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Background Paper

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Federal Scientific and
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I INTRODUCTION

The federal government traditionally has been the major source of support for the national scientific effort. In the late 1950's, for example, the federal government financed approximately 60 per cent of the gross expenditures on research and development (GERD). In more recent times, however, there has been a steady decrease in the federal share of these expenditures and in 1977, 43 per cent of the estimated $1,916 million spent on research and development (R&D) came from the budgets of federal departments and agencies.

In spite of this decrease in the federal share of GERD, the federal government is still the major source of funds for R&D and as such has played an important role in the development and orientation of the national scientific effort. This paper outlines the historical evolution of the federal involvement in scientific and technological activities (S&T) and describes the federal contribution to the development and application of technology in the industrial sector.

II FEDERAL S&T ACTIVITIES, 1915 to 1970

Prior to World War I, science in Canada was in its early infancy. Support for academic science was almost non-existent and, with the notable exception of a few chemical and pulp and paper firms, industry-based R&D received very little support. Almost all of the nation's scientific effort was conducted in federal laboratories and their efforts were devoted to developing and applying techniques for the exploration and exploitation of Canada's abundant natural resources.

In 1915, a group of industrialists urged the federal government to encourage industrial research by funding university programs aimed at improving industrial techniques. This, together with the initiatives of the British government and Canadian universities, led to the establishment in 1917 of the National Research Council (NRC) to review and make recommendations on scientific and industrial research in Canada.

During and immediately after World War I, the main preoccupation of federal science policy was to accommodate the needs of industry with the desires of the academic community. The industrialists wanted the universities to address industrial problems and to produce graduates who were familiar with the particular requirements of industrial research. The universities, on the other hand, were reluctant to host industrial research

institutes. They felt that this arrangement would inevitably lead to a subversion of their more traditional role of advancing the frontiers of knowledge.

The NRC shared this latter concern. The Council therefore proposed, and the federal government accepted, a strategy for the separate development of academic and industrial research. The universities would be encouraged to increase their production of graduates trained in the pure science and the government would support a research complex whose primary function would be to develop the new technologies that Canada needed. Hence, in the late twenties and early thirties, NRC established its own research laboratories and instituted a modest program in support of research in graduate schools.

At the beginning of World War II, NRC assumed responsibility for R&D activities for the armed services and for the development of atomic energy. Within a few months, NRC's staff grew from 300 to nearly 2,000 and its budget increased from $900,000 to almost $7 million. More modest growth also occurred in the research efforts of other federal departments.

During the period 1947 to 1960, a number of new organizations were established and major R&D programs were initiated or expanded. In 1947, for example, the Defence Research Board was created and almost immediately embarked on an ambitious program for the design, development and production of modern weapons. Five years later, Atomic Energy of Canada Limited was established to consolidate and expand the nuclear energy program.

III FEDERAL SCIENTIFIC ACTIVITIES IN THE SEVENTIES

During the sixties, federal support for the natural sciences had grown rapidly. For the period 1963/64 to 1969/70, for example, expenditures on R&D had increased at an average annual rate of 14 per cent. Funding for other scientific activities had kept pace with this growth so that total expenditures had more than doubled. Expenditures on R&D had increased from $246 million in 1963/64 to $537 million in 1969/70 and total expenditures from $307 million to $680 million.

In the seventies, however, there have been major changes in this growth pattern. Federal funding of R&D and overall expenditures on scientific activities have grown much more slowly. Between 1970/71 and 1977/78 expenditures have been compounded at a rate of 7.7 per

cent for R&D and 9.1 per cent for all scientific activities. R&D expenses have increased from $587 million to $987 million and total expenditures from $746 million to $1,374 million. As a result of the more rapid growth in other areas of the federal budget, support for the natural sciences had declined steadily from a peak of 4.9 per cent of total federal expenditures in 1970/71 to 3.1 per cent in 1977/78.

