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Finances of the Nation

TAX SUBSIDIES FOR R & D IN CANADA, 1981-2016

*Daria Crisan and Kenneth J. McKenzie**

For almost 60 years, the Canadian Tax Foundation published an annual monograph, Finances of the Nation, *and its predecessor,* The National Finances. *In a change of format, the 2014* Canadian Tax Journal *introduced a new "Finances of the Nation" feature, which presents annual surveys of provincial and territorial budgets, and topical articles on taxation and public expenditures in Canada.*

In this issue, Daria Crisan and Kenneth J. McKenzie discuss government policy related to innovation, focusing on tax subsidies for research and development (R & D) provided by the federal and provincial governments in Canada. Using various metrics based on the marginal effective tax rate approach, Crisan and McKenzie document federal and provincial tax policy as it relates to R & D over the period 1981-2016. The data are unique in that no similar provincial-level panel, or longitudinal, data set exists for Canada. The article concludes with some comments regarding the "R & D policy puzzle" in Canada.

The underlying data for the Finances of the Nation *monographs and the articles in this journal will be published online in the near future.*

KEYWORDS: R & D ■ SUBSIDIES ■ TAX CREDITS ■ FEDERAL ■ PROVINCIAL ■ INNOVATIONS

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INTRODUCTION

A seemingly perennial focus in Canadian policy discussions concerns the so-called innovation agenda. Policy commentators and governments of all political stripes have lamented Canada's perceived lagging performance in innovation (writ large) and, over the years, have offered several and varied policy responses to address the issue.

For example, in 1972 the Senate Special Committee on Science Policy indicated that

> since 1916 . . . the main objective of Canadian science policy has been to promote technological innovation in industry. . . . Almost every decade since the 1920s has witnessed renewed attempts by successive Canadian governments to achieve it, but on the whole they have all failed.[1]

Fast-forward to 2010, when the Conservative government announced a comprehensive review of government support for research and development (R & D) in Canada. A panel chaired by the technology magnate Tom Jenkins was subsequently mandated to undertake the review and provide recommendations to the government in this regard. In October 2011, the Jenkins report, *Innovation Canada: A Call to Action*, was released.[2] The recommendations included, among others,

- a streamlined "concierge" approach to delivering federal innovation programs;
- simplification of the R & D tax credit system and elimination of credits for capital, with more money targeted via direct government grants; and
- making business innovation a core objective of government procurement.

Some, but not all, of the recommendations were subsequently implemented by the Conservatives over the next four years.

1 As quoted in Andrei Sulzenko, *Canada's Innovation Conundrum: Five Years After the Jenkins Report* (Ottawa: Institute for Research on Public Policy, June 2016), at 5 (irpp.org/wp-content/uploads/2016/06/report-2016-06-09.pdf). See infra note 2 and the related text for more on the Jenkins report.

2 Independent Panel on Federal Support to Research and Development (Tom Jenkins, chair), *Innovation Canada: A Call to Action* (Ottawa: Public Works and Government Services Canada, October 2011) (herein referred to as "the Jenkins report") (rd-review.ca/eic/site/033.nsf/vwapj/R-D_InnovationCanada_Final-eng.pdf/$FILE/R-D_InnovationCanada_Final-eng.pdf).

Fast-forward again to the 2016 federal budget, this time with the Liberals in charge. At a press conference following the budget, the finance minister indicated that "[our] objective of growing the economy is fundamental to us, and our innovation agenda is critical to that. . . . We're setting ourselves up for a long-term innovation strategy."[3] The 2017 budget, again under the Liberals, continued the theme, with a focus on skill development and innovation, and a modest move to more direct financing of R & D by way of government grants as recommended in the Jenkins report.[4] The more things change, the more they stay the same.

Under Canada's constitution, a great deal of power is vested with the provinces; consequently, provincial governments also play an important role in the framing of policy related to innovation and R & D. Indeed, and notably, another of the recommendations of the Jenkins report was to "establish a clear federal voice for innovation, and engage in a dialogue with the provinces to improve coordination and impact."[5] Accordingly, and as always, to understand the policy landscape in Canada it is important to consider the role of the provinces.

The purpose of this article is to present data that document and summarize a particularly important dimension of innovation policy in Canada: tax subsidies provided to businesses for R & D. Using various metrics based on the marginal effective tax rate (METR) approach, discussed below, federal and provincial tax policy as it relates to R & D is documented over a 35-year period, 1981-2016. The data set is, we believe, unique; to our knowledge, no similar provincial-level panel, or longitudinal, data set exists for Canada. Our hope is that it will provide some insight into the variation in tax policy as it relates to R & D both over time and across provinces, and will serve as a useful resource for subsequent analysis.

Regarding the motivation for and context of this study, consider the rationale for providing subsidies for R & D. The economic case for business subsidies for R & D is based on the notion of knowledge spillovers—that the knowledge developed by R & D generates benefits, or spillovers, beyond those accruing directly to the firm undertaking the R & D. These knowledge spillovers suggest that the social rate of return to investment in R & D is greater than the private rate of return (to business owners or shareholders), and that firms therefore tend to underinvest in R & D. As a result, R & D investment and knowledge accumulation are too low from a social point of view. While estimates vary, the bulk of the economic research suggests that knowledge spillovers are substantial, with some estimates suggesting that the social rate of return on R & D may be up to three times higher than the private rate of return.[6] Herein lies the economic case for providing R & D subsidies to businesses.

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3 Quoted in Sulzenko, supra note 1, at 6.

4 Canada, Department of Finance, *2017 Budget: Building a Strong Middle Class*, March 22, 2017, at 75-93.

5 Supra note 2, at E-13.

6 Seminal studies include Zvi Griliches, "Issues in Assessing the Contribution of Research and Development to Productivity Growth" (1979) 10:1 *Bell Journal of Economics* 92-116; and Adam

Canada is generally viewed as underperforming on the R & D front. Figure 1 shows R & D expenditures by businesses (business enterprise R & D spending, or BERD) as a percentage of gross domestic product (GDP) for member countries of the Organisation for Economic Co-operation and Development (OECD) in 2015. With a BERD:GDP ratio of 0.87, Canada is well into the lower half of OECD countries, and much lower than the OECD average of 1.64. Moreover, figure 2 shows that over the period 2000-2016, Canada's BERD:GDP ratio has generally been declining, falling from a high of 1.25 in 2001 to a recent low of 0.87 in 2016.

In the next section, we present our methodology. This is followed by a chronology of the R & D tax incentives at the federal and provincial levels over time. We then present our calculations of tax subsidies for R & D using the METR approach adapted to R & D. We conclude with some speculative thoughts on the "R & D policy puzzle" as it relates to Canada's relatively poor business R & D performance. Two appendixes are also included: appendix A presents the underlying formulas used in our calculations; appendix B presents some of the key parameter assumptions.

METHODOLOGY

The idea behind our measurement of tax subsidies for R & D is similar to the concept of the METR on physical capital, modified to reflect the special nature of R & D. The METR on capital measures the tax wedge between the minimum acceptable after-tax rate of return on a marginal unit of capital required by stakeholders—the so-called hurdle rate of return—and the before-tax rate of return required to generate the hurdle rate of return.[7] This wedge is typically expressed relative to the before-tax required rate of return on capital; therefore, the METR on physical capital measures the share of the before-tax rate of return on a marginal unit of capital required to pay the underlying taxes. However, the wedge can also be expressed relative to the after-tax hurdle rate of return. For example, if the expected after-tax hurdle rate of return on an investment in capital required by shareholders is 5 percent,[8] and the before-tax rate of return required to generate that required after-tax rate of return is 6 percent, the METR on capital expressed relative to the after-tax hurdle rate of return is 20 percent [(6 − 5)/5]. This means that the before-tax rate of return on a

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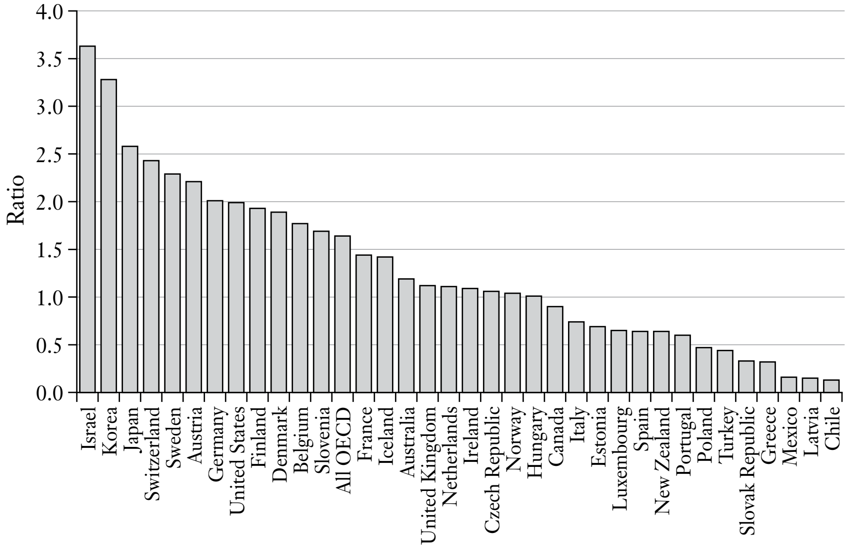
B. Jaffe, *Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits and Market Value*, NBER Working Paper no. 1815 (Cambridge, MA: National Bureau of Economic Research, 1986). More recent estimates are provided by Nicholas Bloom, Mark Schankerman, and John Van Reenen, "Identifying Technology Spillovers and Product Market Rivalry" (2013) 81:4 *Econometrica* 1347-93; and David Colino, *Cumulative Innovation and Dynamic R&D Spillovers*, Job Market Paper (Cambridge, MA: Massachusetts Institute of Technology, Department of Economics, 2016) (economics.mit.edu/files/12082).

7 For a discussion of the METR concept, see Kenneth J. McKenzie, "Inside the Black Box: Marginal Effective Tax Rates on Capital—A Primer," Finances of the Nation feature (2016) 64:4 *Canadian Tax Journal* 795-816.

