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Benefit-Cost Analysis of R & D Support Programs

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PRÉCIS

Étant donné que les connaissances obtenues grâce aux dépenses privées pour la recherche et le développement (R-D) produisent des avantages pour la société et pour l'entreprise qui effectue la recherche, il semble donc logique de croire que l'intervention gouvernementale pour encourager la R-D est une bonne chose. Mais intervenir sur le marché coûte cher et ces coûts peuvent dépasser les avantages dérivés de la R-D supplémentaire. Cet article traite d'une approche visant à évaluer l'avantage économique net découlant des programmes de soutien à la R-D et présente les résultats pour deux programmes fédéraux : le crédit d'impôt pour la recherche scientifique et le développement expérimental (RS&DE) et le Programme d'aide à la recherche industrielle (PARI).

L'approche relative au rapport avantage-coût utilisée dans cet article calcule l'incidence des subventions à la R-D sur le revenu réel en prenant en compte l'avantage créé par les retombées de la connaissance produites par la R-D induite, le coût du financement des subventions avec les impôts qui nuisent inévitablement à la performance économique, le coût de détourner des ressources de leurs utilisations établies par le marché, et les coûts d'administration et de conformité. Le crédit pour la RS&DE se compose de deux éléments : un crédit ordinaire de 20 % et un crédit majoré remboursable de 35 % pour les plus petites entreprises sous contrôle canadien. Le crédit ordinaire produit un avantage économique net, mais le crédit majoré échoue au test du rapport avantage-coût, en raison des coûts de conformité plus élevés et d'un taux plus élevé de subvention. Le PARI échoue également au test du rapport avantage-coût, en dépit de l'hypothèse voulant que la R-D financée par le PARI produise des retombées plus abondantes que la R-D financée par le crédit d'impôt. Les raisons de cet échec seraient dues au coût élevé d'administration et de conformité du programme.

Les recommandations en matière de politique fiscale découlant de l'analyse dans cet article sont que le crédit d'impôt majoré pour la RS&DE devrait être aligné sur un taux de crédit ordinaire inchangé et que le modèle de PARI, qui consiste à fournir aux entreprises un

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nombre substantiel de conseils personnalisés et d'imposer des exigences de déclaration relativement lourdes, devrait être revu afin de réduire les coûts. Le budget fédéral de 2012 a adopté une approche différente : le taux de crédit ordinaire a été réduit à 15 % et le financement du PARI a été doublé sans aucun changement à la structure du programme. Contrairement aux recommandations en matière de politique fiscale faites dans cet article, ces changements réduiront l'avantage net du crédit d'impôt pour la RS&DE et le PARI. En particulier, s'il n'y a aucun changement à la structure du programme, le financement supplémentaire du PARI fera augmenter sensiblement la perte nette du programme.

ABSTRACT

The knowledge created by private spending on research and development (R & D) generates benefits for society as well as for the firm performing the research, so there is a strong case for government intervention to encourage R & D. But intervening in the market has costs, and these costs may exceed the benefits derived from the additional R & D. This article describes an approach for assessing the net economic benefit arising from R & D support programs and presents results for two federal programs: the scientific research and experimental development (SR & ED) tax credit and the industrial research assistance program (IRAP).

The benefit-cost approach used in this article calculates the impact of R & D subsidies on real income taking into consideration the benefit created by knowledge spillovers from the induced R & D, the cost of financing the subsidies with taxes that unavoidably harm economic performance, the cost of shifting resources from their market-determined uses, and administration and compliance costs. The SR & ED credit has two components: a regular 20 percent credit and an enhanced 35 percent refundable credit for smaller Canadian-controlled firms. The regular credit generates a net economic benefit, but the enhanced credit fails a benefit-cost test, owing to higher compliance costs and a higher subsidy rate. IRAP also fails a benefit-cost test, despite the assumption that IRAP-funded R & D generates higher spillovers than R & D funded by the tax credit, owing to the high cost of administering and complying with the program.

The policy recommendations flowing from the analysis in this article are that the enhanced SR & ED tax credit should be aligned with an unchanged regular credit rate and that the IRAP model of providing firms with a substantial amount of one-on-one advice and imposing relatively burdensome reporting requirements should be revisited in order to reduce costs. The 2012 federal budget took a different approach: the regular credit rate was reduced to 15 percent, and IRAP funding was doubled without any changes to the program's structure. In contrast to the policy recommendations made in this article, these changes will reduce the net benefit from both the SR & ED tax credit and IRAP. In particular, without any changes to program structure, the additional IRAP funding will substantially increase the net loss from the program.

KEYWORDS: BENEFIT-COST ANALYSIS ■ EVALUATION ■ R & D ■ SR & ED ■ TAX CREDITS ■ TAX POLICY

CONTENTS

INTRODUCTION

There is abundant evidence that research and development (R & D) plays a key role in the improvement of living standards over time.[1] Per capita income increases when workers have more capital to work with, but additional gains are obtained when both labour and capital are used more efficiently. Innovation by firms is the main driver of these efficiency increases, and R & D is an important part of the innovation system.

Government support for R & D is appropriate because the private market fails to provide the socially optimal amount of investment. This market failure arises because, despite their best efforts and the benefits of patent protection, firms cannot prevent the knowledge gained through their R & D from leaking out, or spilling over, to other firms. These spillovers occur, for example, as researchers exchange ideas at professional meetings and as they move from firm to firm. More generally, discovery in one firm can trigger new avenues of research, inspire new research projects, or find new applications in other firms. Once knowledge has been created by one firm, other firms can make use of it without having to incur all of the costs

1 For a review of this evidence, see Organisation for Economic Co-operation and Development, *The OECD Innovation Strategy: Getting a Head Start on Tomorrow* (Paris: OECD, 2010).

of developing the knowledge. As a result, while society would be better off with additional R & D, private firms do not have the right incentives to provide it because their marginal private benefits are less than the marginal social benefits.

Providing financial support to firms that undertake R & D can therefore be in the interest of all taxpayers because, to the extent that this assistance results in additional R & D, it will contribute to a higher standard of living for all citizens. But while the existence of externalities is a necessary condition for government intervention to improve economic performance, it may not be a sufficient condition: intervening in the economy has costs, and these costs may exceed the benefits of intervention. This article describes an approach for assessing the net economic benefit provided by R & D support programs and presents results for two federal government programs: the scientific research and experimental development (SR & ED) tax credit and the industrial research assistance program (IRAP). In 2010, the SR & ED tax credit accounted for 65 percent of federal payments to business in support of R & D, while IRAP accounted for an additional 4 percent. IRAP is the largest direct assistance program, accounting for 12 percent of total federal direct assistance payments.

While the benefit-cost approach provides a sound conceptual framework for evaluating individual programs and comparing their relative effectiveness, there are practical limitations to its application. Not all of the economic benefits and costs can be quantified, and for those that can, the estimates are not always as precise as is desirable. But the benefit-cost framework may well be the most promising approach for evaluating individual programs and comparing their relative effectiveness. Its key advantages are that it focuses on what should be the ultimate objective of government intervention—an improvement in living standards—and that it captures the costs of providing assistance, which comprise administration, compliance, and the cost of financing the intervention with distortionary taxes.

OVERVIEW OF THE PROGRAMS EVALUATED

The SR & ED Tax Credit[2]

A federal 20 percent SR & ED tax credit is generally applicable to Canadian businesses, with a higher 35 percent federal tax credit available to qualified small businesses that are Canadian-controlled private corporations (CCPCs). The enhanced credit is fully refundable for non-capital spending[3] by most small CCPCs. The effective credit rates are somewhat lower than the statutory rates because spending on buildings is not eligible for the credit and because not all regular claimants are able to use the 20 percent credit immediately, resulting in a reduction of its value. The 2012 federal budget announced a number of changes to the SR & ED tax credit that will reduce

2 The principal SR & ED provisions are contained in sections 37 and 127 of the Income Tax Act, RSC 1985, c. 1 (5th Supp.), as amended, and related regulations.

3 Credits related to spending on capital equipment, which accounts for less than 5 percent of eligible spending, are refundable at a maximum rate of 40 percent.

the amount of assistance provided.[4] The regular tax credit rate will be reduced from 20 percent to 15 percent effective 2014. The budget proposals also narrow the base of the credit for all claimants by removing spending on equipment and eliminating the profit component of contract spending. In addition, the simplified calculation of overhead costs will become less generous.

In order to target the enhanced 35 percent refundable credit to small firms, three criteria are used: an expenditure limit, a taxable income limit, and a capital invested limit. All of these limits must be met for a firm to benefit from both the higher credit rate and full refundability. The expenditure limit to access the 35 percent credit with full refundability is $3 million, while the taxable income limit is $500,000 and the capital invested limit is $10 million. The expenditure limit is gradually reduced to zero as either prior-year taxable income rises from $500,000 to $800,000 or invested capital rises from $10 million to $50 million; when either of these upper limits is exceeded, no R & D spending is eligible for the 35 percent refundable credit.

The SR & ED credit has two key characteristics: it is open-ended with no fixed budget, and investment decisions are made by firms—if the project qualifies as R & D, a tax credit will be received.

In 2007, the last year for which final data are available, approximately 18,000 small CCPCs received about $1.3 billion in SR & ED tax credits,[5] another 1,300 small firms not eligible for the enhanced credit claimed $0.2 billion in credits, and 2,600 large firms received $1.8 billion in credits. The average credit value for CCPCs was about $65,000 in 2007, compared with an average claim of about $700,000 for other firms.

IRAP

IRAP provides assistance to corporations operating in Canada with up to 500 full-time equivalent employees, but most awards are made to firms with fewer than 50 employees.[6] The assistance provided consists of non-repayable "contribution funding" and the provision of technical and business advice by industrial technology advisers (ITAs). Direct assistance to firms can be provided as a grant, a contribution, or a loan; grants and contributions may be repayable or non-repayable. In contrast to the awarding of grants, firms receiving contribution assistance are required to submit progress reports and a final accounting of the use of funds; they may also be audited to verify the accuracy of submitted reports. These conditions make contribution

4 Canada, Department of Finance, 2012 Budget, Budget Plan, March 29, 2012, at 61, 69-71. For the purposes of this article, it is assumed that the changes set out in the budget will be enacted as proposed.

5 This total excludes about 1,800 claims by individuals making contributions to associations formed to undertake R & D.

6 Over 80 percent of IRAP's clients have fewer than 50 employees. National Research Council-Industrial Research Assistance Program (NRC-IRAP), "2011 Program Overview" (unpublished) (herein referred to as "NRC-IRAP 2011").

programs substantially more expensive for the government to administer and for firms to use than tax credits and grant programs.

From 2006 to 2008, IRAP contribution funding for firms averaged approximately $67 million a year. In 2006 (the latest year for which detailed data are available), 1,373 firms received funding; the average award was approximately $45,000 while the median was $36,500.[7]

Funding was expanded substantially in the 2009 budget; contributions to firms rose to about $215 million in 2009-10. The funding increase was temporary, so the number of ITAs and administrative staff was not increased in line with the higher contributions. In order to deal with the increased volume of funding, the average award size increased to approximately $120,000[8] and ITAs spent less time providing advice. Given the temporary nature of these arrangements, only the pre-2009 version of IRAP has been assessed using the benefit-cost framework, although a sensitivity analysis is also included. The 2012 federal budget doubled IRAP funding for administration expenses and contributions to firms from $110 million in 2011-12 to $220 million a year beginning in 2012-13.

While there is no formal competitive process for selecting projects to receive funding, ITAs rigorously assess applicants to ensure that they are "investment ready" and that their projects are worthy of funding. Because there is always a queue of applicants, ITAs can be selective in the allocation of funding. According to a survey,[9] ITAs spend just under half of their time providing business management and technical advice that is not directly related to contribution funding. Many firms receive advice from ITAs without ever receiving contribution funding, some because they are not deemed investment ready and others because funding is unavailable. Further, ITAs maintain a relationship with clients even after the funding period ends. As a result, at any given time only about a third of IRAP clients are receiving funding.

