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Canada's R&D Deficit — And How To Fix It

Removing the Roadblocks

Richard Harris

In this issue...
Canada's research-and-development spending is currently stuck in the mid-range of the world's industrialized nations. Achieving the federal government's ambitious target for raising R&D spending in this decade will require a concentrated effort in both the public and private sectors. And while there are roadblocks in the way of progress, there are also measures, including fiscal reforms, that would help Ottawa achieve its goal.

The Study in Brief

Increasing the rate of productivity growth is the key to raising living standards — and innovation drives productivity improvements. Most national and sub-national governments have developed some policy frameworks to encourage innovation. Internationally, there has been a remarkable convergence of opinion on the importance of research and development (R&D), though there is still considerable diversity over the best policies for encouraging it. This Commentary re-examines the interaction between productivity growth and innovation and Canadian government policy in the field. The paper's major conclusions are that R&D performance in Canada has been weak, in part because of structural factors related to Canada's large natural resource base and the agglomeration of manufacturing in the centre of the country. Significant improvements to the innovation environment, particularly those which generate new private sector jobs and enterprises, are only likely to emerge if governments provide stronger incentives for business investment. The paper also argues that existing federal and provincial resources aimed at supporting business sector R&D should be more focused than those provided by the existing R&D tax credit system. As well, it looks at the spillover effects of innovation improvements in the United States on Canadian undertakings and concludes that they are significant. It notes, however, that the spillover from U.S. defence R&D is likely to be severely limited as long as Ottawa maintains a policy of withholding active support for Washington's military initiatives.

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> One of the many pledges that Paul Martin made before becoming Prime Minister was a commitment to advance the innovation agenda in Canada: "Canada must build a 21st century economy; an economy driven, above all, by individual ingenuity and creativity."[1]

There still has been little in the way of specifics out of Ottawa on the innovation agenda. For the most part, the recent policy focus has been on the health care issue. However, the ability of the country to deliver in the area of social policy presumes that economic growth will continue at rates equal to, or better than, those of the recent past. There is certainly ample evidence that the Prime Minister cares about Canadian innovation performance. In his days as prime minister-in-waiting, he made a highly publicized speech to the Montreal Board of Trade and was quite explicit on the issue. In the speech, he defined the New Economy as "the parts of our economy that are based on the potential of transformative technologies, which are going to be the real economic engines of the years to come."

Most provincial governments have issued similar statements detailing, if not policy commitments, the reasons why innovation is important for provincial growth.[2]

The purpose of this paper is twofold. First, I will briefly review the debate on Canada's own innovation performance, particularly with respect to private sector research and development (R&D). Second, I will draw attention to what are likely to prove to be difficult barriers that the government will have to overcome if the goals of business-led innovation are to be achieved. These include the relative openness and small scale of the Canadian market relative to the U.S.; the historically weak R&D record of the western provinces; the forces of agglomeration acting upon private sector R&D-intensive activities within North America; the state of Canada-U.S. economic integration, which has not been extended to include the U.S. innovation system, and Canada's chronic underperformance on investment. The policy conclusions are relatively modest and stress the importance of open markets, the North American integration agenda, — even in the face of the currently fragile bilateral relationship — internationally competitive levels of taxation, and greater cooperation among federal and provincial governments in support of R&D.

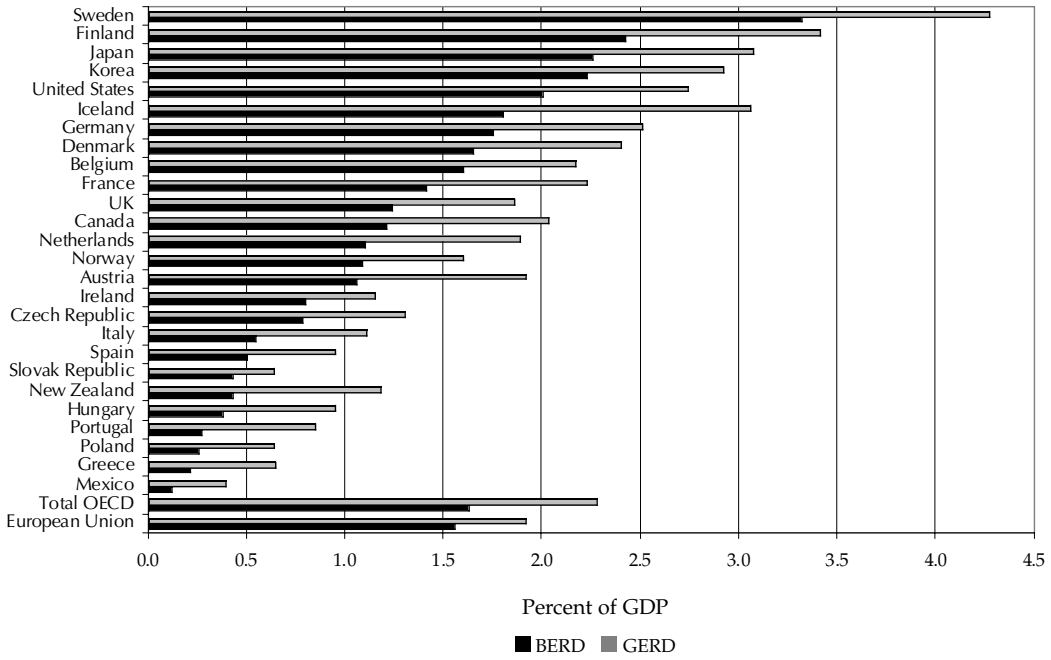
Canada's Lagging R&D Performance — How Important Is it?

