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RESEARCH AND DEVELOPMENT IN CANADA: FEDERAL EXPENDITURES AND POLICIES

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INTRODUCTION

Research and development (R&D)[(1)] activities are important building blocks of innovation.[(2)] Over the past few decades, the importance of science, technology and innovation as key drivers of growth in advanced world economies has become increasingly clear.[(3)] As a consequence, expenditures on R&D have increased considerably in many countries, and government science and technology (S&T) policies have been modified to reflect the emergence of the "new," knowledge-based economy.

Although R&D is commonly a prerequisite for innovation, other measures (e.g., a supply of venture capital, effective knowledge and technology transfer mechanisms, and a strong competition policy) are required to ensure that the fruits of R&D reach the marketplace. In addition to creating wealth, the results of R&D may lead to other (e.g., social, environmental or medical) advances that may improve the quality of life of the world's citizens.

In terms of gross expenditures on research and development (GERD)[(4)] as a percentage of the gross domestic product (GDP) – the Organisation for Economic Co-operation and Development's (OECD) measure of a nation's R&D intensity – Canada lags behind a

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(1) "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications." OECD, *The Measurement of Scientific and Technological Activities: Proposed Standard Practice for Surveys of Research and Experimental Development – Frascati Manual 1993*, OECD, Paris, 1994, p. 29.

(2) Innovation is "a process through which economic and social value is extracted from knowledge through the generation, development and implementation of ideas to produce new or improved products, processes and services." Conference Board of Canada, *Fourth Annual Innovation Report: Including Innovation in Regulatory Frameworks*, Ottawa, 2002, p. 1.

(3) OECD, *OECD Science, Technology and Industry Outlook 2002*, 2002, p. 23.

(4) GERD = total intramural expenditures on R&D performed on the national territory during a given period. It includes R&D performed within a country and funded from abroad but excludes payments made abroad for R&D.

number of other developed countries, and ranks near the bottom of the investment scale for G-7 countries.(5)

This paper focuses on the R&D component of Canada's innovation system. It provides a historical overview of federal expenditures on R&D and federal policies intended to support S&T and R&D in Canada, particularly in the private sector. In addition, it examines recent trends in OECD countries' central government expenditures on R&D and policies for promoting R&D.

R&D, PRODUCTIVITY AND GOVERNMENT SUPPORT

A large econometric literature demonstrates the link between R&D and productivity at the level of firms, industries and countries.(6) A recent empirical analysis of 16 OECD countries (including Canada), for example, revealed that R&D performed in both the private and public (government and university) sectors has a positive and significant impact on productivity.(7)

The argument for government support for R&D is based, in part, on the recognition that the benefits of R&D extend beyond the performers themselves to other sectors of the economy, and that the value of these benefits cannot be completely appropriated (or captured) by the performers of the R&D. Econometric analyses indicate that the social rates of return to R&D investment can be up to five times higher than private rates of return, and that social rates of return on basic R&D are higher than those on applied R&D. In a market economy, lack of appropriability leads to a "failure" by market institutions to invest an efficient or socially desirable quantity of resources in R&D. Patent and copyright laws are intended to provide property rights and increase appropriability (and thus private rates of return to R&D), but these measures are imperfect and do not result in full appropriability. Government

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(5) Conference Board of Canada, *Investing in Innovation: Third Annual Innovation Report (2001)*, p. 63.

(6) See, for example, Zvi Griliches, *R&D and Productivity: The Econometric Evidence*, University of Chicago Press, 1998.

(7) Dominique Guellec and Bruno van Pottelsberghe de la Potterie, *R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries*, OECD STI Working Paper 2001/3, 2001.

intervention in the marketplace to support R&D is thus necessary to compensate for the market's inability to allocate a socially optimal quantity of resources to R&D.[8]

Debate abounds on what should be the nature and extent of government support for R&D. The following sections of this paper present a historical overview of Canadian federal government expenditures on R&D, and federal policies to support R&D in Canada.

CANADIAN FEDERAL R&D EXPENDITURES

In 1971, the federal government's contributions to GERD totalled $589 million[9] (or approximately $2.7 billion in 2000 dollars). In fiscal year 2000-2001, the federal government is estimated to have spent approximately $4.2 billion on R&D activities, of which approximately $3.5 billion contributed to Canada's GERD. For fiscal year 2001-2002, planned federal expenditures on R&D were approximately $4.6 billion.[10] Although the federal government's 2002 Innovation Strategy provides a target of doubling the federal investment in R&D by 2010, no base reference year or amount is provided in the Strategy's documents.[11] Information on the Innovation Strategy's web site suggests that the base year and amount for the target is the federal government's contribution to GERD in 2000.[12] As such, the final federal investment should be in the range of $7 billion annually. Since the announcement of the new federal S&T strategy in 1996,[13] some of the major federal R&D investments have been the creation of Technology Partnerships Canada (1996), the establishment of the Canada Foundation for Innovation (1997), increased funding for the granting agencies (1998, 1999 and 2001), increased funding for the Canadian Space Agency (1999), creation of the Canadian Institutes of Health Research (2000), and the creation of the Canada Research Chairs Program (2000).

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(8) For a complete discussion of market and government failures and the allocation of resources to R&D, see: Donald G. McFetridge, *Science and Technology: Perspectives for Public Policy*, Occasional Paper No. 9, Industry Canada, Ottawa, 1995.

(9) Statistics Canada, *Service Bulletin Science Statistics*, Vol. 20, No. 6, September 1996, p. 4.

(10) Statistics Canada, *Federal Scientific Activities 2001-2002e*, 2002, p. 16.