8 This should be interpreted as the after-tax hurdle rate of return net of inflation, risk, and depreciation.

FIGURE 1 Ratio of BERD to GDP, OECD Countries, 2015[a]



BERD = Business enterprise research and development expenditure.
GDP = Gross domestic product.

a Data are for 2015 for all countries except Australia (2013) and Ireland (2014).

Source: Organisation for Economic Co-operation and Development, "Main Science and Technology Indicators" (https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

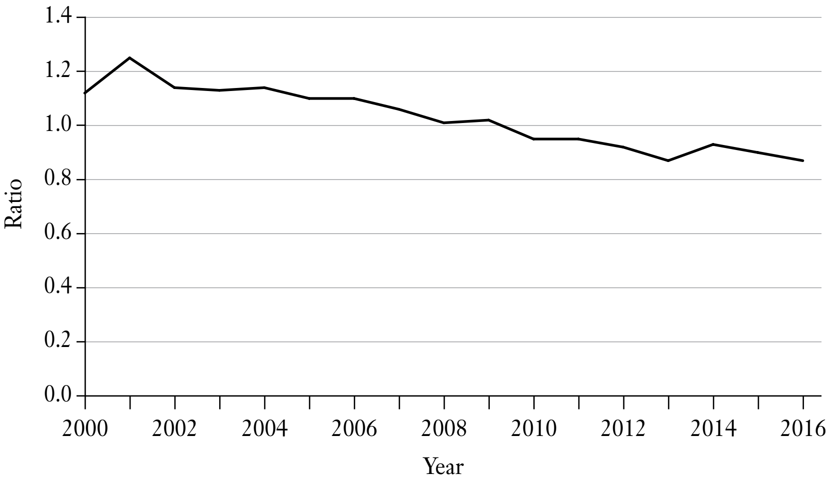
marginal investment in physical capital is 20 percent higher than the after-tax hurdle rate of return required by stakeholders. Thus, the tax system discourages investment in physical capital by increasing the before-tax hurdle rate of return over the associated after-tax hurdle rate of return.

To adapt this concept to R & D, we follow an approach developed by McKenzie.[9] Details of the underlying formulas are provided in appendix A; here we provide an intuitive, heuristic explanation.[10] The approach is based on the idea that intangible

9 Kenneth J. McKenzie, "Measuring Tax Incentives for R&D" (2008) 15:5 *International Tax and Public Finance* 563-81. Applications of the approach include Kenneth J. McKenzie, "Tax Subsidies for R&D in Canadian Provinces" (2005) 31:1 *Canadian Public Policy* 29-44; and John Lester and Jacek Warda, "An International Comparison of Tax Assistance for Research and Development: Estimates and Policy Implications" (2014) 7:36 *SPP Research Papers* [University of Calgary, School of Public Policy] 1-41.

10 There have been previous efforts to incorporate R & D into the METR approach. See, for example, "An International Comparison of Tax Assistance for Investment in Research and Development," in Canada, Department of Finance, *Tax Expenditures and Evaluations 2009* (Ottawa: Department of Finance, 2009), 33-58 (fin.gc.ca/taxexp-depfisc/2009/

FIGURE 2 Ratio of BERD to GDP, Canada, 2000-2016



BERD = Business enterprise research and development expenditure.
GDP = Gross domestic product.

Source: Organisation for Economic Co-operation and Development, "Main Science and Technology Indicators" (https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

R & D capital differs from tangible physical capital in that it typically is not purchased on the market, like physical capital and other inputs into production, but rather is produced in-house by firms, using several inputs into what we may think of as the R & D production process. For example, labour, materials, and physical capital (such as scientists, test tubes, and laboratories) combine to produce intangible R & D capital (such as knowledge) according to some underlying "R & D production function." The resulting stock of intangible R & D capital (which may decrease in value, or depreciate, over time owing to obsolescence, the emergence of competing technologies, and other factors) then generates profits for the firm by way of new product discoveries, innovations to production processes, etc.[11]

Indeed, tax subsidies for R & D are not granted directly for intangible R & D capital per se, but rather indirectly for the expenditures on the various inputs used to produce that intangible capital. As discussed below, in Canada these subsidies have

taxexp-depfisc09_eng.pdf). However, in our view these efforts are an ad hoc application of the approach to R & D, and do not properly reflect the nature of R & D as described in what follows.

11 The idea that R & D expenses build a stock of knowledge that depreciates over time (somewhat similar to how capital investments contribute to a capital stock), and that this knowledge stock is responsible for both private value creation and contemporaneous knowledge spillovers (as discussed in the text below), goes back at least to Jaffe, supra note 6.

primarily taken the form of tax credits and fast writeoffs, which have varied to some extent by type of input. These tax subsidies lower the marginal cost of producing intangible R & D capital by lowering the cost of the underlying inputs. Our measure of the tax subsidy on intangible R & D capital therefore reflects, or aggregates, the tax subsidies on the underlying inputs.

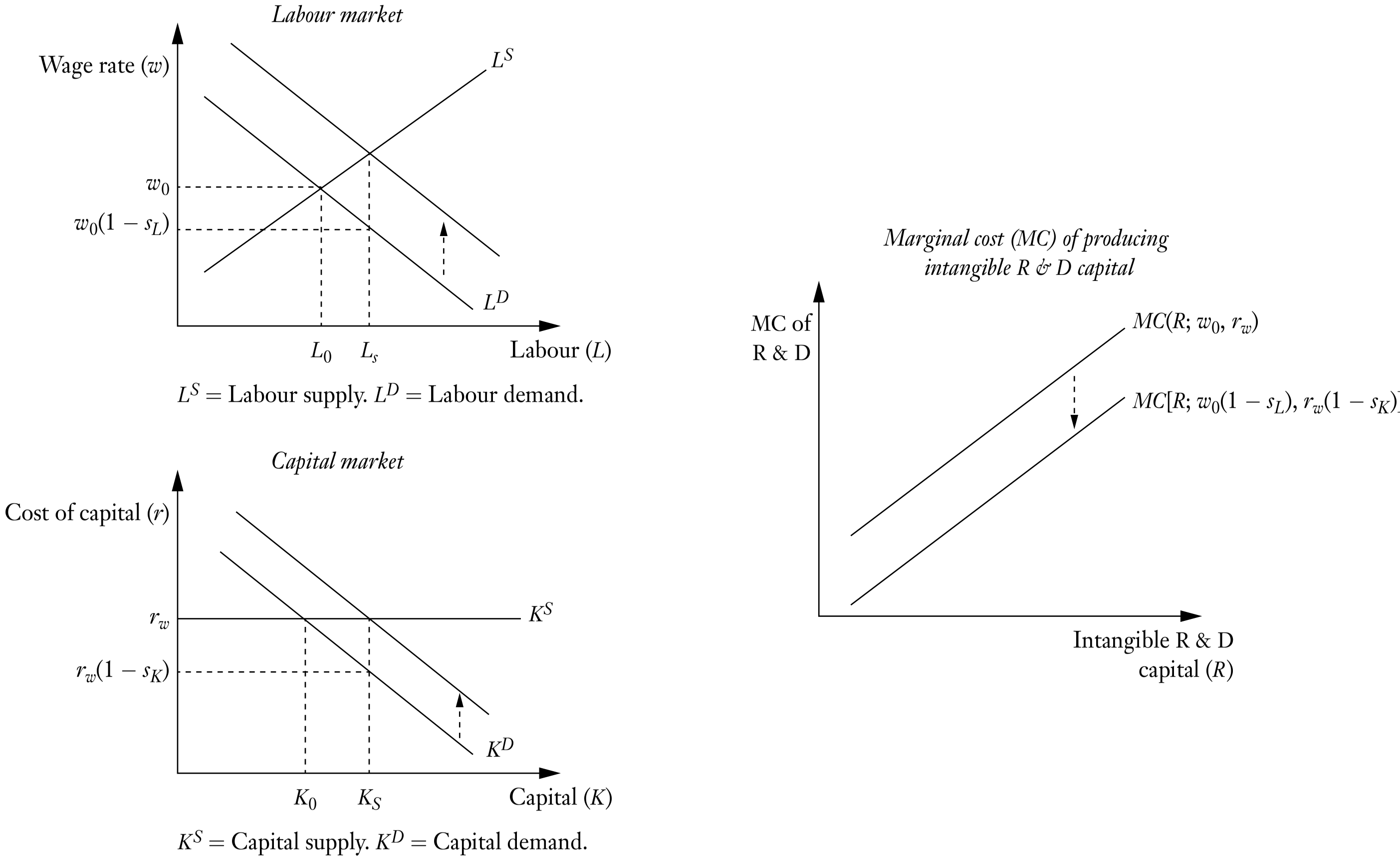
By way of illustration, say that labour (scientists) and physical capital (laboratories) are employed to produce intangible R & D capital (knowledge). The upper panel on the left-hand side of figure 3 depicts the market for R & D labour, and the lower panel depicts the market for physical capital used in R & D. In the absence of tax subsidies, the equilibrium user cost of labour is w_0 and the user cost of capital is r_w. Note that the latter is determined by the world market for capital, and is therefore fixed from the perspective of Canada, by virtue of the reasonable assumption that Canada is a small open economy with very mobile capital. The labour market, on the other hand, is closed; that is, international labour mobility is quite low. The right-hand side of figure 3 depicts the marginal cost of producing intangible R & D capital—the cost of producing an incremental unit of intangible R & D capital—which is a function of the amount of R & D produced (R) and the user costs of the labour and capital inputs used to produce it, denoted by $MC(R; w_0, r_w)$.