Despite the convergence of policy opinion within the Organization for Economic Cooperation and Development (OECD), there remains a fairly substantial variation in R&D outcomes. Figure 1 depicts the ratio of gross expenditures on R&D as a percentage of Gross Domestic Product (GDP) across a range of countries in the last year for which comparable data were available. The figure shows both

1 *Building the 21st Century Economy*, address at the Board of Trade of Metropolitan Montreal, September 18, 2003.

2 A good example is the Alberta Innovation and Science web site at www.innovation.gov.ab.ca and the document *Innovation and Science, Business Plan 2003-2006* available at the web site.

Figure 1: *BERD vs GERD, 2001*



total R&D spending and business-only R&D spending. In 2001, Canada was below the OECD averages on both R&D spending measures, though not by a wide margin. Canada had gross domestic expenditures on research and development (GERD) of 2.03 percent of GDP versus the OECD average of 2.28. Relative to other highly developed countries, however, Canada's GERD ratio is, and has been for some time, at the low end of the rankings — especially in relation to the U.S., at 2.74 in 2001 — as well as such countries as Sweden, Finland, Japan and Germany.

Canada not only has low absolute R&D intensity (R&D intensity is usually defined as the ratio of a company's expenditure on R&D to its sales), it also has a relatively low share of R&D carried out by business — about 60 percent of R&D expenditures in Canada are business financed, known as business expenditures on R&D (BERD), compared to an OECD average of just over 70 percent. Other indicators provide a similar picture. While Canada traditionally shows good growth in international patents filed, it is still well behind a number of other relatively small countries, such as Israel and Finland. Looking at R&D personnel as a share of employment, Canada is about average at a little over 1 percent, but behind leading countries in R&D, such as Sweden (2.28 percent), Finland (1.66 percent) and Japan (1.35 percent).

These statistics have led over the years to numerous calls for measures to improve the nation's performance. Most recently, there have been some attempts by governments to formulate these as specific policy goals. In the Throne Speech of 2003, then-Prime Minister Jean Chrétien stated a commitment to bring Canada within the top five OECD economies as measured by per capita spending on R&D. Moving from the current standing to fifth by the end of the decade will represent a formidable challenge for the government. Adding to the barriers to achieving this goal is the fact that a number of smaller industrial countries, including most of the Nordic states, have soared in R&D spending in the past decade. According to the

Conference Board of Canada's *Second Annual Innovation Report* released in 2000, just improving the Canadian R&D intensity ratio to that of the OECD average would require an investment of about $6 billion in current dollars, with roughly half the increase coming from business and half from government. To actually make the jump to fifth would require Canada to raise its R&D intensity to the level of the number-five country in 2001, the United States, which had an intensity of 2.74.

Growth performance and rankings are a different matter. A striking fact in the recent economic history of industrial-country growth is the remarkable performance of the U.S. economy in the 1990s, relative to the European and Japanese economies. This has led most other countries to re-examine their own lagging growth records and to question whether their levels of R&D were contributing causes of their weaker performances. Canada has done quite well among medium-size OECD countries, with good overall growth performance as measured by total GDP. For example, between the second quarters of 1992 and 2003, Australia's economy grew by 50 percent, Canada's by 44 percent, the United States' by 41 percent and Britain's by 36 percent. Over the same period, the French economy grew by just 22 percent; the euro zone's by 21 percent; Italy's by 17 percent; Japan's by 15 percent, and Germany's by 14 percent.

The OECD, in a recent review of industrial country growth, points to this divergence and notes that providing a comprehensive explanation has eluded researchers. It has resulted, however, in greater attention to innovation as a possible cause. In Canada, a major concern has been the sustained Canada-U.S. gap in living standards; the implications of a weak innovation performance are central to this broader debate. Moreover, the fact that after the recession in 2001, the U.S. productivity acceleration did not slacken despite weak employment growth, has only increased Canadian insecurity over falling behind the U.S. in living standards.[3]

Innovation, while obviously important for a number of political and social reasons, is of national economic importance first and foremost because of the widespread conviction that increased innovation leads to increased rates of productivity and economic growth. As noted, growth in Canada has actually been relatively good in comparison to a number of other industrial countries, in spite of its relatively weak innovation performance. But in terms of productivity growth, a lot remains to be achieved. The appeal of gaining greater growth through technology policy is not unique to Canada. For example, at the March 2002 meeting of the European Council in Barcelona, European ministers announced a goal of "[T]urning the EU into the most competitive knowledge-based economy in the world". One identified objective for achieving this status was raising spending on R&D and innovation in the EU to about 3 percent of GDP from its current level of 1.9 percent by 2010.

While it is far from clear that Europe's poor growth performance is related to R&D spending, it remains a politically appealing objective, even if the means of

3 See Bertstein, Harris and Sharpe (2002). In a recent review of Canada-U.S. productivity performance, Andrew Sharpe (2004 table 4), notes that in the 2000-to-2003 period, U.S. labour productivity in the business sector grew at 3.77 percent, compared to 1.34 percent in Canada.

reaching the target are unclear. R&D is certainly not always a silver bullet. Among the larger nations, for example, Japan has the worst growth record since 1990, while having the highest R&D intensity. All of this indicates that any country should be cautious about expectations of what might be achieved by setting and reaching a particular R&D spending target. While improving the innovation performance clearly facilitates economic growth, other factors are necessary for expansion to occur.

