

**Measuring Fiscal Incentives for Research and Development in
Canadian Provinces**

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ABSTRACT

This major paper examines two issues: the economic rationale for supporting R&D production and the relative fiscal generosity of provincial governments towards R&D. A framework is developed to measure the marginal effective tax rate on R&D production. Using a methodology derived by McKenzie (2004, 2007), I find evidence of deeply generous provincial incentives for R&D. I estimate that the provincial and federal governments combine to reduce the marginal user cost of R&D by 94%.

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1 INTRODUCTION

Research and Development (R&D) is widely considered as beneficial in economics. In macroeconomics, it is often seen as the basic ingredient for economic growth. For example, in the Solow growth model, it is the exogenous factor tucked in the Solow residual increasing the steady state level of capital. Similarly, in the Romer model (1990) it is the endogenous engine of growth: increasing the share of the population engaged in R&D contributes to the stock of ideas - leading to permanent increases in the level of technology and greater productivity in the economy. Furthermore, in growth accounting exercises R&D investments help to understand differences in growth rates across economies.

In the context of microeconomics, firms invest in R&D as a competition strategy. Setting aside uncertainty issues, firms compete in R&D not only to reduce costs but also to capture a larger share of industry profits. For example, a firm investing in R&D receives a patent for its invention. In the short run, this property right allows it to create a monopoly. In the longer run, the monopolist/innovator benefits from monopoly profits which it uses to change its market structure through further investments (plants, laboratories, etc.). These changes may lower the innovator's average unit cost and discourage would-be competitors (Church and Ware, 2000). In a Cournot competition, strategic R&D investments may lead to greater capacity which shifts out the innovator's reaction function (Brander and Spencer, 1983).

Governments have been providing substantial support for private R&D. Underpinning this generosity is the belief that private R&D yields substantial social returns. In particular, the Canadian federal and provincial governments have been providing a mix of incentives to encourage R&D. The purpose of this major paper is twofold. First, it investigates the economic rationale for R&D incentives. Second, it derives a measure of the government incentives and compares the relative generosity of Canadian provinces. The main findings of this paper are threefold. First, the R&D marginal effective tax rate (METR) is negative in all provinces and territories, indicating

that the tax systems subsidize R&D. In particular, the provincial and federal tax systems combine to reduce the user cost of R&D by 94%. Second, differences across provinces in terms of the size of R&D investment tax credits explain differences in provincial METRs. Specifically, Manitoba is the most generous tax system with its 20 per cent investment tax credit. Eight other provinces provide investment credits ranging from 4.5 per cent in Ontario to 15 per cent in Nova Scotia. Nunavut, the Northwest Territories, Alberta and Prince Edward Island are the least generous provinces in that they do not offer any R&D incentives beyond the federal subsidies. Third, the federal R&D subsidy program accounts for a large portion of the R&D METRs in provinces.

The remainder of the paper is organized as follows. Sections 3 through 5 review the literature on the private/social returns to R&D as well as their policy implications. Section 6 illustrates in detail the treatment of R&D in Canada. Section 7 outlines the methodology of McKenzie (2004, 2007) that I amend to derive the measure of fiscal incentives. I provide a discussion of the results and methodology in sections 8 and 9.

2 THE GAP BETWEEN PRIVATE AND SOCIAL RETURNS TO INNOVATION AND POLICY INCENTIVES FOR R&D

R&D creates innovations, increases productivity, boosts standards of living and raises firm profits. However, conventional wisdom holds that firms should make additional investments in R&D. This begs the question: why do firms underinvest in R&D? The following are selected factors

First, firms benefit from R&D investments through streams of profits from innovation (Jones, 2002). However, the market does not compensate them for their contribution towards improved productivity of future research. This is the “knowledge spillover” in that firms’ knowledge spills over to other researchers. As a result, firms tend to invest less in R&D than what would be socially optimal. Second, financial constraints may prevent firms from investing in R&D (Mohnen, 2002). Firms may know the potential profitability of marginal investments in R&D, but cannot use this knowledge

as collateral to borrow funds for the investment. This is the “asymmetric information” problem in that the information on the new investment varies from the lender to the borrower. Here again the result is lower than optimal R&D investment. Third, firms do not capture all the rents from innovation (Jones, 2002). Although firms receive patents generating monopoly profits, these profits are less than the gain to society. This is the “social return distortion”. Firms do not take into account the social gains and underinvest in R&D. To summarize, firms underinvest in R&D because they have no incentive to invest beyond the level that maximizes private rents net of private costs.

2.1 Policy Incentives for R&D

Governments generally step in to provide incentives to firms so that they invest in R&D beyond their privately optimal point. The idea is to reduce the cost of R&D investments and induce a socially optimal level of investment. There are, of course, caveats to this logic. First, governments must know the extent to which firms respond to incentives. Second, governments must know fully the extent of the gap between the private return and the social return. With the above information in hand, governments can formulate optimal incentives inducing the optimal level of R&D investments. These incentives can run the gambit from direct support such as grants, loans and contracts to fiscal incentives delivered indirectly to firms through their investment decision (Warda, 1999). For the purpose of the current study, I concentrate on fiscal incentives. These incentives take three forms: tax credits, allowances and rate reductions applying on two classes of expenditures: capital and current. Capital expenditures refer to expenditures on machinery, equipment and facilities (Warda, 1999) while current expenditures refer mainly to wages, materials, supplies etc.

Governments provide fiscal incentives on capital expenditures by allowing firms to depreciate quickly the value of the capital asset according to a declining balance or a straight line (Warda, 1999). This provision benefits firms in that they can reduce their taxable income by deducting the value of their accelerated depreciation. Ultimately, the capital asset has no book value, but continues to be an input in the production process.

Similarly, fiscal incentives on current R&D expenditures take the form of deductions that allow firms to remove a percentage of expenditures from their taxable income. Many governments allow this deduction to reach 100% of current expenditures in the current year. These reduce the user cost of R&D investment.

Firms benefit further from investment tax credits by reducing their after-tax cost on a level or an incremental basis (Warda, 1999). Governments normally allow firms to apply these credits against their income tax payable. For example, a country allowing a combination of allowances, Z , and credits, θ treats a \$1 R&D investment in the following way. First, taxable income is reduced by Z . Second, the credit reduces tax payable by $(1 - \theta)$. Firms can generally carry forward these credits over a given amount of years.

Rate reduction refers to the fact that governments may choose to impose lower income tax rates on firms investing in R&D. This approach benefits firms by reducing the amount of the innovation R&D profits which is taxed away.

I have discussed why and how governments subsidize R&D investments. The next relevant step is to discuss the effectiveness of fiscal incentives. The following section presents a review of the literature analyzing the effectiveness of fiscal incentives for R&D.

3 REVIEW OF LITERATURE

Economists widely believe that R&D subsidies help correct market failures, bringing R&D investment closer to its socially optimal level. However, the existence of R&D externalities does not automatically provide a rationale for fiscal incentives such as allowances and credits. For one, private R&D investments must be responsive to these incentives. Furthermore, R&D spillovers must be large enough to offset the costs of the incentives. In fact, conventional wisdom holds that raising taxes to finance R&D incentives creates a welfare cost by distorting economic behaviour. Therefore, whether

tax incentives for R&D are beneficial depends on the magnitude of the spillovers relative to the associated economic costs. Before applying my own methodology to the analysis of fiscal incentives, I review the literature on four key variables: the responsiveness of R&D to tax incentives, spillover benefits flowing from R&D, the cost of raising distortionary taxes and the extent to which fiscal incentives reduce the cost of R&D.

3.1 Sensitivity of R&D investments

Analysing R&D fiscal incentives requires an understanding of the responsiveness of private R&D spending to fiscal incentives. The economic evaluation literature points to two related measures of responsiveness: R&D price elasticity and the incrementality ratio. The first measures the percentage change of R&D spending by the private sector for every percentage reduction in the user cost of R&D. The second measures the change in R&D spending per dollar of tax revenue forgone by the government due to tax incentives (Treasury Board Secretariat, 1998). I review in this section studies estimating both measures.

The response of private R&D spending to tax incentives is generally estimated through survey or econometric analysis. Under the survey method, firms are asked to estimate the impact of tax incentives on their R&D expenditures. One such survey was sponsored by the Department of Finance (DoF) and Revenue Canada (RA) in 1997. It asked 501 Canadian firms how much lower their R&D spending would be in the absence of tax incentives. The study found that the federal incentives boosted private R&D spending by 32% and by \$1.38 per dollar of tax expenditure. In contrast, other R&D surveys by Mansfield and Switzer (1985) provide much lower incrementality ratios of 1.02. As is often the case for surveys, certain elements bias estimates. For example, it is possible that respondents exaggerate the benefits of policies that advantage them.

The most common method of estimating responsiveness of fiscal incentives is econometric analysis. Econometricians try to explain R&D investment using a set of

variables including: firm size, profitability, cash flow, and industry type and tax parameters. Researchers isolate the marginal impact of changes in tax parameters of R&D spending by including non tax parameters controlling changes in R&D spending resulting from structural characteristics of firms. For example, Hall and Van Reenen (2000) estimate the price elasticity of R&D with respect to the tax credit by regressing the change of business R&D on changes in the user cost of R&D and control variables. Given that the user cost variable was in logs, the coefficient was also the R&D price elasticity – which they use to calculate the incrementality ratio for R&D. They find a price elasticity and an incrementality ratio of -0.6 and 2 percent respectively. Bloom, Griffith and Van Reenen (2002) develop another estimate of responsiveness to R&D fiscal incentives. Using a sample of OECD countries between 1979 and 1997, they develop a measure of user cost of R&D. They then estimate a model with private R&D as the dependant variable along with user cost, output and fixed effects as explanatory variables; instrumental variables capture the endogeneity of the user cost. Bloom et al find that tax incentives have a significant effect on the level of private R&D spending with an elasticity of -0.1 in the short run and -1 in the long run. Another study from McKenzie and Sershum (2005) also uses an OECD sample of countries over the same period. An interesting contribution of the McKenzie and Sershum is its estimation of the impact of the lower marginal cost of production (due to tax incentives) on R&D spending. Their study finds that a 10% decrease of marginal cost increases private R&D spending by 2% in the short run and 7% in the long run.

The majority of R&D price elasticity and incrementality estimates are based on US data. For example, Hall (1993) studies the extent of private sector responses to the incremental federal tax credit that was introduced in 1981 as part of the Economic Recovery Act. The credit subsidizes additional R&D spending exceeding a baseline average. Hall (1993) uses a panel of US firms during the 1980s and finds price elasticity slightly under 1 in the short run and over 2 in the long run. Hall (1993) subsequently separates the regressions into 1980-1985 and 1981-1991 periods and finds that elasticity increases in later periods. Her findings lead to a unique conclusion: it takes firms time to react to the presence of the credits. Hall (1993) goes on to calculate an incrementality

ratio of \$2.00 of R&D spending per dollar of government forgone revenue. Other US estimates for the incrementality ratio include Berger (1993) who estimates that tax incentives stimulated \$1.25 of R&D spending per dollar of subsidy. Hines (1993) also looks at the R&D spending of US multinationals and finds significant changes surrounding the introduction of the federal credit. He calculates that the tax incentive raises R&D spending by a ratio between \$1.20 and \$1.80. Other studies using US data find lower incentive responses. For example, Tillinger (1991) uses firm level data from 1980 to 1985 and estimates that tax incentives raise spending by only \$0.19. Similarly, McCutchen (1993) finds a slightly higher, but still low, impact between \$0.29 and \$0.35 per dollar of subsidy. Note however, that the McCutchen and Tillinger studies used older data where firms had not reacted fully to the presence of credits.

