THE CHANGING ROLE OF GOVERNMENT LABS IN SCIENCE AND TECHNOLOGY POLICY

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Abstract
This paper discusses the role of government and government labs in the innovation system by looking at the content and context in which this role changed in industrialized countries in the past 40 years. The paper concludes that even though we observe a decreasing trend in the share of government performed R&D in all industrial countries, there is still a substantial role for government labs to play. Also, better measurement mechanisms should be designed to evaluate the effectiveness of science and technology (S&T) in government and higher education as main public S&T institutions.

Keywords: Science and Technology; Government Policy; Government Labs; Canada
JEL classification: O32, O38

1. Introduction

There are several justifications for government support of science and technology (S&T) activities. First, governments are responsible for providing and enhancing scientific knowledge and technology for public sector functions (security, health, and communications). S&T for these tasks may be performed in public research laboratories or contracted out to private firms. The second justification is market failure in S&T and under-investment in innovation activities in the private sector. The rationale for this type of support is that due to the difficulty of firms in fully appropriating all economic benefits of S&T, private firms invest less in innovation than the socially optimal level. Government instruments to expand S&T activity in the private sector may include indirect tools such as R&D tax credits; direct tools such as grants and contributions, procurements, and contracts; and government direct involvement in S&T through government labs. The latter is the subject of this paper.

This paper discusses the changing role of government and government labs in the innovation system, and looks at the content and context in which the role of government labs changed in industrialized countries in the past 40 years. For this purpose, the S&T roles of the private sector, higher education, and government in the past and in the present will be compared. Most of the discussion will be in the Canadian context. As part of the discussion, the role of government in performing S&T in the present day will be also explored. Moreover, as an example of government labs, the functions and impacts of the National Research Council Canada (NRC) will be presented to show the potential impacts of a research-oriented government lab on innovation and economic growth in Canada. The paper concludes that even though we observe a decreasing trend in the share of government performed R&D in all industrial countries, there is still a substantial role for government labs to play. Also, better measurement mechanisms should be designed to evaluate the effectiveness of S&T in government and higher education as main public S&T institutions.

The structure of the paper is as follows. The next Section reviews the role of government in the innovation system over the past 40 years. The objective of this section is to identify the trends of the main S&T players. Section 3 takes this review deeper by highlighting the rationale behind a smaller

