Tax Subsidies for R&D in Canadian Provinces

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Cet article expose la variabilité du taux effectif de l'impôt pour la Recherche et le Développement (R&D) dans les dix provinces canadiennes. Nous montrons que, bien que toutes les provinces bénéficient d'une subvention fiscale assez substantielle, pour R&D, la variation d'une province à l'autre est considérable, allant d'un taux de subvention effectif d'environ 40 % en Alberta à un taux supérieur à 200 % au Québec.

This paper documents the variation in effective tax rates for R&D in Canada's ten provinces. It is shown that while a sizable tax subsidy for R&D exists in every province, the variation across provinces is significant, ranging from an effective subsidy rate of about 40 percent in Alberta to over 200 percent in Quebec.

INTRODUCTION

Government policies to encourage research and development (R&D) are an important public policy issue. This importance arises from the role that R&D plays in fostering innovation and, ultimately, economic growth.[1] Positive spillovers thought to emanate from R&D mean that the social rate of return to investing in R&D is greater than the private rate of return to private companies. In several studies, Jeff Bernstein has investigated the spillovers from R&D in a Canadian context (Bernstein 1988, 1989, 1996; Bernstein and Yan 1997). His estimates consistently show that domestic spillovers from R&D are positive and significant, with the social rate of return exceeding the private rate of return by a factor of two or more in most cases.

The presence of positive, and potentially substantial, spillovers means that if left to their own devices the private sector would tend to under-invest in R&D. The government can address this in several ways. One is to undertake R&D on its own or fund others to do so. Total R&D expenditures in Canada for 2003 were about \$22.5 billion. Of this, government (federal and provincial) funded R&D is expected to account for about \$5.6 billion.[2] Another way that governments can encourage more R&D is through the tax system via the provision of special allowances, deductions, and credits aimed at lowering the cost of undertaking R&D to private businesses. It is difficult to obtain estimates of the cost of R&D tax incentives in Canada. The 2004 Tax Expenditure Accounts for the federal government indicate that the value of federal tax credits granted through the Scientific Research and Experimental Development program were \$1.7 billion in 2003 (Department of Finance 2004).

The use of R&D subsidies delivered via the tax system is widespread internationally. It is generally recognized that Canada has an extremely generous tax incentive system with respect to R&D. The federal government's own Web site boasts that "Canada offers one of the most generous scientific research and experimental development tax incentive regimes in the world" (Department of Finance 2003, 1).

As will be elaborated upon below, the munificence of R&D incentives in Canada arises in large part from the generosity of tax provisions offered by the federal government. However, what is perhaps not well recognized is that some Canadian provinces also offer generous tax incentives for R&D. Moreover, these tax incentives differ significantly across the provinces and, as a result, the tax/subsidy landscape for R&D varies widely across the country.

The purpose of this paper is to document the extent of this variation. To demonstrate this, calculations of marginal effective tax/subsidy rates for R&D are presented for Canada's ten provinces. These calculations are based upon a methodology for measuring effective tax rates that takes the intangible nature of R&D capital explicitly into account.

The results are quite startling. It is shown that the effective tax rate on R&D is highly negative in all of the provinces, indicating the presence of a significant tax subsidy for investment in R&D. However, the size of the subsidy varies substantially, ranging from an effective tax rate of –35 percent in Prince Edward Island, –40 percent in Alberta, to a remarkable –200 percent in Quebec; in the other provinces the subsidy exceeds 100 percent. While the positive spillovers emanating from R&D justify some sort of subsidy, effective subsidy rates of this magnitude do not appear to be justified.

The remainder of the paper is organized as follows. In the next section the tax treatment of R&D at both the federal and provincial level in Canada is briefly summarized. This is followed by an intuitive explanation of the effective tax-rate approach to measuring tax incentives, and in particular of the modifications to this approach that are necessary to account for the special characteristics of R&D. Calculations of effective tax rates for R&D are then presented for Canada's ten provinces. While the emphasis in this paper is on measurement, the paper then moves on to a brief discussion of some policy issues that arise out of the calculations. Knowing the current state of affairs, in particular an economically sensible set of calculations of the effective tax/subsidy rate on R&D capital, is the very important first step in thinking about these deeper issues.

The Tax Treatment of R&D in Canada

R&D tax incentives at the federal level are offered under the Scientific Research and Experimental Development (SR&ED) program. Under this program all eligible current expenditures on R&D are immediately expensed. These include wages and salaries for workers engaged in R&D, as well as expenditures on materials and supplies. Immediate expensing is also extended to expenditures on eligible equipment used in R&D, which would ordinarily be depreciated over time as part of the capital cost allowance (CCA) system. Expenditures on buildings and other structures used in the process of conducting R&D do not receive special treatment, but rather are depreciated as per usual under the CCA system.

The most generous aspect of the SR&ED program is the granting of a 20 percent tax credit on eligible R&D expenditures.[3] Expenditures eligible for the credit include all current expenses as well as expenditures on equipment, but not buildings. Unlike some other countries, the 20 percent credit applies to all eligible expenditures. Some other countries, such as the United States and France, apply the R&D tax credit to incremental expenditures only. For example, in the US a 20 percent tax credit is granted for eligible R&D expenditures in excess of a three-year moving average of previous R&D expenditures. This substantially lowers the benefit of the credit because when a firm invests in R&D it lowers the amount eligible for the credit in future years, therefore reducing the present value of the tax credit. The Canadian nonincremental credit, which applies to all eligible R&D expenditures, is quite generous in comparison.