To summarize, US private R&D spending was responsive to fiscal incentives. Estimates of the price elasticity and incrementality ratio indicate a positive and rising effect. One reason is that using data spanning over a large number of years allows firms to react to the incentives and captures more accurately firms' response.

Using Canadian data, Dagenais, Mohnen and Therrien (1997) estimate a large long run price elasticity of -1.09 with a sample spanning from 1975 to 1992. They further estimate that the incentives increase private R&D spending by \$0.98 per dollar of revenue forgone. Other Canadian studies also investigate the issue using Canadian data. For example, Lebeau (1996) estimates a similarly low incrementality ratio of 0.9 using industry data from Quebec. Both ratios contrast with the majority of studies using the long run price elasticity to estimate incrementality ratios. In particular Klassen, Pitman and Reed (2004) formulate a unique methodology to derive incrementality ratios by regressing directly the log of R&D spending on the credit rate. Their econometric analysis covered 58 Canadian firms between 1991 and 1997 and finds that one dollar of subsidy stimulates \$1.30 in R&D private spending.

Overall, Canadian and American researchers have been able to find that tax incentive stimulate R&D investments in Canada as well as in the US. In fact, the price

elasticity ranges from -0.30 to -1.09 in Canada and -0.12 to -2.00 in the United States. Similarly, the incrementality ratio ranges from \$0.98 to \$1.38 in Canada and \$0.60 to \$3.60 in the United States. These findings suggest that private R&D investment is responsive to tax incentives, thus satisfying the first key variable in the analysis of fiscal measures.

3.2 Spillovers

The second key variable for evaluating fiscal incentives is the presence of R&D spillovers. The following lines review the literature on the existence and extent of social returns to R&D. While firms attempt to protect their innovations through secrecy and property rights, the reality of R&D is that, once the idea has been created, other firms can free ride by imitating the innovation. This is one of the main reasons for which social returns on R&D exceed private returns. So, firms provide R&D investments below the socially optimal level unless they are compensated for the benefits they provide to others. From an economic standpoint, the optimal R&D subsidy should therefore reflect the size of the spillover.

Numerous studies have attempted to estimate the spillover returns to R&D. One common method is to specify a production function with traditional factors along with technological change inputs, including own-firm R&D and outside firm R&D stocks. Mohnen and Lépine (1992) follow this method to estimate returns to R&D in the Canadian manufacturing sector. They transform a Cobb-Douglas production function into growth rates where the coefficients on the foreign R&D stock growth rate gives the size of the foreign R&D return while the coefficient on Canadian manufacturing R&D stock growth rate gives the industry R&D return. Adding the two returns yields a social return to R&D of 86%. A similar study by Bernstein (1996) estimates a domestic rate of return to R&D in Canada by combining the private return to R&D and the domestic spillover effect. While his results vary across industry, he finds a domestic social return to Canadian R&D of 52%. One study by Bernstein and Yan (1997) estimates domestic

spillovers in Canada and Japan. The study uses data on 10 manufacturing industries from 1962 to 1988. Their median estimates of the domestic social return was 141.4% with a private industry return of 17.2%, the spillover return was 124.2%. Bernstein and Yan do not explain why the 1997 estimates differ significantly from the 1996 estimates. Applying the Bernstein private R&D return to the Mohnen and Lépine (1991) social return yields a spillover return of 68.8%. A study from Park (2004) finds even higher spillover rates for R&D. His research finds return rates for 14 OECD countries ranging from 52.4% in Germany to 260.3% in Australia.

The varying spillover return rates suggest certainly measurement and estimation problems. Moreover, recent research from Boadway and Tremblay (2005) suggest that existing firms generate larger spillovers from research than start-up firms. This finding adds to the complexity of spillovers measurements by introducing varying spillovers sizes from one firm to the next. Nevertheless, the economic consensus is that social returns exceed private return by a factor of 2 or more. If an optimal tax policy on R&D must reflect the size of the spillover return then the optimal R&D subsidy must be very generous. The following sub-section discusses the third key analysis variable in the context of an optimal R&D tax policy: the marginal cost of public funds.

3.3 Marginal cost of public funds

Implementing fiscal incentives for R&D requires a closer investigation of the associated opportunity cost, namely the forgone tax revenue. In the context of R&D subsidy, the opportunity cost is the alternative benefit associated with lowering taxes (Dahlby, 2005). For example, governments can reduce personal income taxes rather than introducing R&D fiscal incentives. In the context of that example, governments must earn a return from the fiscal incentives that is larger than could be earned by lowering taxes. Otherwise, they could not justify the subsidy on efficiency grounds. Given that lowering taxes reduces the Marginal Excess Burden (MEB) of taxation (Browning et al, 2000), the marginal cost of public fund of the R&D incentive combines the one dollar tax

reduction and the reduced MEB. Baylor and Beauséjour (DoF, 2004) developed a general equilibrium model that generates an MEB of 0.3 implying a marginal cost of public funds (MCF) of 1.3.

3.4 Fiscal incentives measure

The economic literature provides only a few studies measuring fiscal incentives to R&D. One study from Warda and McFetridge (1983) presents the B-Index: the ratio of the after tax cost of a dollar spent on R&D, to the net income from one dollar of revenue. Warda and McFetridge (1983) include variables such as deductions, tax credits and corporate income tax rates. Their measure is useful in a number of ways. First, it introduces a numerical measure of fiscal provisions: the lower the B-index, the more favourable is the treatment of R&D. Second, it makes it possible to rank the attractiveness of tax systems towards R&D. Third, it serves as a threshold to analyze benefit-cost ratios within firms investing in R&D. In particular, if a project's benefit/cost ratio exceeds the B-index then the firm will find the project profitable. In spite of its usefulness, the B-index has some shortfalls. In particular, it fails to include important factors of influence in firms' decisions such as sales taxes, capital taxes and interest rates.

One measure including these factors is the marginal effective tax rate (METR) developed by Jorgenson (1963) and King and Fullerton (1983). The METR combines in a single measure the various elements of the tax regime, including corporate tax rate, deductions, retail sales taxes and capital taxes. Furthermore, it measures the effective tax burden on a marginal investment. One factor making the METR appealing is not only its simplicity but also its policy implications. For example, a high METR implies that the jurisdiction taxes heavily marginal investments. Therefore, policy makers can set METR targets and set fiscal policies that help reach that target. What's more, the application of METRs to R&D is straightforward since special R&D incentives are simply plugged in the standard METR derivation.

By and large, the literature on fiscal measurement of R&D is very limited compared to spillovers, or price elasticity studies. McKenzie (2007) presents an appealing framework, applying the METR to R&D in the context of multiple inputs and intangible capital. I adopt his methodology as the central piece of this major paper by amending certain assumptions and by measuring fiscal R&D incentives in Canadian provinces. Then, I discuss the results in the context of three key analysis variables listed above. Still, before I discuss the Canadian R&D METR, it is relevant to discuss the fiscal incentives that are provided for R&D at the federal and provincial levels.

4 THE FISCAL TREATMENT OF R&D IN CANADA

The federal government allocates considerable public resources towards the promotion of R&D. Its central subsidy, the Scientific Research and Experimental Development (SRED) program provides small Canadian controlled firms with a 35% refundable investment tax credit. The program additionally provides large Canadian controlled firms with a 20% investment tax credit. The refundable/non-refundable nuance of the credit is an important one. Refundable tax credits are synonymous to cash back to a firm for every dollar it spends on eligible assets. A non-refundable credit, however, is used to offset taxes payable in the current year or any other year as indicated by the legislation. SRED's eligible expenditures include: wages, salaries, materials, supplies as well as certain equipments. Moreover, SRED allows both large and small firms to expense immediately all current expenditures. Buildings and structures are the only assets not eligible for R&D fiscal incentives. Note however, that current expenditures make-up 90% of total R&D expenditures (Statistics Canada, 2005). This large proportion of eligible current expenditures helps explain that the federal subsidy is projected to total \$2.7 billion in 2007, up 27% from the year 2000 (Department of Finance, 2006)

Several provinces offer additional investment tax credits (ITC) piggy backing on the federal program. Note that the federal government grants its credit net of provincial

assistance. As a result, provincial incentives crowd-out federal incentives. Table 1¹ illustrates provincial investment tax credits on R&D investments for large corporations. Manitoba has the highest ITC while four other provinces do not offer credits.

Provinces	Large Canadian Controlled Firm			
	Provincial Credit		Federal Credit	
	Rate	Refundable?	Rate	Refundable?
Alberta	-	-	20%	No
British Columbia	10%	No	20%	No
Manitoba	20%	No	20%	No
New Brunswick	15%	Yes	20%	No
Newfoundland	15%	Yes	20%	No
North West Territories	-	-	20%	No
Nova Scotia	15%	Yes	20%	No
Nunavut	-	-	20%	No
Ontario	4.5%	No	20%	No
Prince Edward Island	-	-	20%	No
Quebec ¹	17,5%	Yes	20%	No
Saskatchewan	15%	No	20%	No
Yukon	15%	No	20%	No

1 - In Quebec, only R&D wages are eligible for R&D tax credits, not materials, equipment or overhead.

Given that every province bears a unique combination of taxes and subsidies, I have an opportunity of measuring their R&D incentives while at the same time ranking their relative R&D generosity. I do this by extending the McKenzie (2004, 2007) two stage methodology in the presence of multiple inputs and intangible capital. The following section outlines his methodology.

5 MCKENZIE METHODOLOGY

In this section, I present an overview of the methodology underlying the calculation of the METR on intangible R&D capital. First, I summarize the computation of the

¹ Source : http://www.investincanada.com/CMFiles/RD_Tax_Credits_eng_05_07.pdf

METR as it appears in McKenzie (2007). Second, I discuss the ways in which the approach in the current study differs from McKenzie's.

The standard method to estimate the METR extends from the neoclassical theory of capital investments where firms accumulate capital until the return on the marginal unit of capital equals its user cost. However, the nature of R&D requires that economists focus on production of R&D rather than investment. McKenzie's new two stage methodology recognizes that R&D is neither bought nor sold as an investment (McKenzie, 2007). Rather, it is produced by firms using multiple inputs. This production consists of two stages. In the first stage, firms select an optimal combination of tangible inputs to produce an intermediate intangible input. In the second stage, firms introduce the intermediate input in their production function and maximize their profits. The following lines discuss McKenzie's method in detail through backward induction.