The percentage of the science expenditures committed to R&D has also changed during this decade. In 1970/71, approximately 79 per cent of these expenditures were for the support of R&D. Over the seven year period this percentage has steadily declined so that in 1977/78 only 72 per cent of these funds was spent on R&D.

Although 27 departments and agencies provide funding for natural science activities, this support is highly concentrated within a relatively few departments. Of the estimated $1,374 million spent in 1977/78, five departments accounted for 68 per cent of the funds and the ten major funders contributed 92 per cent of the total. Fisheries and Environment (DFE) spent $314 million; National Research Council (NRC) $276 million; Agriculture $130 million; Energy, Mines and Resources (EMR) $123 million; Atomic Energy of Canada Limited (AECL) $99 million; National Defence (DND) $84 million; Industry, Trade and Commerce $81 million; the Canadian International Development Agency (CIDA) $62 million; the Medical Research Council (MRC) $58 million and National Health and Welfare $38 million.

The S&T expenditures of almost all of the major science spenders have risen since 1970/71 but the percentage increases have varied widely. CIDA's funding has risen by 1,125 per cent and the expenditures of EMR, NRC and DFE have doubled. The Department of Agriculture's spending has increased by 99 per cent, NHW by 86 per cent and MRC by 69 per cent. However, expenditures by DND and ITC have grown much more slowly and there has been a small decrease in the funds expended by AECL.

During the first half of the decade, federal expenditures in the intramural sector grew at a faster rate than extramural support. Intramural performance of natural science activities increased from 61 per cent in 1970/71 to 64 per cent in 1974/75, industrial decreased from 21 per cent to 19 per cent and academic declined from 16 per cent to 14 per cent. In recent years, however, there has been some movement toward a redistribution of these federally supported activities.

Currently, 61 per cent of the federal funds are being spent intramurally, 20 per cent in industry and 14 per cent in universities.

Expenditures in the social sciences and humanities have grown more rapidly than those in the natural sciences. These expenditures amounted to $140 million in 1970/71 and have increased to their current value of $461 million for an average annual growth rate of 18.5 per cent. Most of this growth has occurred in the programs of Statistics Canada, National Health and Welfare, the Canadian International Development Agency and the International Development Research Centre.

To some extent the relative rates of growth among departments and the distribution of these growth rates among the performance sectors reflect the concerns and preoccupations of the seventies. The heightened interest in the management of the economy, social justice and the welfare of those in less fortunate circumstances undoubtedly contributed to increased expenditures in the social sciences. Similarly, our other concerns - the environment, industrial development, energy, food, health - were expressed in the changes in the pattern of the natural science expenditures.

IV FEDERAL INCENTIVES TO ENCOURAGE R&D IN INDUSTRY

Tax measures were and still are an important part of the federal strategy for encouraging companies to perform R&D in Canada. For almost thirty years, companies operating in Canada have been allowed to deduct from taxable income a portion of their expenditures on scientific research. The rules governing the eligible portion have been changed from time to time but from 1961 onwards the Income Tax Act has contained a provision for a 100 per cent fast write-off of current and capital R&D expenditures.

In 1977 the government introduced an additional benefit. The investment tax credit was extended to include credits in respect of both current and capital R&D expenditures. This credit ranges from 5 per cent of eligible R&D expenses to 10 per cent in certain designated areas. This was soon followed by another

measure which will allow companies to deduct an additional 50 per cent of the amount by which R&D expenditures exceed those that were incurred in the preceding three-year base period. Together these two provisions are expected to result in foregone tax revenue of $85 million in 1978.