Now impose a subsidy for business expenditures on the labour and physical capital inputs devoted to R & D. The subsidy lowers the user cost of labour from w_0 to $w_0(1 - s_L)$, where s_L denotes the marginal effective subsidy rate (MESR) on labour used in R & D.[12] Similarly, the subsidy for physical capital used in R & D lowers its user cost from r_w to $r_w(1 - s_K)$, where s_K is the MESR on physical capital used in R & D. This in turn lowers the marginal cost of producing a unit of intangible R & D capital in the right-hand panel, shifting the marginal cost curve, which is a function of the amount of R & D produced (R) and the user costs of the inputs, down from $MC(R; w_0, r_w)$ to $MC[R; w_0(1 - s_L), r_w(1 - s_K)]$. Thus, the tax subsidies on labour and capital used in R & D lower the marginal cost of producing intangible R & D capital. The MESR on the marginal cost of producing intangible R & D capital is then $s_R = \{MC(R; w_0, r_w) - MC[R; w_0(1 - s_L), r_w(1 - s_K)]\}/MC(R; w_0, r_w)$, which measures the percentage reduction in the marginal cost of producing a unit of intangible R & D capital in-house attributable to the tax subsidies offered on the inputs used to produce that capital. Note that s_R is a function of the subsidies granted to the underlying inputs used to produce the intangible R & D capital, s_L and s_K. The MESR on the marginal cost of producing intangible R & D capital, s_R, is then used to determine the MESR on investing in intangible R & D capital in a manner similar to the standard METR.

A numerical example, using some reasonable ballpark numbers, will prove useful. Say that the MESRs on labour and physical capital used in R & D are $s_L = 20\%$

12 The extent to which the subsidy lowers the user cost of labour to businesses as opposed to increasing the wage rate of scientists (in our example) depends on the relative elasticities of labour demand and supply in the market for scientists.

FIGURE 3 R & D Labour and Capital Markets



and $s_K = 0\%$ respectively; that is, labour used in R & D receives a tax subsidy while capital employed in R & D does not.[13] The MESR on the cost of producing an incremental unit of intangible R & D capital is a weighted average of the effective subsidy rates on the underlying inputs. This gives a MESR on R & D production of $s_R = 18\%$.[14] Thus, the subsidies provided to labour and physical capital employed in R & D lower the marginal cost of producing a unit of intangible R & D capital by 18 percent. Now, as discussed above, the stock of intangible R & D capital produced by the firm produces profits. Say that the minimum after-tax hurdle rate of return on an incremental unit of investment in intangible R & D capital required by stakeholders is 5 percent,[15] and that, given the 18 percent subsidy on the marginal cost of producing a unit of intangible R & D capital, an incremental investment in intangible R & D capital only needs to generate a before-tax rate of return of 1.4 percent. The MESR on investment in intangible R & D capital in this case is 72 percent (= (5 − 1.4)/5).[16] This means that the before-tax rate of return on a marginal investment in intangible R & D capital is 72 percent lower than the after-tax hurdle rate of return required by stakeholders. So we see that in this example the tax system encourages investment in R & D by reducing the before-tax/subsidy rate of return below the after-tax hurdle rate of return required by stakeholders. As will be seen, MESRs for R & D of this magnitude, and indeed substantially higher, have not been uncommon in Canada.

OVERVIEW OF FEDERAL AND PROVINCIAL TAX SUBSIDIES FOR R & D

In this section, we provide a brief summary of R & D tax incentives at the federal and provincial levels over our study period, 1981-2016. We focus on the tax subsidies for large corporations since this is what we report in our data set. Small privately held corporations (CCPCs) are typically eligible for enhanced subsidies, which are not discussed in detail here.

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13 Nor, it might be noted, is physical capital used in R & D taxed at the margin in this example, as it typically is in other uses.

14 As discussed in the appendix, this requires an assumption about the functional form of the "R & D production function." In this article, we assume a fixed-proportions, or Leontief, function that generates an expression of $s_R = a_L s_L + a_K s_K$, where a_L is the share of R & D costs devoted to labour and a_K is the share devoted to physical capital. In this example, we assume that $a_L = 0.90$ and $a_K = 0.10$. With $s_L = 0.20$, and $s_K = 0$, this gives $s_R = 0.9(0.20) + 0.1(0) = 0.18$.

15 Again, this should be interpreted as the after-tax hurdle rate of return required by stakeholders net of inflation, risk, and depreciation.

16 Note that we express the MESR as a positive number, subtracting the lower before-tax rate of return from the after-tax required hurdle rate of return, rather than the other way around, which would generate a negative METR.

Federal

Federal tax incentives for R & D have primarily taken the form of tax credits and the accelerated deduction of R & D expenditures. A very brief chronology follows.[17]

- **1981:** A basic R & D tax credit was introduced, at a general rate of 10 percent, increased to 20 percent for the Atlantic and Gaspé regions, applicable to eligible current and capital R & D expenditures (expenditures on equipment and buildings). An additional tax deduction was also provided, equal to 50 percent of R & D expenditures in excess of the average of the previous three years. For tax purposes, both current and capital expenditures on R & D are fully expensed as incurred. Tax credits (federal and provincial) are "taxable" in that they reduce the amount eligible for immediate deduction.
- **1983:** The incremental 50 percent deduction was eliminated, and the basic tax credit was increased, with a general rate of 20 percent and 30 percent for the Atlantic and Gaspé regions.
- **1986:** The scientific research and experimental development (SR & ED) program was introduced. Capital expenses related to buildings used in R & D were no longer eligible for tax incentives.
- **1992:** The R & D tax credit was extended to machinery and equipment used "primarily" (more than 50 percent) for R & D. Previously only equipment the use of which was "all or substantially all" (more than 90 percent) attributable to R & D was eligible. However, for equipment used primarily for R & D, only a partial tax credit could be claimed, consisting of half of the normal credit, claimed in two equal instalments in the two years following the year of acquisition.
- **1994:** The 30 percent special tax credit for the Atlantic and Gaspé regions was eliminated and replaced by the 20 percent basic credit.
- **2000:** Provincial deductions for R & D in excess of the actual expenditure (so-called superallowances or superdeductions, discussed below) were deemed to be government assistance and excluded from expenditures eligible for federal SR & ED tax credits.
- **2013:** Eligibility of contract R & D payments for SR & ED treatment was restricted to 80 percent of such payments.
- **2014:** The basic tax credit rate was reduced from 20 percent to 15 percent. Capital expenditures were no longer eligible for SR & ED tax treatment.

17 For a more detailed history, see Canada Revenue Agency, "Scientific Research and Experimental Development Tax Incentive, Evolution of the SR&ED Program—A Historical Perspective," April 7, 2015 (canada.ca/en/revenue-agency/services/scientific-research-experimental-development-tax-incentive-program/evolution-program-a-historical-perspective.html); and for an earlier discussion on the history of R & D tax incentives in Canada, see Kenneth J. Murray, "Scientific Research and Experimental Development: A Program in Crisis?" (1995) 43:5 *Canadian Tax Journal* 1265-86.

It should be noted that some types of expenses are explicitly not eligible for R & D tax subsidies, including

- market research or sales promotion;
- social sciences or humanities research;
- medical/surgical techniques;
- prospecting for minerals or petroleum;
- commercial production or commercial use of a new product, material, or process;
- style changes; and
- routine data collection for quality control.

It should also be noted that we assume full taxability, so refundability and carryforward provisions are not relevant to our calculations. We reiterate that our calculations are for large corporations and do not include enhanced subsidies for CCPCs.

Most Provinces

Most of the provinces have simply piggybacked onto the federal program, adding their own provincial tax credits to R & D expenditures as defined by the federal government. (An exception in some cases relates to qualifying contract R & D.) Provincial credits are deemed to be government support for federal purposes and therefore lower the base eligible for federal incentives (that is, are "taxable"). The exceptions to these general statements are Quebec and Ontario, which are discussed separately.

- *British Columbia* introduced a 10 percent R & D tax credit effective September 1, 1999.
- *Alberta* introduced a 10 percent refundable R & D tax credit in 2009. For taxation years ending before March 31, 2012, the Alberta SR & ED tax credit was reduced by the amount of federal investment tax credits received in the prior year (the grind), while the Alberta SR & ED tax credit was considered government assistance for federal purposes, reducing the amount of eligible expenditure for federal SR & ED purposes. Filing for the Alberta R & D tax credit required a complicated two-step procedure to avoid this circular reference. For taxation years ending after March 31, 2012, the federal credit no longer reduces the eligible expenditures for the Alberta SR & ED tax credit.[18]

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18 Alberta, Treasury Board and Finance, *2013 Guide to Claiming the Alberta Scientific Research and Experimental Development (SR&ED) Tax Credit (AT1 Schedule 9 and AT1 Schedule 9 Supplemental* (Edmonton: Treasury Board and Finance, July 2013) (finance.alberta.ca/publications/tax_rebates/corporate/guides/SRED-Tax-Credit-Guide.pdf). Alberta limits its tax credit to

- *Saskatchewan* introduced a 15 percent non-refundable R & D tax credit effective March 19, 1998. The credit became fully refundable for expenditures incurred between March 19, 2009 and March 31, 2012. For expenditures incurred between April 1, 2012 and March 31, 2015, the 15 percent R & D tax credit continued to be refundable for CCPCs up to a maximum of $3 million in qualifying expenditures, but became non-refundable for other corporations. The credit was reduced to 10 percent non-refundable effective April 1, 2015.[19] Eligible expenditures are those that qualify for the federal SR & ED tax credit.
- *Manitoba* introduced a 15 percent R & D tax credit in 1992. The credit was increased to 20 percent in 2005 and reduced again to 15 percent for eligible expenditures made after April 11, 2017. Since 2009, the credit has been refundable for contract R & D with qualifying research institutes. For in-house R & D, one-quarter of the credit was refundable starting in 2011, extended to one-half in 2012. In 2013, when the federal government reduced the eligibility of contract payments to 80 percent and removed the eligibility of capital expenditures, Manitoba opted to restore the 100 percent eligibility of contract payments with eligible institutes in 2014 and to maintain the eligibility of capital expenditures.[20]
- *Nova Scotia* introduced a 10 percent non-refundable R & D tax credit in 1984. The credit was increased to 15 percent and made refundable in 1994. It is based on qualified expenditures eligible for the federal SR & ED tax credit.[21]
- *Prince Edward Island* has no provincial-level R & D subsidies.
- *Newfoundland and Labrador* introduced a 15 percent R & D tax credit in 1996. The credit is refundable and mirrors the federal definition of eligible expenditures.[22]

R & D expenditures up to $4 million; thus, the maximum credit is $400,000. We do not take account of this cap in the calculations presented below, and assume that R & D expenditures in Alberta are fully eligible for the credit. It is straightforward to model a binding cap, which involves setting the tax credit in Alberta equal to zero. We ignore the grind for 2009-2012 and only model the reduction in federal eligible expenditures attributable to the provincial tax credit, similar to our treatment for the other provinces.