5.1 Second Stage: Optimal Level of Intangible R&D Capital

In the second stage, the intangible R&D capital produced in the first stage is an input in the production process. Firms, therefore, employ this input up to the point where its before-tax marginal revenue² equals its after-tax user cost:

$$MR(A(x_i)) = MC(A(x_i))(1 + T_R)(\rho + \delta_A) \quad (1)$$

where A is the intangible R&D capital, x_i is the vector of tangible inputs employed in the production of A , $(\rho + \delta_A)$ is the user cost of A where ρ is the opportunity cost of equity and δ_A is the economic rate of depreciation. T_R is the effective tax rate on R&D production costs. McKenzie re-arranges equation (1) by defining, R_{ga} as the gross of tax, net of depreciation required return on an incremental unit of R&D as $R_{ga} = [MR(A(x_i))/MC(A(x_i))] - \delta_A$. This yields:

$$R_{ga} = [(\rho + \delta)(1 + T_R)] - \delta_A \quad (2)$$

² See equations (8) and (10) in McKenzie (2007)

It follows from (2) that firms only produce marginal units of intangible capital if the associated marginal revenue covers the user cost $(\rho + \delta_A)$ as well as the effective tax on production cost, T_R . In a jurisdiction without taxes, the required rate of return on the intangible capital would be $R_{ga} = \rho$. In this case, firms would only require that the revenue from a marginal unit of A cover ρ , the opportunity cost of equity. However, the tax system introduces a wedge between R_{ga} and ρ . It is the value of this wedge as a percentage of ρ that represents the marginal effective tax rate on intangible capital. Intuitively, the METR is also the effective tax rate that if applied directly to the user cost, ρ would yield the gross of tax, net of depreciation required return on an incremental unit of R&D, R_{ga} (McKenzie, 2007):

$$(1 + METR_{RD})\rho = R_{ga} \quad \text{where} \quad METR_{RD} = \frac{R_{ga} - \rho}{\rho} \quad (3)$$

The only unknown in the calculation of R_{ga} is T_R , the effective tax rate on R&D production costs which measures the percentage change in the production cost of A , due to the taxation of the inputs x_i (McKenzie, 2007). McKenzie obtains T_R by making a few assumptions on the properties of the production cost function. In particular, he uses a Leontieff fixed proportion cost function, consistent with the limited substitutability of inputs in R&D. In light of the above cost function, T_R becomes a weighted sum of the marginal effective tax rates on the individual inputs t_i :

$$T_R = \sum_i S_i(1 + t_i) - 1 \quad \text{where } i = L, K \quad (4)$$

where S_i is the factor share of the R&D input i (McKenzie, 2007). In the absence of taxes, the marginal cost of production is $MC(A; w_i, q(\rho + \delta))$ where w_i and $q(\rho + \delta)$ are the respective user costs of labour and capital. Once again the existence of taxes introduces a wedge in the production cost function such that

$$MC(A; w_i, q(\rho + \delta_K))(1 + T_R) = MC(A; w_i(1 + t_L), q(\rho + \delta_K)(1 + t_K)) \quad (5)$$

or

$$T_R = \frac{MC(A; w_i(1 + t_L), q(\rho + \delta_K)(1 + t_K)) - MC(A; w_i, q(\rho + \delta_K))}{MC(A; w_i, q(\rho + \delta_K))} \quad (6)$$

This is McKenzie's point of departure from stage 2. I proceed with the derivation of t_i , the METRs on individual inputs

5.2 First Stage: R&D Cost Minimization

In the first stage, firms minimize their cost by selecting an optimal combination of inputs to produce the intangible intermediate input A following a given production function $A(L, K, M)$, where L represents the labour and R&D contracts, M are materials, K are machinery, equipments and buildings (McKenzie, 2007). In the absence of taxes, the optimality conditions imply that firms employ these inputs up to the point where their marginal returns equal their user costs,

$$w_i = w_i^G, \quad i = K, L, M \quad (7)$$

where, w_i denotes the individual user costs and w_i^G is the return required by firms on the respective inputs. For simplicity, McKenzie sets w_i to unity, meaning that labour, material and capital are paid their marginal productivity, one dollar. Similarly, capital is paid its marginal productivity equal to its user cost $q(\rho + \delta)$ where $q = 1$. Here again, the existence of the tax system introduces a wedge in equation (7) and becomes

$$w_i(1 + t_i) = w_i^G \quad \text{and} \quad t_i = \frac{w_i^G - w_i}{w_i} \quad (8)$$

where t_i is the marginal effective tax rate on the individual inputs that, if applied to the initial user cost w_i would yield the return required by firms w_i^G . McKenzie goes on to obtain w_i^G by applying the appropriate fiscal provisions raising and lowering the initial

user cost w_i . These provisions include tax credits Φ , deduction of expenses Z , corporate income tax rates u and retail sales taxes rst . He expresses the individual METRs as

$$t_L = \left[\frac{w_L(1-\phi_F-\phi_P)(1-u_F-u_P)Z}{(1-u_F-u_P)} \right] - w_L \quad (10)$$

$$t_M = \left[\frac{w_M(1+rst)(1-\phi_F-\phi_P)(1-u_F-u_P)Z}{(1-u_F-u_P)} \right] - w_M \quad (11)$$

$$t_K = \left[\frac{q(1+rst)(1-\phi_F-\phi_P)(1-u_F-u_P)Z + (C_{tax}(1-u_F-u_P))(1-\phi_F-\phi_P)/q(\delta_K + \rho)}{(1-u_F-u_P)} \right] - 1 \quad (12)$$

where u_F and u_P denote the federal and provincial corporate income taxes and C_{tax} is the capital tax.

McKenzie's two stage method of estimating METRs is theoretically and practically suitable for the production of R&D. For one, it recognizes that R&D is an intangible capital produced in-house by firms. Plus, it measures accurately the tax wedge due to the taxes and credits applied on the inputs. Nevertheless, McKenzie makes certain questionable assumptions in his derivation of the METRs. I believe that changing these assumptions changes significantly the results. Therefore, the main contribution of this major paper is to propose five amendments to McKenzie's methodology, in light of economic theory as well firms' accounting practices.

First, McKenzie assumes that firms finance their production of R&D through equity solely. In that case the arbitrage conditions require that

$$\rho[\gamma\delta + (1-\gamma)c] = i(1-t) \quad (13)$$

Put another way, the investor has choices with his money. One is to purchase equity for which he receives dividends. Another is to deposit his funds and earn the nominal rate of interest. In equilibrium he will be indifferent between both choices if the after tax return on equity and interest are equal. This occurs in equation (13), where i is the nominal interest rate, t is the personal tax rate on interest income, θ is the effective tax rate on

dividend, c is the effective capital gains tax and γ is the dividend payout ratio (McKenzie, 2007). Accordingly, the opportunity cost of using equity becomes:

$$\rho = \frac{i(1-t)}{\gamma\theta + (1-\gamma)c} = \frac{i(1-t)}{c} \text{ if } \gamma = 0. \quad (14)$$

If R&D producing firms do not emit dividends then $\gamma = 0$ and the opportunity cost of equity becomes the ratio of after-tax interest income over the effective tax rate on capital gains; both of which are observable. McKenzie (2007) assumes 24.87%, 10% and 16.16% for t , i and c respectively. Assuming that firms finance production exclusively through equity ignores the reality that firms generally finance their production using debt as well as equity. Given that the federal and provincial income tax regimes allow firms to deduct interest expenses, amending this assumption has a significant impact on the METR. In fact, this deduction puts downward pressure on the R&D METR, the magnitude of which differs across provinces depending on the provincial corporate income tax rate: the higher the tax rate, the higher the magnitude of the interest deduction. Once again arbitrage conditions hold and firms choose an optimal debt equity policy subject to tax savings. Following Boadway et al. (1984), I use the following as the real cost of financing:

$$rf = \beta i(1-u) + (1-\beta)\rho - \pi \quad (15)$$

$$R_n = \beta i + (1-\beta)\rho - \pi$$

where π is the rate of inflation, β is the proportion of production expenditures financed by debt, $(1-\beta)$ is the proportion of production expenditures financed by equity and R_n is the return required by firms in the absence of taxes.

The second amendment I make revisits McKenzie's second stage derivations where the intangible input enters the production process. His approach suggests that input A is employed such that

$$\frac{\partial R}{\partial A} = MR(A(x_i) = MC(A; w_i, q(\delta_A + \rho))(1+TR)(\delta_A + \rho) \quad (16)$$

The optimality condition for input A is such that the before-tax marginal revenue equals the after-tax marginal cost of using input A . I believe that equation (16) should equate the after-tax marginal revenue to the after-tax marginal cost. Focusing on the before-tax marginal return assumes that marginal returns will not be taxed. In reality, firms consider the extent to which corporate taxes reduce profits before producing R&D. One interesting point is worth noting here. McKenzie's method includes corporate income tax rates to calculate METRs on tangible inputs in the first stage. This is problematic given that corporate income tax rates apply only to income generated by intangible capital A . Corporate income taxes in the current paper pertain only to income in the second stage of the derivation rather than the first. Nevertheless, two factors combine to ensure that the above transformation does not change the end METR. First, the derivation of the marginal costs of production in stage 1 includes the partial derivative of the conditional input demand functions. Given that they are homogenous of degree zero in prices, dividing them by $(1-u_f-u_p)$ does not change their optimal input level. Second, the fiscal system allows firms to expense 100% of their R&D input costs. As a result, $(1-u_f-u_p)$ in equations (10), (11) and (12) simplify to unity. One conceptual problem arises in the calculation of METRs for a jurisdiction which allows input cost deductions yielding $Z \neq 1$. Consequently, it is more appropriate to include income tax rate in the second stage.

The third amendment relates again to the second stage of McKenzie's methodology specifically in equation (16). The federal government along with several provinces apply capital taxes on large corporations (Department of Finance, 1996). The base of the tax is the capital value of the firm which includes its total debt and equity. Given that increasing R&D production further increases capital tax payable through higher debt and equity, I find it appropriate to apply capital taxes to the user cost of intangible capital such that equation (16) becomes:

$$R_{ga} = \left[\frac{(1+TR)(rf + \delta_A)(1+C_{tax})}{(1-u_F - u_P)} \right] - \delta_A \quad (17)$$

For the purpose of the current study, C_{tax} includes the federal large corporation, the capital cost allowances available to firms as well as the provincial capital taxes. Theoretically, this transformation changes the McKenzie METR estimates in two ways. First, it accounts for the fact that intangible capital production increases capital taxes paid by firms – meaning a downward pressure on the METR. Second, it accounts for the fact that certain jurisdictions tacitly provide incentives for intangible capital production by exempting R&D producing firms from the capital tax. Including C_{tax} improves, therefore, the relative fiscal generosity of certain provinces.

The fourth amendment relates to the federal and provincial R&D credit in McKenzie's method. His approach suggests that both credits are independent, meaning that the effective tax credit is simply the sum of the provincial/federal credits. In fact, the federal government provides its credit net of provincial assistance (Warda, 1999). As a result, the effective tax credit becomes $\theta_{FP} = (1 - \theta_F)(1 - \theta_P)$ rather than $\theta_{FP} = (1 - \theta_F - \theta_P)$. Provincial R&D tax credits reduce the total amount of expenditures eligible for the federal R&D tax credit and deduction. For this reason, the McKenzie approach overestimates slightly the effective tax credit in provinces where $\theta_P \neq 0$.

The fifth amendment involves the model as a whole. The McKenzie approach suggests that five inputs produce A : equipment, buildings, labour, materials and contracts. This assumption overlooks two facts. First, buildings, whether engaged in R&D or not, are not eligible for the R&D credit (Warda, 1999). Furthermore, they receive the same fiscal treatment across Canada so their inclusion in the METR introduces a level effect and no additional explanatory power for METR differences across provinces. In fact, they put undue upward pressure on the METR. Second, the federal R&D tax treatment includes overhead costs as eligible R&D expenditures (Government of Canada, 2007). These overhead costs generally include costs associated with the use of labour and materials. Accordingly, the federal R&D treatment allows firms to claim a maximum of 65% of R&D salaries as overhead costs. Since firms claim fiscal incentives on machinery / equipment, labour, material, contracts and overhead costs, these should be the inputs of interest in the estimation of the R&D METRs.