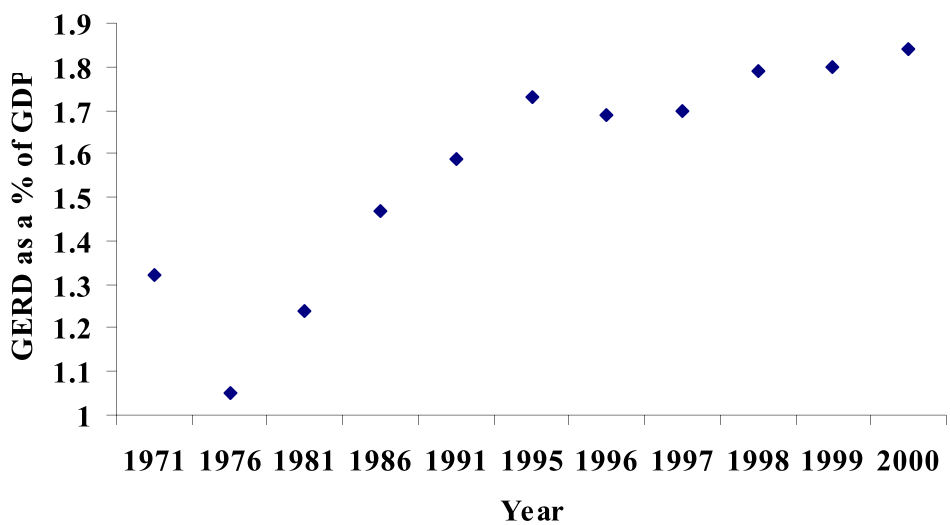
(11) The documents forming *Canada's Innovation Strategy* can be accessed electronically at: http://www.innovationstrategy.gc.ca/cmb/innovation.nsf/pages/index.

(12) See discussion at: http://www.innovationstrategy.gc.ca/cmb/innovation.nsf/TargetAnalysis/Target02.

(13) Government of Canada, *Science and Technology for the New Century: A Federal Science and Technology Strategy*, 1996.

Canada's GERD as a percentage of GDP has increased gradually from 1.32% in 1971[(14)] to an estimated 1.84% in 2000[(15)] (see Figure 1). The level dropped to about 1% in the late 1970s and early 1980s, in part because science and technology issues were not a key focus of the federal government at that time,[(16)] and partly because of the economic climate in the early 1980s. Analysts note that Canada's GERD as a percentage of GDP has moved relatively little in 30 years, and that goals set in the 1980s and 1990s to increase this ratio have not been achieved.[(17)] Between 1991 and 1999, however, expenditures on R&D in Canada increased at an average annual rate of 3.57%, higher than the average rate of growth (2.83%) for OECD countries.[(18)]

Figure 1: GERD as a Percentage of GDP, 1971 to 2000, Canada



The business sector has assumed an increasing role in the funding of R&D in Canada over the past few decades. In 1971, the federal government contributed 45%

(14) Statistics Canada (1996), p. 2.

(15) OECD, *Main Science and Technology Indicators*, Vol. 2002, release 01.

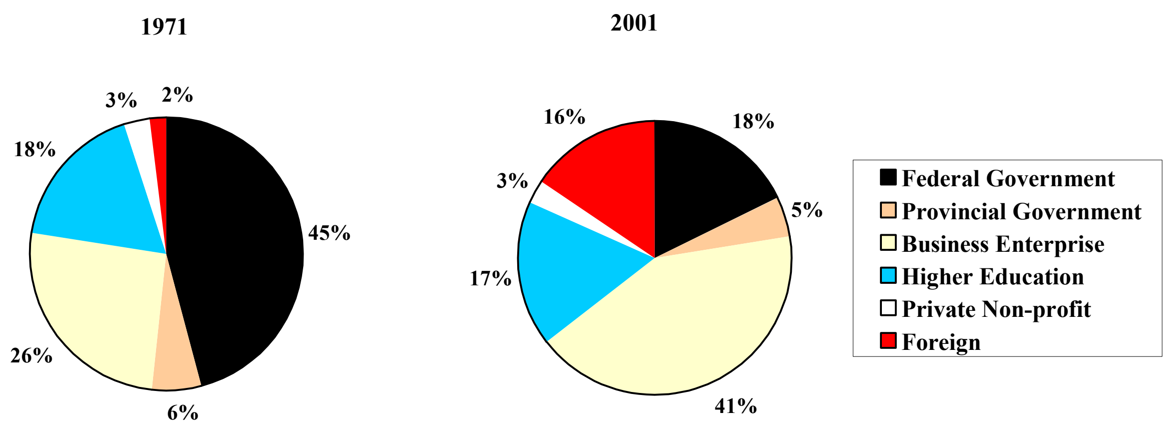
(16) Roger Voyer, "Thirty Years of Canadian Science Policy: from 1.5 to 1.5," *Science and Public Policy*, Vol. 26, August 1999, p. 277.

(17) *Ibid.*

(18) OECD, *OECD Science, Technology and Industry Scoreboard 2001 – Towards a knowledge-based economy*, 2001, p. 17.

($589 million) of Canada's GERD.[19] By 2001, this proportion had dropped to an estimated 18% ($3.72 billion), with the business sector contributing almost 42% ($8.77 billion) of Canada's GERD. Funding from abroad also contributes a relatively high proportion (an estimated 15.5% in 2001)[20] of Canada's GERD. The remainder of Canada's GERD is contributed by the higher education sector, provincial governments and private, non-profit organizations (see Figure 2).[21]

Figure 2: Trends in GERD in Canada by Funding Sector, 1971 and 2001 (Estimates)



A recent survey of Canadian industries suggests that planned total expenditures on R&D will drop by 6.1% in 2002 relative to expenditures in 2001, the first annual decline in planned spending by Canadian industry since Statistics Canada began collecting such data in 1955. The greatest decline (29%) in planned spending is in the communications equipment industry, which will still, however, be Canada's top industrial sector in terms of R&D spending in 2002.[22] Given the importance of industry's contributions to Canada's GERD, this spending decline is worrisome.