For all these caveats, there is a presumption among many innovation advocates that improving Canada's innovation performance is important to reducing the gap between Canadian and U.S. living standards. Certainly the reality is that compared to the U.S., Canada lags significantly on innovation indicators. The formal statistical evidence linking innovation and growth is expanding, though not as persuasive as might be expected. Some recent evidence is provided in a comprehensive econometric study by the OECD of the growth performance of member countries over the 1970-to-2000 period. Looking at a variety of growth determinants, the OECD finds that one of the strongest in terms of magnitude and statistical significance is the level of BERD as a percentage of GDP — referred to as BERD intensity. The OECD (2003) estimates that an increase in the BERD intensity of 0.1 percent (for example, an increase of business spending on R&D to 2.l percent from 2 percent of GDP) raises real output per capita by 1.2 percent. It is also important to note that the same study finds no statistically significant effect of public R&D spending on growth — an important reason why policymakers should be far more concerned about the source of funding, rather than the total R&D level.

The estimated relationship between private sector R&D and income levels is remarkably strong. For example, it implies that if the BERD intensity in Canada were to increase to 3 percent from 2 percent, real GDP per capita would increase by 12 percent. There are few economic policies with a predicted positive impact on living standards that are as large. Canada, which currently has a relatively low BERD ratio, is within the range where the predicted impact would be applicable. An increase in GDP of this amount would enable governments to double spending on health care, holding all other types of spending constant. The central research issue is whether these estimates are believable.

There is fairly broad agreement among economists that the reasons behind the growth effects are the externalities or spillovers inherent in the R&D process and that is the reason there is a public policy case for subsidies to R&D. The case, developed by Schumpeter and Arrow, is that the primary output of R&D investment is the knowledge of how to make new goods and services and that ability, once created by one company, does not preclude its use by another. The benefits to the R&D investment which are appropriated by the company undertaking the investment are less than the total social benefits and companies will be reluctant to invest, leading to the under-provision of R&D investment in the economy. Not only that, even if the appropriation challenge could be completely resolved, for example through patent protection, there remains a potential problem in external financing of R&D. Investors external to the company may require a much higher rate of return than internal investors, and higher than the normal hurdle rates on conventional investments. Reasons for this include the

high degree of uncertainty attached to R&D output and the fact that much of the tacit knowledge created through R&D is embedded in the workers — engineers and scientists doing the R&D.[4] As the social returns to additional R&D spending exceed the private returns, policies which raise R&D spending tend to have a larger growth stimulus than increases in other types of investments that do not have the same type of spillovers.

Still, the large growth effects of business R&D spending estimated by the OECD may be misleading in at least one respect. Many of the externalities generated through R&D are not necessarily national in scope or source. Scholars of innovation have noted that one of the major benefits is an increase in the stock of useful knowledge and much of this now flows across borders fairly easily. Economic growth in Canada depends not only on innovations undertaken here, but also elsewhere. Computers, drugs, or car engines all represent efforts of innovators located in any number of countries. In recent years there has been a lot of research on trying to quantify the R&D productivity growth spillover effects — how much R&D done in one country affects productivity growth in another. The findings have been surprising.

In a widely cited study on international R&D spillover effects, Keller (2001) finds that the average value of a dollar of U.S. R&D to Canadian productivity is 78 percent of the value of a dollar spent domestically on R&D.

Because U.S. R&D spending is about 40 times larger than Canada's, U.S. spending is significantly more important for Canadian productivity growth than is Canada's own. Looking at global R&D spillovers, he estimates that 69 percent of total world technology diffusion to Canada originates in the U.S., while the shares originating in other areas are much lower. Spillovers from Britain, for example, account for 13.5 percent of total world technological diffusion to Canada. The implications of these results are straightforward. Bilateral trade and foreign direct investment (FDI) are important channels of technological diffusion and Canada's heavily U.S.-oriented trade pattern implies that for the time being there are no serious alternative countries as sources of technological spillovers. Not only that, Canada's productivity performance will be affected by levels of R&D spending in the United States no matter what made-in-Canada R&D spending levels are achieved.

The message from these types of studies is that R&D matters a lot for growth, though in the case of smaller, open economies it may be that global and large-partner country innovations are at least as important as Canada's own R&D performance. To the extent that international technological spillovers are the largest factor in overall knowledge advances within the national economy, it makes the link between domestic R&D performance and domestic growth more difficult to establish. A narrow interpretation of these results would be that Canada can free-ride on knowledge created offshore. What has not been resolved, however, is the extent to which domestic R&D itself is a necessary condition for the effective cross-border diffusion of technology. This is an old issue that existing econometric work on international knowledge diffusion has failed to resolve.

4 See Hall (2002) for a review of these arguments.

Despite the econometric evidence linking economic growth to R&D, there is the fact that over longer time horizons growth itself clearly contributes to higher R&D spending. High growth creates profits and retained earnings, which are an important source of business spending on R&D. Moreover, high growth creates opportunities for entrepreneurs that do not exist in low-growth economies. This raises an intriguing chicken-and-egg issue: which comes first — growth or innovation? It might be the case that R&D spending only accelerates growth after it has started, rather than initiating it. In fact, a number of countries, including Canada, Australia, and Ireland have good growth performances, while registering R&D intensities well below the OECD average.