As mentioned above, McKenzie's two stage approach is an excellent contribution to the literature on fiscal R&D measurement. Not only does it outline clearly the theoretical intricacies of METRs, but it also captures the production process of R&D. The current paper extends McKenzie's approach by amending some practical aspects of his methodology. Given the large data sets available through federal agencies, producing estimates from the amendment above is somewhat straightforward. The following section explores further the data I use to estimate the R&D METR in Canada.

6 DATA AND ECONOMIC PARAMETERS FOR METR

This section outlines the economic parameters adopted in the model. They include: the return required by savers, the debt equity ratio, the economic depreciation rate, the tax rates as well as the capital weights used to aggregate the R&D METRs in Canada. It is important to note that some parameters in the current analysis differ from those in McKenzie (2007). One reason is that McKenzie (2007) does not publish all its variables. Another is that some parameters were assumptions that I set aside. Nevertheless, I provide explanations when parameters differ.

Equation (14) makes use of arbitrage conditions and the nominal interest rate i to estimate ρ the opportunity cost of finance through equity. Theoretically speaking, i is the risk-free nominal rate of return; an alternative to equity investment. It follows that a high i implies a higher ρ , which makes R&D production less attractive given the higher financing cost. McKenzie assumes $i = 10\%$. Yet, I find it appropriate to use $i = 4\%$, which is the average return on the government of Canada 10 year bonds over a 10 year period ending in 2006 (Bank of Canada, 2007) – widely considered as the ultimate risk free investment. Any return on investments must at least match this return. Changing this parameter causes some changes in the METR. For one, it makes equity as well as the user cost of finance less expensive, putting downward pressure on the METR. What's more, it reduces the tax wedge which represents the hurdle R&D production overcomes to be profitable.

I have made an amendment to the McKenzie method which suggests that firms finance their production through debt and equity following a given debt / equity ratio β . I base this ratio on data from the Quarterly Survey of Financial Statistics from Statistics Canada (2007). If firms finance their activities through debt and equity, then taking the ratio of their borrowings and total equity should reflect β . To that end, I use the Survey's summary tables and take an average of the debt-equity ratio for all industries spanning in last quarter available. As result, $\beta_{2006} = \text{total borrowings} / \text{shareholder's equity} \approx 0.4$.

While McKenzie adopts a 3% inflation rate, the current study uses a 2% inflation rate; mainly to be consistent with the midpoint of the Bank of Canada's target. McKenzie (2007) applies an 18% economic depreciation on physical capital as well as intangible capital A . While I adopt the same rate for tangible capital, studies have suggested different rates of economic depreciation on intangible capital. In particular Nadiri and Prucha (1993) survey several studies on the issue and estimate a depreciation of R&D capital of 12%. The concept of economic depreciation on intangible capital is a subtle one. What causes intangible capital depreciation? Conventional economic wisdom identifies two factors. First, intangible capital is subject to creative destruction (Schumpeter, 1942), which occurs when new inventions render old ones obsolete. Second, intangible capital is subject to diffusion. This occurs as a result of corporate secret leaks, generic replicas or the expiration of patents. Given the importance of this parameter and the difficulty in estimating it, this study adopts the 12% rate following Nadiri and Prucha (1993).

The tax parameters in this study are obtained from documents of the Department of Finance. They consist of: corporate income tax rate, capital tax, payroll taxes, retail sales taxes and investment tax credits. I make special note of two parameters: the statutory corporate income tax, CIT as well as the payroll tax. I obtain CIT by combining the federal and provincial CIT. The Canadian tax regime treats manufacturing income differently, so CIT on manufacturing include: the federal rate CIT, the federal reduction for manufacturing income as well as the federal surtax on corporate income. The current

study also assumes that firms bear a third of payroll taxes, following Dahlby (2005). Note here that this adjustment does not account for other hidden payroll taxes such as pension plans or payroll premiums. Since these measures follow schemes where firms pay a percentage of the wage capped at a given amount, including them would be tedious without adding much explanatory power to the METR. Table 2 shows the rates used in this study.

Provinces	Table 2 (%)				
	Prov CIT	Fed/Prov CIT	Sales tax	Payroll Tax	Prov Capital Tax
Alberta	10,0	32,1	0	-	-
British Columbia	12,0	34,1	7	0	-
Manitoba	14,0	36,1	7	2,15	0,5
New Brunswick	12,0	34,1	0	0	0,2
Newfoundland	9,5	31,6	0	2	-
Nova Scotia	16,0	38,1	0	0	0,225
Nunavut	12,0	34,1	0	0	-
Northwest Territories	11,5	33,6	0	0	-
Ontario	13,0	35,1	8	1,95	0,285
Prince Edward Isl.	16,0	38,1	10,6	0	-
Quebec	9,9	32,0	0	4,26	0,49
Saskatchewan	11,5	33,6	5	0	0,23
Yukon	8,8	30,8	0	0	-
Canada	-	22,1	6	0	-

This paper makes use of a unique database on capital and investments available at the Department of Finance and Statistics Canada. Researchers have calculated the weights for specific R&D inputs in two steps.

In the first step, researchers at the Department of Finance used T2 tax files from a large sample of firms and disaggregated their R&D investments into current³ and capital⁴

³ Current = labour, overhead, contracts, material expenditures.

⁴ Capital = machinery & equipments expenditures.

expenditures. They then used these expenditures as a proxy for R&D inputs and to answer three questions. First, what portion of firms' expenditures was dedicated to R&D investments? Second, what was the relative importance of a given R&D input in a specific industry? Third, what was the relative importance of R&D investments in every industry⁵?

The second step consisted of merging the data from step one to data from Statistics Canada (STC). The Capital Stock Division at STC have measured the industrial composition of every province. So, the idea in the second step is to merge this provincial industry composition to the industrial R&D expenditures from step one. At the end of these two steps, researchers had the R&D input composition of every industry as well as the relative importance of these industries in every province. In the context of the current study, the relative impact of an R&D fiscal measure not only depends on the R&D input it impacts but also the relative importance of R&D investments in provinces. The following section presents and discusses METR estimates using these various aggregations. It discusses briefly the McKenzie results and examines why they are different.

7 RESULTS

This section provides estimates of the METR on intangible capital for Canadian provinces. The estimates include all corporate tax changes announced in provincial/federal budgets in 2007. The analysis does not include however, assistance such as direct government spending. The results answer the question: to what extent do the provincial/federal tax systems drive a wedge between the before and after tax required return on a marginal R&D production project (McKenzie, 2005)⁶? In theory, if firms undertake a R&D production project, then they will require greater expected returns than they would in the absence of corporate taxes. In other words, if the METR is positive, then the fiscal regime taxes marginal R&D production more than it subsidizes it.

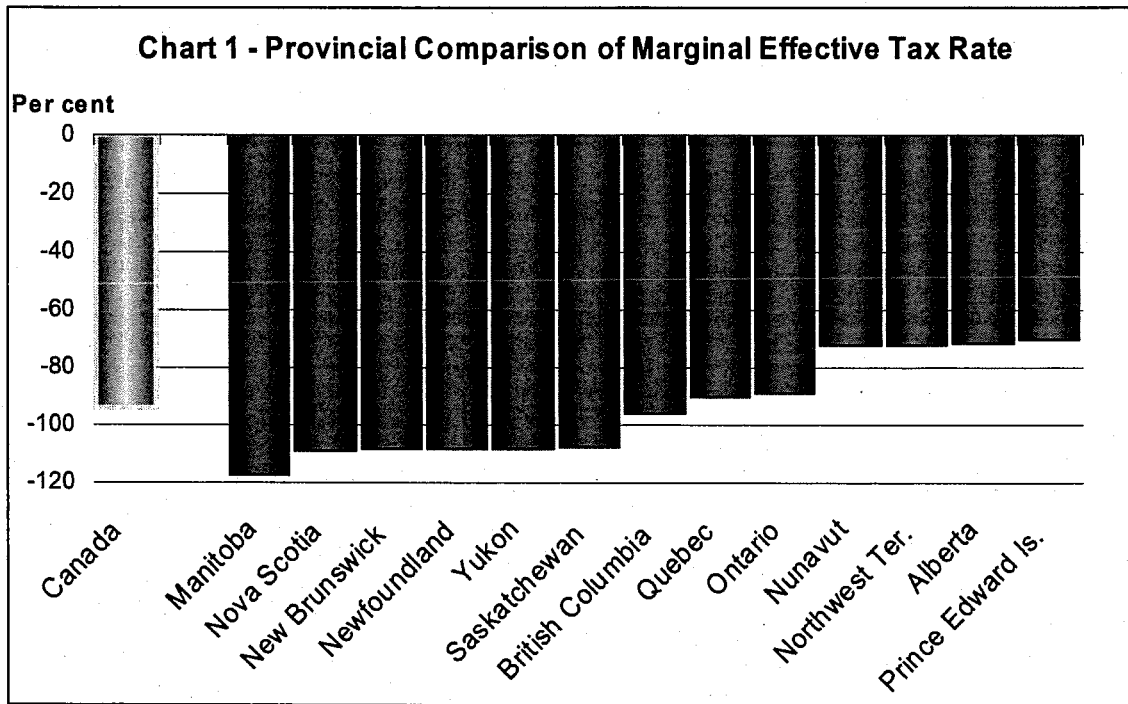
⁵ Industries denote here an amalgam of firms aggregated according to the North American Industry Classification System (NAICS).

⁶ Tax wedge = $Rga - Rn$.

On the other hand, if the METR is negative, the tax system encourages the marginal R&D production by lowering the return required by firms such that R_{ga} becomes:

$$(1 + METR)R_n = R_{ga} \quad \text{where} \quad METR = \frac{R_{ga} - R_n}{R_n} \quad (18)$$

I make a number of working assumptions in order to focus on the comparison of differences in provincial tax systems. For one, in addition to the amendments in the previous section, I focus on large profitable firms producing R&D. This is mainly due to the relatively simpler gathering of provincial corporate tax parameters. Firms claim immediately the credits and deductions as they are earned. The alternative is that firms capitalize credits and deductions rather than expensing them. Doing so causes specific advantages and disadvantages which I cover later in this study. Chart 1 compares R&D METRs for Canadian provinces.



The output in chart 1 differs significantly from McKenzie's (see appendix 1). In particular, Chart 1 presents the R&D METR ranging from -70.6% to -117.6% compared to -32% to -163.1% in McKenzie (2007). There are several reasons for this difference in

range. One is that the current framework lowers the user cost by allowing firms to finance through equity or debt with its deductibility of interest expenses. The user cost of finance is also reduced by a lower nominal interest rate which changed from 10% to 4%. Accordingly, the tax wedge: $R_{ga}-R_n$ is reduced along with the METR in all jurisdictions. The lower user cost, R_n also increases the nominal value of the METR. Another reason for the smaller range of METRs is R_{ga} . R_{ga} in the current study is likely close to McKenzie (2007) given that it reflects existing tax parameters such as taxes and credits. It follows that for a similar R_{ga} , if $R_n < \rho$, then the range of the tax wedge in absolute terms is $|R_{ga} - R_n| < |R_{ga} - \rho|$.