The federal government also supports a number of direct assistance programs. Some of these programs are of general application in that they are designed to assist all industries. Others have a more specific mandate and their purpose is to reinforce the general incentive programs by providing an additional source of assistance to a particular industry or technology sector. Some of the general assistance programs - Enterprise Development Program (EDP) Industrial Research Assistance Program (IRAP), Industrial Research Associations, Industrial Research Institutes, Centres for Advanced Technology, Industry Energy R&D Program, Contracting-Out Policy - and the specific assistance programs - Defence Industry Productivity Program (DIP), Demonstration of Pollution Abatement Technology (DPAT) - are described in more detail below, and all are summarized in Table 1. These programs will provide most of the estimated $78 million in grants and $139 million in contracts that the federal government will spend on industrial R&D in 1978/79.

Recently the federal government announced a number of additional measures to strengthen and encourage research and development in Canada. Several of these measures will be of benefit to industry in general and the small and medium size firm in particular. The Science and Technology Employment Program (STEP) has been expanded to allow universities to hire unemployed scientists and technicians to carry out research projects at the request of private sector firms. Previously this program was restricted to the conduct of R&D in industry. Another measure calls for the establishment of as many as five university-based Industrial Research and Innovation Centres to aid industry in the development of new products or technologies. Thirdly the Unsolicited Proposal Fund will be enhanced by an additional $1.5 million in each of the next two years.

The federal government five-year plan to encourage the use of renewable energy also contains substantial additional resources for industrial R&D. Manufacturers of solar equipment will be eligible to compete for twenty-five $10,000 research grants and ten of the more promising proposals could get $200,000 to $300,000 of

TABLE 1

INDUSTRIAL S&T ASSISTANCE PROGRAMS

PROGRAM	PURPOSE	ADMINISTERED BY	ELIGIBILITY	EXTENT OF ASSISTANCE
CENTRES FOR ADVANCED TECHNOLOGY PROGRAM (CAT)	To assist programs of research relevant to industrial needs	Department of Industry, Trade and Commerce	Canadian universities and other organizations with research capabilities	Grants to cover the costs of establishing and operating a Centre
CONTRACTING OUT POLCIY AND UNSOLICITED PROPOSALS	To promote the development of the Canadian Industrial R&D capability	Department of Supply and Services	Canadian companies or individuals with a demonstrated competence in R&D	Purchase of service
DEFENCE INDUSTRY PRODUCTIVITY PROGRAM (DIP)	To sustain the technological capability of the Canadian defence industry	Department of Industry, Trade and Commerce	Companies incorporated in Canada	Grants and repayable loans on a cost-sharing basis of up to 50% of all expenditures for defence-oriented R&D
ENTERPRISE DEVELOPMENT PROGRAM (EDP)	To support the development or introduction of new or improved products and processes that offer good prospects for profitable commercial exploitation	Department of Industry, Trade and Commerce	Canadian companies demonstrating need for assistance and resources to pursue successful projects	Variety of cost sharing assistance for innovation projects, for product improvement studies and market research
INDUSTRIAL RESEARCH ASSISTANCE PROGRAM (IRAP)	To assist in the development of an R&D capability in Canadian industry	National Research Council	Companies incorporated in Canada and engaged in activities with a significant technological component	Grants for the payment of salaries and wages of R&D staff working on approved projects
INDUSTRIAL RESEARCH ASSOCIATION PROGRAM	To promote industry collaboration in maintenance of R&D facilities	Department of Industry, Trade and Commerce	Technological industry groups or institutes	Grants during facility start-up and early operations. Assistance limited to maximum of seven years
INDUSTRIAL RESEARCH INSTITUTE PROGRAM (IRIP)	To assist Canadian universities to undertake contract research for industrial clients	Department of Industry, Trade and Commerce	Canadian universities	Grants to cover the first three years administrative costs
INDUSTRY ENERGY RESEARCH AND DEVELOPMENT PROGRAM (IERD)	To encourage and assist in the development of more energy efficient industrial processes.	Department of Industry, Trade and Commerce	All companies incorporated in Canada, groups of companies or individuals, research organizations, and consulting firms	Grant usually amounting to 50% of total estimated cost of an approved project. Crown has unlimited rights to the technology
PROGRAM TO STIMULATE THE DEVELOPMENT AND DEMONSTRATION OF POLLUTION ABATEMENT TECHNOLOGY (DPAT)	To stimulate the development of pollution abatement technology which will have wide application in Canada	Department of Fisheries and the Environment	Canadian companies	Negotiable cost-sharing Contract requires that the technology developed be made freely available to other Canadian companies