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(19) Statistics Canada (1996), p. 2.

(20) OECD (2002), *Main Science and Technology Indicators*.

(21) Statistics Canada (1996), p. 4 and (2002), p. 18.

(22) Statistics Canada, *Service Bulletin Science Statistics*, Vol. 26, No. 4, 2002, p. 3.

CANADIAN FEDERAL POLICIES TO PROMOTE R&D

Some commentators have suggested that one of the reasons Canada lags behind other countries in terms of R&D intensity and innovation performance is that the country lacks a cohesive, national science policy, and that policies to promote R&D and innovation in Canada at the federal level have not been integrated into a unified strategy. Other analysts have suggested that an "overarching" federal science policy is not necessary to improve Canada's R&D intensity and innovation performance, but that individual government policies should do more to create the appropriate environment for investment in R&D by the business sector. The following section presents a historical overview of efforts to develop a federal science policy. It also discusses tax incentives for R&D, one of the principal federal policy instruments intended to promote R&D spending by the private sector.

A. Canadian Federal Science Policy: Historical Overview

Until World War I, most Canadian scientific activities were concentrated on natural resources, and scientific government departments or bodies were established to manage these resources. In 1916, the National Research Council (NRC) was created with a mandate to coordinate scientific and industrial research in Canada. Although originally set up as an advisory council, by the end of World War II the NRC had become a large research body and the main scientific institution in Canada. Canada's scientific activities expanded in a piecemeal fashion following World War II with little coordination or vision at a national level.(23)

It was not until 1963, when a Royal Commission on government organization(24) criticized the lack of a national science policy and the paucity of funds directed towards R&D, that the federal government began to address the void in the area of science policy. Following the Commission's report, the government created a Science Secretariat in the Privy Council Office in 1964. In 1970, a Senate committee recommended that an overarching national science policy be formulated for Canada. The committee also called for the formation of three agencies to allocate funds to basic research in the sciences. The Medical Research Council (created as an autonomous body by an Act of Parliament in 1969) and the Natural Sciences and Engineering

(23) Voyer (1999), p. 278.

(24) J. Grant Glassco (Chair), Royal Commission on Government Organization, Ottawa, 1962-1963.

Research Council (created by an Act of Parliament in 1977) were formed from sections already within the NRC; the Social Sciences and Humanities Research Council (also created in 1977) was formed from a unit within the Canada Council. In 1971, the government folded the Science Secretariat into a junior-level Ministry of State for Science and Technology; its status was an indication to some critics that science policy issues were not of central importance to government activities.[(25)]

Federal, provincial and territorial ministers responsible for S&T signed the first national policy on science and technology in 1987. The policy stressed the importance of improving innovation, developing technologies for all sectors of Canada's economy, supporting basic and applied R&D, and ensuring an adequate supply of highly qualified personnel. Further developments during the 1980s included the establishment of a National Advisory Board on Science and Technology in 1987 to provide advice to the Prime Minister; the creation of a single department, Industry, Science and Technology Canada (now Industry Canada), to cover certain federal S&T activities; and the formation of a new House of Commons Standing Committee (the House of Commons Standing Committee on Industry, Science and Technology in its present form) to deal with issues falling under the mandate of this department.

The first comprehensive, integrated federal S&T policy, *Science and Technology for the New Century: A Federal Science and Technology Strategy*,[(26)] was announced in 1996 following an intensive two-year review of federal S&T activities.[(27)] Critics of the 1994 S&T review suggest that although it started with the best of intentions, it developed into a public relations exercise conducted, in part, to minimize the impact of the massive cuts that were announced in the 1995 budget as part of Program Review.[(28)] The resulting 1996 strategy was founded on three national goals for building Canada's innovation system to which S&T resources could be directed over the next century: 1) sustainable job creation and economic growth; 2) improved quality of life; and 3) advancement of knowledge. The strategy proposed

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(25) Voyer (1999), p. 278.

(26) Government of Canada, *Science and Technology for the New Century: A Federal Science and Technology Strategy*, 1996.

(27) See Daniel Brassard, *Science and Technology: The New Federal Policy*, BP-414E, Parliamentary Research Branch, Library of Parliament, Ottawa, April 1996.

(28) See summary in A. Cruikshank and A. Holbrook, *The 1994 Federal Science and Technology Review*, CPROST Report #02-01, Centre for Policy Research on Science and Technology, Simon Fraser University, Vancouver, 2002.

that the federal government strategically focus its S&T activities in four core areas: 1) funding and performing scientific research to support the mandates of departments and agencies; 2) supporting research in universities and colleges, Networks of Centres of Excellence and other non-governmental research institutions; 3) supporting private-sector research and technology development; and 4) providing information and analysis, and building networks. In addition, the strategy announced new institutions and mechanisms of governance for S&T activities, including the establishment of two external science advisory bodies for government.

In 1997, after the cuts stemming from Program Review and following the elimination of the deficit, the federal government began reinvesting in R&D. Successive budgets have continued to offer new or enhanced investments in existing programs and a series of new initiatives. The throne speeches of 1999 and 2001, in particular, highlighted the government's "innovation agenda" and its goal of making Canada one of the most innovative economies in the world. The government has stressed that a major element in achieving this goal is to ensure that Canada's R&D intensity places it among the top five countries in the world (Canada was in 14th place in 2000, using the above-mentioned OECD measure).(29)

In 2002, the federal government released its long-awaited "Innovation Strategy," the first major step in implementing the government's innovation agenda. *Canada's Innovation Strategy* ("the Strategy"), presented as two companion papers,(30) aims to stimulate discussion on ways to substantially improve Canada's economic prosperity and quality of life for its citizens by building a skilled workforce and a more innovative economy. The paper *Achieving Excellence: Investing in People, Knowledge and Opportunity* describes a series of ambitious national goals that are intended to serve as a blueprint for economic growth by improving Canada's innovation capacity. The paper lists goals and targets to improve this capacity through: 1) generating knowledge, bringing ideas to market more quickly, and increasing investment by all sectors in R&D; 2) ensuring a skilled workforce for the knowledge-based economy; 3) modernizing business and regulatory policies while protecting the public interest; and 4) promoting and supporting innovation at the community level. Some of the Strategy's goals and targets deal specifically with improving investment in R&D and strengthening Canada's R&D performance.