The provision of advisory services by government may be addressing a market failure, since potential clients are likely to be more concerned about giving away useful information when they deal with private sector suppliers. That kind of market failure does not, however, justify providing advisory services free of charge; unless there are spillovers to the broader economy from the firms receiving the benefit, advisory services should be provided on a cost-recovery basis. Receiving technical advice is very similar to receiving assistance to undertake R & D to solve a problem with in-house resources, so it may be reasonable to assume that technical advice has the same spillover benefit as the R & D undertaken by the firm. The argument that business management advice provides spillover benefits is much weaker: no new knowledge is being created that can benefit other firms, so it is highly likely that the

7 National Research Council-Industrial Research Assistance Program, "Impact Evaluation of the NRC Industrial Research Assistance Program—Final Report" (online document dated 2007 available on request from NRC-IRAP) (herein referred to as "NRC-IRAP 2007").

8 NRC-IRAP 2011, supra note 6.

9 NRC-IRAP 2007, supra note 7.

firm receiving the advice captures all of the benefits. Unfortunately, there is no solid information on how much time ITAs spend giving business advice to clients.

THE BENEFIT-COST APPROACH

The success of an R & D incentive program is often evaluated in terms of the additional R & D induced by the program (its incrementality) or the increase in some other measure of innovation activity, such as patents, the amount of collaborative research undertaken, or the number of interns hired. The use of different measures of success makes it difficult to compare effectiveness across programs. But even if a common intermediate outcome is adopted as a benchmark, the comparison may not be as informative as expected. For example, two programs could induce different amounts of R & D per dollar of program spending, but the apparent advantage of one program could be offset by higher costs of program delivery. Further, the additional R & D stimulated by the two programs may not have the same impact on economic performance because of different spillover benefits.

The benefit-cost approach focuses on what should be the ultimate objective of government support for R & D—higher real income—and therefore provides a basis for comparing programs and determining how program effectiveness could be enhanced by reallocating funding. The benefit-cost framework is quite flexible and can be implemented using a variety of techniques. For example, some benefit-cost analyses make use of highly complex models intended to capture all of the intended and unintended impacts of the policy being evaluated. Examples of this approach are evaluations of the Canadian federal SR & ED investment tax credit using a general equilibrium (GE) model reported by Finance and Revenue Canada[10] and by Russo.[11] In contrast, Dahlby[12] and Parsons and Phillips[13] use a simpler partial equilibrium (PE) approach: benefits and costs are calculated independently and added up to obtain a net benefit. The analysis in this article makes use of the PE approach.

Using a GE rather than a PE approach is appropriate if the interaction and feedback effects among the various channels of influence are important. For example, a complete model of the economy could capture the impact of increased investment in R & D on the wages of R & D performers. Similarly, a complete model could trace the effect of additional investment in R & D on new products through to exports

10 Canada, Department of Finance and Revenue Canada, *The Federal System of Income Tax Incentives for Scientific Research and Experimental Development: Evaluation Report* (Ottawa: Department of Finance, December 1997).

11 Benjamin Russo, "A Cost-Benefit Analysis of R&D Tax Incentives" (2004) 37:2 *Canadian Journal of Economics* 313-35.

12 Bev Dahlby, "A Framework for Evaluating Provincial R&D Tax Subsidies" (2005) 31:1 *Canadian Public Policy* 45-58.

13 Mark Parsons and Nicholas Phillips, *An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development*, Department of Finance Working Paper 2007-08 (Ottawa: Department of Finance, September 2007).

and changes in the terms of trade. A third possibility would be to model the decision to undertake R & D, including both entry and increased R & D intensity, in response to changes in profitability arising from government assistance and other factors. However, since changes in the R & D-producing sector would not be expected to have a substantial effect on the rest of the economy, thus limiting the scope for feedback effects on the R & D sector, these channels of influence could be incorporated into a PE model with little loss in accuracy. Further, the advantages of using a more complete model have to be balanced against the cost of building a model with enough detail to include all of the impacts and to correctly capture their interactions. Most benefit-cost analyses of R & D tax credits opt for the PE approach, implicitly concluding that the interaction effects are not important enough to justify the extra effort of building a GE model.[14] In contrast, assessments of options to reduce greenhouse gas emissions are usually performed using a GE model, in recognition of the strong interactions between reducing emissions and economic activity.

But even when a choice between PE and GE analysis is made, decisions must also be made about how complete and detailed the analysis needs to be to obtain useful results. This study includes the following benefits and costs:

1. the spillover benefit—the social return less the private return—on the additional R & D induced by the subsidy;
2. the opportunity cost of shifting capital and labour from their alternative market-determined uses;
3. the economic cost of financing the assistance with taxes that harm economic performance; and
4. the costs of administering and complying with the program.

A number of other elements affect the net benefit estimate, including the international investment account and terms-of-trade effects noted above, as well as indirect impacts on market failures related to financing of small firms and the environment.

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14 In addition to the studies cited in notes 10 through 13, supra, the following benefit-cost analyses of investment tax credits have been published since the early 1990s: Australia, Bureau of Industry Economics, *R&D, Innovation and Competitiveness: An Evaluation of the Research and Development Tax Concession*, Research Report 50 (Canberra: Australian Government Publishing Service, 1993); Australian Industry Commission, *Research and Development*, Report 44 (Canberra: Australian Government Publishing Service, 1995); Ralph Lattimore (Australian Productivity Commission), "Research and Development Fiscal Incentives in Australia: Impacts and Policy Lessons," in *Policy Evaluation in Innovation and Technology: Towards Best Practices* (Paris: Organisation for Economic Co-operation and Development, 1997), 91-134; Maarten Cornet, *The Social Costs and Benefits of the Dutch R&D Tax Incentive Scheme*, CPB Report 2001/3 (The Hague: Netherlands Bureau for Economic Policy Analysis, 2001), 47-50; and Joseph Yoon and Sung-Koo Lee, "Innovation Management in the Australian Government: Cost and Benefit of R&D Tax Concession Program," paper presented to the Fifth International Conference on Operations and Quantitative Management, October 25-27, 2004. Only the studies by Finance and Revenue Canada (supra note 10), Russo (supra note 11), and the Australian Industry Commission make use of GE models.

While these elements have not been included in the core analysis of this article, because they are expected to be of a second order of importance, some illustrative analysis is undertaken in the last section. Another issue is the inclusion of sectoral detail in the model. Some of the key model parameters, such as spillovers, vary by sector, so the results will be affected by changes over time in the sectoral composition of the economy. Given that interaction effects between sectors are not expected to be important, the impact of changes in sectoral composition could, in principle, be incorporated by adjusting the overall spillover estimate to reflect sectoral changes. On the other hand, the empirical estimates of spillovers are based on data from varying time periods and varying sectoral coverage, making it difficult to develop a defensible adjustment.

The spillover benefit, or the external return on R & D, used in the model is based on a survey of the empirical literature. The survey and the methodology used to estimate spillovers are described and assessed in the next section. The largest cost of providing support arises from the need to raise taxes to finance the assistance provided to firms. Higher taxes hurt economic efficiency through adverse effects on incentives to work, save, and invest. A GE model developed by Baylor and Beauséjour[15] based on the structure of the economy in the late 1990s suggests that raising an extra dollar of tax revenue from the imposition of the goods and services tax (GST) reduces welfare by 10 cents while raising a dollar through personal or corporate income taxes reduces efficiency by 30 and 40 cents, respectively. Given the mix of tax revenue in 2010, these model results imply that the weighted average marginal excess burden (MEB) of taxation—the efficiency cost of raising a dollar in tax revenue—was 29 cents in that year.[16] Similar results have been obtained by Dahlby and Ferede[17] in an econometric analysis of the sensitivity of tax bases to tax rates. Their analysis indicates that in 2006 the MEB of the GST was 11 cents per dollar while the MEB for personal and corporate income taxes was 17 and 71 cents per dollar, respectively. Adjusted to capture the mix of tax revenue in 2010, the weighted average MEB of taxation was 26 cents per additional dollar raised. Since the Dahlby and Ferede results reflect the structure of the Canadian economy in a more recent period, they are used in the benefit-cost analysis undertaken in this article.

Another cost quantified in the model is the loss in economic efficiency caused by the subsidy-induced reallocation of resources. Government support shifts investment from activities where it earns a competitive private return to activities where it earns

15 Maximilian Baylor and Louis Beauséjour, *Taxation and Economic Efficiency: Results from a Canadian CGE Model*, Department of Finance Working Paper 2004-10 (Ottawa: Department of Finance, November 2004).

16 The MEB for each tax calculated by Baylor and Beauséjour is based on the structure of the Canadian economy over the 1996-1998 period.

17 Bev Dahlby and Ergete Ferede, *The Effects of Tax Rate Changes on Tax Bases and the Marginal Cost of Public Funds for Provincial Governments*, C.D. Howe Institute Working Paper (Toronto: C.D. Howe Institute, March 2011).

a lower rate of return, putting downward pressure on the net economic benefit from providing assistance.[18] This loss in economic efficiency is measured as the producer surplus (the value of production less the cost of inputs used) from the additional R & D induced by the subsidy less the social cost of the subsidy, which is equal to the cost of the program, assuming that it can be financed without affecting behaviour. The model also includes the cost of administering the program and applying for the subsidy, both of which absorb resources that could be used productively elsewhere.

Following Dahlby,[19] the model explicitly includes the marginal costs of compliance and administration. Marginal compliance costs reduce the effective cost reduction obtained by firms from the subsidy, dampening the output response to the incentive. As a result, the spillover benefit is reduced and the increase in producer surplus arising from the subsidy becomes smaller. The marginal social cost of a subsidy is the amount of tax revenue that needs to be raised to finance an increase in the subsidy; this study includes increases in administration expenses that occur as subsidy payments rise in the social cost.

In order to portray administration and compliance expenses more accurately, the number of firms is endogenous in the model. As discussed below, regression analysis of compliance costs indicates that these expenses consist of a fixed cost and a cost that increases with the size of the subsidy. While there is some information available to help develop estimates of fixed and variable administration expenses for IRAP, detailed information on SR & ED administration expenses is not available; accordingly, it is assumed that such expenses have the same characteristics as compliance costs. Changes in the number of firms receiving a subsidy and in the average size of the subsidy will therefore affect the overall level of compliance and administration expenses.

Introducing a subsidy encourages firms to undertake previously marginal projects. These newly viable projects could be undertaken by existing program users or by new users (firms not previously undertaking R & D and newly created firms). Expansion of existing firms involves some combination of bigger projects and more projects per firm; for tax incentives, both of these changes increase the average claim per firm. While entry could occur at all project sizes and thus leave the average project size unaffected, fixed compliance costs are likely to create threshold effects. At

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18 See Rufin Baghana, *Public R&D Subsidies and Productivity: Evidence from Firm Level Data in Quebec*, UNU-MERIT Working Paper 2010-055 (Maastricht, The Netherlands: United Nations University, Maastricht Economic and Social Research and Training Centre on Innovation and Technology, 2010); Tuomos Takalo, Tanja Tanayama, and Otto Toivanen, *Innovation Policy Reform* (Mannheim: University of Mannheim, Centre for Economic Policy Research, 2009); and Torbjorn Hægeland and Jarle Møen, *The Relationship Between the Norwegian R&D Tax Credit Regime and Other Innovation Policy Instruments*, Statistics Norway Research Paper 2007/45 (Oslo: Statistics Norway, December 2007) for estimates of the private rates of return on subsidized and unsubsidized R & D.

19 Bev Dahlby, "Notes on the Calculation of the Optimal De Minimus for an R&D Subsidy Program" (unpublished manuscript, 2011).

low subsidy rates, it will not be profitable to undertake small projects; thus, the average project size will fall as the subsidy rate rises, until the subsidy rate is high enough for most firms to recover their fixed compliance costs through higher profits on the subsidized investment. Beyond this threshold, entry is not expected to have a substantial impact on average project size. Note that for direct assistance programs, the average project size and the number of clients can in principle be chosen by the program managers.

The model developed in this article is used to assess the impact of changes in economic and program parameters, and to determine the optimal subsidy rate. Therefore, an important question is whether the marginal impacts of changes in subsidy rates have been adequately captured. Financing costs and price responsiveness are measured at the margin, and the model includes marginal compliance and administration costs as well as endogenous firm entry. The spillover rate is assumed to be exogenous, but could vary with the subsidy rate. The lower private return earned on subsidized R & D could, in principle, be associated with higher or lower spillovers. For example, if the increased subsidy allowed firms to undertake more basic research projects, spillovers would likely be larger. But since firms undertake very little basic research,[20] it is more likely that a lower private return indicates lower overall quality of the project, resulting in lower spillovers. If this view is correct, it could have far-reaching implications for the amount of support provided to R & D. While a theoretical case can be made for reducing the spillover rate as the subsidy rate rises, a review of the literature did not turn up any empirical work that would support (or reject) this view. In the absence of convincing evidence, spillovers are assumed to be independent of the subsidy rate.