For the most part, the provinces that offer R&D tax incentives on top of the federal incentives piggyback on the federal government's SR&ED program. Several provinces offer tax credits for R&D expenditures in addition to the federal credit: British Columbia (10 percent), Saskatchewan (15 percent), Manitoba (15 percent), New Brunswick (15 percent), Nova Scotia (15 percent), Newfoundland (15 percent). These provincial credits are granted on the same expenditures as the federal credit under the SR&ED program. Quebec offers a 20 percent tax credit, but this applies only to the wages and salaries of R&D workers, and not to other current expenditures or capital. Quebec also offers a 40 percent tax credit for research contracted out to certified institutions, most notably universities and other post-secondary institutions. Ontario takes a slightly different approach. Like Quebec, they offer a 20 percent tax credit for contract research with universities. Also, rather than a more generally available SR&ED type credit, Ontario provides a "super allowance" for eligible expenditures. The Ontario superallowance offers an additional write-off, on top of immediate expensing, equal to 25 percent of eligible current expenditures and equipment. An incremental superallowance of 37.5 percent is available for incremental expenses in excess of a three-year moving average.[4] Two provinces, Alberta and PEI, offer no tax incentives for R&D on top of the federal incentives.

Aside from the special tax treatment of R&D, both the federal government and the provinces impose other taxes that affect R&D costs. For example, various taxes are levied on labour, including payroll, personal income taxes and sales taxes, some fraction of which are borne by businesses through higher wage payments.[5] Moreover, some provinces (Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia) impose special capital taxes on physical capital, as well as property taxes.[6]

Measuring Tax Incentives for R&D: The Effective Tax Rate Approach

When comparing taxes across jurisdictions, most people focus on statutory corporate income tax (CIT) rates. These are the tax rates set out in the *Income Tax Act*. While important, the statutory CIT rate is only one part of the corporate tax system. Equally important is the tax base, which is determined by the various rules that govern the rate and nature of various deductions and write-offs against corporate revenue. There may also be tax credits associated with certain types of investments that further reduce corporate tax liability directly. These credits, write-offs, and allowances can negate the impact of a high statutory tax rate imposed on the income generated by an investment. As discussed in the previous section, in Canada R&D expenditures are eligible for accelerated write-offs and special allowances as well as tax credits at both the federal and provincial level. Moreover, some jurisdictions impose other taxes on capital, such as explicit capital taxes, that are not taken into account in a simple comparison of statutory CIT rates. The latter is particularly important in Canada, where some (but notably not all) provinces levy an explicit capital tax on physical capital in addition to the corporate income tax.

The challenge then lies in developing a summary measure that takes all of the relevant aspects of the tax system into account, and therefore allows a sensible way of comparing the overall impact of the tax regime on the incentive to undertake particular types of investments in different jurisdictions. A commonly used approach is to calculate the marginal effective tax rate (METR) on different types of capital.

While it can be quite complicated in its application, the idea behind the METR is conceptually quite simple. It employs the notion of the hurdle rate of return. Investors have many opportunities for investment, and in order to attract their savings corporations must generate an expected rate of return that at least compensates investors for their forgone investment opportunities — the hurdle rate of return is the minimum after-corporate tax rate of return required to just compensate investors for their forgone investment opportunities.

In order to add value to a business, all investment projects undertaken by a firm must generate an expected rate of return that is at least as great as the hurdle rate of return required by the firm's shareholders after the payment of corporate taxes. Taxes impinge upon the hurdle rate of return by altering the income available to investors. For example, say that the after-corporate tax hurdle rate of return is 10 percent. This is to say, that after the payment of corporate taxes, shareholders require an expected rate of return of at least 10 percent in order to entice them to invest in the corporation. Any investment undertaken by the corporation must generate at least this hurdle rate of return after the payment of corporate taxes. If an investment generates a rate of return lower than this the value of the corporation will fall, if it generates a rate of return higher than this then the value of the corporation will rise. Now say that after taking account of the various write-offs, deductions, and credits allowed under the CIT, paying taxes at the relevant statutory CIT rate, and paying any other taxes imposed on the capital (such as explicit capital taxes), in order to generate a rate of return of 10 percent after the payment of corporate taxes, an investment project needs to generate a rate of return of 15 percent before the payment of corporate taxes. The METR on capital in this case is 33 percent, calculated simply as the difference between the before- and after-corporate tax rate of return, normalized by the before-tax rate of return, or (15%–10%)/15%. The METR thus measures the tax wedge driven between the before- and after-corporate tax rate of return on a marginal investment project, where a marginal project is simply an investment that just earns the required hurdle rate of return after the payment of corporate taxes. In this example, the METR of 33 percent means that the after-tax rate of return on a marginal investment implied by the tax system is 33 percent lower than the before-tax rate of return.