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(29) OECD (2002), *Main Science and Technology Indicators*.

(30) Both papers that make up *Canada's Innovation Strategy* (*Knowledge Matters: Skills and Learning for Canadians* and *Achieving Excellence: Investing in People, Knowledge and Opportunity*) can be found on the Innovation Strategy web site at: http://www.innovationstrategy.gc.ca/cmb/innovation.nsf/pages/index.

Its most important national targets related to R&D in Canada are: 1) to rank among the top five countries in the world in terms of R&D intensity by 2010; and 2) to at least double the federal government's current investments in R&D by 2010. The Strategy recognizes that although the federal government has an important role to play as a facilitator and collaborator in improving Canada's innovation performance, most of the Strategy's national targets will be realized only with the full participation of the provinces, the academic community, and, most importantly, the private sector.

The Strategy, which was originally expected to be presented as a government white paper, was released as two "discussion" papers. Although the papers set out broad goals and targets intended to improve Canada's innovation performance, they contain no detailed federal policy or cost estimates. Following the release of the Strategy, the government held a six-month-long series of meetings and forums with the various stakeholders involved to obtain their views on the Strategy's priorities and targets.(31) A National Summit on Innovation and Learning, held in November 2002, brought together partners in the private sector, non-governmental organizations, academia and government to discuss the priorities for the Strategy and to seek commitment from all sectors for a "Canadian Innovation and Learning Action Plan." An early action associated with the R&D targets outlined in the Innovation Strategy was the production of a framework agreement(32) between the Government of Canada and the Association of Universities and Colleges of Canada. In this document, the universities pledged to double the amount of research performed and triple commercialization outputs by 2010, and the federal government agreed to provide the necessary levels of investment in university research to achieve these aims, including ongoing contributions to the indirect costs of federally funded research.

B. Federal Policies to Promote Private-Sector R&D

Given that increased private-sector participation in R&D is considered to be critical to improving a nation's innovation performance, most commentators assign high

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(31) A summary of participants' views can be found in the document: Government of Canada, *Canadians Speak on Innovation and Learning*, 2002, http://www.innovationstrategy.gc.ca/cmb/innovation.nsf/vRTF/NationalSummitPDF/$file/CanadiansSpeak.pdf.

(32) *Framework of Agreed Principles on Federally Funded University Research*, 2002, http://www.aucc.ca/_pdf/english/reports/2002/frame_cadre_e.pdf.

importance to policies to encourage this involvement. Governments have at their disposal a variety of policy options intended to increase overall R&D intensity, including: directly subsidizing R&D in government laboratories, in universities, and in the private sector; investing in research infrastructure; and providing funds for training researchers. Other more indirect policy instruments include: offering tax credits to the business sector for the performance of R&D; enacting sound intellectual property laws; and ensuring that a strong competition policy and an appropriate regulatory framework are in place.

Direct financing of R&D allows governments to target funding towards particular research areas or projects that are deemed to offer significant social returns. Examples include research in scientific or technological fields with significant spillovers, basic research, or research for specific government missions (e.g., defence or health). Tax incentives provide a means of funding a portion of the R&D conducted in all qualifying R&D-performing organizations. Such incentives benefit a large number of firms and allow individual companies to determine how R&D funds are spent. Tax incentives do not, however, allow government to direct business R&D easily towards areas with high social returns, nor do they appear to influence corporate R&D strategies significantly. Evidence also suggests that tax incentives do not encourage non-R&D performing firms to begin investing in R&D. Because of the differences between these two policy options, governments tend to favour a mix of direct financing and tax incentives as methods to boost R&D spending by the business sector.(33)

Various federal government departments and agencies offer some form of direct financing to promote the performance of R&D by the business sector. Two major programs in this category are the Industrial Research Assistance Program, which provides advisory services and some funding to support innovation in small and medium-sized enterprises, and Technology Partnerships Canada, which provides "conditionally repayable investments" to companies to support R&D in certain strategic areas. The government spent an estimated $854 million on R&D performed by the business sector in fiscal year 2000-2001; of this amount, $462 million was spent on R&D grants and contributions.(34)

The federal government spends much more each year (approximately $1.3 billion) on R&D tax credits than it does on direct financing programs for industry. Tax incentives to

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(33) See the discussion of direct financing vs. tax incentives in OECD (2002), *OECD Science, Technology and Industry Outlook 2002*, pp. 114-115.

(34) Statistics Canada (2002), *Federal Scientific Activities 2001-2002e*, p. 23.

spur private investment in R&D have been a component of Canada's innovation system for more than 50 years. As early as 1944, companies were able to deduct amounts equivalent to 100% of expenditures on scientific research from their taxable incomes. In the present Scientific Research and Experimental Development (SR&ED) Tax Credit Program,(35) qualifying expenditures are eligible for a 20% investment tax credit. This rate increases to 35% for small Canadian-controlled private corporations (CCPCs) on their first $2 million of expenditures. Eligible expenditures include the wages and salaries of researchers, materials, overhead, and machinery and equipment. The credit is fully or partially refundable for small CCPCs. The Program receives more than 11,000 SR&ED tax credit claims per year.