The equations used in the model and parameter values are presented in an appendix to this article. The next section discusses the key parameters used in the model.

ASSUMPTIONS USED IN DEVELOPING THE NET BENEFIT ESTIMATES

Spillovers

Spillovers are generally measured as the decline in costs or the increase in productivity of firms that occurs as a result of R & D undertaken by other firms. Parsons and Phillips[21] use the median result from eight Canadian studies, which implies that a dollar of R & D spending by one firm reduces costs of other firms by 56 cents. This result is consistent with a much larger body of international literature, particularly for

20 In Canada, R & D by SR & ED claimants is distributed roughly as follows: 5 percent basic research, 15 percent applied research, and 80 percent experimental development (Statistics Canada, 2009).

21 Supra note 13.

the United States. A review of the post-2007 literature undertaken by McFetridge[22] revealed only a small number of new empirical studies on spillovers for all countries and no new studies for Canada. The new studies suggest that, if anything, spillovers may have become smaller over time. Given the limited number of new studies, however, for the present analysis it was decided to use the same spillover rate as in Parsons and Phillips in the base case.

Analysts often make the case that firms undertaking R & D have a superior capacity to absorb the spillovers from R & D undertaken by other firms.[23] This "second face" of R & D is captured in estimates of spillovers between domestic firms, but empirical work typically does not capture the impact of domestic R & D on the ability to benefit from R & D undertaken by firms in other countries. An exception is Griffith, Redding, and Van Reenen,[24] who quantify how domestic R & D helps a country to catch up to the technological frontier by facilitating technology transfer. Their empirical estimates indicate that including a catchup term raises the social return to R & D in Canada by about a third. The study by Griffith et al. provides one of the eight estimates of spillovers in the literature survey, but the absence of a catchup variable in the other studies may mean that the spillover rate used in the present analysis is understated.

The standard methodology is subject to a number of other criticisms. First, spillovers are determined by the gap between the social and private returns, but the methodology understates the social return because the effects on consumers are not fully captured.[25] Second, spillovers should be calculated using social and private rates of return that are net of depreciation of the R & D asset. Virtually all researchers assume that the same depreciation rate applies to both rates of return; however, as pointed out by Bloom, Schankerman, and Van Reenen,[26] it is likely that the depreciation rate is lower for the social return. R & D undertaken by one firm benefits other firms through knowledge spillovers, but the firm undertaking additional R & D gains a competitive advantage, which can reduce the profitability of other firms. The depreciation rate applicable to the private return includes any loss of rents arising from increased R & D among competitors; however, because this redistribution

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22 Donald McFetridge, "R&D Spillovers and Spillover Rate of Return Estimates" (unpublished manuscript, 2011).

23 See, for example, Peter Howitt, "Endogenous Growth and Cross-Country Income Differences" (2000) 90:4 *American Economic Review* 829-46.

24 Rachel Griffith, Stephen Redding, and John Van Reenen, "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries" (2004) 86:4 *Review of Economics and Statistics* 883-95.

25 The degree of understatement depends on how much of the benefit is passed on to consumers and on whether the price indexes used to define real output are affected by consumer prices. See Zvi Griliches, "Issues in Assessing the Contribution of Research and Development to Productivity Growth" (1979) 10:1 *Bell Journal of Economics* 92-116.

26 Nicholas Bloom, Mark Schankerman, and John Van Reenen, "Identifying Technology Spillovers and Product Market Rivalry," April 17, 2012 (www.stanford.edu/~nbloom/bsv_2010.pdf).

is not a social loss, the depreciation rate for the social return would be lower than for the private return and spillovers would be understated. Third, very little of the empirical work on spillovers explicitly identifies both the positive and negative effects of R & D undertaken by one firm on other firms. Bloom et al. provide evidence on the importance of identifying both elements in empirical work in order to obtain more accurate estimates of spillovers.

The spillover estimate used in this study captures the average impact of proprietary R & D undertaken by business. However, since spillovers are likely to decline as the product or service gets closer to market, the type of R & D supported can affect the spillover rate that is used in the benefit-cost calculation. That is, everything else being equal, spillovers tend to decline as R & D moves from basic research (undertaken with no specific application in mind), to applied research, to experimental development. [27] A recent study by Luintel and Khan[28] allows spillover effects to be calculated for basic/applied research and experimental development. The study estimates the impact of these two types of R & D on total factor productivity (TFP) using an unbalanced panel of 346 annual observations from 10 OECD countries[29] over the period 1970-2006. The estimated elasticities of basic/applied R & D and experimental development with respect to TFP are 0.065 and 0.093, respectively; but because the stock of basic/applied R & D is about a quarter of the size of experimental development, the impact on TFP of spending an extra dollar on R & D is about 2.7 times larger for basic/applied research than for experimental development. Assuming an average external return on R & D performed in Canada of 56 percent, the study by Luintel and Khan implies that spillovers from basic/applied R & D are about 110 percent while spillovers from experimental development are 42 percent.[30]

Given the broad-based nature of the SR & ED program, the average spillover rate of 56 percent is used in the benefit-cost analysis in this article. Information provided by IRAP administrators indicates that IRAP funding supports projects that are split

27 This statement has to be modified by noting that the degree of openness is a key determinant of spillovers. "Open science," which is characterized by peer review and full disclosure of results, will (everything else being equal) result in higher spillovers than proprietary science, where every effort is made to appropriate the benefits of the research. As a result, research that could be described as "basic" may generate the same spillovers as "applied" research if it is treated as proprietary by the imposition of restrictions on the diffusion of results.

28 Kull B. Luintel and Mosahid Khan, "Basic, Applied and Experimental Knowledge and Productivity: Further Evidence" (2011) 111:1 *Economics Letters* 71-74.

29 The 10 countries included in the analysis are Australia, France, Iceland, Ireland, Italy, Japan, Norway, Portugal, Spain, and the United States.

30 The formula used to calculate the ratio of the marginal impacts of basic/applied research and experimental development is $(0.063/0.095)/(0.2/0.8) = 2.65$, where 0.2 and 0.8 are the average shares of basic/applied and experimental development R & D, respectively, in the Luintel and Khan dataset. The calculated ratio was used as follows to determine the external return on experimental development: $0.56/(2.65 * 0.2 + 0.8) = 0.42$.

roughly 50-50 between basic/applied research and experimental development.[31] This split implies a 76 percent spillover benefit from IRAP projects using the Luintel and Khan results noted above.

Spillovers could vary by firm size, reflecting differences in the nature of the R & D undertaken, in the use of networks and linkages, and in the ability to appropriate or capture the knowledge gained through research. Analysis of R & D data indicates, perhaps not surprisingly, that small firms tend to undertake more R & D related to the development of new products and processes and less related to the improvement of existing products and processes than larger firms.[32] On the other hand, the recent Survey of Innovation and Business Strategy[33] suggests that large Canadian R & D performers are as likely to introduce ground-breaking innovations as small performers. In a study of European firms, Pagano and Schivardi[34] find that larger firm size is associated with faster innovation.

In addition, small Canadian firms are less likely to establish linkages and networks with universities and other firms, so spillovers could be smaller. But small firms may find it harder to protect the knowledge gained through R & D by using patents and other methods, such as the use of complementary technologies. Finally, employees of small firms may be more mobile than employees of large firms, potentially increasing the spillovers associated with R & D undertaken by small firms.

The only empirical evidence on spillovers by firm size is provided by Bloom et al.[35] Their empirical work is based on data from 715 publicly traded firms, 13 percent of which have fewer than 500 employees. Estimates grouped by size of firm show the spillover benefit declining with firm size: spillovers are about 55 percent lower for firms in the bottom size quartile than for firms in the top quartile. The explanation advanced for this finding is that smaller firms tend to operate in technological niches, reducing the scope for knowledge spillovers. The dataset used does not include very small firms; as noted above, these firms may generate larger spillovers because of greater difficulty in protecting their intellectual property, which would offset the niche effect. Nevertheless, if the niche effect continues to grow in importance as firms get smaller, it seems unlikely that the finding on firm size and spillovers would be reversed.

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31 Canada, Review of Federal Support to Research and Development, Expert Panel, *Description of Programs in the R & D Review*, working document (http://rd-review.ca/eic/site/033.nsf/eng/h_00326.html), at 17.

32 Statistics Canada, *Science Statistics: Industrial Research and Development, 2005 to 2009*, Statistics Canada catalogue no. 88-001-X (Ottawa: Statistics Canada, July 2009).

33 Industry Canada, "Survey of Innovation and Business Strategy" (www.ic.gc.ca/eic/site/eas-aes.nsf/eng/h_ra02115.html).

34 Patrizio Pagano and Fabiano Schivardi, "Firm Size Distribution and Growth" (2003) 105:2 *Scandinavian Journal of Economics* 255-74.

35 Supra note 26.

Given the ambiguity of the theoretical literature and the fact that there is only one empirical study of spillovers by firm size, the base case assumption in this study is that spillovers do not vary with firm size.

Responsiveness of Business R & D Spending to Government Support

The amount of additional R & D induced by government support is a key evaluation consideration: everything else being equal, the higher the responsiveness to a subsidy, the higher the net benefit. Studies examining the impact of direct assistance typically estimate how a dollar's worth of direct assistance affects private (self-financed) spending on R & D. When the dependent variable is private spending on R & D, a positive coefficient on direct assistance indicates "crowding in" of private spending or "input additionality," while a negative coefficient indicates "crowding out." A coefficient of zero implies that private spending is unaffected by government assistance (sometimes described as "zero input additionality"). Studies examining the response to tax credits typically estimate the price elasticity of R & D demand. Unitary price elasticity implies that the amount of R & D induced by a small change in the tax credit is equal to the amount of additional tax revenue forgone—that is, self-financed private R & D spending does not change. A price elasticity of less than 1 (in absolute value) indicates crowding out of private spending, while a price elasticity greater than 1 indicates crowding in of private spending on the margin.[36] An extensive review by Parsons and Phillips[37] of the empirical literature up to 2007 indicated that unitary price elasticity for tax credits is the most reasonable assumption. A review of the post-2007 literature by McFetridge[38] found that the assumption of unitary price elasticity for tax credits continues to be reasonable, although there is limited evidence that price sensitivity may have increased in recent years.

The responsiveness of private spending could vary by firm size and type of program. Studies by Baghana and Mohnen[39] using Quebec data, Lokshin and Mohnen[40]

36 Note, however, that the total increase in R & D induced by the credit will be less than the total amount of revenue forgone because the credit applies to all R & D, not just the amount induced by the credit.

37 Supra note 13.

38 Donald McFetridge, "Evidence on the Responsiveness of Business R&D Spending and/or Innovation to Direct and Indirect (Tax-Based) Government Financial Assistance" (unpublished manuscript, 2011).

39 Rufin Baghana and Pierre Mohnen, "Effectiveness of R&D Tax Incentives in Small and Large Enterprises in Québec" (2009) 33:1 *Small Business Economics* 91-107.

40 Boris Lokshin and Pierre Mohnen, *Measuring the Effectiveness of R&D Tax Credits in the Netherlands*, UNU-MERIT Working Paper 2007-025 (Maastricht, the Netherlands: United Nations University, Maastricht Economic and Social Research and Training Centre on Innovation and Technology, 2007).

using Dutch data, and Lach[41] using Israeli data found higher elasticities for small firms; in contrast, Cerulli and Poti[42] using Italian data and Koga[43] using Japanese data found higher responsiveness by large firms. Work by Corchuelo and Martinez-Ros[44] and Blanes and Busom[45] on sectoral variations in elasticities provides indirect support for higher elasticities for small firms—R & D-intensive sectors are more price-responsive and small firms tend to be concentrated in these sectors. While not extensive enough to justify using a higher price elasticity in the base case, this empirical work motivates some sensitivity analysis in the present study.

Theoretical considerations suggest that direct assistance could have a smaller impact on private spending than tax credits. The SR & ED investment tax credit is a longstanding feature of the Canadian R & D support system, and is available on a continuous basis to all firms undertaking R & D. In contrast, direct assistance programs generally offer support for a specific project, and the lack of certainty about ongoing support could reduce their effectiveness in stimulating additional R & D relative to the SR & ED tax credit. As a practical matter, however, the survey by McFetridge points to a price elasticity of approximately 1 (that is, there is neither crowding in nor crowding out of private spending) for direct assistance as well as tax credits. A shortcoming of the studies reviewed is that they do not allow for the possibility that the estimated increase in R & D by subsidized firms could be partly offset by less R & D by the firms not receiving assistance if subsidized firms bid up the price of researchers. Despite this qualification, this study uses a price elasticity of 1 (absolute value) for both tax credits and direct assistance programs in the base case.