A positive METR means that the tax system discourages investment by taxing the return to a marginal project. Thus, investments that would otherwise have been undertaken by the firm in the absence of a tax system, because they generate a rate of return in excess of the required hurdle rate of return and therefore increase the value of the firm, are not undertaken in the presence of the tax. A negative METR means that the tax system encourages investment by subsidizing the return to a marginal investment. In this case, the before-corporate tax hurdle rate of return in actually less than the required after-tax rate of return and investments that otherwise would not have been made are undertaken because of the presence of tax subsidies. A METR of zero means that the tax system is neutral with respect to investment — that is, it neither discourages nor encourages investment — and does not impinge upon the return to a marginal investment.

As an aside, it is important to note that whether the METR is positive, negative or zero has no direct bearing on the amount of revenue collected by the corporate tax system. The METR measures the rate of tax imposed on marginal investments, which just break even in the sense that they generate the required hurdle rate of return. Inframarginal investments, which earn more than the hurdle rate of return, earn positive income, which will be taxed, thus generating revenue for the government.

Calculating METRs allows us to assess the impact of taxes on the incentive to invest in particular types of capital and to compare those incentives across jurisdictions using a single, and sensible, summary measure that accounts not only for differences in statutory tax rates across jurisdictions and types of investment, but also for differences in tax bases due to special write-offs, credits, and allowances, and for differences in other taxes on capital, such as direct capital taxes.

The METR approach has been widely employed to assess the incentive effects of taxes on investments in physical, or tangible, capital. In a Canadian context, for example, several studies done by the C.D. Howe Institute compute and compare METRs for different assets across different jurisdictions (internationally and interprovincially) (see Chen and Mintz 2004*a*, *b*; Chen 2000). Indeed, the Government of Canada itself has utilized the technique to analyze tax reform options (Department of Finance 1998*a*).

While there are fewer studies that look explicitly at investment in R&D, the tendency in the existing studies is to apply, on an ad hoc basis, the same approach to analyze the impact of taxation on the incentive to undertake investment in R&D capital (see e.g., Griffith, Sandler and Van Reenen 1995; Gordon and Tchilinguirian 1998; and Mackie 2002). Yet an important distinguishing feature of R&D suggests that some modifications to the standard METR approach are necessary in this case. This distinguishing feature is that R&D capital is intangible, consisting of knowledge and information. Investment in intangible R&D capital differs from investment in tangible physical capital in that it is a "non-marketed" input into either the production or product development process. By non-marketed, I mean that R&D is not purchased on the market, like physical capital, but rather is produced or created within the firm using intermediate marketed inputs such as labour, materials, and equipment. The resulting stock of intangible R&D capital produced within the firm (knowledge) then enters either the production or product development process.

The standard METR approach treats all capital as a point/input-flow/output process; capital is purchased at a point in time, and then generates a flow of output over time. While this may be sensible for tangible capital, it is not sensible for intangible capital produced within the firm according to a flow/input-flow/output process; a flow of intermediate inputs are used to produce an asset that in turn produces a flow of output over time, as is the case with R&D.

In this paper, a methodology is employed that explicitly accounts for the non-marketed, flow/input-flow/output nature of intangible R&D capital in the measurement of the METRs. While the derivation behind the methodology is quite technical (some aspects of the derivation are included in the Appendix; also see McKenzie 2004), the intuition is straightforward.

The tax system can be viewed as impinging upon the cost to firms of employing various inputs used in the production of R&D. METRs can be calculated in the standard way for the various intermediate inputs used in the creation of in-house R&D — labour (scientists), materials (test tubes), equipment (microscopes), and buildings (laboratories). These inputs differ not only in their tax treatment, and therefore in their METRs, but also in their economic characteristics: labour and materials are current inputs of the point/input-point/output variety, and equipment and buildings are capital inputs of the point/input-flow/output variety. This presents some conceptual difficulty in aggregating the METRs on these various types of inputs together into a single meaningful measure.

For example, assuming for simplicity that there are only two inputs into the creation of intangible R&D capital, if the METR on R&D labour is negative 15 percent (i.e., it is subsidized by the tax system) and the METR on R&D equipment is positive 20 percent, what is the overall effective tax (or subsidy) rate on intangible R&D capital? Given the different nature of the two inputs, it is not appropriate to simply take a (weighted) average of the two METRs. Moreover, it is important to emphasize that these are intermediate inputs, used to produce intangible R&D capital, and do not constitute R&D capital in and of themselves.