19 Saskatchewan, Ministry of Finance, "Research & Development Tax Credit" (finance.gov.sk.ca/Default.aspx?DN=7210d60f-4263-4bf8-9f59-dbbbd8d64f7a).

20 Manitoba, Department of Finance, Fiscal Research Division, "Manitoba Research and Development Tax Credit" (gov.mb.ca/jec/invest/busfacts/govt/rd_taxcredit.html).

21 Nova Scotia, Department of Finance, *Nova Scotia Tax Credit Review: Phase I Report* (Halifax: Department of Finance, March 2000) (novascotia.ca/finance/publish/taxcredit/phasei.pdf).

22 Newfoundland and Labrador, Department of Finance, "Scientific Research and Experimental Development Tax Credit" (fin.gov.nl.ca/fin/tax_programs_incentives/business/scientificresearch.html).

Quebec[23]

Quebec introduced a 10 percent refundable R & D credit starting May 11, 1983, applied to R & D wages only. The credit was non-taxable in Quebec. Starting May 1, 1987, the provincial tax credit was increased to 20 percent and the federal R & D tax credit also became non-taxable in Quebec. Effective May 10, 1996, the federal tax credit for R & D again became taxable in Quebec.

Effective March 10, 1999, citing the federal taxability of the R & D tax credit in Quebec, a superdeduction was introduced. Firms had the option of choosing between the provincial tax credit and the superdeduction, which allows firms to deduct 230 percent of R & D wages in the calculation of their taxable income (460 percent for CCPCs). The superdeduction rate was set such that a small corporation would face the same net-of-tax cost of R & D wages under the refundable provincial tax credit and the superdeduction, and firms could choose between the two instruments according to their specific circumstances.[24] The superdeduction, however, resulted in a significant shift in the cost of the R & D subsidy from the provincial government to the federal government, by eliminating the provincial tax credit and thereby increasing the amount of expenditures eligible for the federal R & D tax credit, as well as the amount of expenditures deductible under the federal corporate income tax (CIT). As noted above, in 2000 the federal government announced the change in the treatment of provincial deductions exceeding the actual amount of R & D expenditures as government assistance. The government of Quebec responded by eliminating the superdeduction on February 29, 2000.

On June 12, 2003, all the provincial R & D tax credits were reduced by one-eighth, and the credit for R & D wage expenditures for large corporations was set at 17.5 percent. Effective November 21, 2012, the provincial R & D tax credits became taxable in Quebec. On June 4, 2014, approximately 30 business tax credits were reduced by 20 percent; the new R & D tax credit for expenditures on wages by large corporations was set at 14 percent.

From 1987 to 1993, Quebec granted a higher 40 percent tax credit for eligible contract R & D with university entities, which was gradually extended to environmental technological innovation (1990), research with designated public research centres (1991), precompetitive research by business consortiums (1992), and precompetitive research by private-public partnerships (2008). In 1994, the eligibility for the 40 percent tax credit was reduced to 80 percent of the value of the research contracts. From March 1999 to March 2000, firms could choose between the provincial

23 Information collected from the 2000 and 2014 provincial budgets: Finances Québec, *Information Bulletin* 2000-4, "New Tax Measures To Support Business Economic and Social Development in Quebec," June 29, 2000; and Finances Québec, *Information Bulletin* 2014-11, "Fiscal Measures Announced in the Update on Quebec's Economic and Financial Situation," December 2, 2014.

24 Presumably, firms without taxable income would prefer the refundable tax credit to the superdeduction.

R & D tax credit and a superdeduction of 460 percent.[25] On June 12, 2003, the tax credit for contract R & D was reduced to 35 percent. The credit was reduced again to 28 percent on June 4, 2014. Less than five months later, on December 2, 2014, all Quebec R & D tax credits were standardized with the R & D wage tax credit. Thus, the contract R & D tax credit for large corporations became 14 percent.

Ontario

There were no provincial tax subsidies for R & D in Ontario until April 20, 1988, when the provincial government introduced a superallowance. The superallowance was an additional deduction for current and capital expenditures on R & D incurred in Ontario, over and above the amount expended. The basic superallowance rate of 25 percent was intended to nullify the taxability of the federal tax credit for provincial purposes. The province also introduced an incremental superallowance equal to one-half of the basic superallowance for R & D expenditures in excess of the average of R & D expenditures over the previous three years. In 2000, when the federal government announced the change in the treatment of provincial deductions in excess of actual R & D spending, Ontario suspended the superallowance. In its place, the province introduced the so-called Ontario superdeduction,[26] which allowed corporations to exclude from their Ontario taxable income the federal SR & ED tax credit, effective March 1, 2000. While the tax exemption of the federal SR & ED tax credit was initially intended to remain in effect for only 24 months, it was not removed until 2009, when it was replaced by a 4.5 percent non-refundable tax credit. Eligible expenditures for the credit mirrored the federal definition of qualifying expenditures for SR & ED tax credit purposes. The rate was reduced to 3.5 percent effective June 1, 2016.

On May 6, 1997, Ontario introduced the Ontario business research institute tax credit, an enhanced refundable tax credit for eligible contract R & D of 20 percent. Ontario rules mirror the federal rules regarding the definition of SR & ED and qualified expenditures, with the credit applying to only 80 percent of contract R & D starting in 2013. Eligible expenditures are capped at a maximum of $20 million.[27]

METRICS ON R & D TAX SUBSIDIES IN CANADA, 1981-2016

In this section, we present the various metrics of tax subsidies for R & D discussed above for the 10 provinces from 1981 to 2016. We begin by reporting our calculations

25 In our model, it appears that for large corporations the superdeduction was more advantageous in the case of contract R & D spending but not for in-house R & D spending; therefore, we only include the superdeduction in the after-subsidy cost of contract R & D.

26 Not to be confused with the Quebec superdeduction, which functions more like the Ontario superallowance.

27 In our model, we assume that the cap is not binding and firms fully benefit from the tax credit.

of the MESR for current inputs and capital inputs used in R & D separately. This is followed by the MESR on the cost of producing R & D, and finally by the MESR on investment in intangible R & D capital. We group the 10 provinces into three geographical regions:

1. Atlantic Canada: Newfoundland and Labrador [NL], Prince Edward Island [PE], Nova Scotia [NS], and New Brunswick [NB];
2. western Canada: Saskatchewan [SK], Alberta [AB], and British Columbia [BC]; and
3. central Canada: Quebec [QC], Ontario [ON], and Manitoba [MB].

Figures 4A, 4B, and 4C show the MESR on current inputs used in the production of intangible R & D capital, namely, in-house labour, contract R & D with eligible research institutions, and materials. Between 1981 and 1983, no province offered a specific R & D tax credit. R & D support came from the federal government in the form of an R & D tax credit and an additional deduction for incremental R & D spending. The Atlantic provinces enjoyed the highest MESR on current R & D spending during this period, around 21 percent, owing to the enhanced federal R & D tax credit for Atlantic Canada.

Quebec was the first province to offer its own R & D tax credit, in May 1983. The credit was initially set at 10 percent and was applicable to wages only. Nova Scotia followed suit with a 10 percent tax credit in 1984; however, the NS credit applied to all types of R & D spending, not just wages. With this credit and the more generous federal tax credit for the Atlantic provinces, Nova Scotia had the highest MESR on current R & D spending from 1984 to 1987, at 37 percent.

As described above, in May 1987, Quebec changed the treatment of the federal R & D tax credit, essentially making it non-taxable at the provincial level. At the same time, the provincial tax credit on wages was doubled from 10 percent to 20 percent and a specific tax credit for contract R & D was introduced at the very generous rate of 40 percent. As a result, the MESR on current inputs in Quebec rose above 40 percent. Quebec's regime remained the most generous until 2012, even when the contract R & D tax credit was reduced to 80 percent of the value of the contracts in 1994 and the taxability of the federal tax credit was restored in 1996. In 1999, a temporary boost to the MESR was achieved in Quebec owing to the short-lived superdeduction, which was particularly favourable to contract R & D.

Since 2012, Manitoba has had the highest MESR for current R & D spending, owing to the combination of a generous 20 percent tax credit and the province's decision to maintain the 100 percent eligibility of contract payments made with eligible research institutions (the case that we consider in our model).