The relative generosity of provincial incentives differs under both frameworks. Specifically, McKenzie (2007) shows Quebec as the most fiscally generous province by a wide margin. Quebec is followed by Saskatchewan and New Brunswick. Yet, estimates in chart 1 put Quebec as the seventh most generous province (out of thirteen provinces and territories) while Manitoba is the most generous. McKenzie's estimates show Manitoba as the sixth most generous province in the country. The fact that Manitoba has the highest provincial tax credit, 20%, suggests that it should be near the top of the ranking. Furthermore, the 17.5% R&D credit in Quebec applies only to R&D wages, not to materials, equipments or overhead costs which dampens the effect of the incentive. On the other hand, five provinces offer 15% credit on all R&D cost, making their effective provincial credits more generous than Quebec's.

On the other hand, McKenzie's showing of Prince Edward Island and Alberta as the least generous provinces is supported by the current study. Indeed, neither Alberta nor Prince Edward Island offer provincial incentives for R&D in excess of federal incentives. The same can be said for the Northwest Territory and Nunavut. In fact, if one assumes that provinces compete for R&D resources through heavy R&D subsidies, then one must conclude that Alberta and Prince Edward Island have decided to stay out of the competition. One possible reason could be that their industrial structures contain firms that are not sufficiently responsive to federal incentives.

The provincial ranking in Chart 1 also reveals four groups of provinces: those with a high, medium, low and zero provincial R&D credits. Manitoba stands as the most generous R&D province with the highest provincial tax credit and the lowest METR of -117.6%. Saskatchewan, Newfoundland, Nova Scotia, New Brunswick and the Yukon compose the second group with a medium investment credit of 15%. Their R&D METRs range from -107.5% in Saskatchewan to -108.9 % in New Brunswick. Such a low range suggests that movements in ranking in this group are insignificant and likely explained by differences in statutory tax rate, sales tax or capital tax. Note that while these provinces rank from 2 to 5 in McKenzie's estimates, their nominal range varies significantly from -129.4% in Newfoundland to -139% in Saskatchewan. This 10% range suggests that an economic parameter other than credits and taxes explain provincial difference. Interestingly, the three most industrialised provinces, British Columbia, Ontario and Quebec make up the third group with low investment tax credits. British Columbia has the lowest METR of the group with -96.4% while Ontario has the highest with -88.9%. This should also be expected given that Ontario's 4.5% investment tax credit is the lowest in the group. Note that the estimates put the Quebec METR between the British Columbia and the Ontario METR. In fact, its 17.5% credit on wages yields an effective R&D credit less generous than 10% yet higher than 4.5%. Alberta, the Northwest Territory, Nunavut and Prince Edward Island form the last group with zero investment tax credit resulting in relatively higher R&D METRs ranging from -70.6% in Prince Edward Island to -72.2% in the Northwest Territory. Chart 1 illustrates nearly identical METRs for Alberta, the Northwest Territory and Nunavut. This is due in large part to their nearly equal provincial/territorial corporate income taxes. Moreover, none of these provinces/territories apply retail sales taxes. Accordingly, the METR in these provinces reflects only the inputs cost deduction and the federal investment credit. The METR in Prince Edward Island is slightly higher because the province has the highest provincial retail sales tax.

Chart 2 shows the regional aggregation of provincial METRs. Estimates show that Atlantic firms face the lowest R&D METR. This is due in large part to generous tax incentives in New Brunswick, Nova Scotia and Newfoundland. Conversely,

Northern territories have the highest METRs among Canadian regions. This is because the Yukon is the only territory from the group that offers incentives beyond the federal incentives.

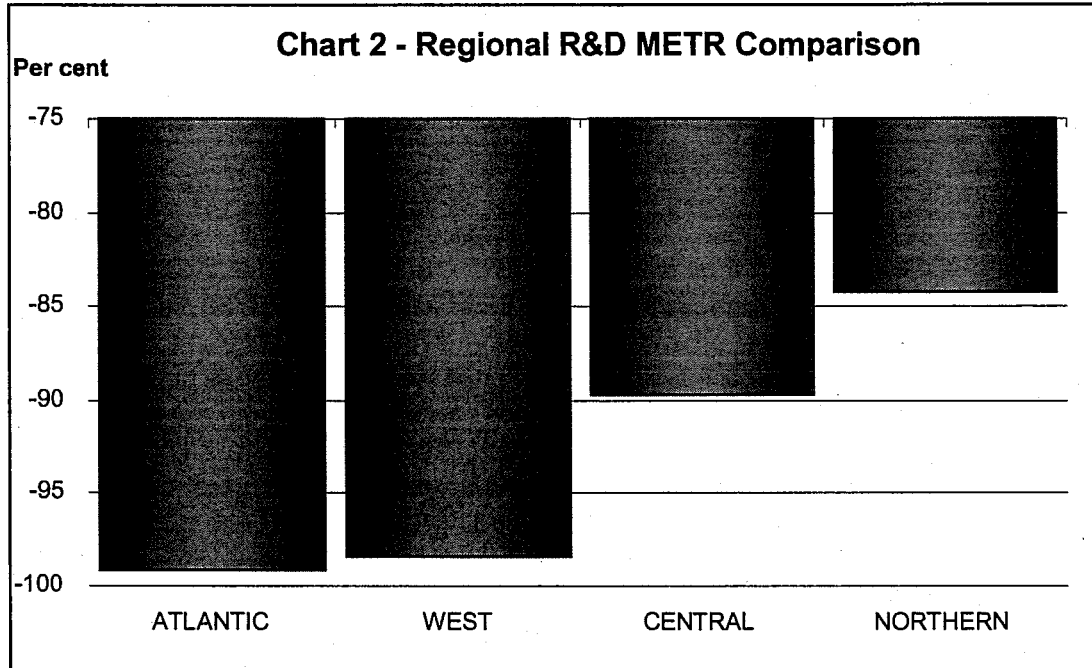
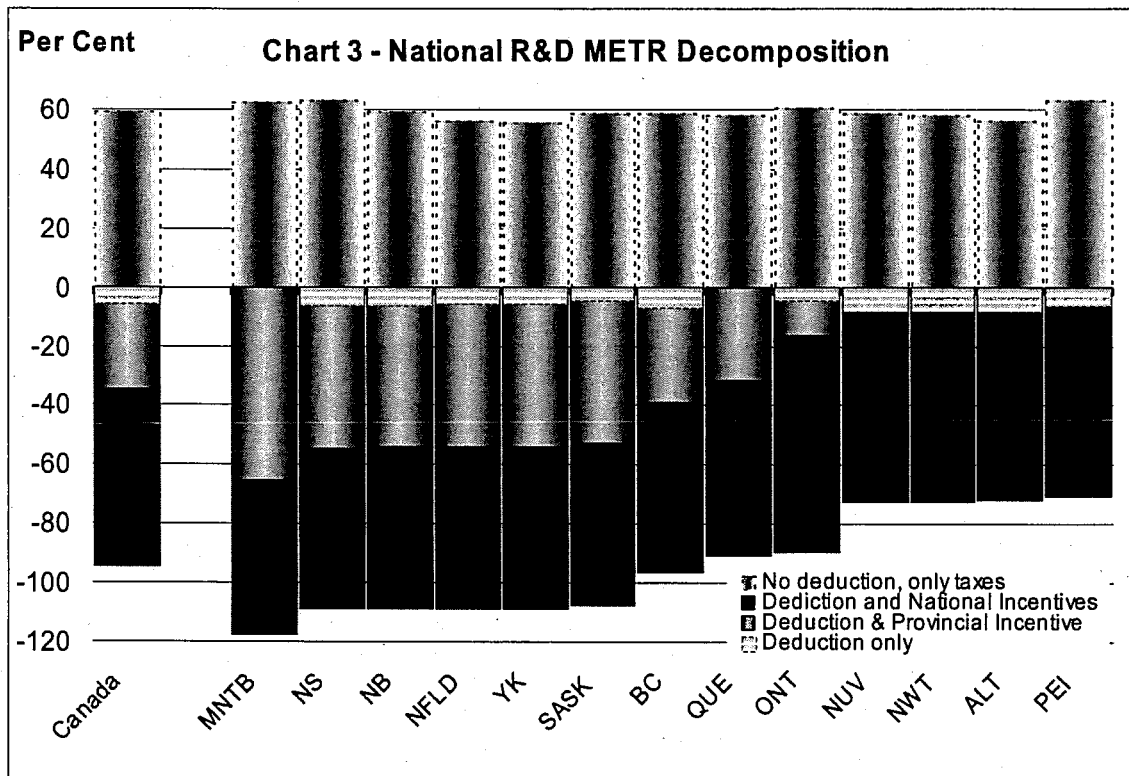


Chart 3 decomposes the national and provincial METR in three groups of incentives: tax deduction, provincial and federal investment tax credits. It is useful to view this chart in the context of a fictional example. Imagine a firm deciding whether to undertake an additional R&D production. The firm finances the R&D project through equity and debt. I have shown in previous sections that this marginal investment must return at least $R_n = \beta_i + (1 - \beta) \rho - \pi$, the user cost of finance, otherwise the firm will not undertake the R&D project. If the tax system applies federal and provincial taxes to R&D projects without subsidies then, the national METR would be 59.2% (as shown in Chart 4). In other words, firms would require a return of $(1.592 * R_n)$ before undertaking the R&D project. However, if the tax system applies taxes as well as the 100% input cost deduction then the national METR reduces dramatically from 59.9% to -5.6%. In this case the firm only requires that the project returns $(-0.944 * R_n)$ before undertaking it. In fact, the impact of the interest and expense deductibility would be larger without income insensitive taxes such as payroll, retail and capital taxes. Saskatchewan, Ontario

Manitoba and Quebec, in particular apply capital taxes, putting a substantial upward pressure on their provincial METR. For example, in spite of interest and input deductibility, the Quebec and Manitoba METR hover near zero. Alberta, Nunavut and the Northwest Territory do not apply such taxes so they show deeper negative METRs than other provinces. The deductibility of debt interest puts further downward pressure on the user cost of finance resulting in firms requiring a return slightly less than R_n before undertaking the project. If provincial systems add R&D tax credits to the example, then the national METR becomes negative: -34.9%. For instance, firms in British Columbia benefiting from a combination of tax deduction and provincial credits only require that the marginal R&D project return be 61.1% of the user cost⁷ since the tax system subsidizes the rest.



The last component of tax incentives is the federal tax credit. Chart 4 indicates that the 20% federal credit pushes the national METR from -34.9% to a deep -94.02% and reduces the provincial METR by an average of -59%. Its largest impact is in Prince

⁷ $(1 + METR)R_n = R_{ga} = (1 - 0.3893)R_n = 0.611 * R_n$.

Edward Island, Alberta, Nunavut and the Northwest Territory while it is smallest in Manitoba. This should be expected given that the federal credit is applied net of provincial assistance. So, a higher provincial incentive reduces the extent of the federal incentive. Nevertheless the provincial and federal R&D incentives combine to apply an extremely generous tax system. In the context of the above example, the firm only undertakes an R&D project if the expected marginal return R_{ga} equals the user cost. However, the Canadian tax system affects this equality by reducing the user cost of R&D by 94.02%. In the absence of fiscal measures, this user cost would be $R_n \approx 4.6\%$; the cost of finance associated with the project. However, incentives allow the firm to undertake a project earning a before tax return as low as 0.0027%⁸ and still make economic sense. This is because the R&D METR introduces an expected return “floor” on R&D projects. Indeed, if the firm only requires a return as low as 0.0027%, the tax subsidies will step in, increasing the project’s return to match its cost of finance, 4.6%. On the other hand, if the firm undertakes a project with an expected return exceeding 0.0027% then the project’s after tax return exceeds its cost of finance. Needless to say that Canada subsidizes heavily R&D production.

