described as "picking winners", a process, it is argued, in which governments do not excel. The difficulty is real but should not be exaggerated. To deal with this objection, it is suggested that in evalua-

ting proposed areas of concentration and technologies within them, consideration should be given to the following criteria:

- the industry can be weaned off the high level of support needed in its infancy as technology and markets mature;

- the expected long-term benefits of an enhanced industrial capability are commensurate with the cost of the support required;

- initiatives of longer-run potential are directed at identified opportunities, national needs or problem areas;

- rapid changes are taking place in technology and its supporting science;

- Canadian strengths which can be built on exist in government or universities;

- there are Canadian companies with a developmental management and technical competence or a potential to compete internationally; and

- the preceding factors combine to offer special opportunities for industrial growth generally, and balanced regional growth in particular, while at the same time enabling other federal objectives in the sectors to be attained.

A difficulty often associated with this approach is that support for industrial R&D in a particular sector is not concentrated in a single department, but scattered across the government because there usually is more than one department interested in the sector. Some co-ordinating mechanism is therefore required. This normally takes the form of an interdepartmental committee. Experience suggests that while committees of this sort may be satisfactory to co-ordinate mission-oriented R&D, they may be less satisfactory when the objective is to assist in supporting the development of high-technology industries.

If this approach is more widely adopted as part of the government's R&D policy, it will be necessary to select certain areas of concentration. There are at least five sectors which might lend themselves in major ways to this approach: communications, space,

energy, oceans, and possibly certain areas of transportation. In the case of the first three, the government is more or less explicitly committed to such an approach. But in addition to those particular sectors, there are certain technological trends from which Canada must seek advantage either directly in their development or in their application to industrial processes and which also lend themselves to a concentration approach. They include biotechnology, cold regions technology, robotics, micro-processors, toxicology and environmental technology.

4. University Research

Federal government support of university research has been reviewed at great length by the government. The analysis of the challenges and problems facing university research and the rationale for federal government support for such research have been widely accepted both inside and outside the government.

The rationale involves a major new element -- research in areas of national concern -- which in turn has led to a major new departure in the programmes of the Nat-e ural Sciences and Engineering Research Council (and th other Councils), the strategic grants programme. This programme is in a state of evolution and it is expected that with experience and time it will move towards more precise objectives. This is an important development and should be encouraged.

5. The Relative Importance of Each Role

This analysis suggests that the first claim on federal R&D funds should be given to departmental mission-oriented R&D. The reason, a simple straightforward one, is that unless the government supports it, it will not be performed. Yet the greater part of this R&D assists the operations of the private sector to which it renders essential and fundamental services and without which it could not operate effectively.

The assignment of the first claim on R&D funds to mission-oriented R&D should not necessarily mean that it should increase more quickly in either absolute or relative terms than other types of R&D. It means that it should be financed at a level adequate to allow it to perform its essential functions.

For somewhat similar reasons, it is suggested that second claim on R&D funds be given to university research.

A question to be considered in the case of industrial R&D is the relative emphasis to be given to sector and non-sector-oriented measures. There is no doubt that room has to be made for general support programmes. They provide the flexibility and adaptability needed to assist sound projects no matter in what sector they arise. The strength of the general approach is also its weakness. It builds on existing R&D capacity, but as noted, that capacity is not large and is not as diversified as in other countries. The base on which the general approach rests is therefore deficient and it is doubtful whether through it alone we can take early and full advantage of the opportunities offered by R&D, especially in those sectors where intensive R&D efforts are one of the elements essential to industrial and commercial success. In most industrialized countries, these sectors receive significant support from their governments.

D. The Allocation of Funds Among the Main Roles

An initial and tentative allocation of the additional federal funds called forth by the target to the various R&D roles of the government would constitute a major step in the establishment of R&D priorities and in furthering the longer term planning process which is so important to the success of R&D activities. It could be taken into account during programme planning, and as a criterion in project selection. It would be confirmed later, or modified, by examination of specific proposals related to each of the main roles.

There is unfortunately no scientific way for arriving at a precise allocation.

It is a question of judgement that has to be exercised in the light of the considerations set out in this paper, the potential use to which the funds would be put under each role and the existing demands for funds under each. A number of options can be developed on this basis. These are presented in the table below.

	OPTION I Percentage Distribution of Increase	OPTION II Percentage Distribution of Increase	OPTION III Percentage Distribution of Increase
Mission-oriented	53	39	32
Industry Support (both general & sector oriented)	30	40	47
University	17	21	21

NOTE: Distribution of Increase is for each role 1985-86 over 1980-81.

Option III would appear to be a reasonable compromise for initial planning purposes. It provides for steady but restrained growth in the mission-oriented R&D required to support policy formulation and assist private sector activity, while directing the largest part (one-half) of new resources to industry-related R&D, both general and sector-oriented.

CONCLUSION

The federal government is committed to raising the level of R&D expenditures in Canada. It will have to meet its share of the additional funding required and allocate it among the three major R&D responsibilities that it has.

However, increased expenditures by the federal government are not enough if the target is to be reached. Other policies will have to be used. They range from tax incentives and government procurement to contracting-out and government regulations.

In addition, the overall effectiveness of the government policies and programmes will be dependent on a number of other factors such as the development of forward plans, the establishment of priorities and of clear objectives, joint endeavours with other performers of R&D, and the development of national and international markets. The endeavour has to be a common one and shared by all.

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