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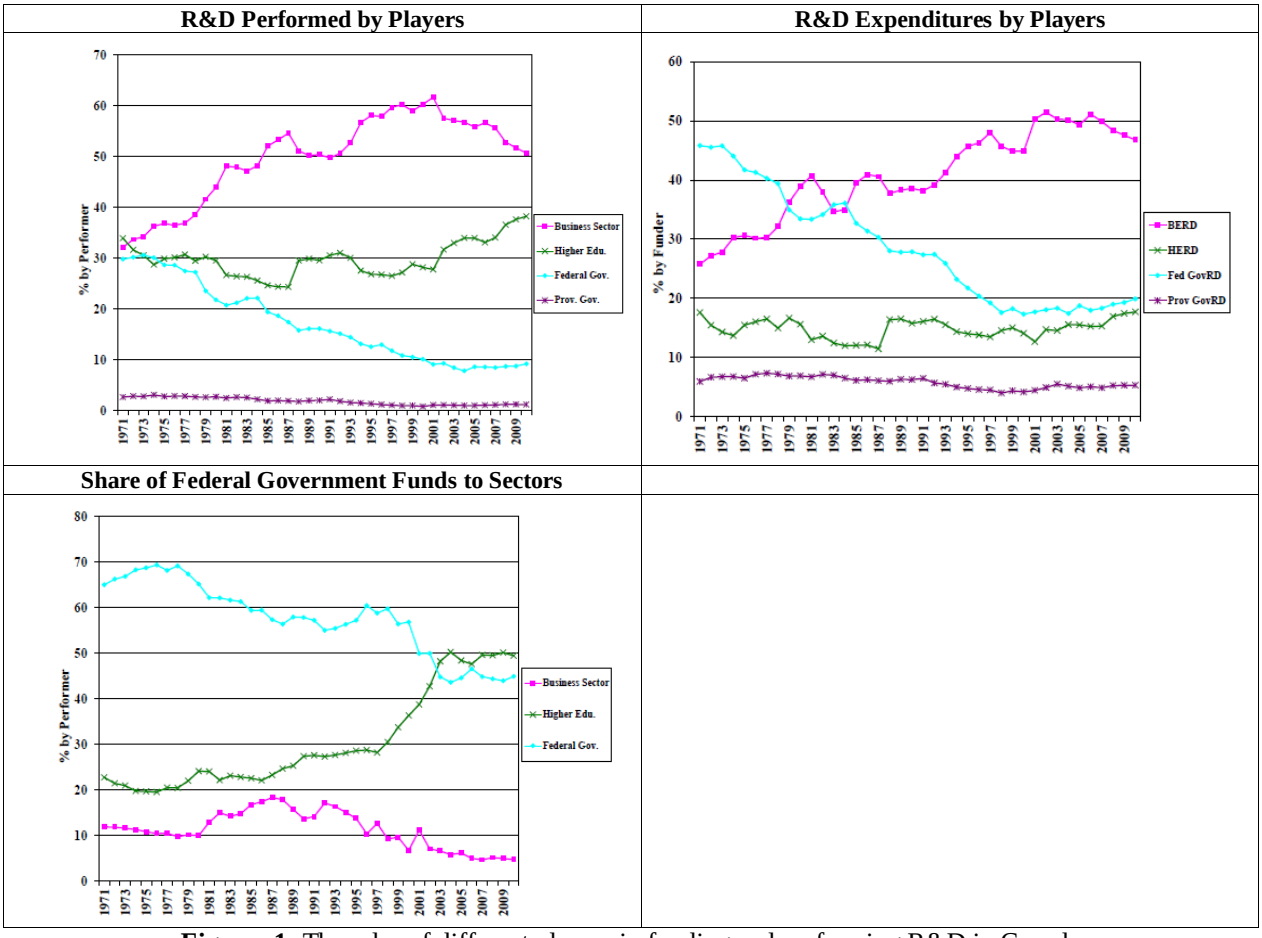
role for government labs in innovation in the present system. Section 4 discusses the potential roles of government labs in the present day. Section 5 presents NRC as the Government of Canada's largest S&T institute. This section also presents some of the findings of the studies that have assessed the economic impact of NRC on the Canadian economy. This assessment is particularly important since to the best of my knowledge, it is one of few empirical assessments of government labs in Canada. Section 6 concludes and discusses the findings.

2. The Role of Federal Government S&T

According to endogenous growth models, the main drivers of economic growth are investment in machinery and equipment, increase in labour force, and increase in productivity. However, by looking at the economic growth of developed countries in recent decades, it becomes clear that the productivity growth accounts for the larger part of economic growth in these countries. Higher productivity means improvements in labour and capital, as well as more efficient use of these two factors. The main contributor to productivity growth is the development of new methods of production through technology growth and innovation. This could happen through increasing the stock of general knowledge either by performing S&T domestically or by importing it through interaction with other countries. This section presents domestic S&T players with an emphasis on the role of government S&T.



Figures 1- The roles of different players in funding and performing R&D in Canada *(1971-2009)*
Source: Statistics Canada (CANSIM, Table 358-00011)

There are three main categories of S&T investors and performers in a country: the business sector, institutions of higher education (universities and colleges), and governments (federal, provincial, territorial, and local). The strength of a country's innovation system depends on the complementary strengths of these three key sectors and the alignment among them. The general

perception of these players is that the business sector is focused on applied and commercial S&T, universities are mostly involved in fundamental research, and governments support national research missions in areas such as defence, energy, space, and regulations, which are mainly of a "public good" nature (Crow and Bozeman; 1998 [3]; Doern and Kinder, 2002 [5]).