With the elimination of the special tax credit for R & D contracts in 2014, the MESR for current inputs in Quebec fell below that for Manitoba and the Atlantic provinces (with the exception of Prince Edward Island). However, its regime remained more generous than Ontario's. Ontario toyed with a superallowance from 1988 until 2000, and following that the superdeduction until 2008, a contract R & D

FIGURE 4A The Marginal Effective Subsidy Rate on Current R & D Spending, Atlantic Canada, 1981-2016

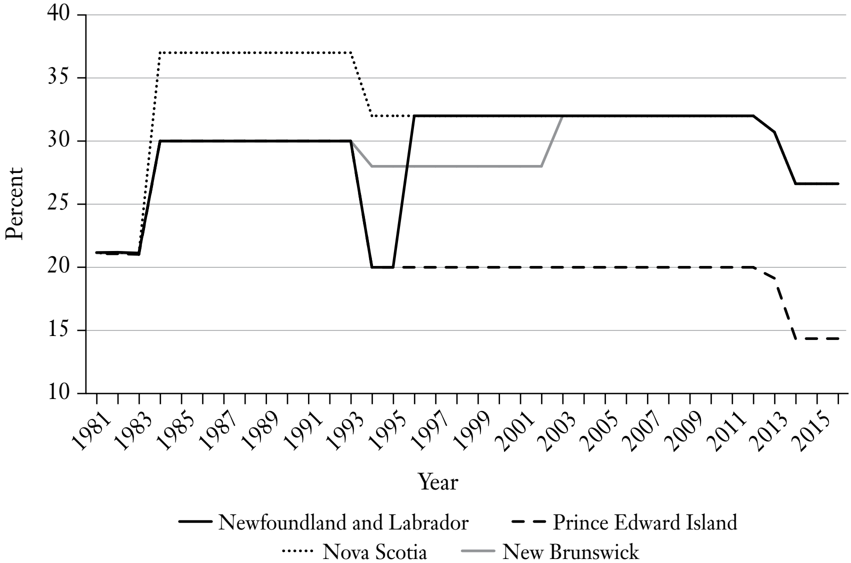


FIGURE 4B The Marginal Effective Subsidy Rate on Current R & D Spending, Central Canada, 1981-2016

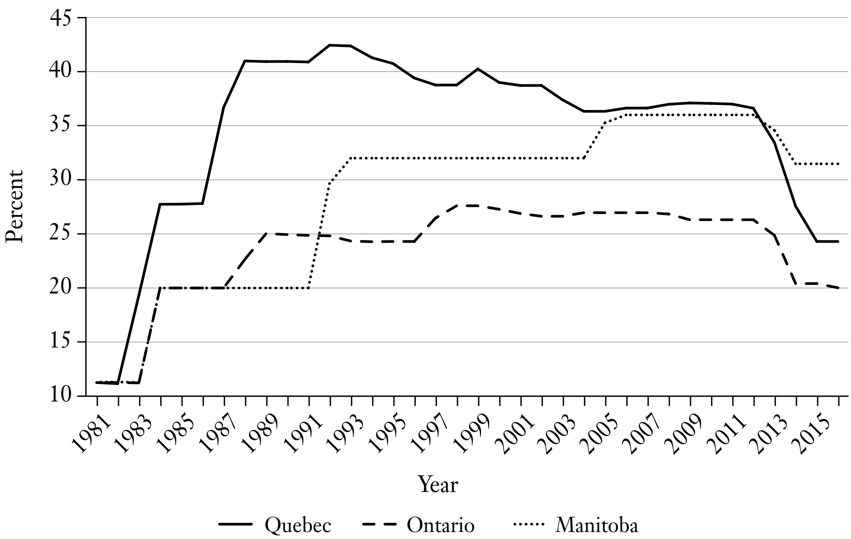
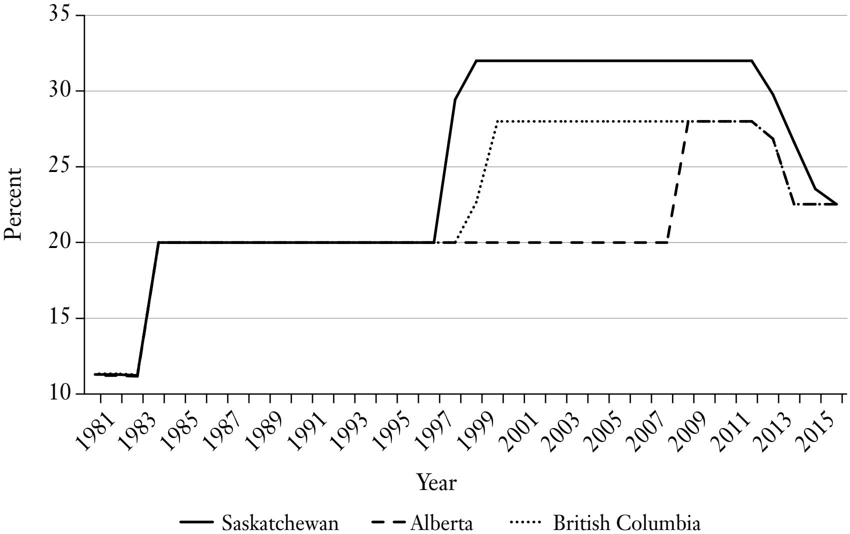


FIGURE 4C The Marginal Effective Subsidy Rate on Current R & D Spending, Western Canada, 1981-2016



tax credit starting in 1997, and a general R & D tax credit starting in 2009, but the combined effect never resulted in a MESR that exceeded Quebec's.

The western provinces were slow to adopt R & D tax credits; Saskatchewan did so in 1998, British Columbia in 1999, and Alberta in 2009. Moreover, compared with the rates in other provinces, the credits have been relatively low. Saskatchewan offered the most generous regime in western Canada between 1999 and 2012, with a MESR for current inputs of 32 percent.

The MESR for capital expenditures (equipment and buildings) used in R & D has typically been much lower than for current inputs, as illustrated in figures 5A, 5B, and 5C. Until 1983, the largest and the only positive MESRs for capital were in Atlantic Canada, owing to the enhanced R & D tax credit for this region offered by the federal government. In the rest of Canada, the MESRs for capital were negative in 1981-1983, and only turned positive in 1984 when the additional deduction for incremental R & D was replaced by an increased federal tax credit for R & D. Note that a negative MESR means that capital inputs used for R & D are being taxed, rather than subsidized, at the margin, much like other capital used in production.

As in the case of current spending, Nova Scotia had the lowest MESR on capital inputs starting in 1984 when it introduced its own R & D tax credit. Between 1983 and 1991, the Atlantic provinces were followed by Quebec, which did not apply its credit to R & D capital spending but did have the lowest provincial CIT in the manufacturing and processing sector (the sector we consider in our model).

In 1987, the MESR for capital in all provinces decreased when the federal government eliminated the eligibility of capital expenditures on buildings for the R & D tax credit. In Ontario, Manitoba, and the western provinces, the MESR became negative

FIGURE 5A The Marginal Effective Subsidy Rate on Capital R & D Spending, Atlantic Canada, 1981-2016

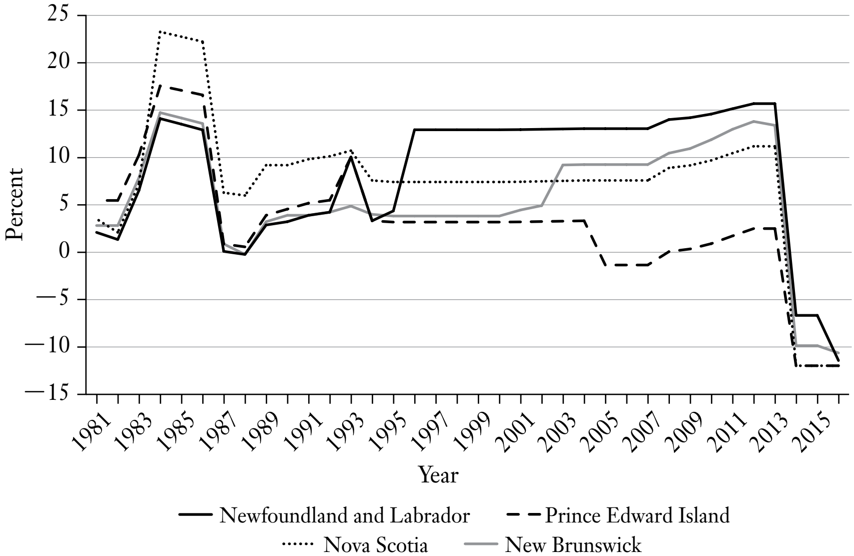


FIGURE 5B The Marginal Effective Subsidy Rate on Capital R & D Spending, Central Canada, 1981-2016

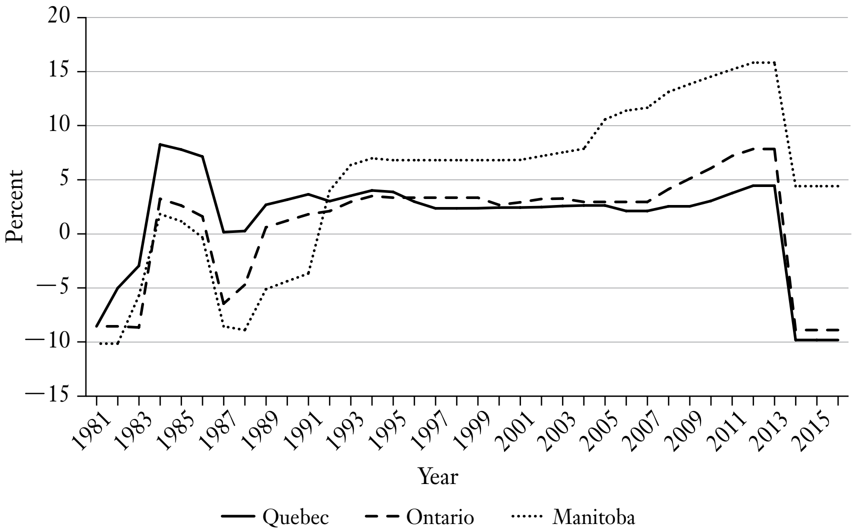
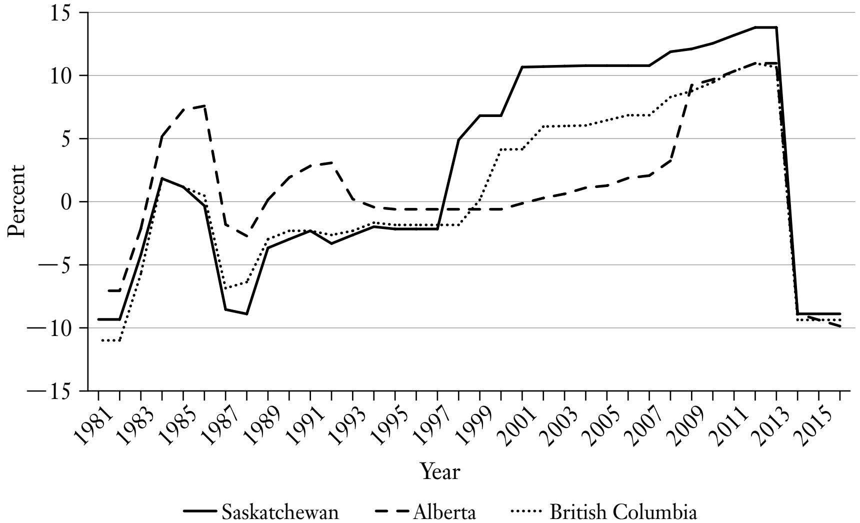


FIGURE 5C The Marginal Effective Subsidy Rate on Capital R & D Spending, Western Canada, 1981-2016



again. As the provinces introduced their own R & D tax credits (or, in Ontario, the superallowance), the MESR turned positive, in Ontario in 1989, Manitoba in 1992, Saskatchewan in 1998, and British Columbia in 1999.