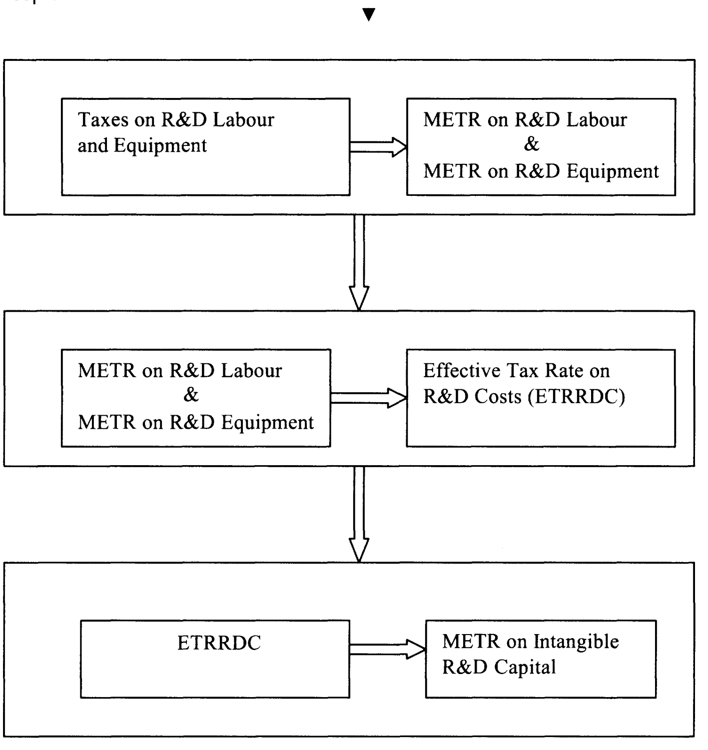
The METRs on the various inputs used in the production, or creation, of intangible R&D capital can be aggregated together in a meaningful way by recognizing that taxes (or subsidies) imposed on these inputs collectively affect the marginal cost of producing an incremental unit of intangible R&D capital within the firm. The taxes imposed on the intermediate R&D inputs are then aggregated together in a summary measure called the effective tax rate on marginal R&D costs (ETRRDC). The ETRRDC measures the percentage change in the marginal cost of producing an incremental unit of intangible R&D capital within the firm, and can be thought of as the excise tax rate implicitly imposed on the production of an incremental unit of intangible R&D capital that arises from the various taxes imposed on the inputs used to produce that unit of capital. With the ETRRDC in hand, the METR on intangible R&D capital can then be calculated in the usual way.

Let us say, for example, continuing with the simplified case of two inputs into the R&D production process, that the METR on labour (scientists) used in the production of R&D is negative 15 percent and the METR on equipment (microscopes) used in the production of R&D is positive 20 percent. Using the underlying R&D production function, say that the subsidy on labour and the tax on equipment act to jointly reduce the marginal cost of producing a unit of intangible R&D capital by 12 percent; that is, the ETRRDC –12 percent.[7] Thus, we see that the tax system implicitly subsidizes R&D by lowering the marginal cost of producing a unit of intangible R&D capital by 12 percent.

While the ETRRDC is useful information in and of itself, we would still like to determine the METR on intangible R&D capital in a way that is comparable to the METRs on tangible, physical capital. This can be done as follows. Given the implicit subsidy on the cost of producing R&D capital captured in the ETRRD, if the after-tax required hurdle rate of return on an investment in R&D required by the market is 10 percent, the before-tax rate of return required to yield this hurdle rate of return is 8.8 percent (determined by 10%(1–12%)). The METR on intangible R&D capital is then –13.6 percent, calculated in the same way as the METR on tangible physical capital as the tax wedge between the before- and after-tax hurdle rate of return divided by the before-tax rate of return ((8.8%–10%)/8.8%). Thus, in this example, the tax system subsidizes investment in R&D because the after-tax rate of return on a marginal investment in R&D capital is 13.6 percent higher than the before-tax rate of return.

There are several different types of effective tax rates in play here. As such, it is perhaps useful to pause and briefly summarize the various effective tax-rate concepts employed in the approach. This is done with the help of the schematic in Figure 1. Various taxes are imposed on the intermediate inputs used to create intangible R&D capital in-house (e.g., labour and equipment). These taxes are summarized by the METRs on R&D inputs — the first box in the schematic. The various METRs on the R&D input costs are then aggregated together to determine the ETRRDC in the second box, which is the percentage increase (or decrease in the case of a subsidy) in the marginal cost of producing a unit of intangible capital implied by the taxes levied on the R&D inputs. The ETRRDC in turn affects the before-tax hurdle rate of return on a marginal unit of investment in R&D capital, raising this rate of return over the after-tax hurdle rate in the case of a tax which discourages investment in R&D, and lowering it in the case of a subsidy. This final effective tax rate is measured in the usual way by the METR on intangible R&D capital in the final box.

FIGURE 1
Effective Tax-Rate Concepts



Viewing R&D as an intangible asset that is produced in-house not only reflects the process underlying R&D, but is consistent with the way that tax incentives are actually delivered. As discussed in the previous section, these incentives are based on the expenditures on the intermediate inputs used in the process of creating, or producing, R&D (labour, materials, physical capital), not on the intangible R&D capital itself. Moreover, not only does the tax treatment vary across these inputs, but so do the characteristics of the inputs themselves, labour and materials being of the nature of current (point/input-point/output) inputs while equipment and buildings are of the nature of capital (point/input-flow/output) inputs into the R&D production process.

In the following section this approach to calculating the METR on intangible R&D capital is applied to the ten Canadian provinces.

Effective Tax Rates for R&D in Canadian Provinces

Table 1 contains various effective tax-rate calculations for R&D for Canadian provinces. Several things are notable from these calculations.