Economic theory suggests that the most important role of governments to support S&T is to ensure a competitive marketplace and to create an environment for the private sector to compete domestically and internationally (e.g. Government of Canada, 2007 [7]). There are also other reasons for governments to engage in S&T activities more actively: the main being the existence of market failure in S&T due to the difference between the private and social rates of returns to S&T activities. The second reason is to provide public goods to citizens. This category includes food safety, health, environment, defence, and so forth. Governments may carry out these tasks by using direct and indirect instruments (e.g. grants and tax credits) or by engaging directly in S&T activity in government labs. In what follows, the roles of government and other players in funding and performing S&T activities over the past four decades will be presented.

Figure 1 presents funding and performing of R&D by investor type for Canada from 1971 to 2009. Over the past 40 years, the federal government's share in funding R&D decreased significantly from 45% in 1971, to less than 20% in 2010. On the other hand, the share of the business sector increased from 25% to around 50% over the same period. The shares of higher education and provincial governments in funding R&D remained relatively constant at about 16% and 6%, respectively. Also, while all major players (business sector, higher education, and federal government) had an equal share in performing R&D in 1971, the share of the business sector and higher education has increased significantly since then. Other observations from Figure 1 are that provincial governments perform only around 2% of total R&D, and that most of the federal government funds go to the higher education.

Figure 2 suggests that the same trend is observed in all OECD countries: the share of government performed R&D significantly decreased in all developed countries over the past three decades. However, the decrease in the share of government performed R&D was more significant in Canada: while Canada had one of the highest shares of government performed R&D in 1981, this share became one the lowest by 2009.

OECD (2010) [15] also confirms this trend by using a similar measure: Canada's in-house government R&D as a share of GDP fell slightly to 0.188 percent in 2008 from 0.195 percent in 2006 so that the gap between Canada and other G7 countries continued to widen (Science, Technology and Innovation Council, 2011 [16]). The most significant decrease in terms of government performed R&D occurred in Australia. Moreover, Figure 2 shows that Canada has the highest share of R&D performed by the higher education sector among industrialized countries. At the same time, its share of business performed R&D is one of the lowest among the OECD countries.

These graphs suggest that while all countries shifted their government R&D resources to the business sector and higher education, Canada's emphasis was more on higher education as an engine of growth compared to other countries. The rationale behind this shift will be discussed in the next two sections.