Administration and Compliance Costs

SR & ED

The compliance cost estimates used for the SR & ED program are based on results from a survey of program users undertaken in 2011 on behalf of the federal government's expert panel for the Review of Federal Support to Research and Development.[46]

41 Saul Lach, "Do R&D Subsidies Stimulate or Displace Private R&D? Evidence from Israel" (2002) 50:4 *Journal of Industrial Economics* 369-90.

42 Giovanni Cerulli and Bianca Poti, *The Heterogeneous Impact of Publicly Funded R&D on Firm R&D Investment*, *Innovation and Economic Performance: The Italian Case*, Doctoral School of Economics, Sapienza University of Rome Working Paper 10 (Rome: Sapienza University of Rome, 2010).

43 Tadahisa Koga, "Firm Size and R & D Incentives" (2003) 23:7 *Technovation* 643-48.

44 Beatriz Corchuelo and Ester Martinez-Ros, *The Effects of Fiscal Incentives for R & D in Spain*, Business Economics Working Papers wb092302 (Madrid: Universidad Carlos III, Departamento de Economía de la Empresa, 2009).

45 J. Vicente Blanes and Isabel Busom, "Who Participates in R&D Subsidy Programs? The Case of Spanish Manufacturing Firms" (2004) 33:10 *Research Policy* 1459-76.

46 Canada, Review of Federal Support to Research and Development, unpublished survey results released to the author through an access to information request.

Firms were asked about the cost of preparing claims, as well as the cost of responding to followup questions by the Canada Revenue Agency (CRA) arising from the use of in-house resources and payments to third parties. A total of 213 firms responded to the survey; 184 of these responses contained usable information on compliance costs (table 1).

The distribution of claims by size in the survey is not identical to the actual size distribution of SR & ED claims, so the responses to the survey were aggregated using the actual distribution of claims as weights rather than the survey distribution. For both categories of firms, the survey oversampled large claims. Adjusted for sampling bias, compliance costs amount to just over 14 percent of the value of credits received by firms qualifying for the enhanced credit ("small firms") and just under 5 percent for other firms, which consist of large firms as well as smaller firms that do not qualify for the enhanced credit.

Compliance costs per dollar of credit claimed decline sharply with claim size, reflecting a substantial "fixed cost" in making a claim. Costs for the smallest claims (up to $25,000) are 33 cents per dollar claimed, but decline to 15 cents for claims in the $50,000-$100,000 range and to 8 cents for claims in the $250,000-$500,000 range. For the purposes of this study, the issue of fixed and variable compliance costs was investigated more systematically using regression analysis. As shown in table 2, per firm spending on compliance costs was related to a constant, to capture fixed compliance costs, and to the dollar amount of the credit claimed, to capture variable costs. A number of other variables—dummy variables for first claims and very small claims, the use of third parties to prepare claims, and the split between claim preparation and followup by the CRA—were included in the regressions for the enhanced credit, but these variables were either insignificant or had an unexpected sign. Inclusion of these variables in the regression equation did, however, reduce the coefficient on the intercept by about 1 standard error, while the change in the coefficient on the amount of credit received was marginal. The possibility that fixed compliance costs vary by firm size was also investigated. Firm size could have an independent effect on compliance costs if larger firms, generally making larger claims, are implicitly held to a higher standard than small firms by the CRA through a higher incidence of audits and through more demanding information requirements when firms are audited.

For small firms, the sample size is 124, or less than 1 percent of the firms claiming the enhanced credit. The simple regression explains a trivial amount of the variance in compliance costs but a statistically significant coefficient on the amount claimed is obtained (table 2), implying that compliance costs increase by 1.7 cents per dollar increase in the amount claimed. The estimated intercept suggests very high fixed compliance costs—roughly $16,000 per claim—but the survey oversampled large firms, so the coefficient overstates true average fixed costs. A better estimate of average fixed compliance costs can be obtained by calculating the fixed cost share of total compliance costs implied by the regression results. For small firms, this share is approximately 80 percent, implying fixed compliance costs of about $8,200 per claim in 2007 (the most recent year for which a complete set of data

TABLE 1 SR & ED Compliance Cost Survey Results

	Enhanced credit	Regular credit	Overall
Compliance cost[a]			
Aggregated using survey weights	0.089	0.018	0.048
Aggregated using population weights	0.142	0.047	0.086
Number of observations	124	60	184

[a] Cost per dollar of tax credit claimed.

Source: Canada, Review of Federal Support to Research and Development, unpublished survey results released to the author through an access to information request.

is available). The regression results suggest, however, that firm size has an independent effect on fixed compliance costs; the estimated coefficient on firm size in table 2 implies that fixed compliance costs amounted to about $6,700 per claim in 2007.[47] For the "other firm" category, where the sample size is about 2.5 percent of claimants, the regression results indicate that per firm fixed costs range from $13,500 to $15,500. Since the equations that include the firm size index are able to "explain" substantially more of the variance in compliance costs per claim, results from these equations are used in the base case analysis of the SR & ED credit.

Data available from the CRA[48] indicate that administration costs for the SR & ED program amount to 1.6 percent of tax revenue forgone. It was assumed that about 60 percent of the total administration expenses are related to small firms. This assumption results in average administration expenses of 2.5 percent of the credit received for small firms and 1.2 percent for other firms. Administration expenses vary with the number of claims processed as well as with the average claim size. Administration expenses are likely to change less than proportionately with the number of claims owing to economies of scale; in the absence of any information on fixed costs in processing claims, a 1 percent change in the number of claims processed is assumed to change administration expenses by 0.75 percent, the same as for IRAP, which is discussed below. Program administrators spend more time assessing large claims than small claims; in the absence of information on how administration costs vary with claim size, the results for compliance costs are assumed to apply to administration expenses.

47 The survey responses provide information on employment for seven size groups. The firm size index has a value of 1 for firms with up to 5 employees and reaches a value of 7 for firms with more than 500 employees. The firm size index replaces the intercept in the regression equations. When entered in log form, the firm size index was highly significant and did not affect the coefficient on the amount of credit received; on the other hand, the adjusted R^2 fell from 0.294 to 0.027.

48 See supra note 46.

TABLE 2 SR & ED Compliance Cost Regression Equations and Results[a]

	CCPCs[b]		Other firms	
Intercept	16,303		118,528	
	(0.000)		(0.034)	
Firm size index[c]		5,734		24,006
		(0.000)		(0.012)
Credit received ($)	0.0173	0.0166	0.00738	0.00667
	(0.029)	(0.049)	(0.000)	(0.002)
R^2 (adjusted)	0.030	0.294	0.180	0.342
N	124	124	60	60
Fixed compliance costs[d]				
Share of total (%)	80.1	65.7	57.6	66.1
Value in 2007 ($)	8,200	6,730	13,500	15,500

[a] The dependent variable is the dollar cost of compliance; *p*-values are in parentheses.
[b] Canadian-controlled private corporations with fewer than 500 employees.
[c] Firm size is defined in terms of employment. The index has a value of 1 for firms with fewer than 5 employees, rising to 7 for firms with more than 500 employees.
[d] These calculations make an ad hoc correction for sampling bias and scale the results to be consistent with the estimated level of compliance costs in 2007, the base year for the benefit-cost analysis.

Source: Author's calculations.

IRAP

A compliance cost survey of IRAP clients was also undertaken by the R & D expert review panel.[49] In addition to compliance costs, firms were asked about project size, award amounts, the size and age of the firm, the amount of help received from ITAs in preparing applications, and their experience with IRAP. The reference period was projects completed in 2009. Seventy-nine responses, representing about 5 percent of firms obtaining assistance, were received. Seven responses showed either zero compliance costs or compliance costs that were several times larger than the amount of assistance received; these responses were excluded from the analysis of compliance costs. Unfortunately, the detailed information required to test and correct sampling bias is not available. It is, however, worth noting that the distribution of firms by number of employees in the survey sample matches the distribution for all IRAP clients quite closely, so sampling bias may not be an important issue.

The survey indicates that compliance costs, including both the cost of applying for the assistance and the cost of reporting on the use of funds received, amount to 11.6 cents per dollar of assistance received.[50] This estimate covers costs over the life of the project that received funding. Estimated costs are lower than for the small firm SR & ED credit, perhaps indicating that these costs are understated, given that

49 Canada, Review of Federal Support to Research and Development, Expert Panel, *Survey of Firms Data*, working document (http://rd-review.ca/eic/site/033.nsf/eng/h_00326.html).

50 The estimated cost is split roughly 60-40 between initial application and followup.

performance reports are required for IRAP but not for SR & ED. On the other hand, ITAs typically provide a substantial amount of assistance preparing firms to apply for funding; this likely reduces the costs borne by clients while increasing administration expenses.

Compliance costs are a relatively stable percentage of amounts awarded up to about $100,000, averaging about 21 percent in each $25,000 interval. But once award sizes exceed $100,000, compliance costs decline sharply as a share of the amount of assistance provided, averaging 8.7 percent for awards in the $100,000-$200,000 range and just under 8 percent for larger awards.

Regression analysis provides evidence for the existence of fixed compliance costs, suggesting that their average share could range from about 35 percent to 55 percent of total compliance costs (table 3). As shown in the table, the equations with the highest explanatory power exclude a constant term and include two independent variables: award size and the number of hours spent by ITAs helping to prepare applications. ITA assistance is probably capturing the impact of firm age and experience with IRAP on fixed costs; one might expect that the partial effect of additional assistance would be to reduce costs. Including a variable to capture first-time awards, interacting with award size, adds marginally to the explanatory power of the regression (compare equations 2 and 6 in table 3) without substantially affecting the estimated fixed costs. Given the ambiguity about what the ITA assistance variable is capturing, the average fixed cost share from all regressions, 46 percent, is used in the base case analysis.

Administration costs of IRAP amounted to 37 cents per dollar of program spending prior to 2009. Part of the reason for such high costs is the expense related to providing business management and technical advice to client firms. Excluding these advisory costs, administration expenses averaged about 20 cents per dollar of program spending. These relatively high costs reflect, at least in part, the rigorous assessment of requests for assistance by ITAs and the thorough followup on the use of funds and outcomes. IRAP also periodically acts as a delivery agent for other programs, or provides assistance by assessing potential projects for funding (for example, for the Atlantic innovation fund or the Canadian innovation commercialization program). IRAP's substantial presence in the regions also adds to costs. Finally, the 2007 evaluation of IRAP[51] drew attention to the high ratio of management support staff to ITAs (nearly two staff members per ITA).

The advice component of administration expenses was calculated using a 2007 survey of how ITAs allocate their time.[52] In 2006, ITAs spent 34 percent of their time developing funded projects and managing contribution agreements, 18 percent providing advice, 12 percent engaging in networking and linkage activities, and 36 percent performing administrative and other tasks. It was assumed that networking and linkage activities were a component of the advice function, and that time

51 Supra note 7.

52 Ibid.

TABLE 3 IRAP Compliance Cost Regression Equations and Results[a]

					Fixed compliance costs[c]		
Regression	Intercept	Award size	First award[b]	ITA assistance	Dollars	Percentage share of total	Adjusted R^2
1	5,814 (0.008)	0.058 (0.000)			5,814	50	0.168
2		0.062 (0.000)		375 (0.000)	4,062	39	0.576
3	2,830 (0.172)	0.051 (0.000)		337 (0.000)	6,481	56	0.331
4	5,235 (0.015)	0.043 (0.009)	0.046 (0.036)		5,235	45	0.208
5	2,344 (0.247)	0.037 (0.012)	0.043 (0.029)	331 (0.000)	5,930	51	0.367
6		0.046 (0.000)	0.046 (0.021)	361 (0.000)	3,911	37	0.600

[a] The dependent variable is the dollar cost of compliance; p-values are in brackets. $N = 72$.
[b] A dummy variable = 1 for a first award, interacting with award size.
[c] Compliance costs are on average 11.6 percent of the amount awarded. Note that the sum of fixed and variable costs is less than 11.6 percent when the intercept is dropped.