In 1994, when the special federal tax credit for R & D in the Atlantic provinces was eliminated, the MESR for capital fell in that region. This decrease was partly offset in Nova Scotia and New Brunswick as they introduced their own R & D tax credit rates of 15 percent and 10 percent, respectively. In 1994 and 1995, Nova Scotia remained the most generous province followed closely by Manitoba, which also offered a provincial tax credit of 15 percent.

Following the reduction in the provincial CIT rate to 5 percent in 1995 and the introduction of an R & D tax credit of 15 percent in 1996, Newfoundland and Labrador provided the most generous subsidy for R & D capital, which it maintained until 2010. Interestingly, from 2010 to 2013, Manitoba and Newfoundland and Labrador had almost identical MESRs on R & D capital, and the largest in Canada, but achieved this in two different ways: the first through a generous 20 percent tax credit on R & D with a provincial CIT rate of 12 percent; the second through a lower R & D tax credit rate of 15 percent with a lower provincial CIT rate of 5 percent.

Since 2013, with the change in the federal treatment of capital spending for R & D as ineligible for the SR & ED tax credit, the MESR on capital used in R & D in all provinces except Manitoba became negative. Manitoba is the only province that still extends its R & D tax credits to R & D equipment, although in the absence of the federal tax credit the impact of this credit is significantly muted.

As noted above, the MESR on the production of a unit of intangible R & D capital is a weighted average of the MESRs on the underlying inputs, and measures the percentage reduction in the cost of producing an incremental unit of intangible R & D capital. In this regard, it is important to note that R & D is a very labour-intensive process. Current inputs account for about 90 percent of R & D expenditures, and capital expenditures account for about 10 percent. Expenditures on labour account for about two-thirds of current expenditures. The results are displayed in figures 6A, 6B, and 6C.

Given the labour-intensive nature of R & D, Quebec offered the highest MESR on the production of R & D in Canada between 1988 and 2005, despite restricting its tax credit to wages and contract R & D. The peak was attained in 1992 and 1993, with a subsidy rate of 38.8 percent. Before 1988, the Atlantic provinces of Prince Edward Island and Nova Scotia offered the most generous treatment of R & D inputs, owing to the enhanced federal credit for the Atlantic region. Quebec took the lead following the increase in the tax credits for wages and contract R & D in 1987 and the new treatment of the federal SR & ED tax credit as deductible.

Since 2006, Manitoba has had the highest MESR on the production of R & D, as a result of the increase in its R & D tax credit from 15 percent to 20 percent in 2005, which coincided with Quebec's scaling back of its R & D programs, starting in 2003.

At the other end of the spectrum, Alberta and Prince Edward Island each had a MESR on the production of R & D of around 18 percent from 1994 until 2008. Since the introduction of an R & D tax credit of 10 percent in 2009, Alberta's MESR exceeded Ontario's (now second to last) and is almost identical to British Columbia's.

Between 2012 and 2014, the base of qualifying expenditures for the federal tax credit was narrowed by reducing to 80 percent the eligibility of contract R & D and eliminating capital expenditures. As a result, the MESR on the production of R & D in all provinces except Manitoba dropped by approximately 7 percentage points (more in Quebec owing to provincial changes). Manitoba limited the magnitude of this decrease to 5 percentage points by not following the federal rule regarding eligible spending. In 2016, Manitoba had a MESR for the production of intangible R & D of 29 percent, followed by New Brunswick with 23.2 percent.

The last metric we calculate is the MESR on investment in intangible R & D capital, illustrated in figures 7A, 7B, and 7C. The overall MESR on investment in intangible R & D measures the percentage reduction in the gross-of-tax rate of return on a marginal investment in intangible R & D capital relative to the net-of-tax rate of return required by investors. Recall that when the MESR rate on intangible R & D capital is positive, the tax system subsidizes investment in R & D by lowering the gross-of-tax rate of return on a marginal investment below the after-tax hurdle rate of return required by investors. Moreover, when the MESR rate exceeds 100 percent, the gross-of-tax rate of return is in fact negative. This means that an incremental R & D project may generate economic losses before taxes and still be a worthwhile investment, given the generous subsidy offered by the federal and provincial governments.

The MESRs on investment in intangible R & D capital more or less mirror the MESRs on production discussed above, with the exception that they are substantially

FIGURE 6A The Marginal Effective Subsidy Rate on the Production of Intangible R & D Capital, Atlantic Canada, 1981-2016

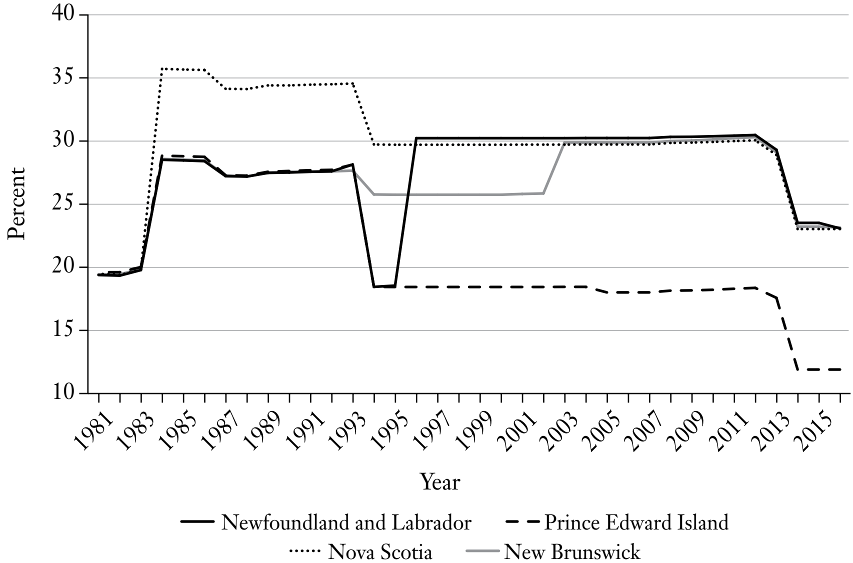


FIGURE 6B The Marginal Effective Subsidy Rate on the Production of Intangible R & D Capital, Central Canada, 1981-2016

FIGURE 6C The Marginal Effective Subsidy Rate on the Production of Intangible R & D Capital, Western Canada, 1981-2016

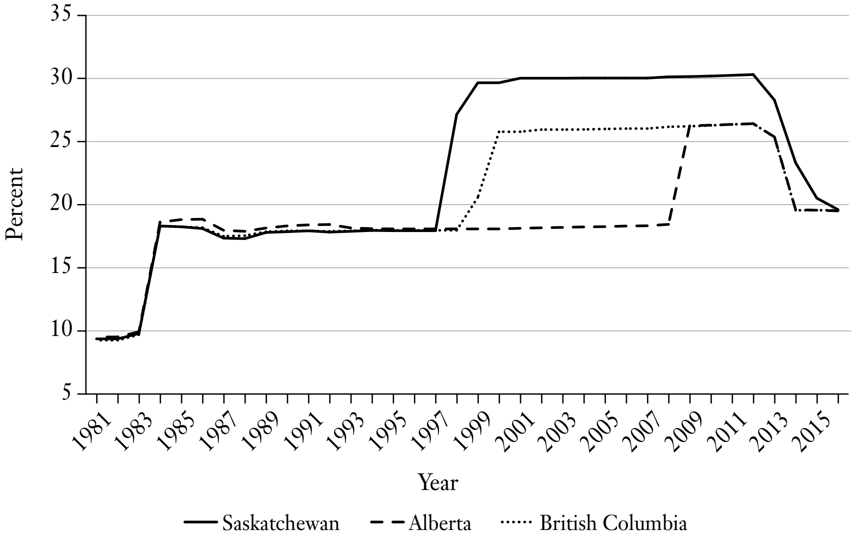


FIGURE 7A The Marginal Effective Subsidy Rate on Investment in Intangible R & D Capital, Atlantic Canada, 1981-2016

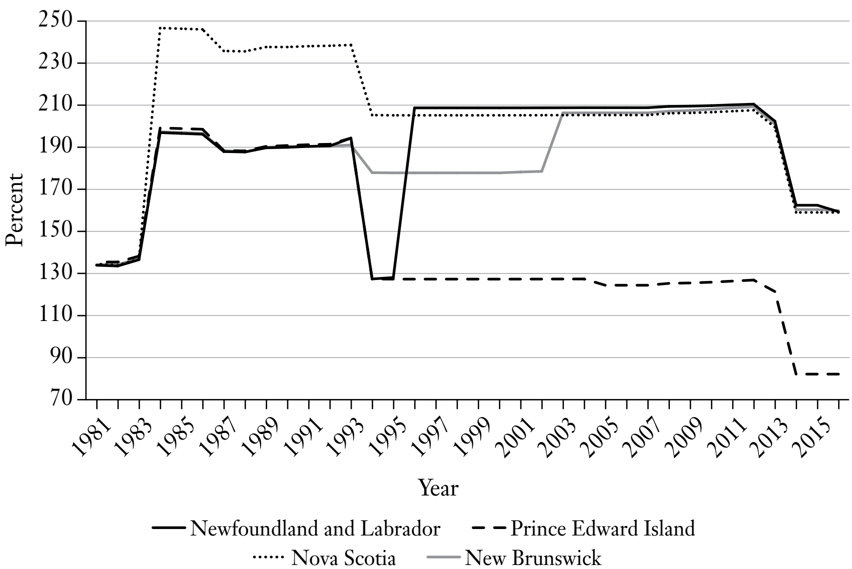


FIGURE 7B The Marginal Effective Subsidy Rate on Investment in Intangible R & D Capital, Central Canada, 1981-2016