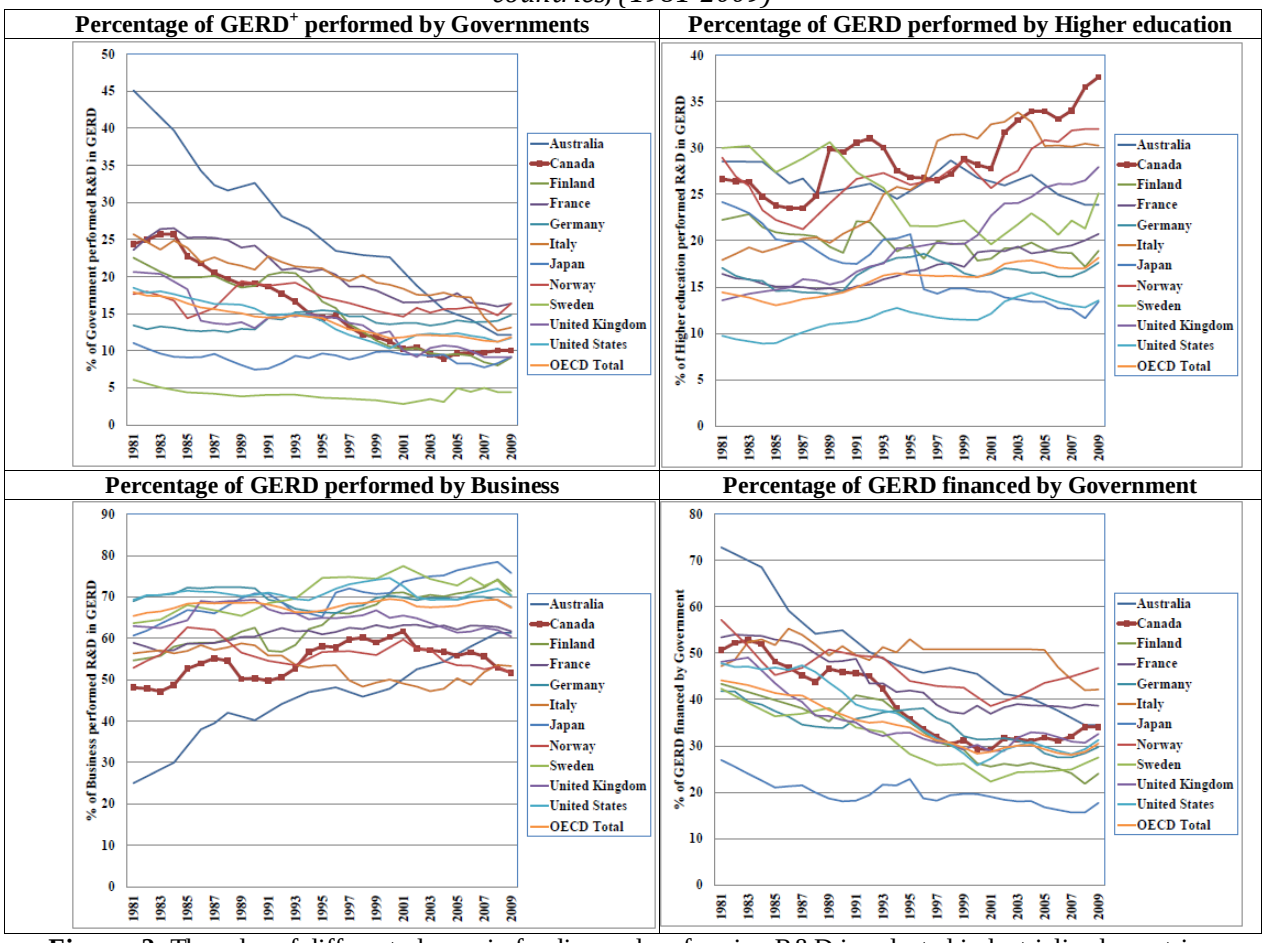
3. The Changing Place of Government in the Innovation System

As discussed in the previous Section, a decreasing trend in the role of government S&T programs in Canada and other industrialized countries is observed in the past four decades. This section discusses the reasons behind this change. Two periods may be considered for the purpose of this study: until the post-World War II period and after. Until the post-World War II, the federal government played a central role in the development and financing of S&T activity in Canada (a situation typical of many countries at the time) due to the following reasons (Council of Science and Technology Advisors, 1999 [2]):

- **In this earlier period, the federal government created the required S&T capacity in order to respond to specific national needs;**
- **Research projects in federal labs were coveted and were a key component of many scientific career paths;**

- **Government possessed almost all of the country's S&T facilities, infrastructure and expertise; and,**
- **Linkages between the various players in the innovation system (university-industry-government) were weak.**

Figures 2- The roles of different players in funding and performing R&D in selected industrialized countries, (1981-2009)



Figures 2- The roles of different players in funding and performing R&D in selected industrialized countries, (1981-2009)

Source: OECD (2010a)

+ GERD: Gross Domestic Expenditures on R&D

However, this picture changed significantly due to government S&T policies since the 1970s:

- **Government began to invest heavily in S&T capacity in universities;**
- **Government made extensive efforts to support R&D in industry by offering tax incentives, doing collaborative research projects, and, in a few cases, assisting in the establishment of privately-owned research facilities.**

As a result of government policies, Canada's universities have become highly research intensive, and Canada's industrial R&D is world-class in many fields. S&T linkages among government, universities and the private sector also improved significantly (Treasury Board Secretariat, 2008 [17]). Because of these changes, the Canadian innovation system is no longer dominated by the federal government. In other words, the growing strength of S&T in Canadian universities, industry and non-profit research institutes means that there are more S&T skills, knowledge and capabilities available from outside government than in the past, and the vast majority of relevant research will be undertaken outside of federal labs. This change in the relative strength of S&T players put pressure on government to change its S&T role. Meanwhile, other

factors can also be mentioned for this trend. For example, globalization had an important role in this change. A key characteristic of globalization is the integration of domestic and foreign markets. The implication of this process is that policy decisions must be backed up with world-class science and technology. Another factor was the increased public expectations from governments in the areas of health and safety, environmental issues, security, economic and social well-being. These issues have raised public expectations about what governments can and should be doing, as well as a level of excellence in both science and decision-making (Dufour and de la Mothe, 2001 [6]).