Barriers to Canadian Business R&D Performance

Canada is very different from most other OECD countries in that it is of medium size as measured by population and total GDP, though large geographically. It has a very asymmetric trading pattern focused on the United States and an industrial structure still relatively concentrated in natural resources — about 30 percent of exports are commodity based.

Openness, Scale and Specialization

Over the years, policy analysts and scholars have attempted to explain the weak Canadian innovation performance by reference to these specific factors. Probably the most well-documented finding is the relatively weak R&D performance by large foreign multinational enterprises (MNEs). Foreign-controlled companies account for 42 percent of R&D spending in Canadian manufacturing, though they have a significantly lower propensity to perform R&D when it is defined as the ratio of R&D spending to sales — 0.77 as opposed to 1.19 for domestically controlled companies. Because of Canada's reliance on foreign-based MNEs, it would appear that this structural impediment is not something that can be easily overcome. Canadian governments could implement policies to attract the R&D-intensive activities of MNEs. However, because the U.S. is the world's major location for this type of activity and it is often related to U.S.-based concentrations of scientific and engineering expertise, it is not clear exactly how Canada could achieve such an objective.

A second structural cause that is often mentioned is Canada's lack of specialization in high-technology areas. Generally, the natural resource industries, Canada's traditional area of specialization, are less high-tech and thus less likely to undertake R&D. In most countries, high-tech industries are responsible for the largest share of BERD. In Finland, Germany, Japan, Switzerland and the United States, these industries account for three-quarters or more of BERD. In low-R&D-intensity countries, such as Norway and Australia, high-tech industries, as well as medium-high-tech industries, account for less than 40 percent of business-performed R&D, a fact that can also be attributed to the natural resource intensity of their industrial structure. Canada did experience an increase in its BERD intensity during the 1990s — mostly attributable to information and

communication technologies (ICT), such as those of Nortel Networks Corp. Still, the constraints of a resource-based economy were evident. One OECD study says that substantial increases in BERD ratios are extremely unlikely in economies that do not have a growing share of GDP from high-tech industries.[5] However, caution is warranted on this conclusion because of the importance of R&D in the knowledge-intensive service sectors. Because services and service-sector trade are growing almost everywhere, there is substantial room for increases in measured BERD ratios even in countries which do not have a large high-tech manufacturing base.

More detailed studies have tended to show that Canadian companies are quite good at process R&D, though not as strong on product R&D. This is consistent with a resource-based comparative advantage, where competitiveness is often improved through cost reductions, rather than through the invention of new products. For example, the World Economic Forum each year produces a *Current Competitiveness Index* based on survey data that is claimed to measure both "the quality of the microeconomic environment and the sophistication of company operations and strategy" in 58 countries. In this group, Canada ranks 27th in the world in propensity to compete with unique products or processes. In "Extent of Branding", which is related to the ability to compete through new product innovation, Canada is ranked 21st.[6]

As in most other countries, large companies account for the largest share of business-conducted R&D. In Canada, almost 40 percent of business R&D was concentrated in 10 companies in 2000 (Statistics Canada 2002). The R&D expenditures of Nortel were equivalent to more than one-third of Canadian BERD in 2001, although the company's R&D was conducted in more than 10 countries, including Australia, China, France, Britain and the United States, in addition to Canada. An important structural characteristic of the Canadian economy is that because of its small market size relative to the U.S., there is a relatively smaller proportion of large companies (those with 500 or more employees) in the economy, and this may be a structural impediment to gaining a higher BERD ratio.

Openness and small market size affects the level of business R&D in other ways, as well. R&D is a labour-intensive activity — labour that is very highly skilled and extremely mobile. The general view is that human resources have not limited Canada's growth generally, though the case of R&D specialists may have little to do with the general availability of labour with post-secondary education.[7] However, there are limits to the supply of researchers capable of working in a modern public or private R&D laboratory. The competition for these types of people is global and intense.

Because so many countries have stated intentions of increasing total resources dedicated to R&D, some have raised the prospect of a growing global shortage of R&D workers. Certainly if Canada were to meet its stated target of becoming fifth in the OECD in R&D intensity this would imply a very substantial increase in the

5 See Sheehan and Wyckoff (2003).

6 The *Annual Global Competitiveness Report* is available on the web at www.weforum.org.

7 The evidence on the general role of human capital in Canadian growth is reviewed in Harris (2002).

number of R&D workers in Canada. This is an issue that requires further consideration. It may be that current immigration policy and training of graduate students is sufficient to meet the goal, though this is far from evident. As the brain-drain debate highlighted, Canada has already lost a large number of these people.[8] Whatever policies are in place to encourage innovation, making sure Canada can either train or attract the necessary people will be a necessary condition if real business spending on R&D is to increase. If supply of these types of workers proves to be limiting, R&D activities will simply locate elsewhere.

R&D Across Canadian Provinces — Is Agglomeration of R&D Necessary for Growth?