Reading vertically down any of the provincial columns, note that METRs are shown for five inputs used in the production of intangible R&D capital: labour, materials, contract R&D, equipment,

TABLE 1
Effective Tax Rates on R&D, Canadian Provinces, 2004

	Alberta (%)	British Columbia (%)	Saskat-chewan (%)	Manitoba (%)	Ontario (%)	Quebec (%)	New Brunswick (%)	Nova Scotia (%)	PEI (%)	New-foundland (%)
METR on R&D labour	–13.0%	–22.5%	–28.0%	–27.0%	–18.8%	–30.4%	–27.8%	–27.5%	–10.7%	–25.8%
METR on R&D materials	–19.2%	–29.3%	–34.3%	–34.3%	–26.7%	–19.2%	–34.3%	–34.3%	–19.2%	–34.3%
METR on contract R&D	–13.0%	–22.5%	–28.0%	–27.0%	–41.2%	–53.6%	–27.8%	–27.5%	–10.7%	–25.8%
METR on R&D equipment	–23.7%	–33.2%	–36.6%	–36.6%	–29.9%	–22.4%	–37.3%	–37.4%	–23.7%	–38.0%
METR on R&D buildings	37.6%	41.0%	39.0%	48.0%	40.4%	37.3%	42.1%	47.3%	31.2%	27.6%
METR on R&D costs	–13.2%	–22.5%	–27.8%	–26.9%	–24.3%	–30.7%	–27.6%	–27.2%	–11.9%	–26.7%
METR on R&D	–40.3%	–96.6%	–153.5%	–142.0%	–112.7%	–202.0%	–151.0%	–146.2%	–35.0%	–139.5%

and buildings. Contract R&D is treated just like labour but is entered as a separate input because of its differing tax treatment in some provinces (Ontario and Quebec). For every province the METRs on the R&D inputs are negative for all of the inputs, indicating a tax subsidy which lowers the user cost, except for buildings. This is because expenditures on buildings used in conducting R&D do not receive special tax treatment or incentives, but rather are treated in the same manner as expenditures on buildings used for other purposes.

The wide variation in the R&D METRs across the different inputs is notable in and of itself. For example, for Ontario, the METRs on labour, materials, contract R&D, equipment, and buildings are: –18.8 percent, –26.7 percent, –41.2 percent, –29.9 percent, and 40.4 percent. These differential subsidy rates suggest that the tax system may change the cost-minimizing combination of inputs used to generate R&D. If the positive externalities emanate from the R&D itself, and not from the employment of different inputs, then the Diamond and Mirrlees (1971*a*,*b*) production efficiency theorem, which says that an optimal tax system should not distort production decisions, suggests that the Canadian tax system (federal and provincial) might be highly distortionary on these grounds. If, on the other hand, some inputs employed in R&D generate more, or greater, externalities than others, differential subsidy rates across different inputs may be justified. This might be true, for example, in the case of R&D contract employees, who may be thought to generate greater externalities by sharing ideas with colleagues and students. While this may well be possible, I am not aware of any empirical research that investigates this issue, as all of the empirical research on spillovers looks at aggregate R&D expenditures.

Aggregating the METRs on the intermediate R&D inputs together in the form of the ETRRDC, the sixth row of the table shows the percentage reduction in the marginal cost of producing an incremental unit of intangible R&D capital in each province.[8] While the cost of producing R&D is subsidized in all provinces, as indicated by the negative ETRRDC, the size of the cost subsidy varies substantially across the provinces. In Alberta, for example, the tax system reduces the marginal cost of producing a unit of R&D capital by 13.2 percent; in Quebec the implicit R&D cost subsidy is over twice as high, at 30.7 percent.

The final row of the table presents calculations of the overall METR on intangible R&D capital. As would be expected given the generous tax treatment of the expenditures on R&D inputs, as reflected by the negative ETRRDC, these METRs are all negative, indicating the presence of a significant tax subsidy for investment in R&D capital in Canada. However, the calculations also indicate a substantial degree of variation in the METRs on R&D across the provinces. As discussed above, neither Alberta nor PEI offer specific provincial incentives for R&D over and above the federal incentives. In spite of this, the METR on R&D capital in these two provinces is –40.3 percent and –35.0 percent respectively, indicating the presence of a significant subsidy because of the federal tax system. All of the other provinces top up the federal system with their own incentives. The result is effective subsidy rates that can be described as "substantial" to say the least: with effective tax rates of –202.0 percent in Quebec, –151.0 percent in New Brunswick, –112.7 percent in Ontario.

To put these METRs in context, consider again the example from the previous section. If investors require a hurdle rate of return of 10 percent after the payment of corporate taxes, an incremental R&D project in, say, Quebec can earn a before-tax rate of return as low as 3.3 percent and still make economic sense from the perspective of a value-maximizing firm. In the absence of tax incentives, such an investment would never take place. This is, needless to say, a substantial subsidy for investment in R&D.

Discussion

The primary purpose of this paper is one of measurement and documentation. However, it is useful to discuss some policy issues that arise from the calculations. In the previous section it is shown that the tax subsidies for R&D offered in some of the provinces are substantial. As discussed in the introduction, the presence of positive spillovers from R&D suggests scope for some type of government subsidy. Perhaps the most fundamental issue that arises from the calculations presented above is whether subsidies of the magnitude reported in Table 1 are justifiable on economic grounds. While fundamental, this issue is a very difficult and complicated one.

Some of the factors that are relevant to this issue are addressed in a recent paper by Bev Dahlby (2005), who looks at the case for additional provincial tax subsidies for R&D in an Alberta context. He points to three key parameters that are relevant to an assessment of this issue.