The pace of technological change and the rate of advancement in knowledge was another factor that affected government involvement is S&T. As Dufour and de la Mothe (2001) [6] emphasize, "New products and technologies often require new types of regulatory responses or new needs for regulatory science. Governments need to be able to keep pace with these developments to ensure the safety of their citizens and the environment, and to ensure that commercial development is not adversely affected by government delays in product/process approvals. In some rapidly advancing, technology-intensive fields, government scientists need a level of expertise that often requires hands-on, continuing experience in leading-edge research to understand the results they are required to assess". Finally, part of the decrease in the role of governments in innovation is due to the concept of the New Public Management (NPM). Under NPM, countries such as the United Kingdom, Australia, and New Zealand have changed their governance (including S&T) structure quite extensively; though, the Canadian federal government adopted a relatively moderate approach in implementing NPM (Doern and Kinder, 2002 [5]). In any case, governments around the world were under pressure to reduce government spending and to ensure top value for that spending. As a result, there is more stress on demonstrating clear needs for federal investments in S&T today. Finally, there are also questions about the efficiency and effectiveness of government labs in performing S&T activities. For example, the following concerns have been raised about the efficiency of government labs (Dufour and de la Mothe, 2001 [6]):

- **Government labs are not always the best way to foster the commercialization of technologies;**
- **It is difficult to introduce competition in government labs to obtain better results;**
- **The performance incentives within federal labs are weak because they are neither salary-based (as in the private sector) nor publication based (as in the universities);**
- **Public intervention has benefits as well as costs. All government programs, including government labs, generate costs of administration and compliance. Just as there are market failures, there may also be "government failures" (Government of Canada, 2011 [8]);**
- **It is generally believed that the private sector and universities are more efficient than government in performing S&T.**

The result was that for most countries government labs were required to either be transferred to universities or satisfy the needs of the private sector. Some implications of this new vision were to look for full value for money, put intramural R&D activities to a market test, transfer of technology, and develop accountability and performance measures to assess and make full use of the in-house research capacity (Dufour and de la Mothe, 2001 [6]).

Different governments took different approaches in dealing with these challenges based on their political systems and the historical development of their S&T systems (Council of Science and Technology Advisors, 1999 [2]). For example, France's central government still performs a substantive amount of S&T either internally or through private sector contractors. In most cases, the reason for government direct involvement is the riskiness of the long-term project where the economic outcomes cannot be assessed before-hand, and there is a need for public involvement, not only as a funder, but also as an initiator and a first user (Laredo, 2001 [11]). This is in contrast with, for example, the United States that has a strong private sector orientation.

An interesting example is the United Kingdom. Until the election of Mrs. Thatcher's Conservative government in 1979, it was assumed that it was the government's responsibility to procure S&T assistance for both the public administration and the public good, and that this should be supplied mainly through publicly funded or owned research organizations. However, the introduction

of NPM changed this concept by forcing government to reduce the size of the public sector. S&T functions were then seen as clear targets for reforms. Yet, despite many reviews of S&T status in the United Kingdom, the majority of publicly-funded S&T organizations still remained in the public sector domain (Boden et at., 2001 [1]).