Source: Author's calculations.

spent on other tasks was proportionate to time spent on the core activities of providing advice and managing contribution agreements. With these assumptions, these core activities each account for about half of an ITA's time.[53]

As noted above, the elasticity of administration expenses with respect to the number of projects funded is set at 0.75. This estimate was developed by assuming that the number of ITAs varies equiproportionately with the number of projects funded and that the elasticity of other administration expenses with respect to the number of projects is 0.5.

Firm Response to Changes in the Subsidy Rate

There does not seem to be any empirical evidence on how subsidies affect the average size of projects undertaken by existing firms and how they affect the number of firms undertaking R & D projects, so a stylized approach is used in the model. The number of claimants and the size of the average claim respond to the subsidized cost of R & D, with the combined response constrained to ensure that the change in overall claims reflects the assumed elasticity of demand for R & D. The number of firms undertaking R & D falls to zero when the value of the subsidy falls below the fixed costs of compliance, but these threshold effects on the average claim size are

53 The advice share is 47 percent, calculated as (18 + 12)/(18 + 12 + 34).

ignored. In the base case, firm entry and changes to the average claim size of existing firms contribute equally to the change in overall investment resulting from movements in the subsidy rate.[54] This approach appears to be reasonable when applied to open-ended tax incentive programs, but—as noted earlier—for direct assistance programs, the average project size and the number of clients can in principle be determined by program managers.

Subsidy Rates

SR & ED

The effective credit, or subsidy, rates provided by the SR & ED investment tax credit are the statutory credit rates adjusted for differences between actual spending on R & D and spending that is eligible for the credit and the delayed use of the non-refundable credit because of insufficient taxable income. Large firms can use the SR & ED credit only to the extent that they have taxable income, and (as noted earlier) delays in claiming the credit reduce its value. Prior to the 2012 federal budget, the only spending on R & D not eligible for the credit was investment in buildings. In addition to reducing the statutory rate for the regular credit from 20 percent to 15 percent, the 2012 budget changes will eliminate capital equipment from eligible expenditures and reduce eligible spending on contract R & D to 80 percent of actual spending in order to approximately eliminate the profit component from the base.[55] Elimination of spending on equipment was motivated by a desire to simplify the program and thereby reduce administration and compliance costs. Given the small amount of expenditures on equipment as a share of total spending, these savings are expected to be a small fraction of overall administration and compliance costs. The modification to contract spending will reduce a bias in favour of contract research over in-house R & D.

The budget changes will also reduce the generosity of the simplified calculation of overhead expenses. Under current rules, firms have the option of claiming overhead expenses either based on actual spending or as 65 percent of wage costs; the budget reduces the "markup" to 55 percent.[56] The derivation of the effective credit rates for the current and post-budget rules is presented in table 4. Note that the estimates assume that the 65 percent markup was providing excess benefits and that the reduction to a 55 percent markup closely approximates actual overhead expenses. Similarly, the calculations assume that the 20 percent adjustment to contract expenses eligible for the credit closely approximates the profit share of contracts. As a result of the budget changes, the gap between the enhanced and regular credits will widen from 18.5 to 20.8 percentage points by 2014.

54 The semi-elasticity of the number of firms and investment per firm with respect to the subsidy rate is 0.5 in the base case.

55 See supra note 4.

56 Ibid., at 412. The reduction will be phased in, with a rate of 60 percent applying in 2013 and 55 percent thereafter.

TABLE 4 SR & ED Investment Tax Credit Rates

	Enhanced credit	Regular credit
	percent	
Current system		
Statutory rate	35.0	20.0
Adjustment for present value of delayed claims	0.0	−3.0
Exclusion of buildings from eligible expenditures	−1.7	1.0
Excess benefit from simplified overhead expenses calculation[a]	1.5	0.5
Excess benefit from including profit component in eligible contract expenses[b]	0.9	0.7
Effective credit rate	35.7	17.2
2012 budget changes[c]		
Statutory rate change	na	−5.0
Exclusion of equipment from eligible expenditures	−0.9	−0.6
Reduction of excess benefit from simplified overhead expenses calculation	−1.5	−0.3
Reduction of excess benefit from including profit component in eligible contract expenses	−1.0	−0.5
Interaction effects with pre-budget adjustments[d]	nil	0.7
Effective credit rate	32.3	11.5

[a] Assumes that the revised calculation announced in the 2012 budget closely approximates actual overhead costs.
[b] Assumes that the revised calculation announced in the 2012 budget closely approximates the profit component of contract R & D.
[c] Effective January 2014, except for the change to contracts, which is effective January 2013.
[d] The adjustments for delayed claims and the exclusion for buildings become smaller with a lower statutory rate.

Source: Canada, Review of Federal Support to Research and Development, Expert Panel Report, *Innovation Canada: A Call to Action* (Ottawa: Public Works and Government Services Canada, 2011) (http://rd-review.ca/eic/site/033.nsf/eng/h_00287.html) and author's calculations.

IRAP

IRAP contributions are based on the wages and salaries of persons directly involved in R & D plus 75 percent of contract costs. Contributions are formally capped at 100 percent of eligible costs for smaller projects (contributions under $100,000) and up to 75 percent for larger projects; as a practical matter, however, IRAP applies a 75 percent cap on all projects. Eligible costs account for 57 percent of costs in the typical project receiving the broadly based SR & ED tax credit,[57] so the maximum subsidy rate on total costs is about 43 percent.

57 See Canada, Secretariat to the Review of Federal Support to Research and Development Expert Panel, *Assessing the Scientific Research and Experimental Development Tax Credit*, working document (http://rd.review.ca/eic/site/033.nsf/eng/h_00326.html), at 4.

The compliance cost survey provides information on the effective subsidy rate in 2009. On average, firms received awards amounting to 20.4 percent of project costs, with awards and project values measured over the life of the project. But as noted above, the survey results may be subject to sampling bias. Unfortunately, official data on the effective subsidy rate in 2009 are not publicly available.

As discussed above, advice provided by ITAs is included as part of IRAP's assistance to firms, implicitly assuming that advice allows firms to undertake R & D in much the same way and with much the same impact as contribution funding. Thus, this approach embodies a favourable assumption about the impact of advisory services. The subsidy rate including advisory services is 23.9 percent.

Stacking of Benefits

Most provinces and territories also offer additional investment tax credits to firms that perform scientific R & D within their borders, as shown in table 5. Provinces generally follow the federal definitions for allowable SR & ED activities and expenditures. Most of these credits are refundable, subject to certain restrictions related to either the location of the facility or the size of the R & D company. Quebec has a refundable credit, but the base for the credit is restricted to labour costs and 50 percent of contract spending. Quebec's credit rates for labour, at 17.5 percent and 37.5 percent, are roughly equivalent to provincial credit rates applicable for total R & D spending, at 8 percent and 20 percent, respectively. The combined federal-provincial tax credits for small businesses range from 35 percent in Prince Edward Island and the Northwest Territories (which do not provide R & D credits) to 48 percent in Manitoba and Quebec. The range for large businesses in 2012 is 20 percent (the federal-only rate) to 36 percent in Manitoba; the range decreases to 15 percent to 32 percent in 2014. Note that combined federal and provincial tax credit rates are not additive, since the federal credit is paid out only on R & D spending net of provincial credits.

In addition to provincial tax credits, firms can take advantage of federal and provincial direct assistance programs. Firms claiming the federal SR & ED tax credit are required to deduct all other government assistance from the base for the credit. An inspection of the SR & ED database indicated that in 2007, the average benefit received by SR & ED claimants from all sources amounted to 44 percent of spending on R & D for small firms and about 22 percent for large firms (table 6). In 2007, approximately 70 percent of all firms claiming the enhanced credit received financial assistance amounting to 40 percent to 50 percent of their spending on R & D (figure 1). About 1,600 enhanced credit claimants, roughly 9 percent of the total, received assistance amounting to more than 50 percent of their R & D spending. Although the other programs used by SR & ED claimants are not included in the benefit-cost analysis undertaken in this study, a comparison of the overall subsidy rates of SR & ED claimants (column 3 of table 6) with the optimal rates obtained from the benefit-cost framework provides a rough indication of whether the additional support is adding to or subtracting from the net benefit from the SR & ED incentive.

TABLE 5 Federal and Provincial R & D Investment Tax Credit Rates

Province	Statutory provincial tax credit rate	Federal statutory rate plus effective provincial rate[a]		
			Other firms	
		CCPCs	2012	2014
		percent		
Alberta and British Columbia	10	42	28	23.5
Manitoba	20	48	36	32.0
New Brunswick, Newfoundland and Labrador, Nova Scotia, Saskatchewan, and Yukon.	15	45	32	27.8
Northwest Territories and Prince Edward Island	0	35	20	15.0
Ontario (small/large firms)	10/4.5	42	24	23.5
Quebec (small/large firms)[b]	37.5/17.5	48	27	22.4

[a] The federal credit is 35 percent for small CCPCs; for other firms, it is 20 percent in 2012, to be reduced to 15 percent in 2014, as proposed in the 2012 federal budget. The base for the federal credit excludes provincial credits. For example, the combined rate for CCPCs in Manitoba in 2012 is calculated as $0.35*(1 - 0.20) + 0.2$.

[b] The Quebec credit rates shown are paid on wages and salaries plus 50 percent of contracts.

Source: Canada, Review of Federal Support to Research and Development, Expert Panel Report, *Innovation Canada: A Call to Action* (Ottawa: Public Works and Government Services Canada, 2011) (http://rd-review.ca/eic/site/033.nsf/eng/h_00287.html) and author's calculations.

TABLE 6 Assistance Provided to SR & ED Claimants in 2007 as a Percentage of R & D Spending

	SR & ED[a]	Other programs[b]	All programs[c]
Enhanced credit claimants	35.7	13.1	44.1
Regular credit claimants	17.2	6.4	22.5
Combined	22.4	8.4	28.9

[a] Effective rates; see table 4.

[b] Includes all other federal and provincial programs used by SR & ED claimants.

[c] The SR & ED tax credit applies to R & D spending net of other program assistance.

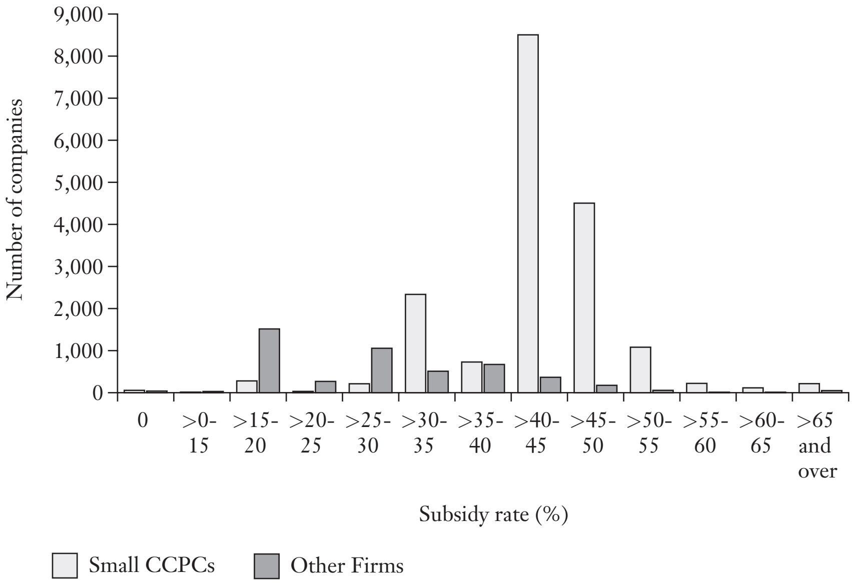
Source: Canada, Review of Federal Support to Research and Development, Expert Panel, *Survey of Firms Data* (http://rd-review.ca/eic/site/033.nsf/eng/h_00326.html) and author's calculations.

SIMULATION RESULTS

SR & ED: The Regular Credit

Simulation results for the federal SR & ED non-refundable, or regular, credit are summarized in figure 2, which shows how the net economic benefit changes with the credit rate, holding other parameter values constant. The SR & ED credit is evaluated without taking into account support available from other programs. Recall that the number of firms applying for the credit drops to zero when the subsidy rate is so low

FIGURE 1 Distribution of Government Assistance[a] to SR & ED Claimants in 2007, by Subsidy Rate



[a] Includes all forms of assistance from all levels of government.