Looking at the United States, there is a remarkable concentration of total U.S. R&D within a relatively few states. Using 1997 data, California had the highest level of R&D expenditures — nearly $42 billion — representing approximately one-fifth of the nation's $199 billion total. The six states with the highest levels of R&D expenditures — California, Michigan, New York, New Jersey, Massachusetts, and Texas (in decreasing order of magnitude) — accounted for almost half of the entire U.S. R&D expenditure. California's R&D effort exceeded, by nearly a factor of three, the next-highest state, Michigan, with $14 billion in expenditures. At the other end of the spectrum, the lowest 20 states accounted for only 4 percent of total R&D.[9] The picture is of a remarkable geographical agglomeration of R&D activity within the U.S.

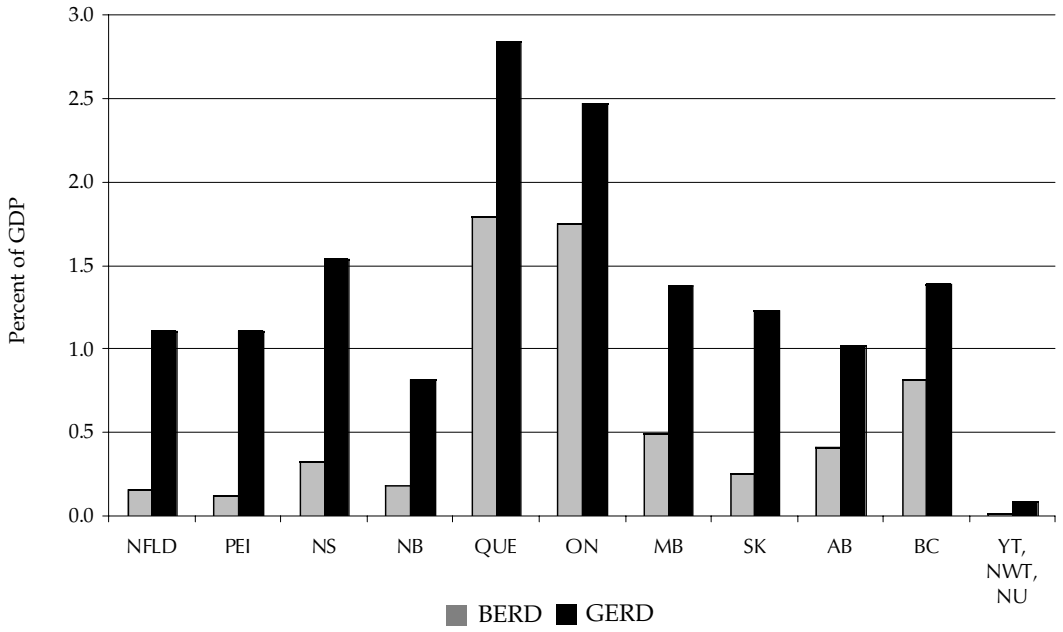
The situation in Canada is not that different. Figure 2 shows total R&D spending by province in terms of total expenditure. It also breaks this down into GERD and BERD components. Clearly, the national data are overwhelmingly affected by the Ontario and Quebec aggregates. Those two provinces have GERD ratios slightly above the OECD average and in that sense are fairly typical OECD economies. With the exception of Nova Scotia, all other provinces have R&D intensities less than 1.5 percent — not unlike those of most U.S. states. Canada, therefore, can be thought of as somewhat average for a country with a large geography and many small provinces. Moreover, within Ontario and Quebec we know that a great deal of the R&D is located in the major metropolitan areas — Ottawa, Toronto and Montreal. This type of data has led to the suggestion that R&D is subject to major agglomeration economies, perhaps due to the knowledge spillovers having a dense network of R&D specialists who can interact with each other. The image of Silicon Valley is usually invoked when these issues are raised; R&D agglomeration is closely linked to the related concept of industrial clustering.

From a policy perspective, therefore, the Canadian R&D problem is resolvable in two ways. One approach is simply to encourage existing patterns of concentration. If agglomeration economies are sufficiently powerful, it can be argued that policy should not attempt to undo whatever clustering is market induced and governments should emphasize innovation policies that contribute to

8 See Easton, Harris and Schmitt (forthcoming), *Brains on the Move*, C.D. Howe Institute.

9 See Sheehan and Wyckoff (2003).

Figure 2: *Provincial Comparision: Business versus Total R&D Spending, 2001*



this type of clustering. A second approach is to focus on raising R&D levels in those regions that are particularly low, but may have some chance of emerging as the location for new clusters. There are a number of reasons why the second approach may be useful. For one thing, the difficulty with policy that seeks to explicitly encourage concentration of R&D within central Canada is that at the federal level this would go against the long-standing emphasis on encouraging regional development in both the East and the West. For another, despite the U.S. example, there are a number of smaller countries in which innovation has flourished — Finland, Sweden, and Israel are examples of small states with highly successful business-led R&D, which is not embedded in very large geographic innovation clusters and in fact are some distance from their major export markets. As well, with globalization and modern ICT, some of the forces that contributed to spatial agglomeration have clearly diminished. R&D workers can network quite effectively with their colleagues on a routine basis without being next door. Moreover, what may be of particular importance in the Canadian case is facilitating knowledge transfers from the U.S.