Australia had a more radical change in transferring its S&T facilities to universities and the business sector as illustrated in Figure 2. The Australian government established the Advisory Council of Science and Industry in 1916 as the first step towards a "national laboratory". This resulted in the establishment of the Council for Scientific and Industrial Research (CSIR) in 1926 to carry out scientific research to assist primary and secondary industries in Australia. CSIR was renamed to the Commonwealth Scientific and Industrial Research Organization (CSIRO) in 1949, and since then, expanded its activities to almost every industry. CSIRO was a main player in S&T development policy of Australia in the 1980s and 1990s (Martin, 1995 [12]). However, similar to other industrialized countries, the situation changed in Australia in the past decades with a reduction of the share of government labs in S&T spending and a greater emphasis on the business sector and universities as engines of innovation. Though, a study on the commercialization of research in Australian universities in recent years shows that, despite improvements in this area in universities, there are still significant difficulties in transferring innovations from Australian universities to industries (Zhao, 2004 [18]).

With respect to the Canadian government, reviewing the S&T recommendations of different advisory councils in the past 50 years shows that there has been a consistent tendency to recommend that government labs perform more like private sector entities, or that their roles be taken over by contractors or third part institutes such as universities. Also, reviewing these reports suggests that the importance of government labs for economic growth received more attention than the role of government labs for public good. Doern and Kinder (2002) [5] have done a comprehensive review of S&T recommendations to Canadian governments in the past and pointed out some of the challenges.

Despite these trends in reducing the role of government S&T, according to the Council of Science and Technology Advisors (1999) [2], almost all governments of the OECD countries have some in-house R&D capability, even a highly private-sector-oriented government such as the United States. In smaller countries, this capability is a relatively important element of the overall national R&D system; in larger countries, in-house R&D is relatively less important.

4. What Are the Roles of Government Labs?

Despite the changes in the scope of government S&T activities, there is still a considerable role for government performed S&T. This section discusses the core tasks of government labs that cannot be taken over by university labs or industry because of their essential "public good" nature (The Council of Science and Technology Advisors, 1999 [2]; Dufour and de la Mothe, 2001 [6]; Doern and Kinder, 2002 [5]; Government of Canada, 2007 [7]). These tasks include:

- **specific S&T tasks that some departments are required to carry out by legislation;**
- **specific requirements for S&T in support of policy formulation and government decision making that, in many instances, cannot be conducted at arms' length by third parties because of the complexity of the issue, security, etc., or when a rapid response is required. Also, contracting out all of these responsibilities to academic or private sector would not only create a government contract monitoring and management problem, but could also lead to breaches of security and a lost assurance to government;**
- **in selected fields, an in-house S&T capability is an essential element for government to maintain the credibility it requires to be an effective regulator and a negotiator in national and international agreements;**
- **to undertake testing and approval in areas related to drugs, bio-medical devices, vaccines, blood products, etc, which require government involvement as well as research capability and scientific assessments in order to evaluate and verify outside results for the protection of citizens. The same is true for regulatory control of food and consumer product safety, environment, defence, etc., as well as to support emergency preparedness dealing with issues such as earthquakes, floods, and so forth.**
- **to establish and negotiate standards in order to harmonize domestic and international**

- **regimes to protect citizens and provide a favourable business climate;**
- **the need for confidentiality in working with third parties, with government scientists acting as an "honest broker" in bringing together partners that would normally be competing;**
- **the need to maintain long-term data collection and analysis programs that, otherwise, would not be done by the private or university sector;**
- **to provide technical assistance to small and medium sized businesses (SMEs) which are working in a technology-intensive area and which do not have the needed in-house expertise or equipment. No firm or university could easily provide this service due to the lack of expertise, experience, and/or conflict of interest;**
- **to conduct basic research, not because government researchers are expected to contribute to the stock of capital knowledge, but because basic research will support government researchers to be involved in the latest developments, findings, and techniques so that they can be called upon as required in support of government decisions. This makes a difference between the role of government scientists and that of university/industry scientists (Dufour and de la Mothe, 2001 [6]). Support for science policy often involves providing timely information to government decision makers about what to do on a particular issue.**

Although, it is important to note that the federal government needs to have a degree of scientific and/or technological capacity to be able to exercise the option of outsourcing the research and assessing the quality of the results. The government department or agency should have a clear understanding of its needs for the specific scientific or technology research and/or development.