7.1 Sensitivity Analysis

When interpreting this study’s results, it is important to note that its conclusions are sensitive to some of the parameter assumptions. For example, under the current framework, a rate of economic depreciation of 25% as opposed to 18% would have yielded a negative required return by firms. Similarly, a debt/equity ratio of 50% should have generated a Canadian METR of -100.86%. Other assumed parameters include the rate of inflation as well as the nominal rate of interest. To calculate a range of parameter estimates, I add and subtract percentages from the base estimates. Doing this makes possible an estimation of the contribution of these parameters on the final METR. Furthermore, it allows an analysis of “what if” situations. For instance, what if the rate of economic depreciation of the intangible capital was 5% or 25% as opposed to the 18% in the analysis?

⁸ $(1 + METR)R_n = R_{ga} = (1 - 0.9402)R_n = 0.06 * 0.046 = 0.0027\%$

I present the sensitivity simulations with Appendices 3 through 8 where the initial trend line is the base case provincial ranking. I then perform two simulations, and superimpose the new ranking trend lines. The simulations reveal that while changing parameter assumptions affect the nominal METR, they do not change much of the rankings. For example, changing the rate of economic depreciation from 12% to 5% or 25% change the national METR from -94.02% to -66% and -122% respectively. However, appendix 3 shows little movement in terms of ranking. Manitoba remains the most generous province while Prince Edward Island and Alberta are the least generous provinces. Movements in ranking occur at the tails of the trend. For example, changing the rate of depreciation from 12% to 5% moves Alberta from the 12th rank to the 13th, while Prince Edward Island jumps from 13th to 12th. These are negligible changes given that the movements are due to the nominal proximity of the provincial METRs. Appendix 4 and 5 tell a similar story for sensitivity simulations from the rate of inflation as well as the nominal rate of interest: changing the assumption changes the METR while leaving ranking relatively unchanged. In contrast, a change in the debt/equity ratio from 30% to 20% or 40%, changes the ranking significantly because it transforms firms' financial structures at the provincial level. The biggest change is within the groups of provinces offering a 15% tax credit: Nova Scotia, Newfoundland, Yukon and Saskatchewan. A lower debt/equity ratio implies a lower debt deduction for firms, which in turn puts an upward pressure on the provincial METRs. For this reason, Nova Scotia falls from the second most generous province to the fifth. Similarly, the Yukon bounces from the fifth most generous to the second. It is also helpful to keep in mind the corporate income tax rate as it relates to the debt/equity ratio. For a given debt/equity ratio a higher provincial corporate income tax rate puts a greater downward pressure on the METR because $R_f = \beta i(1-u) + (1-\beta)\rho$. For this reason the 10% debt/equity ratio simulation minimizes the debt deduction associated with the corporate income tax rate. On the other hand, a higher debt/equity ratio amplifies debt deductions, as is the case for the 50% simulation. The combination of a 16% corporate income tax rate pushes Prince Edward Island from the 13th to the 11th, ahead of Alberta and the Northwest Territory.

The above simulations suggest that the current methodology yields sensitive METR estimates. Therefore, the interpretation of the results should emphasize the relative generosity of provinces rather than nominal interpretations.

7.2 Discussion

It becomes relevant at this point to discuss some policy implications arising from the above calculations. I have shown in previous sections that tax incentives in Canada are quite large. Given the presence of positive spillovers from R&D production, it is not surprising to see negative METR. However, the fundamental issue is whether it is fiscally optimal to have a system generating such deeply negative METRs. Dahlby (2005) investigates the optimal tax treatment of R&D in the context of provincial distortionary taxes. He outlines three elements relevant to this issue.

The first element is R&D spillovers. These spillovers ensure that the social returns to R&D exceed the private returns. As a result, the optimal tax policy on R&D is a subsidy equal to the external rate of return on R&D. From this perspective, governments must provide subsidies regardless of the tax sensitivity of R&D production (Dahlby, 2005). This seems to support the idea that such deeply negative R&D METRs in Canada must be maintained despite low tax responsiveness.

Bernstein (1996 and 1997) estimates the external rate of return to R&D. He concludes that the social rate of return exceeds the private rate of return by a factor ranging from one to two and a half depending on the industry. In light of this, the effective subsidy rate to R&D production should reduce private costs by the same margin (as is the case in the METR estimates). The second relevant element in this issue is tax sensitivity of R&D. Optimal R&D tax treatment requires higher subsidy in the presence of high tax sensitivity. As I have mentioned above, studies from Mansfield & Switzer (1985), Bernstein (1996) and the Department of Finance (1997) estimate that an additional dollar of R&D subsidy stimulates investment to the effect of \$1.00 to \$1.38.

Given that these studies do not include the responsiveness of provincial incentives, the federal/provincial responsiveness might be significantly larger. This suggests that the tax sensitivity of R&D tax expenditures complements such highly negative METRs.

The third relevant element relates to the marginal cost of public funds (MCF) (Dahlby, 2005). In the presence of distortionary taxes, providing a tax subsidy to R&D implies other tax increases to finance government expenditures. So, the opportunity cost of providing an additional dollar of R&D tax subsidy is the forgone opportunity to lower other distortionary taxes (Dahlby, 2005). Dahlby goes on to suggest that an optimal policy must compare the marginal benefit from enhancing the tax subsidy with the marginal cost of public funds. Dahlby (1992) calculates the MCF across provinces and finds that it ranges from 1.40 in Quebec to 2.00 in Alberta.

The above elements provide helpful intuition in the interpretation of current estimates. First, additional provincial R&D tax subsidies may not be warranted in certain provinces. Federal incentives already reflect external the rate of return, large spillovers as well as R&D tax sensitivity. Furthermore, as in any federation, the federal government can raise revenue at a lower cost than provincial governments. As a result, it might be optimal to leave it as the single provider of R&D incentives. Second, the provincial METR ranking could be a reflection of their MCF. For instance, given that Alberta has a higher MCF, it is not surprising that it provides no incentives beyond the full deductibility and the federal credit. Conversely, Manitoba and Nova Scotia benefit from lower MCF allowing them to apply additional provincial incentives and lower METRs.

7.3 Discussing the methodology used

While the current methodology allows for an intuitive comparison of provincial METR, it ignores some other elements of influence that may be captured in subsequent

frameworks. In particular, by assuming that all firms expense all costs, the current methodology fails to capture the R&D incentives when firms decide to capitalize expenditures rather than expense them. For example, if an R&D project spans over a period of ten years, then the firms will employ a flow of inputs in the production process until the project is completed or when a discovery is made. From these perspectives, firms can treat R&D expenditures in two ways. They can expense them – that is all costs are written off at the time they are incurred. This option reduces profits through cost reporting (Atallah and Khazabi, 2005). Alternatively, firms can capitalize expenditures – that is a portion is written off in the current period while another portion is reported as expenses in future periods (Atallah and Khazabi, 2005).

Several factors influence firms' decision to capitalize rather than expense R&D costs. For one, capitalization increases R&D current profits by suppressing cost, which attracts investors. Second, expensing encourages faster reporting of R&D expenditures (Atallah and Khazabi, 2005), which serves to reveal strategic information about the firm to competitors. Capitalizing expenditures helps to hide R&D expenditures from competitors. Third, Section 3450 of the Canadian Institute of Chartered Accountants (CICA) requires that firms capitalize costs that meet certain criteria (Atallah and Khazabi, 2005). It follows that Canadian firms listed on the US as well as the Canadian stock markets may opt for a single reporting method and adopt capitalization across both jurisdictions.

Furthermore, while the current methodology assumes that all firms expense all R&D cost to benefit from the 100% cost deduction immediately, Callimaci and Landry (2003) find that 28% of firms, high-tech and biopharmaceutical firms, capitalize a portion of their R&D cost. Mintz and Mackie-Mason (1991) find that the time delay under capitalization reduces the value of cost deductibility and hence incentives. They also find that capitalization distorts the optimal time path when firms choose a debt/equity ratio – firms begin with a low debt/equity ratio that rises over time. This finding relates to the high METR sensitivity to changes in the debt/equity ratio: if indeed the debt/equity ratio of firms changes over time, the current METR calculation fails to capture the true

measure of the tax wedge. Mintz and Mackie-Mason (1991) further find that capitalization affects the time taken to complete a project. If delaying deductibility increases overall current input costs then firms have an incentive to finish the project more quickly than under expensing. This finding could provide an intuitive explanation of firms' R&D behaviour. On one hand, it could be that firms only capitalize expenses in the presence of short term projects with a high probability of success. Then again, capitalizing firms may rush the completion of R&D projects resulting in lower social return to R&D and lower spillovers in the long run.

While the current methodology reconciles theory and practice in R&D production, it still lacks certain important features. A subsequent analysis should amend the cost and production functions to account for the time delay in the accumulation of intangible capital as well as its use in the production function. Subsequent amendments of the methodology should also include considerations of expensing versus capitalization as they relate to the optimal time (as well as the probability of success) of a given R&D project. Doing this would provide helpful insight in the tax wedge introduced by the tax system.

8 CONCLUSION

I have achieved in this major paper two purposes. First, I investigated the economic rationale for R&D incentives. Second, I have amended the framework of McKenzie (2007) for measuring the relative R&D generosity of Canadian provinces. Using ranges of economic parameters, I have shown that the federal and provincial incentives combine to create a deeply generous tax system for R&D. The analysis suggests that tax credits have a large effect on METRs – making certain provinces largely generous relative to others. More generally, the analysis highlights the fact that the federal government's R&D incentives suffice to transform Canada into a vastly generous jurisdiction.

It is difficult to determine whether the current methodology captures all the economic realities related to R&D on the private and social sides. For one, some

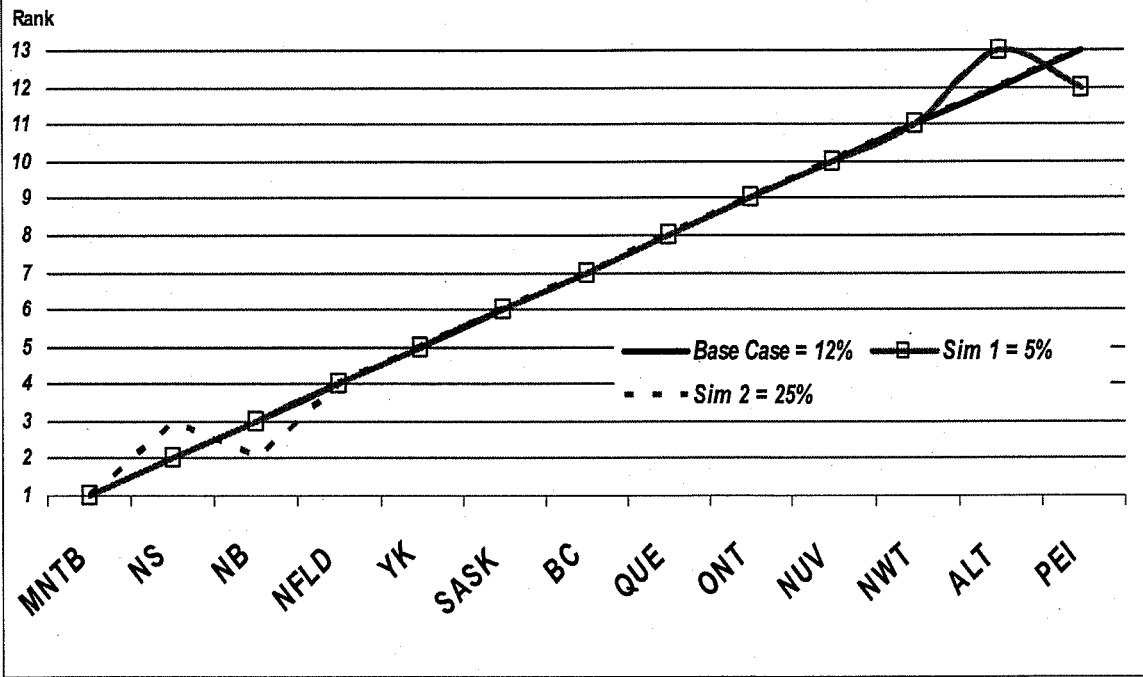
accounting practices by firms affect R&D production but cannot be measured. Also, the methodology is silent on the economic efficiency of these incentives. In light of this, the measuring of fiscal incentives should be done in the context of parameter ranges and provincial ranks. Furthermore, the presence of time in the production of R&D warrants an ongoing improvement of the methodology.