To raise Canadian R&D performance it seems clear that because the two largest western provinces — British Columbia and Alberta — have for some time contributed to a lower national level of R&D spending as shown in Figure 2, they must be part of the solution. These provinces are now undergoing considerable economic diversification and urbanization. The lower mainland in B.C. and the Calgary-Edmonton corridor have much of the infrastructure necessary to support R&D intensive businesses — world-class universities, a skilled labour force, attractive cities, and close proximity to the technological clusters in the western U.S. — Seattle, Denver, Portland and San Francisco. Just bringing the R&D intensity in these two provinces up to the levels now existing in Ontario and Quebec would go a substantial way toward achieving the national goal of joining

the OECD's top-five list. Other provinces in Atlantic and western Canada should have similar aspirations.

Improving the R&D performance of Alberta and British Columbia will not be easy, however. Both have some significant structural problems, despite being close to other high-growth western regions such as Colorado, Washington, and California. Both still depend heavily on the export of natural resources and these remain the politically dominant industries. There are strong demands on the provincial governments to support the resource industries and regions, sometimes at the expense of an innovation-led economic agenda, though these forces are weakening. With increased economic diversification, higher energy and mineral prices, and growth in service industries the hinterland regions are also experiencing the beginnings of some innovation-led growth. The economic diversification of the last decade in Alberta and B.C. should be sustained and a strong emphasis on private- and public-sector innovation should be maintained. Currently, Alberta is in a stronger position than British Columbia in this regard.

The oil and gas sector is a natural focus of high-risk entrepreneurial activity. As currently measured, much of this does not count as R&D, yet in many ways it is economically equivalent to it. In this sense, the Alberta R&D figures do not tell the whole story and the recent success of the Calgary-Edmonton corridor in sustaining growth in innovative companies may be indicative of better things to come. Still, Alberta could probably do a better job of allocating more of its resource rents to innovation. In the case of British Columbia, the situation is somewhat less promising. Damage to the lumber industry caused by the softwood lumber dispute and tax rates that have been high relative to nearby competitors in Alberta or Washington have been a drag on the growth of high-tech innovative sectors. There are, however, visible signs of a turnaround in the lower mainland of B.C.

One area where government policy might be better focused is on the incentives provided to businesses to undertake R&D. One cause for concern about Canada's current public R&D programs is the longstanding observation that, despite having one of the OECD's most generous tax subsidy programs for R&D, Canada continues to rank low on the organization's global scale. In 2001, the OECD reported that Canada was the second most generous country in terms of tax subsidies to R&D and ranked third among small- and medium-sized nations, behind Italy and the Netherlands. In 1999, an estimated 11,000 Canadian companies, mostly small- and medium-size enterprises (SMEs), claimed $1.4 billion in federal scientific research and experimental development (SR&ED) tax credits.

These credits can also be augmented by a number of provincial tax-credit programs. Ottawa says these programs are fairly effective and Finance Canada estimates that for every $1.00 of support the government puts into the plan, it generates approximately $1.38 of additional R&D spending by companies. But the reality is that total business spending on R&D is still low in comparison to Canada's international competitors, casting doubt on tax subsides as the most effective way for the government to stimulate private sector R&D spending. Moreover, as reported by the OECD, the top five countries that are identified as

offering the most generous rate of tax subsidy, Spain, Canada, Portugal, Austria, and Australia do not have particularly strong BERD performances.[10]

There are a number of countries that use direct subsidies, or grants, to specific companies as the principal means of encouraging R&D despite the potential problems usually associated with this type of program — interest-group pressure, sometimes referred to as rent-seeking, and the necessity of some process for selecting companies to receive grants, which appears as an attempt by government to pick winners. Many commentators say that these types of interventions are doomed to fail. The evidence, however, suggests otherwise. Countries that use direct grants include some of the most successful states in terms of achieving high levels of business-funded R&D and success at commercializing that research. Examples include Israel, Finland and Denmark.

A study of the program in Israel was carried out by Manuel Trajtenberg (2002). He argues that the Israeli program is extremely successful in leveraging private sector R&D efforts. A special government agency in the industry ministry, known as the Office of the Chief Scientist (OCS), operates the program. Companies that want to undertake R&D can apply to the OCS for a grant. Successful applicants are eligible for up to 50 percent of total R&D costs and up to 66 percent in the case of start-ups. A careful expert-based selection mechanism is used to make some effort to keep sound technical evaluation free from political interference. Successful projects, defined as those generating commercial sales, are required to pay back the R&D grants through a royalty plan. The funded projects have been sufficiently successful that Trajtenberg estimates 33 percent of the OCS budget just constitutes "recycling" of funds within the high-tech sector, and not government subsidies to R&D. The Israeli program has a strong element of conditionality in that funded projects must lead to production in Israel and the know-how generated by the project cannot be transferred to third parties.

Because of the lack of success in stimulating business R&D through tax incentives, it may be time for Canadian policymakers to consider some other alternatives. A type of grants program along the lines of the Israeli one deserves consideration. The principal objection in the case of Canada is almost certainly the political economy argument. In a highly decentralized federation it would be difficult to imagine taking the politics out of any such decision. Ottawa's record with federal-regional economic development does not create confidence that a federal grant-making institution along those lines could operate without political interference. The countries using such plans all tend to be small both in population and in geography, enabling efficient internalization of the relevant external effects and the minimization of pressure from special-interest groups. That points to the provinces as being potentially the best administrators of the grant programs. All provinces are now involved to some extent in supporting R&D. Alberta recently moved in this direction and other provinces should consider such a model. It might be better for the federal government to spend current tax dollars by lowering overall corporate tax rates or providing additional incentives for investment.