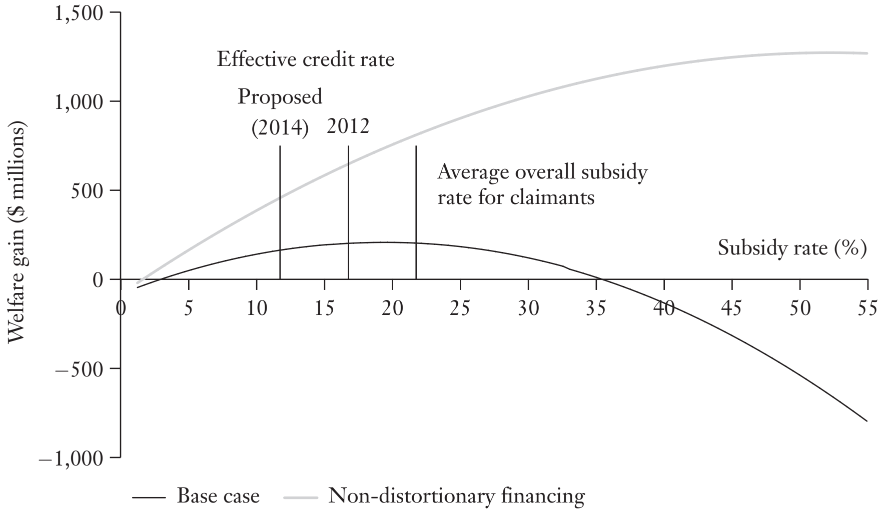
Source: Canada, Secretariat to the Review of Federal Support to Research and Development Expert Panel, *Assessing the Scientific Research and Experimental Development Tax Credit*, working document (http://rd-review.ca/eic/site/033.nsf/eng/h_00326.html).

that the increase in producer surplus from additional investment is not large enough to cover the fixed costs of making the application.[58] Further, the model depicts an "all-or-nothing" approach to participation in the program, though in reality participation is likely to be less than assumed when the subsidy net of compliance costs is very low. Including threshold effects on participation would reduce the welfare loss at low subsidy rates without affecting the loss at higher subsidy rates.

With the base case assumptions—unitary price elasticity of demand for R & D, spillovers equal to 56 percent of the induced R & D, and a marginal excess burden of taxation of 26 percent—the regular credit shows a positive net benefit for rates ranging from 3 percent to 35 percent (figure 2). The gain is maximized at $210 million with a 19 percent effective credit rate, but the net benefit does not change much in the neighbourhood of the optimal rate. As a result, the stacking of program benefits, which raises the effective subsidy rate to approximately 22 percent, is not particularly

58 The comparison with fixed costs is appropriate in this case because marginal compliance costs are deducted from the nominal subsidy when calculating the producer surplus.

FIGURE 2 Net Benefit from the Regular SR & ED Tax Credit—Base Case and Non-Distortionary Financing



damaging in the case of firms receiving regular SR & ED credits.[59] At the observed effective credit rate of 17.2 percent, the gain is $205 million, or 10 percent of the tax revenue forgone. The 2012 budget changes, which will reduce the effective credit rate to 11.5 percent, will lower the net gain by $40 million, to $165 million.

The inclusion of the cost of financing the credit with distortionary taxes in the analysis has a dramatic impact on the results.[60] First, if the credit were assumed to be financed by corporate income taxes rather than equiproportionately by all major taxes, the regular credit would show a net loss ranging from $45 million to $600 million.[61] Second, if the credit could be financed without harming economic performance, the regular SR & ED credit would generate a much larger net benefit—almost $700 million, or about a third of the tax revenue forgone—at the observed effective credit rate. Third, financing with distortionary taxation also has a dramatic impact on the optimal credit rate. In the absence of financing costs, the standard result is that the net benefit is maximized by setting the subsidy rate equal to the spillover rate; but with

59 This conclusion is based on the results from increasing the SR & ED credit rate to 22.5 percent without changing administration or compliance costs, as would be necessary if other assistance programs were explicitly modelled.

60 Note that the amount of tax revenue that has to be raised to finance the subsidy is determined as the amount of assistance provided plus administration expenses less the tax revenue obtained from the change in output resulting from spillovers and the variation in producer surplus.

61 Recall that the weighted average marginal excess burden (MEB) of taxation used in the model is 26 cents per additional dollar raised; Dahlby and Ferede estimate the MEB for corporate income tax at 71 cents, while Baylor and Beauséjour obtain an estimate of 40 cents. See supra notes 15-17 and the related text.

the inclusion of marginal compliance and administration expenses in the model, the optimal credit rate is slightly lower: a 52 percent credit rate results in a maximum net benefit of $1.4 billion and a tax expenditure of about $8.5 billion.

Sensitivity Analysis: Spillover Rate and Price Elasticity

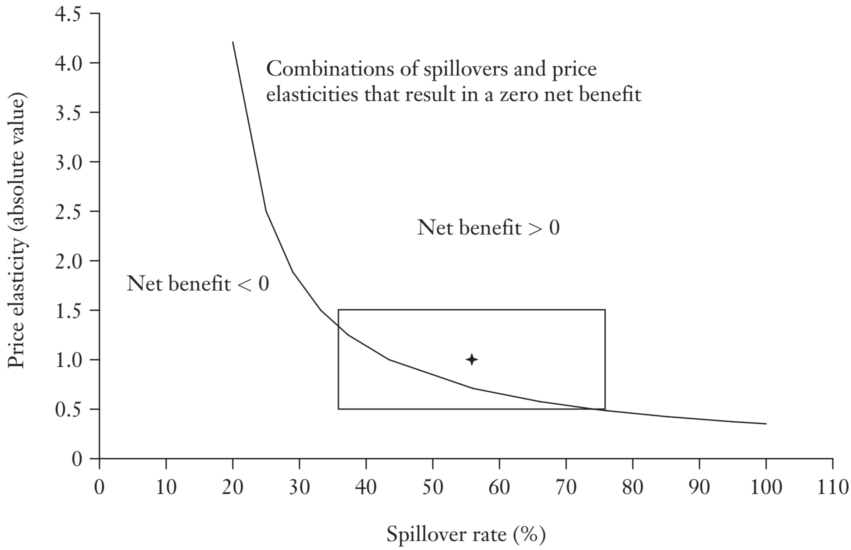
Assuming that the credit has to be financed with distortionary taxes, the two most important parameters in the model are the spillover rate and the responsiveness of R & D to changes in its price. Unfortunately, there is not enough information available on the probability distributions of the estimates for these key parameters to make it possible to develop a rigorous confidence interval for the calculated net benefit. A practical alternative is to determine how the net benefit changes as these parameters are varied and to assess the probability that the net economic benefit is positive.

The results of this sensitivity analysis for the regular credit are summarized in figure 3. The line shows combinations of spillover rates and price elasticities that result in a zero net economic benefit when other parameters are held constant at their base case values. For example, with a price elasticity of −1, a spillover rate of 43 percent would be sufficient to generate a zero net benefit; and if the base case value of the spillover rate is maintained, a price elasticity of −0.7 would result in a zero net economic benefit. Points above the line indicate combinations of spillovers and price elasticities that generate a positive net benefit, and points below the line show combinations that result in a negative net benefit. The rectangle represents subjectively determined plausible ranges for the spillover rate and price elasticities. For price elasticities, values in the −0.5 to −1.5 range are considered plausible (plus or minus 0.5). For spillovers, a range running from 36 percent to 76 percent is used, plus or minus 20 percentage points. The part of the rectangle that is above the line contains all of the plausible combinations of spillovers and price elasticities that would result in a net economic benefit greater than or equal to zero. The proportion of the rectangle above the line, which is just over 70 percent, therefore gives a rough indication of the probability that the true value of the net benefit is greater than or equal to zero.

SR & ED: The Enhanced Credit

In sharp contrast to the regular SR & ED tax credit, the enhanced credit has a negative net benefit for all credit rates (figure 4). Higher average administration and compliance costs per dollar of credit claimed have a straightforward impact on the net benefit, but the impact of higher marginal costs is more subtle. Marginal compliance costs reduce the effective subsidy rate, lowering the spillover benefit at the margin, while marginal administration expenses increase program costs at the margin; higher marginal costs for the enhanced credit therefore exert additional downward pressure on the net benefit for a given level of average costs. Higher marginal costs also reduce the optimal credit rate: the loss associated with the enhanced credit is minimized at a 14.5 percent credit rate, compared with an optimal rate of 19 percent for the regular credit.

FIGURE 3 Regular SR & ED Tax Credit—Sensitivity Analysis



✦ = Base case parameter values

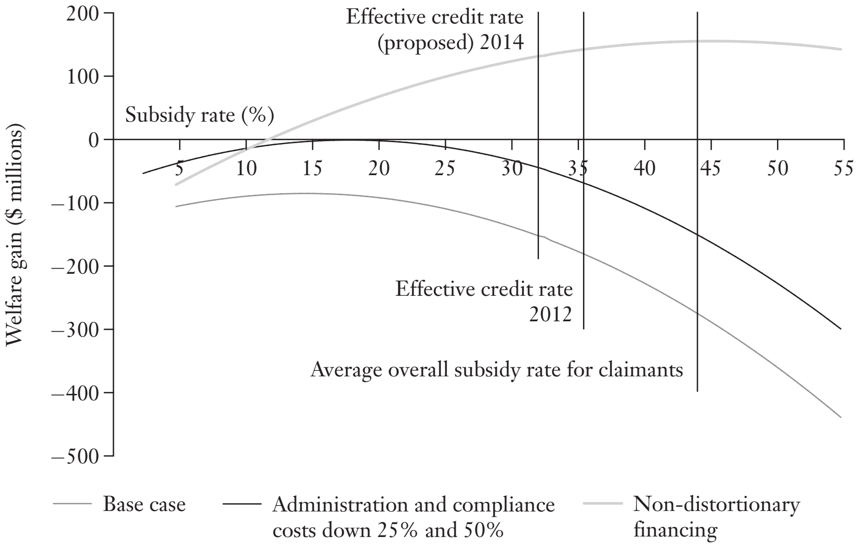
At the observed effective federal credit rate of 35.7 percent, there is a net loss of $185 million, or almost 15 percent of the tax revenue forgone through the credit. The net loss increases to approximately $275 million with an effective credit rate of 44 percent, the average overall subsidy rate received by firms claiming the enhanced credit. Changes announced in the 2012 budget will lower the effective credit rate to 32.3 percent; this reduction will decrease the net loss by about $30 million.

As with the regular credit, if the enhanced credit could be financed without harming economic performance, it would generate a large positive net economic benefit over a wide range of credit rates (figure 4). Further, if the financing source were considered to be revenue from the GST, which has a marginal excess burden of about 0.1, the enhanced credit would generate a net economic benefit of up to $15 million for credit rates ranging from 20 percent to 38 percent. On the other hand, if financing is to be attributed to a specific source of tax revenue, it would be more appropriate to assume that the source is corporate income tax revenue; in this case, the net loss would be in the $350 million-$750 million range with the observed credit rate.

The expert review panel on R & D recommended that the small firm SR & ED credit be simplified by changing the base for calculating the credit.[62] The credit base

62 See Canada, Review of Federal Support to Research and Development, Expert Panel Report, *Innovation Canada: A Call to Action* (Ottawa: Public Works and Government Services Canada, 2011), at 6:10 (http://rd-review.ca/eic/site/033.nsf/eng/h_00287.html).

FIGURE 4 Net Benefit from the Enhanced SR & ED Tax Credit—Base Case and Selected Alternatives



now includes wages, spending on materials, overhead expenses, investment in capital equipment (other than buildings), and contracted R & D. The panel proposed redefining the base to comprise wage payments and contract expenses, while increasing the rate to preserve the value of the credit. This change would reduce compliance and administration expenses by eliminating a number of complex calculations related to expenses for materials, overhead, and capital equipment. The panel also recommended that the CRA improve its pre-claim project review service in order to make eligibility more predictable, in particular by providing firms with pre-approval of their eligibility for the credit. This change also would reduce administration and compliance costs. The 2012 budget changes remove capital equipment from the base in order to reduce administration and compliance costs; the budget also announced that the CRA will conduct a pilot project to assess the feasibility of a formal pre-approval process.

There is not enough information available to make it possible to determine the impact on administration and compliance costs of the initiatives proposed by the panel, but administration costs would have to be reduced by a quarter, and average and marginal compliance costs cut in half, in order for the enhanced credit to generate a zero net benefit for subsidy rates in the 15 percent-21 percent range (figure 4). These reductions would leave administration and compliance costs per dollar of enhanced credit claimed approximately 50 percent higher than for the regular credit.