development funding. Another $114 million has been allocated for federal-provincial or federal-industrial projects to develop and demonstrate novel solar technologies. Another $143 million will be used to encourage forest producers to develop efficient methods for the combustion of wood waste and $40 million will be offered for research on innovative techniques such as biomass plantations and the conversion of biomass to liquid fuels or chemicals.

V FEDERAL S&T GRANTS PROGRAMS AND THE CONTRACTING-OUT POLICY

The various federal programs to provide direct assistance to firms to encourage S&T performance are summarized in Table I. Many of these programs have a relatively long and successful history. The Industrial Research Assistance Program (IRAP), for example, was introduced in 1962 and has contributed significantly to an increased technological capability of many Canadian companies. Since its inception IRAP has supported over 743 projects in 348 companies at a total cost of $273 million, $109 million of which was provided by NRC. The IRAP funding has been of particular benefit to firms in the chemical, electrical and electronic, paper, food and pharmaceutical sectors.

The Defence Industry Productivity program (DIP), on the other hand, has been most effective in areas such as aeronautics, electronics and ship-building. DIP funding was instrumental in the development of a tactical military microwave communications system, satellite communications equipment, aircraft flight simulators, a battlefield surveillance system, a flight data recorder and an aircraft crash position indicator. This latter development was a result of technology transferred from NRC laboratories. The federal government invested $24 million in these projects and resulting sales have exceeded $450 million.

Other programs, such as the Industrial Research Institute Program (IRIP) and the Industrial Research Association Program, are designed to respectively encourage the establishment of centres at Canadian universities to perform research for industry, and to stimulate industry groups or institutes to set up centres to perform R&D for member firms. These programs are only intended to assist in the start-up and early operation of facilities which are expected (within three and seven years respectively) to be self supporting.

The Contracting-Out policy is, again, different in nature. It was originally introduced in 1972 as the R&D Make-or-Buy Policy, with the objective of having new federal R&D needs in the natural sciences performed in industry (except in certain specified cases where, for example, statutory requirements preclude contracting-out). Later, the policy was extended by the Unsolicited Proposals adjunct to cover work proposed by private sector performers on behalf of federal departments. Then, in April 1977, the policy was further extended to cover all S&T in the natural sciences and some social science activities. It was renamed the Contracting-Out Policy.

The Contracting-Out policy is intended to increase the probability that research on projects of the federal government will lead to industrial innovation. Such innovation is more likely to take place in firms where the R&D staff have developed research results and the technologies themselves. The policy, therefore, is in a sense a bridge between direct S&T assistance and technology transfer programs.

VI TRANSFER OF TECHNOLOGY FROM FEDERAL LABORATORIES

Significant contributions to the health of various sectors of industry have been made by the transfer of technology from federal government laboratories. For example, research performed by Agriculture Canada has led to technology advances on the farm, and the S&T work of Atomic Energy of Canada Limited is largely responsible for the sizeable nuclear energy industry in Canada.

An example of Agriculture Canada's technology transfer has been its work to produce improved rapeseed varieties, so as to produce a rapeseed low in eurucic acid and glucosinolate and thus to maintain their important Japanese market. Other successes have been the introduction of new grape varieties in Ontario, a new soybean variety to extend the region suitable for this crop, and experiments are now in progress on growing new varieties of dill and Jerusalem artichoke in Manitoba.