In comparison to other industrialized nations, Canada provides one of the most attractive tax regimes for performing R&D. In addition to the federal program, most provinces offer similar tax incentives for conducting R&D. A comparison of tax treatment packages for R&D among the G-7 countries and Australia, Korea, Mexico and Sweden categorized Canada as a "leading promoter" in terms of the degree to which it promotes R&D through tax incentives; no other country received this designation. Additionally, Canada, Italy, Japan and Korea were the only countries that have programs that provide tax credits for R&D by small companies.(36)

Studies on the impact of public expenditure on business R&D suggest that tax incentives have a positive effect on business-financed R&D.(37) An evaluation of the Canadian SR&ED tax credit program published in 1997 found that the incentives had a cost-effectiveness ratio of 1:1.38 (i.e., each dollar of tax revenue forgone as a result of the tax incentives generated $1.38 in additional R&D spending). A survey conducted as part of the evaluation showed that almost 60% of firms reported that their SR&ED expenditures were higher as a result of the tax incentives.(38)

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(35) For a historical overview of tax incentives to promote R&D in Canada and a discussion of the current SR&ED Program, see: Odette Madore, *Scientific Research and Experimental Development: Tax Policy*, 89-9E, Parliamentary Research Branch, Library of Parliament, Ottawa, August 1998.

(36) Jacek Warda, *Measuring the Attractiveness of R&D Tax Incentives: Canada and Major Industrial Countries*, Statistics Canada, 1999.

(37) Dominique Guellec and Bruno Van Pottelsberghe, *The Impact of Public R&D Expenditure on Business R&D*, OECD, 2000.

(38) Department of Finance and Revenue Canada, *The Federal System of Income Tax Incentives for Scientific Research and Experimental Development: Evaluation Report*, 1997.

INTERNATIONAL TRENDS IN R&D EXPENDITURES AND POLICIES

A. Expenditures on R&D in OECD Countries

Except during 1991-1994, expenditures on R&D (both in absolute terms and as a percentage of GDP) have increased in most OECD countries over the past two decades, and have accelerated since the mid-1990s. Most of the increase between 1994 and 2000 is attributable to increased spending in the United States. As a result, the gap in spending between the United States and the European Union and Japan has widened. In 2000, R&D expenditure in the United States accounted for approximately 44% of the OECD total, almost equalling the combined total expenditures by the European Union (28%) and Japan (17%). Canadian expenditures on R&D represented only 2.7% of the total OECD expenditures on R&D in 2000.[39]

OECD expenditures on R&D as a percentage of GDP declined in the early 1990s, but from the mid-1990s to 1999, R&D intensity increased continuously in Japan and the United States. In Japan, this growth largely reflected a drop in the value of GDP in 1998 and 1999, rather than large increases in R&D expenditures. In the United States, the rise was a result of significant increases in R&D expenditures, since GDP also grew rapidly over this period. In the European Union, R&D intensity remained relatively stable.[40] In 2000, Sweden, Finland and Japan led the OECD countries in terms of GERD as a percentage of GDP, while Canada placed 14th (below the OECD average of 2.24%; see Figure 3).[41]

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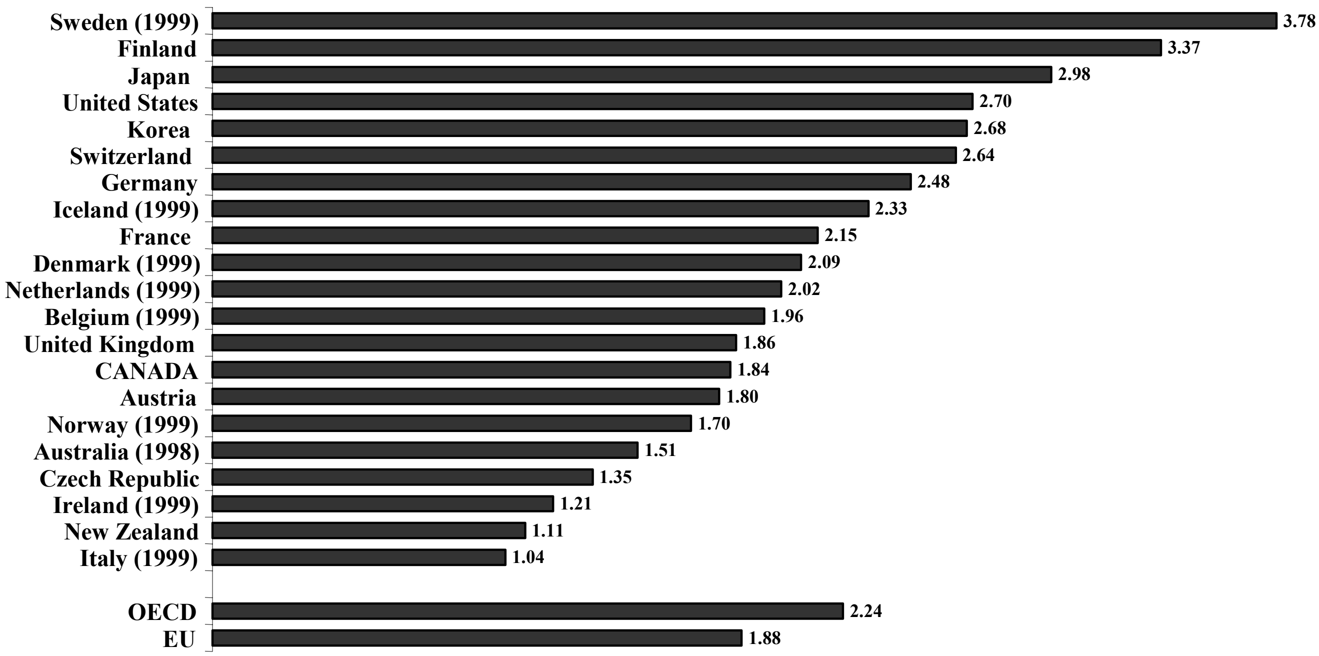
(39) OECD (2002), *Main Science and Technology Indicators*.