The welfare gain is not sensitive to changes in how entry and the average claim size respond to movements in the subsidy rate. For a given subsidy rate, a reduction in the number of firms applying for the credit, offset by an increase in the average claim size, increases the net benefit by reducing fixed compliance and administration costs. In the base case, the changes in investment arise in equal measure from changes in the number of firms and in the average claim size. That is, a 10 percent increase in investment induced by a reduction in the subsidy rate arises from a 5 percent increase in both the number of firms performing R & D and the average claim size. Two other scenarios are considered: the change in investment arises entirely from either a change in the number of firms or a change in the average claim size. These extreme assumptions cause fixed administration and compliance costs to vary by about $10 million at the optimal credit rate of 14.5 percent.

The sensitivity of the net economic benefit to changes in the spillover rate and price elasticity is summarized in figure 5.[63] Spillovers ranging from 58 percent to 76 percent, in combination with price elasticities ranging from −1.5 to −0.9, would generate a net benefit that is greater than or equal to zero. But these combinations represent just over 10 percent of the combinations contained in the rectangle in figure 5. It is therefore unlikely that the true value of the net economic benefit arising from the enhanced credit is positive rather than negative as shown in the base case.

Considered together, the net benefit from the regular and enhanced credits is about $25 million, which is less than 1 percent of the amount of tax revenue forgone. In contrast, the study by Parsons and Phillips,[64] which provides results only for the overall program, reports a net benefit of 11 cents per dollar of tax revenue forgone. Assessing the regular and enhanced credits separately makes a small contribution to the difference in findings: the combined net benefit rises to about 3 percent of the tax revenue forgone when the weighted average credit rate is used for both components of the SR & ED investment incentive.[65] The approach to modelling administration and compliance costs in this study—separately identifying fixed and variable components, and reducing the effective credit rate by variable compliance costs—reduces the net benefit; eliminating this feature from the model raises the overall net benefit to about 4 percent of the tax revenue forgone. Finally, the overall subsidy rate used in Parsons and Phillips appears to be understated, and thus tends to raise the net benefit in that study.[66]

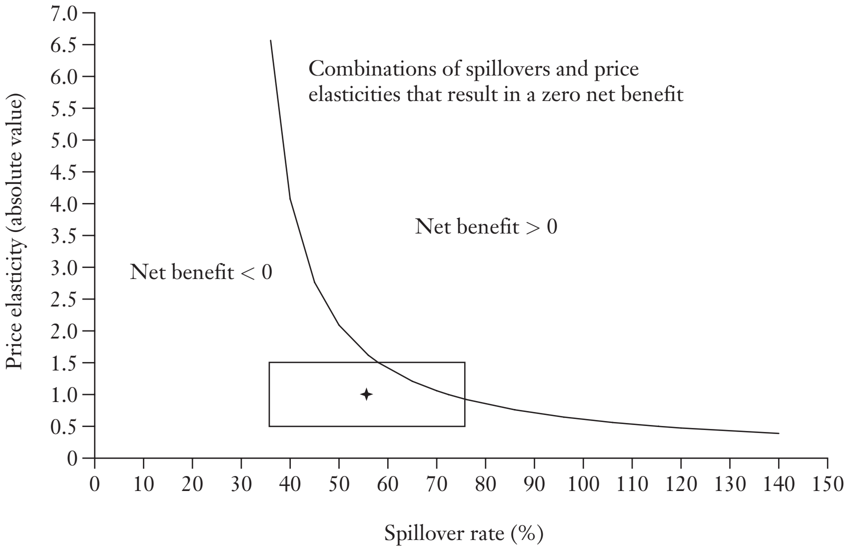
63 Higher marginal compliance and administration expenses for the enhanced credit make the tradeoff between the spillover rate and the price elasticity steeper than for the regular credit. Note that the smallest spillover rate for the enhanced credit plotted in figure 5 is 40 percent, as compared with 20 percent for the regular credit in figure 3: a spillover rate of 35 percent must be accompanied by an elasticity of −6.5 for the enhanced credit to generate a zero net economic benefit.

64 Supra note 13.

65 The weighted average subsidy rate is 22.7 percent. Using this rate for the enhanced credit causes the net benefit to increase because the enhanced credit rate is much closer to the optimal rate. In contrast, the increase in the regular credit rate does not raise it much above the optimal rate.

66 Parsons and Phillips define the subsidy rate as the percentage point change in the user cost of capital, but it appears that the model structure is not completely consistent with this approach, leading to an understatement of the subsidy rate.

FIGURE 5 Enhanced SR & ED Tax Credit—Sensitivity Analysis



✦ = Base case parameter values

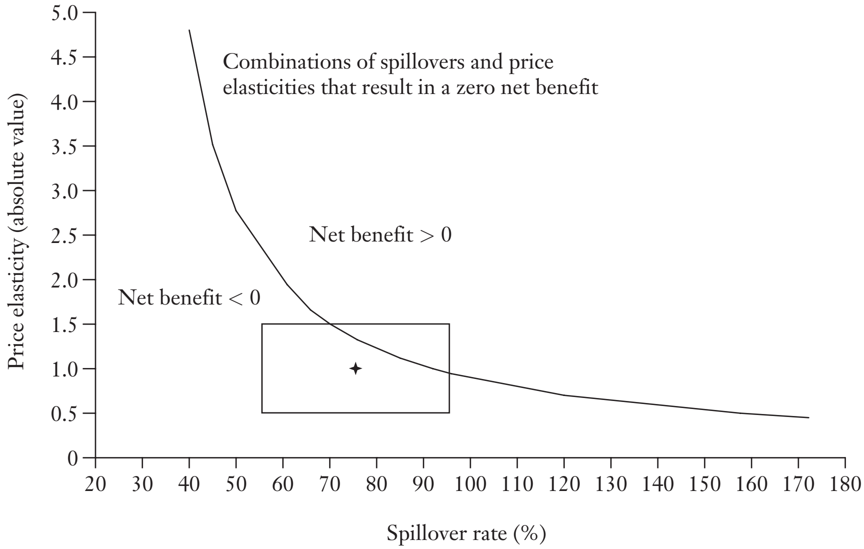
IRAP

Constant Funding Levels

Assessed without considering government support available from other programs, the 2008 version of IRAP shows a welfare loss of $12 million, or approximately 10 percent of the total amount spent on the program. This loss occurs despite assuming higher-than-average spillovers from IRAP-funded projects and assuming that business and technical advice provided by ITAs generates these same high spillovers. A key reason for this poor result is high administration costs—even with the exclusion of advice, administration expenses amount to approximately 20 percent of total program costs. Cutting administration costs by 40 percent would be sufficient to get the welfare gain into positive territory; reducing administration expenses by a third and compliance costs by 25 percent would have the same impact. If it were possible to finance the program without harming economic performance, there would be a net economic benefit of $15 million; however, if the program were assumed to be financed by corporate income tax measures, the net economic loss would be in the $30 million-$60 million range.

Figure 6 shows the sensitivity of the IRAP net benefit results to changes in the spillover rate and price elasticity. The analysis makes use of the same ranges as for SR & ED—plus or minus 20 percentage points for the spillover rate, and plus or minus 0.5 for the price elasticity—but the midpoint of the range for spillovers is about 20 percentage points higher. Spillovers ranging from 70 percent to 96 percent, in combination with price elasticities ranging from −1.5 to −0.95, would generate

FIGURE 6 IRAP—Sensitivity Analysis



✦ = Base case parameter values

non-negative net economic benefits, but these combinations account for only about a fifth of the plausible combinations contained in the rectangle in figure 6.

Optimizing the benefits from a direct assistance program such as IRAP raises different issues than determining the optimal subsidy rate for a tax incentive program. In contrast to an open-ended tax incentive program, it is of interest to assess how the benefits from a given level of funding could be maximized, as well as to determine the optimal level of funding.

The net-of-administration cost to the government of a direct assistance program is determined by the subsidy rate, the average size of subsidized projects, and the number of program participants. Program costs can be kept roughly constant by making offsetting changes to these parameters. Model simulations indicate that the benefits achieved from such adjustments are relatively small. For example, increasing the average project size by 50 percent and reducing the number of projects funded by 50 percent reduces administration and compliance costs by about $6 million, or just under 20 percent, which is not sufficient to change the sign of the net benefit. Savings are realized because a decline in the number of projects funded reduces both administration and compliance costs. However, the savings are perhaps less than expected because an increase in the average project size puts upward pressure on these costs: larger subsidies, whether they arise from a higher subsidy rate or a larger project size, are more closely scrutinized by both program administrators and program participants. Note that the same savings would be realized by raising the subsidy rate and reducing the number of projects in order to keep program funding constant. On the other hand, no administration and compliance cost savings would be realized from reducing the subsidy rate and increasing the project size, since neither the average subsidy payment nor the number of projects would change.

In order to achieve a zero net benefit through scale-induced reductions in administration and compliance costs, the number of projects funded would have to decline by almost two-thirds, offset by an almost threefold increase in the average project size, to about $650,000.

Variable Funding Levels

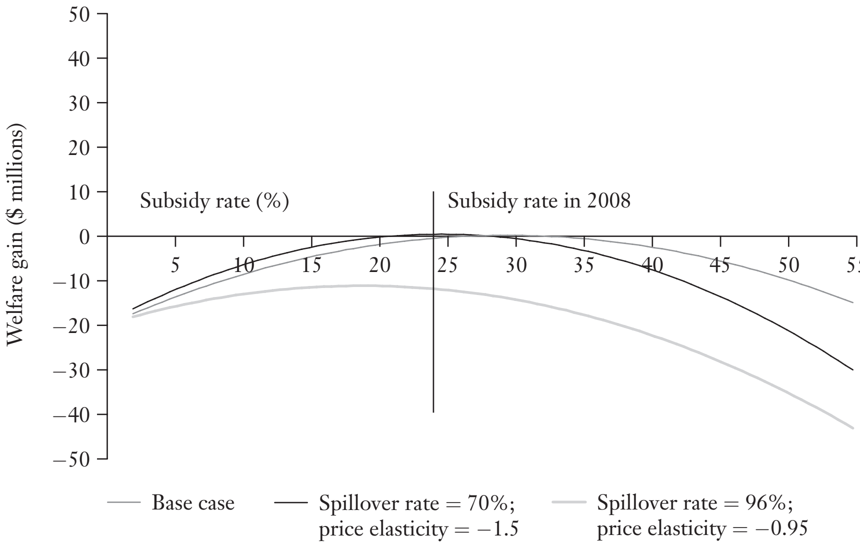
IRAP is Canada's largest direct assistance program, but it is still quite small in scale: total subsidy payments were $93 million in 2008, rising to about $175 million in 2012-13 as a result of the additional funding announced in the 2012 federal budget. By way of comparison, the estimated cost of the enhanced SR & ED tax credit in 2011 was about $1.5 billion. An implication of the analysis in the preceding section is that increasing funding without changing the subsidy rate or the average size of projects funded would not necessarily improve the performance of the program. In the absence of economies of scale in administering the program, doubling funding as announced in the 2012 federal budget with no change in the subsidy rate or the average size of projects funded would double the welfare loss, since all of the spillover benefit and all of the costs would double. However, there are fixed costs in administering IRAP; as a result, a doubling of funding increases the net loss by 50 percent.

The optimal level of funding for IRAP is explored in figure 7, which shows the welfare gain as the subsidy rate and the amount of program funding vary. In these simulations, changes in the subsidy rate are associated with equal changes in both the number of projects funded and their average size. With the base case assumptions, IRAP generates a welfare loss at all subsidy rates. The loss is minimized at $11 million with a subsidy rate of 17 percent and program funding of $83 million (including administration expenses). While the welfare loss is not much different than the value calculated for 2008, the optimal subsidy rate is substantially lower than the observed 23.9 percent rate, and program funding would be about $30 million lower.

Figure 7 also shows the impact of changes in the spillover rate and price elasticity on the optimal program size and the subsidy rate. In addition to the base case, two combinations of spillovers and price elasticities are shown in the figure; these combinations represent the extreme values of the plausible range that will result in a zero net economic benefit. (With reference to figure 6, these combinations represent the points where the zero net benefit line intersects the rectangle that depicts the plausible range of values for the spillover rate and price elasticity.)