5. Federal Government Labs

Figure 3 presents the main federal departments and agencies that undertake S&T in Canada and the share of each of total budget in 2007-08 fiscal year. These departments undertake S&T to provide public good, support economic development objectives, and perform basic research. The National Research Council of Canada (NRC) as the Government of Canada's premier research institute will be described in more detail in this section.

Federal involvement in industrial S&T began with the establishment of NRC in 1916. NRC is Canada's premier S&T organization. Its establishment was influenced in part by the wartime debate in Britain and Australia on the creation of similar research bodies (Dufour and de la Mothe, 2001 [6]). Its first lab, in 1932, was designed to promote industrial development through R&D. Its labs' efforts underwent more change after World War II when it spun off several new entities. NRC is now comprised of more than 20 institutes and national programs, spanning a wide variety of disciplines and offering a broad array of services. The institutes and programs are organized into five key areas[2]:

- **Life Sciences,**
- **Physical Sciences,**
- **Engineering,**
- **Technology and Industry Support,**
- **Corporate Management.**

At the end of the first quarter in fiscal year 2010-11, NRC's total planned spending authorities were $888 million. NRC accounts for roughly thirty percent of intramural federal government R&D. It is important to note that there was already a noticeable movement at NRC in the 1980s towards greater business representation and away from academic representation, so that at the start of the 1990s, NRC was already a business oriented council (Doern, 2000 [4]). The most recent Government of Canada's S&T report, *Innovation Canada: A Call to Action - Review of Federal Support to Research and*

[2] http://www.nrc-cnrc.gc.ca/eng/about/corporate-overview.html. A complete list of NRC institutes and programs is available at http://www.nrc-cnrc.gc.ca/eng/ibp/index.html.

Development (2011), recommends that NRC become even more industry-oriented, and that most of its research labs be transferred to universities (Government of Canada, 2011 [8]).

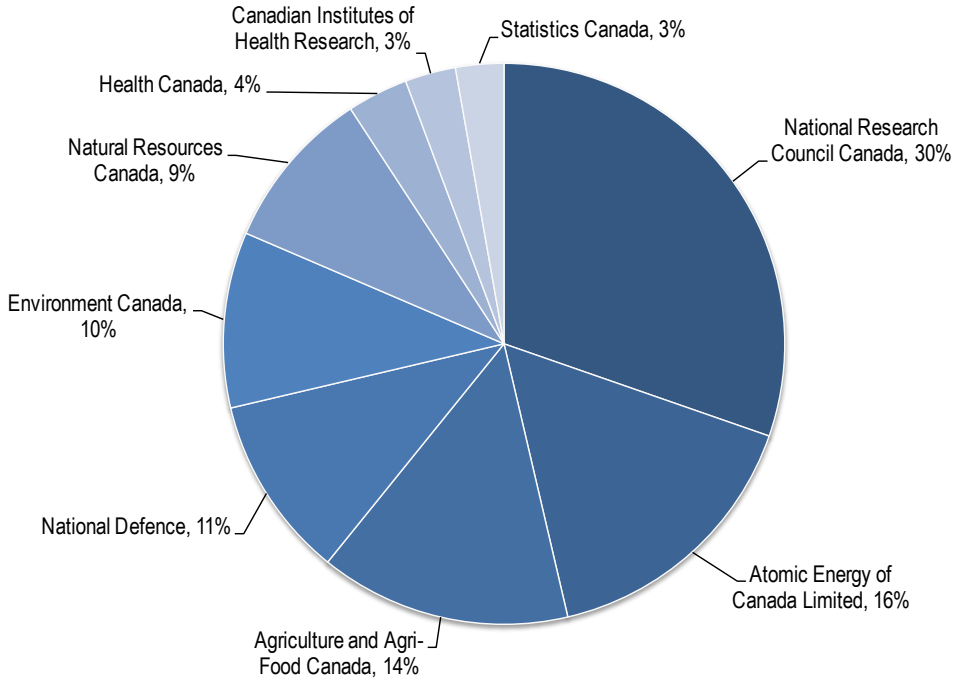


Figure 3- Canadian Federal R&D Spending by Government Department and Agency (2007-08)