(40) OECD (2001), p. 16.

(41) OECD (2002), *Main Science and Technology Indicators*.

Figure 3: R&D Intensity (GERD as a Percentage of GDP) for OECD Countries (2000 *or* Latest Available Figures)



The effect of the current economic slowdown on global R&D expenditures is unclear at this time. Internationally comparable data are not yet available for 2001-2002, but available evidence suggests that overall R&D budgets remain strong. Some analysts have expressed concern, however, about industry's ability to maintain growing levels of R&D investment in an environment characterized by decreasing revenues and profits. If the economic recovery takes longer than expected, R&D expenditures could decline.(42)

The relatively high expenditures on R&D in the United States reflect, in part, the large amounts of funds dedicated to defence-related R&D. Following World War II and throughout the Cold War, spending on defence and national security dominated U.S. federal R&D expenditures. Although the defence R&D budget decreased steadily during the 1990s, it has increased over the past two years, and defence-related R&D spending represented more than half (52.1%) of the fiscal year 2002 R&D budget estimates (US$103.2 billion or approximately CAN$164 billion). The fiscal year 2003 budget provided an 18.4% boost to the Department of Defense's R&D budget, bringing it to US$58.8 billion (approximately CAN$93.5 billion), which

(42) OECD (2002), *OECD Science, Technology and Industry Outlook 2002*, p. 32.

is an all-time high.[43] Much of the defence-related increase has gone towards spending on counter-terrorism R&D following the terrorist attacks of September 2001.

Other big spenders on defence-related R&D (relative to their total R&D budgets) are the United Kingdom, France and Spain. Defence-related expenditures and procurement contribute little to R&D expenditures in Canada. In 1998, Canadian defence-related R&D spending represented only 5.6% of federal government expenditures for R&D (well below the OECD average of 30.3% in 1998).[44] Some analysts point to this small percentage to explain Canada's relatively low position on OECD R&D intensity scales. However, top performers in terms of the GERD/GDP indicator, such as Finland and Switzerland, both have lower expenditures on defence R&D as a proportion of total government budgets for R&D than does Canada.

B. Performers and Sources of Financing for R&D in OECD Countries

The most striking international trend in national R&D expenditures over the last two decades has been the decline in the proportion of GERD funded by government sources, and a corresponding increase in the proportion funded and performed by the business sector. In the OECD, business enterprise R&D now accounts for the majority of R&D activity, in terms of both performance and funding. In 1999, funding by the business sector amounted to more than 60% of domestic R&D expenditures in OECD countries, whereas funding from government sources accounted for only about 30% (see Figure 4).[45]

The role of the business sector in funding R&D does, however, differ markedly across countries and regions. About 72% of R&D in Japan and 67% of R&D in the United States is funded by the business sector, compared with 55% in the European Union. Government is still the major source of R&D funding in a third of all OECD countries. Between 1991 and 1999, the average rate of growth of business enterprise R&D[46] in the OECD was 2.97%. The average annual growth rate in Canada over that period (5.93%) was even higher. Despite this high rate of growth, Canada lags behind many other OECD countries in terms of business R&D intensity (expenditure by industry relative to its domestic product): Canada's business R&D intensity was at 1.26% in 1999, compared to the OECD average of 1.89%.[47]

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(43) American Association for the Advancement of Science, AAAS R&D Funding Update, "Still No End in Sight: Congress Postpones Appropriations, Record R&D Increases On Hold," 2002.

(44) OECD (2001), pp. 40-41.

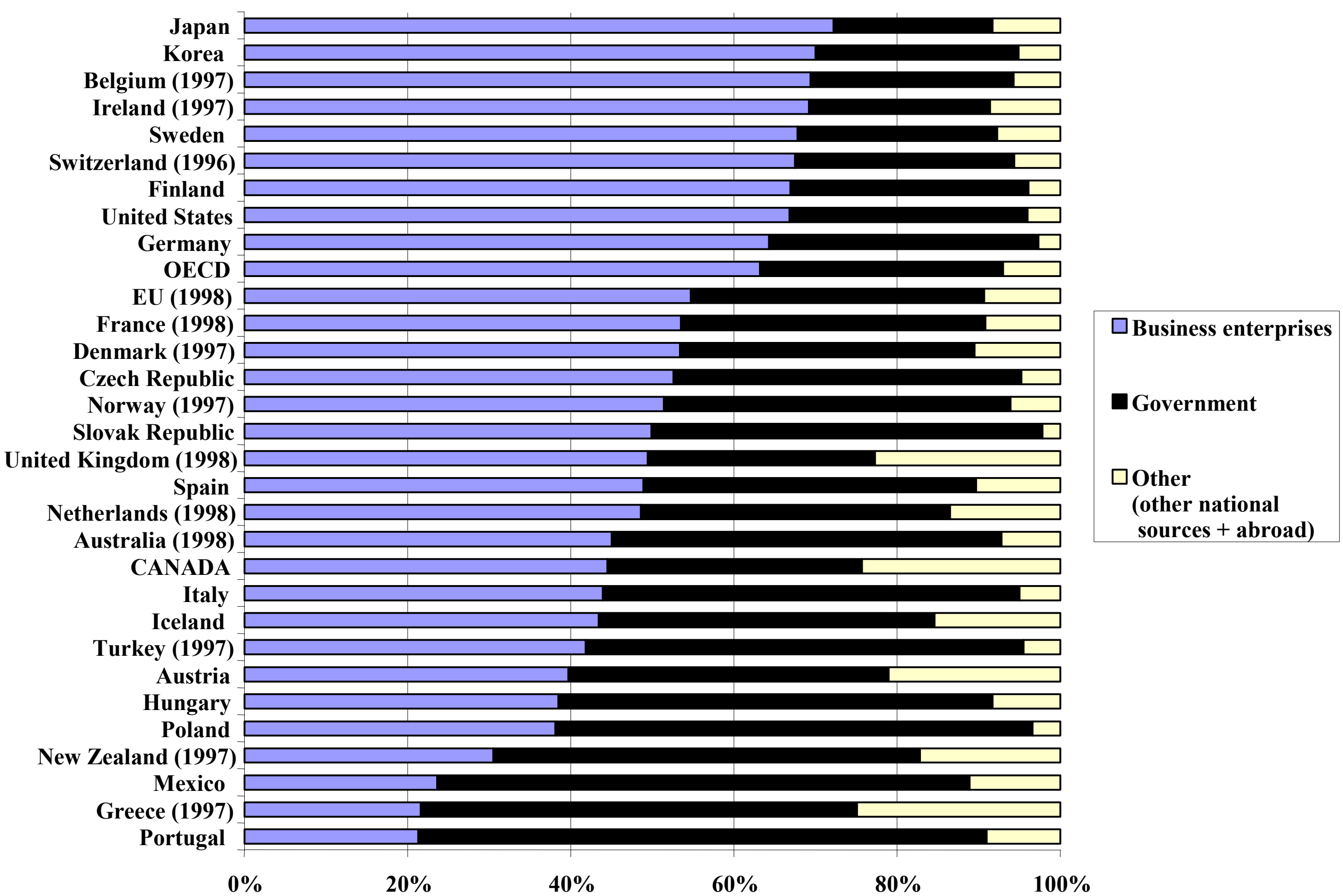
(45) OECD (2001), p. 19.