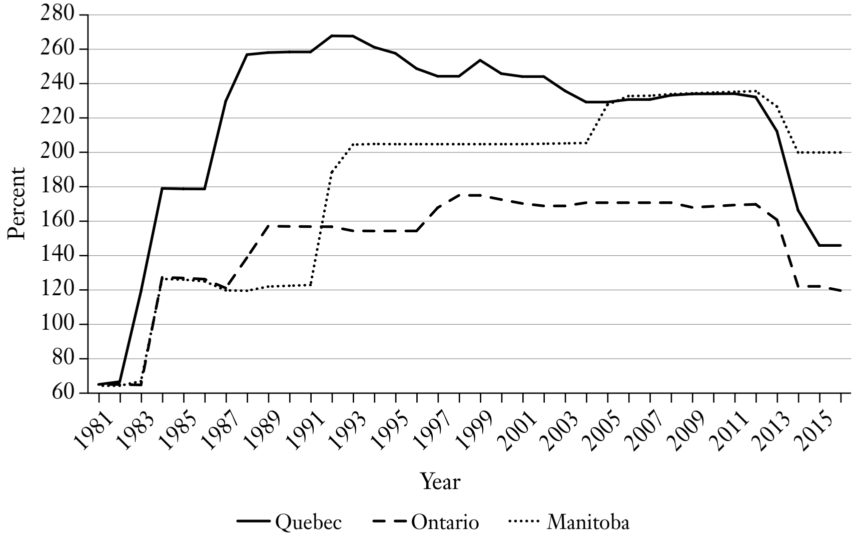
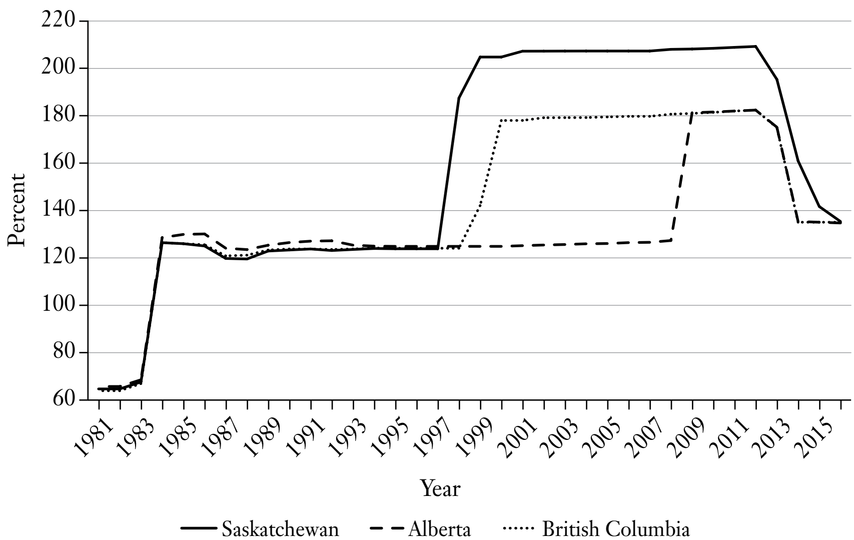


FIGURE 7C The Marginal Effective Subsidy Rate on Investment in Intangible R & D Capital, Western Canada, 1981-2016



higher. For example, the largest MESR on intangible R & D capital was offered by Quebec in 1992 at a rate of 267.8 percent. Assuming that the minimum after-tax hurdle rate of return on an incremental unit of investment in intangible R & D capital required by stakeholders is 5 percent, this implies that the gross-of-tax rate of return on R & D on a marginal investment was negative 8.4 percent ((1 − 267.8%)∗5%). This coincides with a MESR on the production of R & D capital in 1992 of about 39 percent. The MESR on investment in intangible R & D capital is therefore almost an order of magnitude higher than the associated reduction in its marginal cost. The reason for this is much the same as the reason why sales taxes levied directly on the purchase of a capital good lead to a disproportionate increase in the marginal effective tax rate in standard METR studies: the subsidy lowers the cost of producing R & D directly, and the MESR on investment in intangible R & D measures the percentage change in a rate of return.

As shown in the figures, the MESR on investment in R & D in Canadian provinces has varied considerably over the 35-year period examined, and there has been substantial variation between the provinces. On the whole, the MESR on R & D investment has been very high throughout the period, typically well in excess of 100 percent, and even 200 percent, although there has been a drop recently as the federal government has reduced both the size and the scope of the SR & ED tax credit. In 2016, only one province, Prince Edward Island, had a MESR on intangible R & D capital of less than 100 percent. The 82.2 percent MESR on R & D investment in that province implies that an incremental unit of investment in intangible R & D capital can earn a gross-of-tax rate of return of only 0.9 percent in order to be considered worthwhile. The highest MESR on investment in intangible R & D capital in 2016 was 200 percent in Manitoba, in which case a marginal investment in intangible R & D could earn a negative 5 percent rate of return before taxes and subsidies and still generate the after-tax hurdle rate of return required by shareholders.

CONCLUSIONS

This article has presented various metrics, based on the marginal effective tax/subsidy rate methodology, documenting the evolution of federal and provincial tax subsidies related to R & D across Canadian provinces over time, from 1981 to 2016. As far as we know, the data set is unique. The emphasis here has primarily been on presenting the data and providing an overview of the underlying methodology. As we have shown, the MESR on investment in intangible R & D capital in Canada, taking into account both federal and provincial programs, has been substantial over the entire period examined. There has also been significant time-series and cross-sectional (across provinces) variation in R & D tax subsidies in Canada over the period studied.

Although this article is primarily descriptive, it is nonetheless useful to conclude with some brief comments on what may be viewed as an "R & D policy puzzle" that seems to have plagued Canada for decades. In this regard, we note first that by any metric Canada offers high tax subsidies for R & D relative to international comparators. For example, using a similar marginal effective tax/subsidy rate approach, Lester and Warda show that Canada ranks near the top of R & D tax subsidies relative to developed countries, even when only federal programs are considered.[28]

Second, most empirical estimates suggest that R & D expenditures are quite sensitive to tax subsidies. McKenzie and Sershun, for example, use an international data set to estimate a long-run elasticity of R & D expenditures with respect to the user cost of R & D capital ranging between −0.46 and −0.83.[29] Using the higher estimate, which is consistent with much of the existing research, a 10 percent decrease in the user cost of intangible R & D capital attributable to tax subsidies is associated with an 8.3 percent increase in R & D expenditures.

Thus, we see that Canada offers extremely high tax subsidies for R & D, particularly when provincial programs are included, and that R & D expenditures are thought to be quite responsive to these subsidies. Yet, as discussed in the introduction to this article, Canada ranks quite low in the BERD:GDP ratio relative to other developed countries, and that ratio has been falling over time. This is the "R & D policy puzzle."

We conclude with three comments in this regard. The first is the rather obvious point that it may well be that Canada's R & D performance would have been even worse in the absence of the subsidies. Of course we don't observe this counterfactual, but it is consistent with the above observations.

The second comment is more speculative, and relates to the nature of R & D subsidies in Canada. As discussed in the Jenkins report, Canada relies much more than other countries on the type of "indirect" tax subsidies that we consider here, which are generally available to all companies, as opposed to "direct" subsidies, such as targeted grants. It could be that the nature of R & D subsidies in Canada—the reliance on indirect tax incentives rather than direct grants—is the problem. The Jenkins report reflects this view in its recommendation that "the government should rebalance the mix of direct and indirect funding by decreasing spending through the SR & ED program and directing the savings to complementary initiatives outlined in our other recommendations."[30] Indeed, subsequent changes to the SR & ED and other federal programs following the release of the Jenkins report move modestly in this direction.

This leads to our third, and final, observation. To our knowledge, there is in fact very little rigorous empirical evidence regarding the efficacy of direct versus indirect government subsidies for R & D. Moving in this direction may well be the right thing to do, but this seems to us to be based more on faith, and perhaps some frustration with the Canadian "R & D policy puzzle," than on solid empirical evidence. Our hope is that the data presented here provide, at least in part, the basis for additional research in this regard in a Canadian context. Indeed, in parallel

28 See Lester and Warda, supra note 9.

29 Kenneth J. McKenzie and Natalia Sershun, "Taxation and R&D: An Investigation of the Push and Pull Effects" (2010) 36:3 *Canadian Public Policy* 307-24.

30 Supra note 2, at E-10.

research we are undertaking an empirical investigation of the effectiveness of direct and indirect incentives in promoting business R & D investment in Canadian provinces.

APPENDIX A FORMULAS

This appendix presents some of the basic formulas used in our computations. Readers may refer to a previous article by McKenzie for formal derivations and further discussion.[31] As discussed in the text, for most provinces, the R & D subsidy regime is a straightforward extension of the federal SR & ED tax credit program. Ontario and Quebec are exceptions and through the years have provided a mixed bag of various and sundry subsidies, including standard tax credits, superallowances, and superdeductions.

The After-Tax Cost of a $1 Expenditure on Inputs Used in R & D

In our underlying calculations, we distinguish three types of current costs used in R & D—labour, contract R & D, and materials—and two types of physical capital—equipment and buildings. For simplicity, in what follows we present the formulas for labour, which is the primary component of current costs, and generic capital. For the most part, other current costs (contract R & D and materials) are treated in a similar manner, though in some cases the size of the credit and/or the definition of eligible expenditures differs.[32]

Most Provinces

For most provinces in most years, the after-subsidy cost of a $1 current expenditure on R & D is

$$1 - s_L = (1 - u_f - u_p)(1 - \theta_f^L)(1 - \theta_p^L),$$

where u_f is the federal statutory CIT rate, u_p is the provincial statutory CIT rate, θ_f^L is the federal tax credit, and θ_p^L is the provincial tax credit for current expenditures employed on R & D. This formula reflects the fact that current costs are expensed for CIT purposes, that federal and provincial tax credits are "taxable" (that is, reduce the amount that can be expensed for tax purposes), and that the federal tax credit applies to expenditures net of the provincial credits.