Environment Canada is successfully transferring several technology developments from its Forest Products Laboratories to industry. A new steam process could increase production of a certain type of particle board by up to 100 per cent, and obtain for Canada world-wide customers for the technology and equipment. A weather-resistant fire retardant is already widely marketed and

a new preservative for difficult-to-treat woods is nearing the commercial stage. The newly developed ribbed tree-shear blade, now being produced and marketed, reduces damage to harvested timber in rugged terrain.

In the Department of Energy, Mines and Resources, the Cnaada Centre for Mineral and Energy Technology has developed improved techniques to determine the steepest safe slopes for various rock formations in open pit mines. Various firms (such as the Iron Ore Company of Canada, INCO-Thomson, and the Luscar Coal Company) are now using these techniques to reduce the amount of waste rock to be removed from pits. A second technology transfer success is the assistance provided to Canadian industry to construct fluidized-bed furnaces to burn coal, especially high sulphur coal, and wood more efficiently.

Federal laboratories have also contributed to the transfer of technology to manufacturing industries. The Department of Communications, for example, has been active in technology transfer in the areas of visual and interactive displays (an integral feature of modern data systems) and in improving the capacity of the private sector to assume a prime contractor role in space-related activities. The Communications Research Centre and the David Florida Laboratories have cooperated with Canadian firms on transponder development for Canadian satellites. This has involved the development of other items such as solar arrays control systems, micro-wave components, antennae and efficient battery management systems.

There are many examples of successful technology transfer from the Department of National Defence. The Canadian Marconi Company, produced a dual antenna frequency modulation system. The firm has sold 250 systems for Canadian military use and export sales exceed $300 million. Collaborative research with Cominco Ltd. led to the development of cathodic protection of ships' hulls against corosion. This technology has been applied to all Canadian Forces' vessels and has been adopted by other navies and commercial lines. The resultant annual export market for zinc for electrode purposes is valued at $100,000 and is growing rapidly.

The National Research Council is the largest source of inventions patented by the Canadian Patents Development Ltd. and operates the Program of Industry/Laboratory Projects (PILP) and the Technical Information Services (TIS).

PILP is a cooperative program between industry and NRC whereby laboratory-initiated projects are contracted out to industry for further development. Some of the significant PILP projects include: extraction of oil from oil sands; ertical wind turbines for electric power generation; a railraod switch that is protected from snow and ice; reduction of hydrogen in steel; and computer-aided learning systems. It has been estimated that, in addition to 3,000 construction jobs, about 1,700 permanent jobs would be created through these projects. Over a five year period this would result in sales of $2 billion. Because of the enthusiastic response of industry and government scientists to this program, the federal government has recently decided to extend the PILP program to other government departments and agencies.

The TIS service is aimed primarily at fulfilling the technical information needs of industry with particular emphasis on the small firm which often operates without an R&D capability. TIS receives annually between 20,000 to 25,000 enquiries and provides in-depth assistance to about 600 to 700 firms. Some 4,000 firms receive monthly lists of information. A survey of a sample of firms that were assisted indicates increased profits before taxes of over $500,000; increased gross sales of $3.6 million; reduced operation costs of $300,000; and the saving of 150 jobs.

The R&D program of AECL has been developed in close cooperation with the manufacturers of nuclear equipment and with the provincial utilities. As a result, AECL has made a number of significant contributions to these industries. Innovation of AECL laboratories in nuclear fuel design and performance, neutron flux detectors, a decontamination process in the heat transport system, improved quality of bellows sealed values, and a computer code for steam boiler conditions have been successfully transferred for application in the nuclear industry.

Canadian Patents and Development Ltd. (CPDL) is an important intermediary in the transfer of technology from federal laboratories to industry. This Crown company is a clearinghouse for inventions arising from publicly financed research and development. Many of these inventions are patented, and attempts are made to find licensees who will develop and commercially produce the invention. Its recent federal laboratories-related licenses include transversely excited CO_2 lasers, a small versatile scanning electron microscope, a process for making dehydrated mashed potatoes, and a

fire retardant for wood. For the fiscal year 1977/78, this Crown corporation earned a revenue of $800,782 on royalties and licensing fee.