(46) Business enterprise R&D covers R&D activities carried out in the business sector by performing firms and institutes, regardless of the origin of funding.

(47) OECD (2001), p. 21.

Industrial R&D has become more global in nature. The proportion of R&D financed by foreign sources increased throughout the OECD area in the last decade and now stands at between 3% and 7% in most countries. In Austria, the reported share of R&D funding from abroad increased from 2.6% to 19.8% of GERD between 1993 and 2000, the highest level amongst R&D-intensive OECD nations. The lowest level of R&D funding from abroad is in Japan, where it represented only 0.4% of GERD in 2000. In Canada, 15.8% of GERD was financed by foreign sources in 2000, placing Canada behind only Greece, Austria and the United Kingdom in terms of this measure on OECD tables.(48) As part of its Innovation Strategy, the federal government is attempting to attract more foreign investment to Canada, which may lead to an even larger contribution to Canada's GERD by foreign-controlled firms.

Figure 4: R&D Expenditures by Source of Financing
Percentage Share in National Total, 1999



(48) OECD (2002), *Main Science and Technology Indicators*.

R&D conducted abroad is an important source of new knowledge and technologies for most countries, particularly smaller or developing economies. For example, Canada's innovation performance relies heavily on R&D conducted in the United States. Although an argument could be made for smaller economies to "free-ride" on R&D investments made abroad to increase their own productivity, evidence suggests that this is not an optimal strategy. The impact of foreign-produced knowledge on a country's productivity may depend on the capacity of the receptor country to absorb and make efficient use of that knowledge; countries that invest in their own R&D appear to benefit most from foreign R&D.(49) Furthermore, small countries can become innovation leaders in niche markets, which may result in increased productivity. Finland's success in the area of information and communications technologies is an example of such a phenomenon.

C. Recent Trends in Science and Innovation Policies in OECD Countries

The central governments of many OECD countries have established explicit S&T policies over the past few decades. In recent years, high-income OECD economies such as Austria, France, Italy and Japan have attempted to revise their policies to deal with such problems as: a science system that is insufficiently linked to the business sector; insufficient commercialization of public R&D; and inadequate diffusion of technology across the economy. Other, lower-income OECD countries are developing or improving policies to address problems related to low levels of R&D intensity, and the relatively low proportion of R&D financed and performed by the business sector. In general, changes made to S&T policy sets in recent years include the following: 1) renewed commitment to the public funding of scientific research; 2) major reforms to universities, especially regarding the commercialization of research; 3) increased funding to specific fields and sectors (e.g., biotechnology); 4) measures to support start-up firms (e.g., developing or strengthening venture capital markets and reforming regulatory structures); 5) increased emphasis on networking and collaboration, including the establishment of centres of excellence and the promotion of clusters; 6) measures to train more S&T researchers; and 7) expansion of international S&T co-operation.(50)

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(49) Dominique Guellec and Bruno van Pottelsberghe de la Potterie (2001).

(50) OECD (2002), *OECD Science, Technology and Industry Outlook 2002*, pp. 53-54.

Although governments continue to invest public funds in the traditional areas of health, defence, environment and basic research, there is an increasing tendency for governments to fund research in particular fields of S&T deemed to be of strategic importance (e.g., biotechnology and nanotechnology). The governments of some OECD countries and regions have had mechanisms in place for a number of years to set national or regional S&T priorities. For example, the rolling five-year Framework Programmes (FPs) of the European Union, which began in 1984, set objectives and priorities and provide financial support for European Union R&D activities. For FP5 (1998-2002), the approach became more strategic, with funding being directed to a smaller number of program areas with the goal of addressing key socio-economic problems (e.g., unemployment and health issues). The main focus of FP6 (2002-2006) is the creation of a European Research Area as a vision for the future of research in Europe. The FPs form the basis of the European Union's research and technological development policy.(51)

Other countries, such as the United States, have shied away from establishing formalized priority-setting mechanisms for allocating R&D funds, in part because of the potential or perceived problems associated with governments "picking winners." The U.S. government has pumped large amounts of funding into defence and medical research over the last few years (the National Institutes of Health will receive US$27 billion [approximately CAN$43 billion] in 2003, a doubling of its budget since 1998), but other areas of research have seen flat or declining funding levels. A number of commentators suggest that some research areas of present or potential national importance are not receiving appropriate consideration under the present system for allocating research funds. A recent study of the current system for priority setting in the U.S. federal research budget suggested that a strengthened process for research allocation decisions is needed. The study recommended that better data, analyses and expert advice be made available to Congress and the Executive branch to help inform decision-making for R&D priority-setting and budget allocation.(52) Even in the world's leading R&D-intensive nation, Sweden, efforts are being made to improve priority-setting mechanisms for R&D funding, and to allocate extra resources to a number of priority fields.(53)

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(51) For further details on the European Union's Framework Programmes, see: http://europa.eu.int/comm/research/faq.html.