The first is the size of the spillovers from R&D, and therefore the difference between the social and private rate of return on investments in R&D capital. The bigger this difference the stronger the case for R&D subsidies. As indicated in the introduction, while estimates vary widely, most studies find that social rates of return to R&D exceed private returns by a factor of two or more.

The second is the sensitivity of R&D to tax subsidies: the more sensitive, the stronger the case for those subsidies. Again, there is a wide range of estimates of the sensitivity of R&D with respect to tax subsidies. Early studies suggested relatively low elasticities of R&D with respect to its after-tax price, in the range of 0.25 (in absolute value); more recent estimates suggest more sensitivity, with elasticities in excess of unity. Thus, a 10 percent reduction in the cost of R&D due to a tax incentive leads to an increase in R&D expenditures of 10 percent or more (see Bloom, Griffith and Van Reenen 2002).

The third factor is the opportunity cost of the funds used to finance R&D tax subsidies. Tax subsidies for R&D must be financed by imposing higher taxes on other activities. Those higher taxes come at a cost, as measured by the marginal cost of public funds (MCF), which incorporates both the revenue cost and the incremental efficiency cost due to higher taxes; the higher the MCF, the weaker the case for tax subsidies. Estimates of the MCF also vary widely, and depend upon the tax under consideration; however, most estimates are in excess of 1.4, so that raising one more dollar in tax revenue to finance a $1.00 subsidy for R&D costs the private sector $1.40, consisting of the $1 in tax revenue raised plus $0.40 in incremental efficiency costs (Dahlby 2005).

Dahlby (2005) considers the existing range of estimates for these parameters (which vary widely) and concludes that for a broad range of "reasonable" parameter values the case for a provincial tax subsidy for R&D in Alberta is weak. Recalling that Alberta (along with PEI) currently offers no additional incentives and has the lowest R&D subsidy in the country, this suggests that the very high subsidy rates in the other provinces documented above, may be excessive. However, it is important to emphasize that the research in this area is tentative and the results vary widely, depending upon the parameters.

As also documented above, the variation in the effective tax/subsidy rates across the provinces is quite striking. Independent of the fundamental issue regarding the overall magnitude of the subsidies, another issue concerns the "fiscal federalism" implications of this variability in R&D subsidies across provinces. Various questions arise in this context. Does the fact that provinces are able to set their own R&D tax incentives give rise to "subsidy competition" for R&D between the provinces (which, for some reason, only Alberta and PEI have been able to resist)? Is the resulting tax subsidy for R&D "too high" as a result? Are there systemic differences between the provinces that suggest the subsidy rates should differ? And to the extent documented here? Aside from the parameters discussed above, some of the relevant factors include the size of local versus national versus international spillovers from R&D. Needless to say, the state of our knowledge and understanding of these factors is such that it is difficult to answer these questions with any degree of precision. However, understanding the current set of calculations of the effective tax/subsidy rate on R&D capital is the first step in studying these issues.

Notes

[1]Boskin and Lau (1994) estimate that R&D in Canada accounted for about 10 percent of economic growth in Canada between 1964 and 1990.

[2]This data is from Statistics Canada (2004).

[3]The system described here, and which forms the basis for the calculations below, applies to large corporations. Small businesses, Canadian Controlled Private Corporations (CCPCs), are eligible for even more generous treatment.

[4]The Ontario super allowance is not included in the calculations that follow. Also, note that Ontario does not tax back the federal tax credit for R&D.

[5]In the calculations that follow, it is assumed that 30 percent of the taxes imposed on labour are borne by businesses.

[6]Property taxes are not included in the calculations that follow because of difficulties in obtaining effective property tax rates that are comparable across provinces.

[7]This calculation is based upon a Cobb-Douglas R&D production function with labour's share at 90 percent and equipment's share at 10 percent. This yields an ETRRDC

of $(1-0.15)^{.9}(1+0.20)^{.1}-1$, which is approximately −12 percent. See McKenzie (2004).

[8]The ETRRDC in the table is calculated assuming a Cobb-Douglas R&D production function with shares of 45 percent for labour, 20 percent for contract R&D, 25 percent for materials, 5 percent for equipment and 5 percent for buildings. These factor shares are based upon Department of Finance (1998*b*).

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APPENDIX

A two-stage approach to calculating METRs on intangible R&D capital is followed (McKenzie 2004). In the first stage, R&D capital is treated as an intermediate output produced within the firm using tangible inputs. In the second stage, the R&D capital is an input into either the production or product development process.