APPENDIX

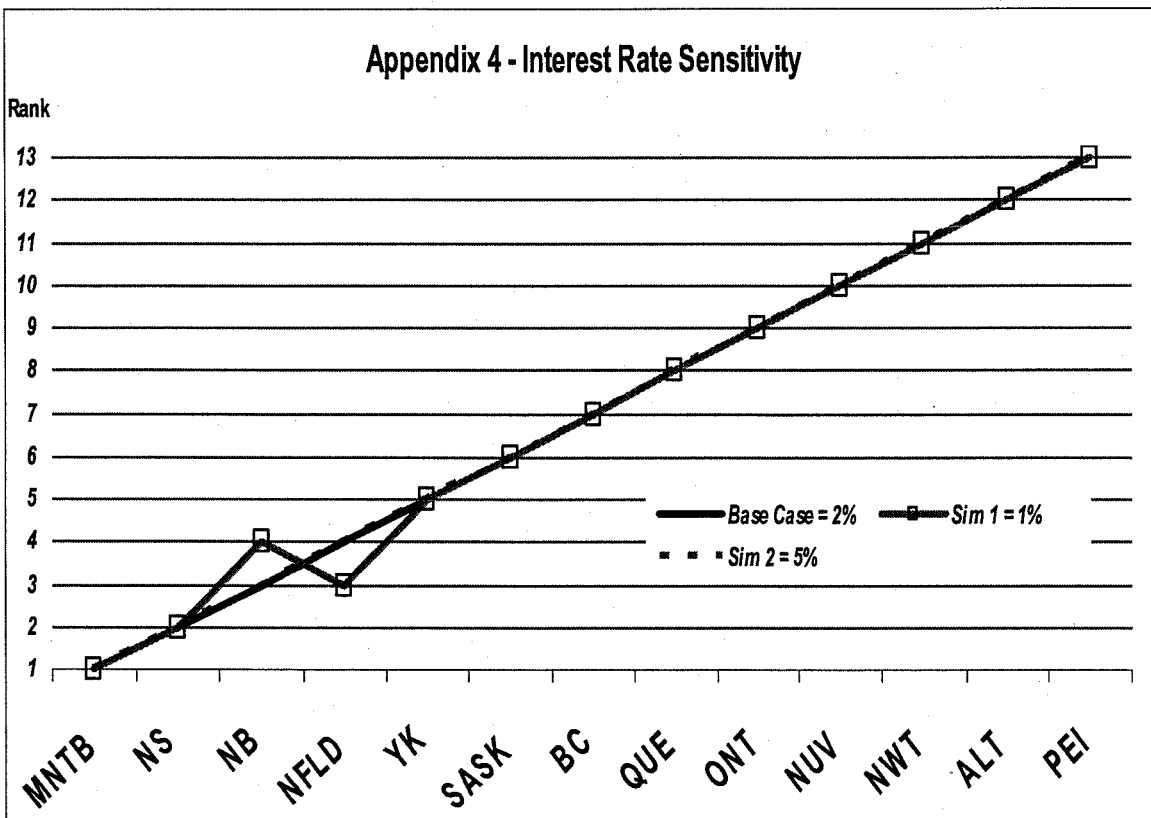
Appendix 1		R&D Marginal Effective Tax Rates	
PROVINCES	McKenzie (2007) (%)	Adéa (2007)	(%)
Quebec	-163.1	-90.4	
Saskatchewan	-139.1	-107.4	
New Brunswick	-136	-108.7	
Nova Scotia	-130.2	-108.9	
Newfoundland	-129.4	-108.5	
Manitoba	-126.4	-117.6	
Ontario	-99.3	-89.0	
British Columbia	-88.7	-96.4	
Alberta	-37.6	-71.9	
Prince Edward Is.	-92.8	-70.6	
Yukon	N/A	-108.4	
Nunavut	N/A	-72.2	
Northwest Territories	N/A	-72.1	
Canada	N/A	-94.0	

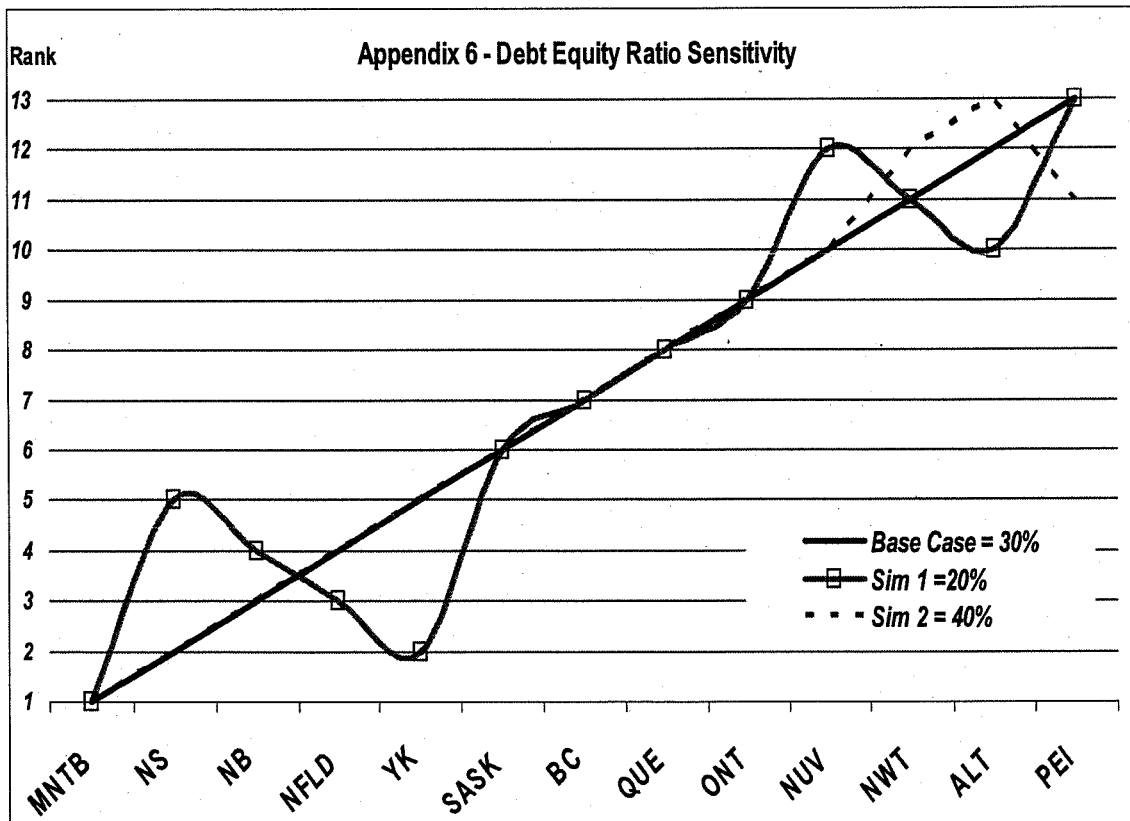
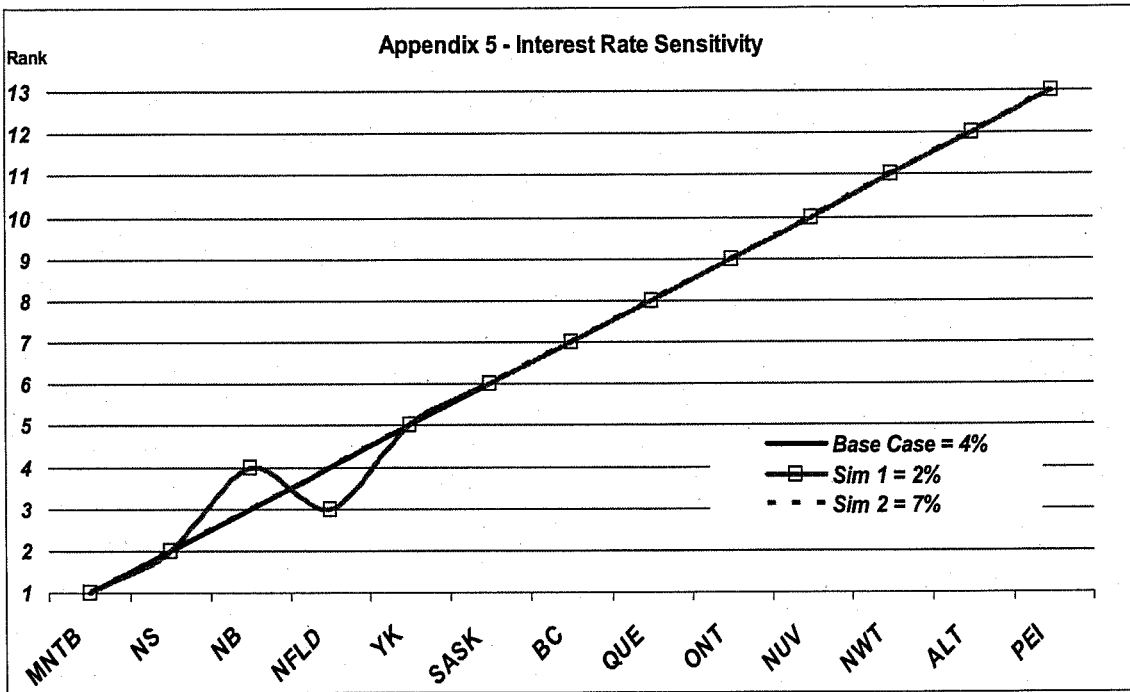
Appendix 2		
Province	Provincial Code	Region
Alberta	ALT	WEST
British Columbia	BC	WEST
Manitoba	MNTB	WEST
New Brunswick	NB	ATLANTIC
Newfoundland	NFLD	ATLANTIC
Nova Scotia	NS	ATLANTIC
Nunavut	NUV	NORTHERN
Northwest Territories	NWT	NORTHERN
Ontario	ONT	CENTRAL
Prince Edward Island	PEI	ATLANTIC
Quebec	QUE	CENTRAL
Saskatchewan	SASK	WEST
Yukon	YK	NORTHERN