(52) National Science Board, *Federal Research Resources: A Process for Setting Priorities*, October 2001.

(53) Swedish Research Institute, *Fact Sheets on Sweden: The Swedish Research System*, August 2001.

The central governments of a number of OECD countries (e.g., the United Kingdom, Australia and Canada) have recently developed, or are developing, specific policies that focus on improving their nations' innovation performance. In the United Kingdom, for example, a white paper[(54)] released in 2000 focused on three areas in which the government has a role to play in improving the United Kingdom's innovation performance: funding basic and strategic research (including investments in people and infrastructure); encouraging the exploitation of knowledge and new technologies by facilitating collaboration between business and academia; and ensuring that citizens have confidence in the new products that science can deliver. A second science and innovation white paper[(55)] released in 2001 focused on improvements that need to be made in the United Kingdom in five key areas: developing a more highly skilled workforce; building strong regions and communities; spreading the benefits of new research and technologies and developing new world-beating industries; ensuring markets operate effectively and fairly; and strengthening the country's position in European and global trade. *Canada's Innovation Strategy* is very similar in terms of priorities and focus to the United Kingdom's two innovation white papers.

At a multinational level, the European Union has recently indicated that it wants to increase innovation in Europe, and make Europe the world's leading knowledge economy. To help reach this goal, the European Commission recommended that under-investment in R&D in Europe relative to its major competitors must be addressed. In March 2002, the Barcelona European Council called for R&D investments in the European Union to be increased, with the aim of approaching 3% of GDP by 2010, up from 1.9% in 2000. The Council also called for an increase in the level of private-sector funding, from its current level of 56% to two-thirds of total R&D investment in the European Union. A series of policy measures to reinforce the attractiveness and profitability of R&D investment in the European Union have been proposed. Many of the measures relate to the framework conditions for conducting R&D (e.g., a sufficient supply of high-quality human resources, a strong public research base, an adequate intellectual property rights system and innovation-friendly competition rules), and to governments' financial support to business R&D in Europe.[(56)]

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(54) Department of Trade and Industry, *Excellence and Opportunity: A science and innovation policy for the 21st century*, Norwich, U.K., 2000.

(55) Department of Trade and Industry, *Opportunity for all in a world of change: A white paper on enterprise, skills and innovation*, 2001, http://www.dti.gov.uk/opportunityforall/pages/contents.html.

(56) Commission of the European Communities, *More Research for Europe: Towards 3% of GDP*, Brussels 2002.

Clearly, Canada is not alone on the world's stage in terms of its wish to boost investments in R&D and improve innovation performance. Federal government estimates suggest that Canada's GERD will need to equal 2.75% or even 3% of GDP for Canada to attain top-five status in terms of R&D intensity.(57) As such, Canadian R&D spending may need to triple between 1999 and 2010, placing Canada's GERD in the range of $50 billion annually. Increased spending on R&D by the business sector will be essential for reaching the federal government's national R&D investment target. Increased investments in R&D will have to proceed hand in hand with increases in the availability of highly skilled workers in order for these investments to be effective.

CONCLUSION

Total expenditures on R&D in Canada have increased over the past few decades as the importance of R&D and innovation to economic growth and improving the quality of life have become fully appreciated. The federal government has also formulated, or made revisions to, federal science and innovation policies over the last decade and set targets for national levels of investment in R&D.

The business sector has overtaken the federal government in terms of expenditures on R&D as a percentage of Canada's GDP over the past two decades, a pattern witnessed in most industrialized countries. Despite this change, federal government policy still acknowledges the important role that government has to play in funding R&D, especially in areas of basic research, and in providing an appropriate regulatory and competitive framework to encourage R&D investment by the private sector. Governments around the world recognize the essential role that the private sector plays in fulfilling national R&D investment targets and contributing to innovation. As such, most OECD countries, including Canada, have tax incentives and other policy instruments designed to boost investment in R&D by the business sector. The combination of federal and provincial R&D tax credits offered in Canada makes this country's R&D tax incentives package one of the most attractive in the world.

Although Canada is only a minor player in terms of global levels of R&D investment, and lags behind the United States (and other countries) in terms of investment in

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(57) Government of Canada, *Innovation Target Analysis*, 2002, http://www.innovationstrategy.gc.ca/cmb/innovation.nsf/TargetAnalysis/Target01.

R&D as a percentage of GDP, R&D activities are of vital importance to economic growth, global competitiveness, quality of life and advancement of knowledge in Canada. Canada only has to look at countries such as Sweden and Finland to witness how measures such as increased and strategic investments in R&D, partnerships among government, academia and industry, and strong government policies can contribute to improvements in all of the aforementioned areas, even in relatively small economies.

Since many OECD countries have set goals to improve investments in R&D and to move ahead on global research intensity scales, Canada will have to continually revise its policies and goals relative to R&D expenditures in order to advance internationally. Although the federal government has an important role to play as a facilitator and collaborator in improving Canada's R&D intensity and innovation performance, the full participation of the provinces, the academic community and, most importantly, the private sector is required to reach this goal. The federal government's objective of moving into fifth place globally in terms of research intensity is an extremely ambitious goal requiring foresight, commitment and investment from all stakeholders if it is to be achieved.