Source: Statistics Canada, Federal Scientific Activities

It is worth noting that NRC is one of few government departments that tried to assess its socio-economic impacts quantitatively at the national level: in an effort to provide quantitative evidence of the impacts and return on investment to taxpayers of their activities, NRC has developed several methods to empirically measure the impacts related to its S&T activities on various levels of the Canadian economy (Kijek, et al. (*forthcoming*); Nikzad et al. [10], 2012a [13] and 2012b [14]). These measures assess the impact of:

- **NRC labs on Canada's total factor productivity (TFP);**
- **NRC expenditures on business R&D;**
- **NRC expenditures on GDP;**
- **NRC services and the Industrial Research Assistance Program (NRC-IRAP) on companies (NRC clients).**

These studies show that NRC activities have a considerable positive impact on the Canadian economy. Based on these studies, NRC was found to have had a positive and (statistically) significant impact on Canadian productivity so that the total value of NRC's impact on Canadian productivity is estimated at approximately $1.2 billion annually in terms of increased GDP growth. NRC's expenditures results ultimately in increased Canadian Business Expenditures on R&D (BERD) with an estimated $1.69 increase in BERD for every dollar spent on NRC S&T activities. Also, using data on both NRC client and non-client company data, NRC has a positive and (statistically) significant impact on private sector clients' sales, high skilled R&D employment, total employment and exports. In terms of increased employment, NRC creates between 8,000 and 10,000 direct private sector jobs annually, of which 3,500 and 4,500 are direct high skilled, "high-value", private sector R&D jobs.

It is worth mentioning that these studies look only at the monetary values of the impacts, while other potential impacts such as health, environment, safety, and like are missing in the study because of the difficulty in estimating these impacts. Our understanding of NRC and other government S&T programs will be improved if we can also include measures of "non-market"

impacts of government's S&T.

6. Conclusion and discussion

This paper reviewed the S&T role of government labs in Canada and other industrialized countries in the past 40 years. A decreasing trend of government S&T and an increasing share of the private sector and universities in S&T are observed in all industrialized countries. However, statistics show that this move was more significant in Canada: while Canada had one of the highest shares of government performed R&D in 1981, this share became one of the lowest by 2009. Also, the same statistics show that Canada has the highest share of R&D performed by the higher education sector among industrialized countries. At the same time, its share of business performed R&D is one of the lowest among the OECD countries. Considering that S&T and innovation performance of Canada is lagging behind many developed countries [8,16], a question may be raised as to which instruments should be used to spur innovation. Noticeably, the same trend is observed in the current and forthcoming innovation policies of the federal government.

Another question that arises is how successful different S&T players perform in term of spurring innovation, producing and transferring new technologies, and increasing economic growth. One consideration about the S&T policy in Canada is that while we have an understanding of government S&T impacts (for example NRC labs as mentioned in Section 5), we know very little about the impact of university S&T on innovation in Canada despite the fact that they are currently the instrument of choice among policy makers. Assessing the impact of universities and government labs on innovation and economic growth will help the transition of government labs to other sectors.

To conclude, even though government labs are not the main players in S&T anymore, there is still significant role for them to play. The S&T performed by government, universities and industry each responds to different needs and time frames, and often require different skills and a different research culture. This means that in many cases, S&T from one of these sectors cannot be substituted for any of the others. Because of these differences, different performance criteria and standards are also necessary (Boden et at., 2001 [1]). Examples of further work in this area includes self-assessment and peer reviewed publications that are used by many US Government labs (Jordan, 2001 [9]). Also, according to Boden, et al. (2001) [1] the concept of commercialization needs to be redefined so that it accommodates "the primary function of public sector research establishments – that of benefit to the nation rather than simply additional revenue for government". Regarding this, the following actions are suggested to better design policies around government labs:

a. To design better measures to assess the performance of government labs, universities, and the private sector in terms of S&T policies. This helps better assess the impact of different policies in terms of S&T outcomes, and is a prerequisite for evidence-based policies;

b. Frame the principal roles of government labs in the present day. This will help change the structure of government labs more efficiently.

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