10 See OECD (2001), Appendix A.6.6.

The U.S. Innovation System and Its Implications for Canada

Canadian business innovation is clearly dependent to some degree on developments occurring globally and in the United States. With the relatively high degree of economic integration between Canada and the U.S., and the heavy dependence of Canada on knowledge and technology originating in the U.S., it is unrealistic to discuss appropriate innovation polices for Canada without dealing with the realities of geography and Canada-United Sates economic integration. It is not even clear that the most appropriate unit of analysis for innovation is the national economy; as in so many other areas in which economics predominates, it may be more realistic to look at the regions of Canada integrated on a north-south basis with U.S. innovation systems. Increased Canada-U.S. integration has resulted in Canadian companies becoming increasingly linked to U.S. firms and other U.S. institutions as part of North America-based knowledge networks. This is all for the good.

However, much of the U.S. innovation system is linked to large strategic initiatives motivated by defense and security, and to health research. It is in these areas that the border remains a major impediment to Canadian businesses attempting to form linkages. Still, the U.S. R&D industry represents a huge opportunity for Canadian business — the frostiness in Washington over Canada's refusal to join the Ballistic Missile Defence program (BMD), notwithstanding.

Just how big is the opportunity? In 2003, Washington's R&D budget was US$112 billion. Using a purchasing power parity (PPP) measure of Canadian GDP, that is equal to about 12 percent of Canadian GDP. Of this, two agencies are responsible for almost 75 percent of that spending: the Department of Defense gets 49 percent and the National Institutes of Health, 25 percent. Private-sector U.S. R&D in the same year was equal to about 27 percent of Canadian GDP, on a PPP basis. Using U.S. market exchange rates would make these figures even larger, of course.

The private sector share of U.S. R&D has been growing steadily from an even split with government spending in 1976. Defense R&D remains the largest area of concentration for the federal government's investments, though since 1986, the proportion of all federal R&D funds going to defense has been in steady decline, dropping to 54 percent of all federal outlays in 1998 from its peak of 69 percent in 1986. However, defense R&D spending is still three times higher than that for health.

For its part, health R&D, carried out mainly by the National Institutes of Health, has experienced the largest inflation-adjusted increases since 1990 of any federal R&D program, rising 21 percent in real terms.

The Bush administration has pushed for a substantial boost in the R&D allocation for the defence department and existing trends point to an increased share of R&D funded through Washington. What is clear is that these represent very large markets in North America. If Canadian companies had unfettered access to those markets it would fundamentally alter the prospects for the entire Canadian R&D system and serve to more effectively integrate Canadian R&D with that taking place in the U.S.

Currently, there are serious barriers to Canadian participation in these markets, not the least of which is the fact that much of this activity is either directly or indirectly related to the defense and security budgets. While much of the world views the United States as the bastion of free enterprise in most areas, Washington is highly interventionist when it comes to R&D policy, often invoking national security to justify its actions, even in areas that might be seen as primarily of commercial interest.

An example of such interventionism is governmental support for U.S. technology companies that are developing capabilities in flat-panel displays, aimed at recapturing state-of-the-art television production, lost when Japan drove the United States out of the TV manufacturing business in the 1970s. The argument in support of this intervention is that advanced video capacity is essential to staying current with information-technology-based warfare.

Because of the close links to the defense and security agenda, Canadian companies have limited ability to participate in these markets as a result of the current chilly state of Canada-U.S. relations. If Canada wishes to pursue a national security strategy that is quite independent of the United States and its security concerns, then there seems little chance that the type of integration of defense industries that occurred during the Cold War, for example, through the Canada-U.S. defense-sharing production agreement, will take place again. In that case, there will be real consequences for innovation within Canada. There is no sense in pretending otherwise. The longer-term consequence will be that economic integration will be limited to those areas where defense-related R&D and security linkages are not deemed important.

The same argument that is made in the case of the defense sector could also be made for other areas where U.S. government policy has an important impact on R&D decisions, such as the National Institutes of Health, the Department of Energy and the National Science Foundation. In all these cases there is substantial business participation, either directly or through links to government-directed R&D. The U.S. competitive advantage in such areas as biotechnology and alternative energy sources is directly affected by U.S. government R&D efforts. Canadian participation in research networks funded out of these U.S. agencies is modest at best. It is clear that Canadian companies do not have access to these networks on the same grounds as U.S. domestic ones. But the situation could clearly be improved and should be a priority for the Canadian government in its efforts to strengthen bilateral relations.

The Investment-R&D Link

Business decisions to conduct R&D are part of the larger strategic business framework. Decisions by companies on investment spending for machinery and equipment (M&E) and buildings, often referred to as capex, are conventionally thought of as separate from the decision to spend on R&D. However, there are good reasons to suppose they are related. One link between R&D and capex spending is that companies that invest a lot expect to grow. R&D is most valuable to companies that expect future growth.

Growth can be either labour intensive or capital intensive. R&D can be important as a source of capital-intensive growth by inventing new products that are capital intensive, or developing improved production processes for existing products that are more capital intensive. Why should growth, however, be capital intensive? One reason is that the current wave of global technological progress driven by ICT is heavily biased against growth in labour-intensive activities. This theme is also a familiar part of the literature on wage-skill differentials and technological change.