VII FEDERAL SUPPORT FOR UNIVERSITY TO INDUSTRY TECHNOLOGY TRANSFER

This section deals with the important issue of tapping the scientific resources of Canadian universities and making it available for innovation in Canadian industry. There are a number of federal programs that are designed to facilitate the development of this type of university-industry interface. The most successful of these have been programs of the Department of Industry, Trade and Commerce (ITC).

Over the past 11 years, ITC has developed two specific programs in this area: The Industrial Research Institute Program (1967) and the Centre of Advanced Technology Program (1970). Both programs assist universities to provide scientific services and to conduct research and development projects for those industrial firms which are unable to maintain adequate facilities and personnel. It is anticipated that an improved interaction between industry and university will assist universities in gaining a better appreciation of industrial problems and enable industry to become more aware of pertinent scientific and technical work being done in universities.

Since 1967, ITC has sponsored ten university-based Industrial Research Institutes. Federal assistance has taken the form of grants to underwrite the administrative cost of operating an institute during its formative years when income from contracts is insufficient to meet start-up expenditures. Each institute is expected to become self-supporting within five to seven years. Of the nine institutes that are still operating, seven are already self-supporting. For the year 1975 the Industrial Research Institute at the University of Waterloo had obtained contracts exceeding $1 million

For the second program, ten Centres of Advanced Technology have been established, five at universities and five with provincial research councils. Total grants authorized for these centres to March 31, 1977, amounted to $6,380,000.

The following are some examples of successful transfers of technology from university laboratories to industry which have resulted from the two ITC programs: production of strontium glazes for bricks and tiles;

instrumentation for detecting enzyme catalyst; modification of dynamometers for torque and thrust measurement and the development of new ocean-related products - rotary gas valves, electric slip rings, flexible wave shaft and program chart recorder; prototype machining and solution of metal cutting problems; simulation of manufacturing plants through computer modelling; trail production of Dill oil; development of fire and moisture resistant insulation blocks from peat moss.

VIII RECENT FEDERAL TECHNOLOGY TRANSFER INITIATIVES

The development of indigenous scientific and technological capability is of vital importance to the continued maintenance of Canada's capacity to take advantage of advances in scientific knowledge. In order to achieve this goal, it is essential that effective mechanisms be established to enable scientific techniques and devices developed in federal laboratories to be translated into marketable processes and products.

To facilitate the industrial use of knowledge generated in federal laboratories, the government has recently stated that the transfer of technology should become an objective of all of its laboratories. The intent of this policy decision is to enable all government laboratories to identify at an early stage any research that is of possible interest to industry, and to plan for the successful transfer to, and exploitation by, industry of the results of this research.

This policy initiative is being reinforced by several other measures such as: expanding the role of Canadian Patents Development Ltd. (CPDL) to act as a clearinghouse of information on technology available in government laboratories and on technology required by Canadian industry; providing an additional $5 million to NRC in 1978/79 for its Program of Industry/Laboratory Projects (PILP), and extending the PILP concept to other government laboratories; rewarding scientists and laboratory directors for their efforts to transfer technology and removing impediments to the movement of scientists between government laboratories and industry.

In addition, the federal government has stated the urgent need for a shift in focus of university-based industrial research towards innovations of economic use. In this direction, $2 million has been allocated in the current fiscal year for the establishment of up to five Industrial Research Innovation Centres at Canadian universities. A further $6-8 million has

been made available for the creation of six "Regional Centres of Excellence" to achieve better integration of government, university and industrial research activities. These Centres of Excellence are to be based on the natural and human resources of each areas so as to assist in further development of the industrial capacity of each region. The fields covered by the first six of these centres include: Materials, Cold Water Enginering, Organic Soils, Coal, Fermentation and Food Distribution.