Appendix 3 - Economic Rate of Depreciation Sensitivity



Appendix 4 - Interest Rate Sensitivity





Appendix 7		Ranking Change Economic Depreciation BC = 12%			Ranking Change Interest Rate BC = 5%			Ranking Change Debt Equity Ratio Base BC = 30%			Ranking Change Inflation Rate BC = 2%		
PROV	Base Case	5.00%	25%	INT 2%	INT 7%	DER 20%	DER 40%	INFL 1%	INFL 5%				
MNTB	1	-	-	-	-	-	-	-	-				
NS	2	-	+1	-	-	+3	-	-	-				
NB	3	-	-1	+1	-	+1	-	+1	-				
NFLD	4	-	-	-1	-	-1	-	-1	-				
YK	5	-	-	-	-	-3	-	-	-				
SASK	6	-	-	-	-	-	-	-	-				
BC	7	-	-	-	-	-	-	-	-				
QUE	8	-	-	-	-	-	-	-	-				
ONT	9	-	-	-	-	-	-	-	-				
NUV	10	-	-	-	-	-	-	-	-				
NWT	11	-	-	-	-	-	+1	-	-				
ALT	12	+1	-	-	-	-	+1	-	-				
PEI	13	-1	-	-	-	-	-2	-	-				

Appendix 8		Ranking Change Economic Depreciation BC = 12%			Ranking Change Interest Rate BC = 5%			Ranking Change Debt Equity Ratio Base BC = 30%			Ranking Change Inflation Rate BC = 2%		
PROV	Base Case	5.00%	25%	INT 2%	INT 7%	DER 20%	DER 40%	INFL 1%	INFL 5%				
MNTB	-117.6	-80.6	-154.8	-254.0	-93.6	-111.4	-123.4	-112.9	-122.7				
NS	-108.9	-75.9	-142.1	-235.8	-86.5	-101.4	-115.9	-104.5	-113.8				
NB	-108.7	-75.2	-142.3	-235.2	-86.4	-102.4	-114.5	-104.4	-113.3				
NFLD	-108.5	-75.1	-141.9	-235.3	-86.2	-102.8	-113.8	-104.5	-112.9				
YK	-108.4	-75.0	-141.8	-235.0	-86.1	-102.8	-113.5	-104.4	-112.8				
SASK	-107.4	-74.3	-140.7	-232.4	-85.4	-101.2	-113.2	-103.2	-112.1				
BC	-96.4	-67.8	-125.1	-209.0	-76.5	-89.2	-103.1	-92.5	-100.8				
QUE	-90.4	-62.7	-118.4	-194.3	-72.1	-83.6	-96.8	-86.2	-95.0				
ONT	-89.0	-62.7	-115.4	-192.5	-70.6	-80.9	-96.4	-85.1	-93.3				
NUV	-72.2	-52.5	-91.9	-156.1	-57.3	-63.3	-80.4	-68.6	-76.2				
NWT	-72.1	-52.3	-91.9	-155.9	-57.2	-63.4	-80.2	-68.6	-76.1				
ALT	-71.9	-52.0	-91.9	-155.5	-57.1	-63.7	-79.5	-68.4	-75.8				
PEI	-70.6	-52.1	-89.1	-152.8	-55.9	-60.1	-80.3	-66.9	-74.8				
CANADA	-94.0	-66.0	-122.1	-203.4	-74.7	-86.6	-100.9	-90.0	-98.4				

REFERENCES

- Atallah, G. and Khazabi, M. (2005) "A Model of R&D Capitalization" International Journal of Business and Economics Vol.4-2 pp 107-121.
- Bank of Canada (2007) Government of Canada Marketable Bonds Average Yield
<http://www.bank-banque-canada.ca/en/rates/bond-look.html>.
- Baylor, M. and Beauséjour, L. (2004) "Taxation and Economic Efficiency: Results from a Canadian CGE Model" Department of Finance,
<http://www.fin.gc.ca/wp/2004-10e.html>.
- Berger, P. (1993) "Explicit and Implicit Tax Effects of the R&D Tax credit" Journal of Accounting Research Vol. 31 pp 131-171.
- Bernstein, J and Yan, X. (1997) "Canadian-Japanese R&D Spillovers and Productivity Growth" Applied Economics Letters Vol. 3-12 pp 763-767.
- Bernstein, J. (1996) "International R&D Spillovers for Between Industries in Canada and the United States, Social Return and Productivity Growth", Canadian Journal of Economics Vol. 29-2 S463-467.
- Bloom, N. Griffith, R. and Van Reenen J. (2002) "Do Tax Credits Work? Evidence from a Panel of Countries 1979-1997" Journal of Public Economics Vol. 85-1 pp 1-31.
- Boadway, R and Tremblay J.-F. (2005) "Public Economics and Startup Entrepreneurs" CESifo Working Paper p 877.
- Boadway, R., Bruce N. and Mintz, J. (1984) "Taxation, Inflation, and the Effective marginal Tax Rate on Capital in Canada" Canadian Journal of Economics Vol.17-1 pp 62-79.
- Browning, E. and Liu, L. (2000) "Alternative Measures of the Marginal Cost of Funds" Economic Inquiry Vol. 38.4 pp 591-599.
- Callimaci, A and Landry, S. (2003) "The Effects of Management Incentives and Cross Listing Status on the Accounting Treatment of Spending" The Journal of International Accounting, Audit and Taxation Vol. 12-2 pp 131-152.
- Canada Revenue Agency (2004) "Scientific Research and Experimental Development (SR&ED)" <http://www.craarc.gc.ca/taxcredit/sred/aboutus-e.html>.
- Church J.R and Ware, R. (2000) Industrial Organization: A Strategic Approach New York: Irwin/McGraw Hill.

- Dagenais, M. Mohnen, P. and Thérien, P. (1997) "Do Canadian Firms Respond to Fiscal Incentives to Research and Development?" Cirano Scientific Series, 97s-34.
- Dahlby, B. (1992) "Taxation and Social Insurance" Canadian Tax Paper No.93, Canadian Tax Foundation.
- Dahlby, B. (2005) "A Framework for Evaluating Provincial R&D Tax Subsidies", Canadian Public Policy Vol.31-1 pp 45-58.
- Department of Finance (2007), "Tax Expenditure and Evaluation Report"
[Http://www.fin.gc.ca/taxexp/2006/taxexp_3e.html#Table2](http://www.fin.gc.ca/taxexp/2006/taxexp_3e.html#Table2).
- Department of Finance and Revenue Canada (1997) "The Federal System of Income Tax Incentives for Scientific Research and Development: Evaluation Report"
http://www.fin.gc.ca/resdev/fedsys_e.pdf.
- Department of Finance, (1996) Capital Tax Issues
<http://www.fin.gc.ca/taxstudy/wp96-8e.pdf>.
- Fullerton, D. and King, M. (1983). "The Taxation of Income from Capital: A Comparative Study of the U.S., U.K., Sweden, and West Germany, the Theoretical Framework"- NBER Working Papers 1058.
- Government of Canada (2007) R&D incentives in Canada
http://www.investincanada.com/CMFiles/RD_Tax_Credits_eng_05_07.pdf.
- Government of Canada (2007): "Do your Research and Development in Canada ... It Pays off" http://www.investincanada.com/CMFiles/RD_Tax_Credits_eng_05_07.pdf.
- Hall, B. (1993) "R&D Tax Policy During the 1980's: Success or Failure?" Tax Policy and the Economy, Vol 7 pp 1-35.
- Hall, B. and Van Reenen, J. (2000) "How Effective are Fiscal Incentives for R&D: A Review of the Evidence" Research Policy Vol. 29-4,5. pp 449-469.
- Hines, J (1993) "On the Sensitivity of R&D to Delicate Tax Changes: the Behaviour of U.S. Multinationals in the 1980's" Studies in International taxation. Chicago University Press.
- Jones, C. (2002) Introduction to Economic Growth New York City: W.W. Norton & Company.
- Jorgenson, D. (1963). "Capital Theory and Investment Behavior". American Economic Review, Vol.53-2 pp. 247-259.

- Klassen, K. Pitman J. and Reed M. (2004) "A Cross-National Comparison of R&D Expenditure Decisions: Tax Incentives and Financial Constraints" Contemporary Accounting Research Vol. 21-3 pp. 639-680.
- Lebeau, D. (1996) "Les Mesures Fiscales d'Aide à la R&D et les Entreprises Québécoises", Conseil de la Science et de la Technologies, Gouvernement du Québec.
- Mackie-Mason, J. and Mintz, J. (1991), "Taxation and Uncertainty When Capital Takes Time to Build", mimeo.
- Mansfield E. and Switzer L. (1985), "How Effective are Canada's Direct Tax Incentives for R&D?" Research Policy Vol. 14-2.
- McCutchen, W. "Estimating the Impact of the R&D Tax Credit on Strategic Groups in the Pharmaceutical Industries" Research Policy Vol 22-4 pp 337-351.
- McFetridge, D. and Warda, J. (1983), "Canadian R&D Incentives: their Adequacy and Impact" Canadian Tax Paper no. 70, Toronto: Canadian Tax Foundation.
- McKenzie, K. (2005), "Tax Subsidies for R&D in Canadian Provinces", IAPR Technical Paper 05014. Revised version published in Canadian Public Policy Vol. 1, pp 29-44.
- McKenzie, K. (2004). "Measuring Tax Incentives for R&D". IAPR Technical Paper 01002 <http://www.ucalgary.ca/iaprfiles/technicalpapers/iapr-tp-041002.pdf>
- McKenzie, K. (2007). "Measuring Tax Incentives for R&D", mimeo.
- McKenzie, K. and Ser shum N. (2005) "Taxation and R&D: An Investigation of Push and Pull Effects." IAPR Technical Paper 05015.
- McKenzie, K. Mintz, J. and K. Scharf (1997) "Measuring Effective Tax Rates in the Presence of Multiple Inputs: A Production Based Approach" International Tax and Public Finance Vol. 4 pp 337-359.
- Mohnen P, and Lépine, N. (1992) "R&D, R&D Spillovers ad Payments for Technology: Canadian Evidence", Structural Change and Economic Dynamics Vol 2-1.
- Mohnen, P. (2002) "R&D Tax Incentives: Issue and Evidence" Cirano Scientific Series 99s32, Montréal.
- Nadiri, I. and Prucha, I. (1997) "Estimation of the Depreciation Rate of Physical and R&D Capital in the U.S. Total Manufacturing Sector" NBER Working Paper No. 4591.

Park, J (2004) "International and Intersectional R&D Spillovers in the OECD and East Asian Economics" Economic Inquiry Vol. 42-4 pp 739-757.

Romer, P. (1990) "Endogenous Technological Change," Journal of Political Economy, Vol 98: S71-S102.

Schumpeter, J. (1942), Capitalism, Socialism and Democracy London: HarperCollins.

Statistics Canada (2005) "Industrial Research and Development Intentions Survey" <http://www.statcan.ca/english/freepub/88-202-XIE/88-202-XIE2005000.pdf>
Catalogue # 88-202-XIE.

Statistics Canada (2007): "Quarterly balance sheet and income statement, by North American Industry Classification" CANSIM, Table 187-0001.

Tillinger, J. (1991) "An analysis of the Effectiveness of the Research and Experimentation Tax Credit in a q Model of Valuation" Journal of American Taxation Association, Vol 13 pp 1-29.

Treasury Board Secretariat, (1998) "Benefit Cost Analysis Guide", http://www.tbs-sct.gc.ca/fin/sigs/revolving_funds/bcag/bca2_e.asp

Warda, J (1999) "Measuring the Attractiveness of R&D Tax Incentives: Canada and Major Industrial Countries." Statistics Canada, Catalogue no. 88F0006XIB-99010, <http://www.statcan.ca/english/research/88F0006XIE/88F0006XIB1999010.pdf>.