Stage 1

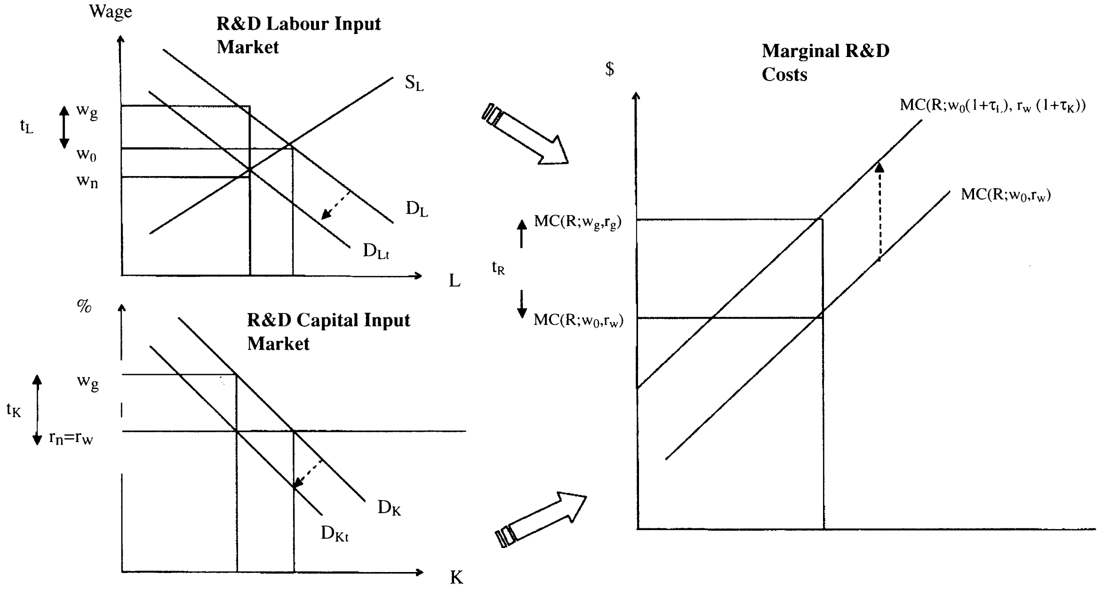
In Stage 1 the firm minimizes the cost of producing a given amount of R&D capital. The approach followed in the first stage is identical to that followed in McKenzie, Mintz and Scharf (1997), who developed the concept of the effective tax rate on marginal production costs. The difference here is that rather than combining inputs to produce a final output for sale, the firm combines inputs to produce an intermediate output (R&D capital) that is subsequently used as an input into production (or product development).

McKenzie, Mintz and Scharf (1997) provide a technical derivation of the basic formulas, which are augmented here to account for the special tax treatment of R&D-related expenditures. Here the formulas are merely stated and the idea behind the ETRRD and marginal effective tax rate on intangible R&D capital is expanded upon using a diagrammatic approach.

The two left-hand panels in Figure A1 show the input markets for labour (scientists) and capital (laboratories) employed in the production of R&D. In the absence of any taxes, the user cost of labour is w_0 and the user cost of capital is r_w. Note that the capital market is modelled as a small, open economy where provinces treat the cost of capital as fixed by the world rate of return on capital, which is sensible in a Canadian provincial context. The resulting input user costs then feed into the marginal cost curve for the production of R&D capital illustrated in the panel on the right, where the marginal cost is a function of the user cost of the inputs and the quantity of R&D capital produced, $MC(R;\, w_0,\, r_w)$, where R is the quantity of R&D produced.

Now consider the impact of taxes levied in the two R&D input markets, beginning with a demand-side tax imposed on the labour market. For illustrative purposes consider a payroll tax imposed on employers; supply side taxes on labour, such as the payroll taxes levied on workers, the personal income tax, sales taxes, etc., will have similar effects. The payroll tax shifts the demand curve for labour to the left and drives up the cost of labour to the firm from w_0 to w_g. Note that the entire burden of the tax is not borne by employers as some of the burden is shifted to workers due to a lower take-home wage, w_n. In terms of its impact on the costs of conducting R&D we are interested only in the portion of the tax borne by business. The share of the tax borne by businesses is determined by the relative elasticities of supply and demand. Most estimates suggest that the labour supply is relatively inelastic and labour demand quite elastic. This suggests that most, but importantly not all, of the burden of taxes levied on labour falls on workers. A review of the empirical literature by Dahlby (1992) suggests that about 70 percent of taxes levied on labour are borne by workers and 30 percent by businesses. The key point is that some of the burden of the tax falls on business, driving up the user cost of labour from w_0 to w_g. The marginal effective tax rate on labour is then equal to the percentage increase in the user cost of labour to firms, $\tau_L=(w_g-w_0)/w_0$. Thus, we can write the gross-of-tax user cost of labour as a function of the METR on labour, or $w_g=w_0(1+\tau_L)$.

FIGURE A1
Effective Tax Rates in Different Markets



In the lower panel a tax is imposed on capital employed in R&D, say a corporate income tax. This shifts the demand for capital curve to the left. Because Canada is a small, open economy on the capital market, the after-tax return to capital is fixed at the world rate, r_w, and the before-tax user cost of capital to business increases by the full amount of the tax. The METR on capital employed in the production of R&D is $\tau_K=(r_g-r_w)/r_w$, and therefore the gross-of-tax user cost of capital is $r_g=r_w(1+\tau_K)$.

The tax induced increase in the user cost of labour and capital drive up the cost of producing R&D capital within the firm. This shifts the R&D marginal cost curve up from $MC(R; w_o, r_w)$ to $MC(R; w_o(1+\tau_L), r_w(1+\tau_K))$. The effective tax rate on marginal R&D costs, ETRRDC, is the percentage increase in the marginal cost of undertaking R&D,

$$T_{RD} = [MC(R; w_o(1+\tau_L), r_w(1+\tau_K))-MC(R; w_o, r_w)]/ MC(R; w_o, r_w). \qquad \text{(A1)}$$

To determine T_{RD}, the R&D production (and therefore cost) function must be parameterized. As in McKenzie, Mintz and Scharf (1997), a Cobb-Douglas production function is assumed.