Many innovations are labour-saving and are developed for the producing sectors of Europe, the U.S. and Japan. The net effect is that R&D tends to be highly complementary with spending on new capital goods. There is now some new evidence linking R&D intensity to capex.[11] Moreover, the empirical link runs both ways — more R&D causes more capex and more capex causes more R&D. In a British study, highly successful companies in terms of productivity, growth and profitability were those that had both high capex and R&D indicators.[12]

The link between capex expenditures and R&D is highly relevant to the Canadian debate on weak BERD performance. There are a number of studies, recently reviewed by Rao, Tang, and Wang (2003), which have identified low capital intensity of production as an important structural characteristic of Canadian industry. This is particularly true with respect to M&E investment. Canadian investment in M&E per worker was between 30 percent and 60 percent of U.S. levels in the 1990s. There are also a number of studies pointing to this particular indicator as a highly important factor in Canada-U.S. productivity differences.[13] These results raise the interesting issue of whether the factors that explain Canada's relatively weak M&E intensity also factor into lower BERD ratios, despite a very generous set of tax incentives for companies in Canada that spend on R&D.

There is now a growing literature on the relative investment performance of Canada versus the United States. Two main factors have been identified as the probable source of the difference: relative component prices of labour to capital, and taxes. On the relative factor-input price side, Canada had a much lower relative price of labour to capital than the U.S. during the 1990s. The primary reasons were a weak labour market with substantial unemployment, which kept real wage growth low and, until fairly recently, a depreciating currency relative to the U.S. dollar, which tended to raise the price of imported capital goods relative to that in the United States. The net effect is that business in Canada was induced to substitute cheap labour for more expensive capital, while U.S. companies were faced with the opposite set of incentives. Arguably, the factor price effects were medium-term macro factors, which have subsequently reversed. However, the tax explanation for a weak investment performance has not changed.

Taxation policy in Canada remains relatively less supportive of investment spending by companies than U.S. policy. There are a number of studies which all

11 See Chiao (2002) and OECD (2001).

12 See http://www.innovation.gov.uk/rd-scoreboard/analysis.asp.

13 See Rao, Tang, and Wang (2003) for a review of the link between business productivity and M&E intensity.

point in the direction of the United States having offered more substantial incentives to invest in M&E than was the case in Canada. In an OECD study by Gordon and Tchilinguirian (1998), there is a comparison of marginal effective tax rates (METRs) on a range of real assets including R&D and M&E capital. In the case of M&E, the gap between the METRs in the U.S. and Canada gives a 5.88 percentage point advantage to the United States in after-tax real rates of return — that is, after taxes at the margin, the return on a dollar of investment in machinery in the U.S. yielded a rate of return almost 6 percent higher than in Canada during the 1990s. A substantial part of this difference is due to differences in the treatment of capital cost allowances, with higher rates of depreciation allowed in the U.S. This study also looked at R&D and found that the net subsidy was about the same in both countries.

In a more recent OECD study by Yoo (2003), there is some interesting evidence on both marginal and average effective tax rates (AETR) on host country FDI. Canada is consistently identified as one of the high-tax host countries in the OECD. The results pertain to all types of investment — machinery, structures and inventories — in the average FDI bundle. The AETR on inward FDI to Canada in 2001 was estimated at 38 percent and the METR at 28 percent. The same rates in the U.S. were 28 percent and 26 percent. This study suggests that at least for FDI, as of 2001, the tax differences between Canada and the U.S. were not large.

This study, however, does not distinguish between different types of investment. Chen and Mintz (2005) consider the case of Canada-U.S. corporate tax comparisons in some detail. For large corporations they estimate the average effective tax rate on capital in Canada was 31.3 percent versus 23 percent in the United States. Effective rates also vary by province.

By 2008, Ontario's effective tax rate on capital will be 30 percent, British Columbia's, 26 percent, Quebec's, 27.5 percent and Alberta's, 20.7 percent.[14] These provinces account for almost 90 percent of corporate profits in Canada. Compared to the United States, with a projected effective tax rate of 24 percent, only Alberta will be competitive with respect to the taxation of capital. Alberta's advantage arises from having no provincial sales tax and capital tax, with a relatively low corporate income-tax rate (taken to be 11 percent).

In short, taxes on capital in Canada are still high relative to the United States. There are a number of reasons for this, including provincial capital taxes and accelerated depreciation allowances in the U.S., some of which are scheduled to end in 2008. Even if they do not, however, Canadian governments will still tax capital at rates significantly higher than in the United States. Other factors, such as lower wages and a lower dollar relative the U.S. currency, can offset the disadvantages of high taxes, though this tends to bias the type of businesses attracted to Canada — those that do not require a lot of capital investment and can benefit most from cheaper labour. It is precisely these that are the least intensive in capex and R&D intensity.

Canada must improve its business investment performance. This is the case independent of the R&D argument. However, because of the increasing evidence of links between R&D and investment, there is yet another good reason for

14 Chen and Mintz (2004).

governments to improve the investment climate within Canada relative to the U.S. Lowering taxes on M&E investment to U.S. levels would certainly be a major positive step.

Conclusion

Canada's weak record on business-conducted R&D is worrisome. There is substantial evidence that it is costing Canada both in terms of productivity growth and high-wage job opportunities. This paper has identified a number of policy levers at the federal and provincial levels that could potentially improve the situation. The Prime Minister should make good on his commitment to ensure that Canada has an innovation-driven economy by ensuring that these policies are implemented with dispatch.

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