In 1981, 1982, and part of 1983, the federal government granted an additional tax deduction equal to 50 percent of current R & D expenditures in excess of the

31 McKenzie, "Measuring Tax Incentives for R&D," supra note 9.

32 An important exception is Quebec, where tax subsidies are for the most part applied to labour only. With respect to overhead, since we are dealing with large corporations, we presume that they do not follow the so-called proxy approach to measuring R & D overhead for tax purposes.

average of the previous three years. As demonstrated by Eisner, Albert, and Sullivan,[33] when the base is defined using a past average of spending, an adjustment is needed to the statutory tax credit or depreciation rate to account for the fact that current-year spending increases the base in future years and therefore reduces the effectiveness of the incentive. Modifying that approach, for these years we have

$$1 - S_L = (1 - \theta_f^L)[1 - u_f(1 + d) - u_p] + \frac{d}{3} * (1 - \theta_f)u_f * \sum_{i=1}^{3}(1 + r^f)^{-i},$$

where d is the incremental deduction rate.[34]

For most provinces in most years, the after-subsidy cost of a $1 expenditure on physical capital used in R & D is

$$1 - S_K = (1 - \theta_f^K)(1 - \theta_p^K)[1 - (u_f + u_p)Z],$$

where Z is the present value of tax depreciation deductions on $1 spent on physical capital.[35]

Quebec

Quebec R & D subsidies largely have applied to R & D labour only, so $\theta_p^K = 0$ in the above expressions for $1 - S_K$. Moreover, at various times provincial and/or federal tax credits have not been taxable at the provincial level.

Quebec introduced an R & D credit in 1983. From 1983 to April 1987, the provincial credit was non-taxable in Quebec, giving

$$1 - S_L = (1 - \theta_f^L)(1 - \theta_p^L)(1 - u_f) - [(1 - \theta_f^L)(1 - \theta_p^L)]u_p.$$

From May 1987 to May 1996, the federal credit was also non-taxable in Quebec, yielding

$$1 - S_L = (1 - \theta_f^L)(1 - \theta_p^L)(1 - u_f) - u_p.$$

From May 1996 to November 2012, Quebec reverted to the 1983 regime, with the federal credit taxable in Quebec but the provincial credit non-taxable, but in 1999 and 2000 firms had the option of choosing between the provincial tax credit

33 Robert Eisner, Steven H. Albert, and Martin A. Sullivan, "The New Incremental Tax Credit for R&D: Incentive or Disincentive?" (1984) 37:2 *National Tax Journal* 171-83.

34 We assume here that firms have "static expectations" in the sense that they do not anticipate changes in tax parameters that are introduced in the future.

35 For a declining balance capital cost allowance rate of α, $Z = \alpha/(r^f + \pi + \alpha)$, where r^f is the after-tax real cost of finance, defined below, and π is the rate of inflation. When expenditures on physical capital used in R & D are expensed for tax purposes (as has been the case throughout most of the period examined), $Z = 1$.

and a superdeduction, which allowed firms to deduct 230 percent of eligible labour R & D (460 percent for contract R & D).[36] The resulting formula is

$$1 - S_L = (1 - \theta_f^L)[(1 - u_f) - du_p],$$

where d is the superdeduction rate.

Since November 2012, Quebec has reverted to the standard approach, with both federal and provincial tax credits taxable at the provincial level.

Ontario

There were no provincial tax subsidies for R & D in Ontario until 1988, when the provincial government introduced a superallowance. The basic superallowance rate of 25 percent was intended to nullify the taxability of the federal tax credit for provincial purposes. The province also introduced an incremental superallowance of 12.5 percent for R & D expenditures in excess of the average of R & D expenditures over the previous three years. Thus, for Ontario from 1988-2000, we have

$$\begin{aligned} 1 - S_L = {} & (1 - \theta_f^L)(1 - u_f - u_p) - (d + d_i)(1 - \theta_f^L)u_p \\ & + \frac{d_i}{3}(1 - \theta_f^L)u_p \frac{1}{3}\sum_{t=1}^{3}(1 + r^f)^{-t}, \end{aligned}$$

where d is the basic superallowance rate (25 percent) and d_i is the incremental superallowance rate (12.5 percent).

Both the basic and incremental superallowance were eliminated in March 2000 and replaced by the superdeduction, which allowed firms to deduct their federal R & D tax credit from their taxable income. The superdeduction was maintained until the end of 2008. During this period, we have

$$1 - S_L = (1 - \theta_f^L)(1 - u_f) - u_p.$$

In 2009, the superdeduction was replaced with a standard 4.5 percent tax credit (3.5 percent since June 2016), taxable at both the federal and provincial levels, and the standard formulas apply.

The MESR on the User Costs of Labour and Capital Used in the Production of Intangible R & D Capital

Given the expressions for the after-subsidy cost of a $1 expenditure on labour (that is, current costs) and capital used in R & D, the MESR on R & D labour is[37]

$$s_L = 1 - \frac{1 - S_L}{1 - u_f - u_p},$$

36 In our calculations, for large firms it is more advantageous to take the superdeduction option in the case of contract R & D, but not for in-house R & D spending.

37 By choice of units we normalize the cost of one unit of labour and capital to $1.

where $1 - S_L$ is the after-subsidy cost of a \$1 expenditure on labour determined above.

The MESR on R & D physical capital is

$$s_K = \frac{(r^n + \delta_K) - r_K^g}{r^n + \delta_K},$$

where δ_K is the economic depreciation rate on physical capital, and $r^n = i\beta + \rho(1 - \beta) - \pi$ is the real after-tax net of depreciation rate of return required by stakeholders on a marginal investment in physical capital, which is equal to the weighted average real rate of return on debt (i) and equity (ρ), where β is the share of the capital expenditure financed by debt and π is the expected inflation rate. r_K^g is the before-tax rate of return on an incremental unit of physical capital, given by[38]

$$r_K^g = \frac{(r^f + \delta_K)(1 - S_K)}{1 - u_f - u_p},$$

where

$$r^f = (1 - u_f - u_p)i\beta + \rho(1 - \beta) - \pi$$

is the real after-tax cost of finance, reflecting the tax deductibility of nominal debt interest (but not equity) for tax purposes, and $1 - S_K$ is the after-subsidy cost of a \$1 expenditure on capital used in R & D determined above.[39]

The MESR on the Production of Intangible R & D Capital

To determine the marginal effective subsidy rate on the in-house production of intangible R & D capital, we must make an assumption regarding the functional form of the R & D production function. We assume a simple fixed-proportions, or Leontief, functional form that assumes that capital and labour are employed in fixed proportions in the production of intangible R & D.[40]

Under the fixed-proportions assumption, the MESR on the production of intangible R & D capital (s_R), which is the percentage reduction in the marginal cost of producing one unit of intangible R & D capital, is given by

$$s_R = 1 - [a_L(1 - s_L) + a_K(1 - s_K)],$$

38 Note that this differs from the standard METR on capital measure in that the before- and after-tax required rates of return are expressed gross rather than net of depreciation.

39 We assume in our calculations that R & D expenditures are financed at the margin by equity, so that $\beta = 0$. If we assume some debt financing, r^f will be lower and the effective subsidy rates on R & D will be higher than those reported here.

40 More flexible functional forms in the family of constant elasticity of substitution functions do not substantially affect the results.

where a_L is the share of R & D expenditures accounted for by labour, a_K is the share accounted for by physical capital, and s_L and s_K are the MESRs on labour and capital used in the production of intangible R & D capital determined above.

The MESR on an Investment in Intangible R & D Capital

The before-subsidy rate of return on an incremental investment in intangible R & D capital required to generate the after-subsidy minimum hurdle rate of return required by stakeholders is

$$r_R^g = (1 - s_R)(r^f + \delta_R) - \delta_R,$$

where s_R is the MESR on the production of intangible R & D capital determined above, r^f is the real after-tax cost of finance (as above), and δ_R is the economic rate of depreciation on intangible R & D capital.

The MESR on an investment in intangible R & D capital is then

$$MESR = \frac{r^n - r_R^g}{r^n},$$

which measures the percentage reduction in the before-tax rate of return required to generate the required after-tax hurdle rate of return attributable to the subsidies offered for expenditures on R & D.

APPENDIX B PARAMETER VALUES

We use the following parameter values in our calculations:[41]

- nominal interest rate net of risk and depreciation (i), 5 percent
- rate of inflation (π), 2 percent
- nominal rate of return on equity net of risk and depreciation (ρ), 4.54 percent
- post-2012 weighted average capital cost allowance (CCA) rate on equipment (α_e), 19.3 percent
- post-1986 weighted average CCA rate on buildings (α_b), 6.3 percent
- economic depreciation rate on equipment used in R & D (δ_e), 19.3 percent
- economic depreciation rate on buildings used in R & D (δ_b), 6.3 percent
- percentage of R & D financed by debt (β), 0 percent
- economic depreciation rate on intangible R & D capital (δ_R), 15 percent

41 These parameters were for the most part provided by the School of Public Policy (Calgary), and are consistent with the parameter values used in its standard METR model. See, for example, Philip Bazel and Jack Mintz, "2015 Tax-Competitiveness Report: Canada Is Losing Its Attractiveness" (2016) 9:37 *SPP Research Papers* 1-40. Also see Lester and Warda, supra note 9.

- R & D input shares (the a_i's):
  - labour, 59.5 percent
  - materials, 11.4 percent
  - contract, 19.8 percent
    - total current inputs, 90.7 percent
  - equipment, 6.2 percent
  - buildings, 3.1 percent
    - total capital inputs, 9.3 percent
- CIT rates, tax credit rates, etc.: various by province and year