In the above discussion it is assumed that the various taxes imposed on the R&D inputs increased the user costs of those inputs to the firm, and therefore increased the marginal costs of producing a unit of R&D capital. The calculations discussed in the text indicate that federal and provincial taxes in Canada actually act as subsidies to labour and capital, lowering the user costs and reducing the marginal costs of producing R&D capital. In this case, the curves shift in the other direction, lowering the gross-of-tax user costs of labour and capital to businesses and reducing marginal R&D costs.

The above discussion assumes two broad inputs into the production of in-house R&D. The empirical application in the text includes five different inputs. For each input the effective tax rates reflect both federal and provincial tax bases. For completeness the formulas for the gross-of-tax user costs, which are used in the derivation of the METR on each input, are produced (but not derived) below.

Labour

The net-of-tax cost of labour (w_0) is normalized to one.

For all provinces except Ontario, gross-of-tax wages are:

$$w_g = (1+t_L)(1-\phi_p-\phi_f)$$

where t_L is the effective payroll tax rate, ϕ_p is the provincial R&D tax credit rate and ϕ_f is the federal R&D tax credit rate.

For Ontario:

$$w_g = [(1+t_L)(1-u_p-u_f(1+s)-(1-u_p-u_f)\phi_f+u_pu_fs]/(1-u_p-u_f)$$

Contract Labour

Same as labour for all provinces except for Ontario.

For Ontario gross-of-tax wages are:

$$w_g = [(1+t_L)(1-u_p-u_f(1+s)-(1-u_p-u_f)(\phi_f+\phi_p)+u_pu_fs]/(1-u_p-u_f)$$

where s is the Ontario superallowance rate.

Materials

The net-of-tax cost of materials (m_0) is normalized to one.

For all provinces except for Ontario and Quebec the gross of tax cost of materials are:

$$m_g = (1+t_L)(1-\phi_p-\phi_f)$$

For Quebec:

$m_g = (1+t_L)(1-\phi_f)$

For Ontario:

$m_g = [(1+t_L)(1-u_p-u_f(1+s)-(1-u_p-u_f)\phi_f)+u_p u_f s]/(1-u_p-u_f)$

Equipment

For equipment the net-of-tax user cost (r_w) is $r-\delta_E-\pi$, where r is the cost of finance, δ_E is the economic rate of depreciation and π is the rate of inflation.

For all provinces the gross-of-tax user cost of capital is:

$r_g=[(r^f-\delta_E-\pi)(A+t_c(1-u_p-u_f)(\ 1-\phi_p-\phi_f)/(r^f+\delta_E)]/(1-u_p-u_f)$

where t_c is the capital tax rate.

For all provinces except Ontario and Quebec the term A is:

$A=(1+t_E)(1-u_p-u_f)(1-\phi_p-\phi_f)Z_E$

where t_E is the sales tax rate on equipment and Z_E is the present value of tax depreciation deductions on equipment.

For Ontario:

$A=(1+t_E)(1-u_p-u_f(1+s)-(1-u_p-uf)\phi_f+u_p u_f s)Z_E$

For Quebec:

$A=(1+t_E)(1-u_p-u_f)(\ 1-\phi_f)Z_E$

Buildings

For buildings the net-of-tax user cost (r_w) is $r-\delta_B-\pi$, where r is the cost of finance, δ_B is the economic rate of depreciation and π is the rate of inflation.

$r_g=[(r^f-\delta_E-\pi)(A+t_c(1-u_p-u_f)/(r^f+\delta_E)]/(1-u_p-u_f)$

where $A=1-(u_p-u_f)Z_B$, with Z_B the present value of tax depreciation deductions on buildings.

Stage 2

In Stage 2 the intangible R&D capital produced in Stage 1 is an input into the production process. To decide how much R&D capital to produce the firm will produce up to the point where the after-tax marginal revenue arising from an incremental unit of R&D capital equals its after-tax user cost, or

$$(1-u)MR(R) = MC(R;\, w_o(1+\tau_L),\, r_w(1+\tau_K))\,(r+\delta) = MC(R;\, w_o,\, r_w)(1+T_{RD})\,(r+\delta), \tag{A2}$$

where $MR(R)$ is the marginal revenue arising from another unit of R&D capital, u is the CIT rate, r is the real after-tax opportunity cost of finance determined by international financial markets and δ is the rate of depreciation on R&D capital. The second equality on the right-hand side follows from the definition of the ETRRD in (A1).

Re-arranging equation (A2), we define the gross-of-tax, net-of-depreciation rate of return to an incremental unit of R&D as, $r_g^{RD}=[MR(R)/\, MC(R;\, w_o,\, r_w)]-\delta$, yielding

$$r_g^{RD} = [(r+\delta)\,(1+T_{RD})/(1-u)] - \delta. \tag{A3}$$

The marginal effective tax rate on intangible R&D capital is then $\tau_{RD} = (r_g^{RD} - r_w)/\, r_g^{RD}$.