- If the true value of the spillover rate is 70 percent and the true value of the price elasticity is −1.5, the current values of the subsidy rate, the project size, and program funding would be very close to their optimal values.
- If the true values of the spillover rate and the price elasticity are 96 percent and −0.95, respectively, the optimal subsidy rate would be slightly higher than the observed rate, and program funding would be about 15 percent higher.

FIGURE 7 Optimizing IRAP—Base Case and Sensitivity to the Spillover Rate and Price Elasticity



A third combination, not shown in figure 7, has the true values of both the spillover rate and the price elasticity at the extreme values of the plausible range, 96 percent and −1.5, respectively. In this case, the optimal subsidy rate would be 37.5 percent and program funding would be approximately $200 million.

EXTENSIONS TO THE BENEFIT-COST FRAMEWORK

As noted above, not all of the factors likely to affect the net benefit are included in the core analysis in this article. Other benefit-cost studies have included profits accruing to foreign firms as a “leakage” (cost),[67] the logic being that transferring the subsidy payments abroad reduces real domestic income. In addition, R & D subsidies indirectly deal with the market failure associated with the financing of small firms undertaking R & D, and there may be further social benefits from promoting the growth of innovative startups into large successful firms. Similarly, R & D subsidies promote investment in environmental protection and health technology, which can help alleviate market failures in these areas. Although using R & D subsidies to deal with these issues is clearly inferior to measures that act directly on the market failure, there is an indirect benefit that could be included in the benefit-cost analysis.

67 See, for example, Australia, Bureau of Industry Economics, supra note 14.

This section presents and discusses illustrative calculations of how the loss in real income arising from the transfer of the subsidy to foreigners could affect the benefit-cost results. Owing to a lack of sufficient information, it is not possible to illustrate the impact of alleviating the financing constraints of small firms or of promoting the growth of innovative startups. In the case of environmental protection, the issue is that in many cases the benefits from reducing pollution are global while the costs of abatement are local. For example, policies to reduce carbon (CO_2) emissions provide global benefits while the entire costs are borne by Canadians. As a result, a benefit-cost analysis of subsidizing R & D in order to reduce CO_2 abatement costs would show a net loss when undertaken from a national perspective, but this finding would not contribute to the policy debate on government support for R & D. The information required to perform an assessment of the net benefit from subsidizing R & D that is oriented to controlling local pollution is not available.

R & D subsidy payments can be transferred to foreigners through lower export prices, as well as through profits accruing to foreign-owned enterprises receiving such subsidies. The R & D subsidy reduces costs, but unless Canadian producers are facing a horizontal demand curve for their products, some of the subsidy will be passed on to foreign purchasers, thereby reducing real income in Canada. Determining how much of the subsidy is transferred depends on the amount of additional R & D induced by the subsidy, the success rate in commercializing R & D projects, the export share of sales, and the supply and demand elasticities for commercialized products. In addition, there will be a difference in the timing of the increase in R & D investment and export sales, which will reduce the present value of the transfer.

The results of the calculations are presented in table 7. Some background on the calculations follows:

- In the base case, the price elasticity of demand for R & D is set at −1.
- There is no comprehensive information available on the success, or commercialization, rate of R & D undertaken by firms. The survival rate of R & D-intensive startups likely provides a floor on the overall success rate. A longitudinal analysis of such startups by Song et al.[68] found a five-year survival rate of approximately 22 percent. Since it seems likely that the probability of success for individual projects, particularly those undertaken by larger firms, would be higher than for startups, a 33 percent success rate was used in the calculations.
- The export intensity of firms undertaking R & D is not available. Export intensity is assumed to be 50 percent, which is equal to the average export intensity of firms in the manufacturing sector, where about half of Canada's R & D is performed.
- The amount of the subsidy that gets passed on in lower export prices is assumed to be 25 percent, which is consistent with a unitary supply elasticity

68 Michael Song, Kasenia Podoynitsyna, Hans Van Der Bij, and Johannes I.M. Halman, "Success Factors in New Ventures: A Meta-Analysis" (2008) 25:1 *Journal of Product Innovation Management* 7-27.

and a demand elasticity of −3 for commercialized R & D projects. The passthrough percentage would be lower for a higher demand elasticity.[69]

- Profits accruing to foreigners are an issue for the regular SR & ED credit; the enhanced credit is available only to Canadian-controlled firms; and while foreign-controlled firms are eligible for support from IRAP, it is assumed that the share of foreign-controlled firms is small enough to ignore. The estimate in table 7 for the regular SR & ED credit was developed assuming that half the firms (and profits) claiming the regular credit are foreign-controlled,[70] a 15 percent nominal pre-tax return on the investment,[71] and a 9 percent return after corporate income and withholding taxes.
- Discounting is based on a three-year pre-commercialization investment period followed by a 10-year payoff period, which is shorter than implied by the commonly used 15 percent depreciation rate for R & D. With a 4 percent discount rate, the present value of a dollar in sales spread over the 13-year period is 72 cents. The same discounting factor is used in both calculations.

The resulting negative adjustments to the enhanced SR & ED credit and IRAP (shown in table 7) increase the net loss by about 20 percent for both programs. For the enhanced SR & ED credit, this change is enough to reduce the probability that the program is generating a net economic benefit, from about 10 percent in the base case to about 6 percent; for IRAP, the negative adjustment reduces the probability of a positive net benefit from 20 percent to 16 percent. For the regular SR & ED credit, the negative adjustment amounts to about half of the base case net economic benefit; this adjustment reduces the probability that the regular credit is generating a net benefit from approximately 70 percent to just over 50 percent. The larger adjustment to the regular SR & ED credit reflects the impact of transfers of the subsidy via profits earned by foreign-controlled firms.

69 The formula for calculating the passthrough percentage, or the incidence of the subsidy, is $\eta/(\eta + \varepsilon)$, where η is the price elasticity of supply and ε is the absolute value of the price elasticity of demand.

70 From Statistics Canada data (supra note 32, at table 5-5) it was determined that the share of business R & D performed by foreign-controlled corporations averaged 33.7 percent from 2005 to 2007. The share of business R & D performed by small CCPCs is approximately 30 percent, so the share of foreign-controlled firms in R & D performed by firms eligible for the regular credit is approximately 50 percent (33.7/(1 − 0.3)).

71 Estimates of the gross depreciation rate of return on R & D are typically in the 20 percent-30 percent range, while empirical work suggests a depreciation rate of 15 percent. See Bronwyn H. Hall, Jacques Mairesse, and Pierre Mohnen, *Measuring the Returns to R&D*, NBER Working Paper no. 15622 (Cambridge, MA: National Bureau of Economic Research, December 2009), at 23, for a review of the empirical work on rates of return, and Bronwyn H. Hall, *Measuring the Returns to R&D: The Depreciation Problem*, NBER Working Paper no. 13473 (Cambridge, MA: National Bureau of Economic Research, October 2007), for estimates of the depreciation rate for R & D.

TABLE 7 Benefit-Cost Base Case Results and Illustrative Extensions

	SR & ED (2007)		
	Regular credit	Enhanced credit	IRAP
	$ millions		
Base case net benefit	204.9	−178.2	−12.4
Additional elements:			
Subsidy transfers to and from foreigners, via			
Export prices	−58.2	−38.6	−2.8
Profits of foreign controlled firms	−46.5	0.0	0.0
Acting on other market failures			
Pollution abatement	?	?	?
Financing of small firms	na	?	?
Sum of quantified elements	−104.7	−38.6	−2.8

POLICY IMPLICATIONS

The results for the enhanced credit call into question the policy of providing additional support for small firms: the optimal rate for small firms is lower than for large firms, reflecting higher delivery costs, although the income loss associated with a slightly above-optimal rate is small. As mentioned previously, there are a number of benefits from supporting small firms that are not captured in the model used in this study. A frequently made argument is that enhanced credits help overcome financing constraints faced by small firms. That is a strong argument in favour of refundability, but providing a higher credit rate to deal with a capital market imperfection is not an efficient solution, since it does not deal directly with the market failure.[72] The capital market failure faced by small innovative firms is generally thought to be the result of difficulties that investors face in assessing the quality of both projects (adverse selection) and entrepreneurs (moral hazard). Subsidizing the cost of undertaking R & D does not address these issues and is therefore likely to be less cost-effective than a well-structured intervention to deal directly with the market failure.

Another argument for providing increased support for small firms undertaking R & D is that social benefits, in addition to knowledge spillovers, are realized when young innovative firms make the transition to large successful firms. But it is easy to overstate the social benefits of promoting the growth of young innovative firms. In most cases, the owners and the employees of the growing firm appropriate all of the benefits; thus, there is no external return to justify government intervention. In some cases, however, the successful firms are able to generate rents on export sales,[73]

72 For a discussion of this point, see Staff of the International Monetary Fund, "Taxation of Small and Medium Enterprises," a background paper prepared by International Monetary Fund staff for the International Tax Dialogue Conference, Buenos Aires, October 2007, at 13. The authors conclude that firm age is likely to be more highly correlated with financing problems than firm size, making size-related initiatives inefficient.

73 There would also be a social benefit if strong export demand allowed workers in the growing firm to earn rents that generate additional tax revenue.

which raise national income; taxation of these rents benefits society generally and therefore justifies government support. Note that in the absence of export sales, rents earned by owners and employees of the growing firm represent a transfer of income from producers to consumers, not additional national income.

In order to rigorously assess the argument, the marginal social benefit in the form of extra tax revenue on export sales should be compared with the marginal cost of the additional benefit provided to small firms. Determining the marginal social benefit requires the following information:

1. the number of additional startups induced by the extra support;
2. the number of these additional startups that make the transition to large successful firms; and
3. the timing and the size of the rents earned on export sales by these successful firms.

This information is not, to say the least, readily available. But an estimate of the marginal social cost of providing additional assistance to small firms is available from the benefit-cost analysis: the marginal social cost of raising the refundable credit from 20 percent to 35 percent is about $65 million a year, assuming that the additional support is financed by a share-weighted increase in all taxes. However, if the source of financing is assumed to be higher corporate income taxes, the marginal social cost would be in the $175 million-$375 million range, which is a more substantial, but perhaps not insurmountable, hurdle. It is, however, worth bearing in mind that the benefit-cost estimates are based on the assumption that spillovers are the same for large and small firms. While there is an extensive body of empirical literature on spillovers, the only empirical analysis of the issue found that spillovers decline with firm size because smaller firms operate in technological niches that limit the scope for spillovers.[74]

A higher sensitivity to subsidies (that is, a higher price elasticity) by small firms would also justify additional support for innovative startups. While the limited evidence available points to higher price elasticities for small firms, the price elasticity would have to be −1.6, which is outside the plausible range of values used in this study, in order for the enhanced credit to generate a positive welfare gain.

Overall, considerations other than those captured in the model do not provide support for preferential treatment of small business. Nevertheless, the 2012 federal budget announced changes that will widen the gap between the SR & ED tax credits for small and large firms, and also provide additional funding for IRAP, which will benefit small and medium-sized firms. Reducing the regular credit further below its optimal value lowers the net benefit, while reducing the enhanced credit closer to its optimal value decreases the net loss, together creating a small deterioration in the net benefit from the SR & ED tax credit. The doubling of funding for IRAP, in the

74 Bloom et al., supra note 26. See the discussion at note 35, supra, and the related text.

absence of changes to administration and compliance costs, will increase the net loss generated by the program.

The policy approach that follows from the benefit-cost analysis undertaken in this article is to align the enhanced statutory credit rate with an unchanged regular credit rate and leave IRAP funding at its current level. As shown in table 8, this approach would generate a net benefit of about $90 million, in contrast to a net loss of about $10 million under the budget changes. Reducing the enhanced credit rate would also make the stacking of benefits from other programs and other levels of government less problematic by reducing the overall subsidy rate closer to the optimal rate.

The net benefit obtained by scaling back the enhanced SR & ED credit assumes that the source of financing is spread equiproportionately across all major taxes. The net benefit would be in the $200 million-$400 million range if the source of financing, and hence the allocation of the savings, were assumed to be corporate income taxes instead. But in this case, the SR & ED investment tax credit would be generating an overall net loss in the $350 million-$1,250 million range (table 8).

CONCLUSION

This article has presented an evaluation of two Canadian federal R & D support programs, the SR & ED tax credit and IRAP (Canada's largest direct assistance program). These programs are evaluated using a benefit-cost framework that calculates the impact of R & D subsidies on real income, taking into consideration the knowledge spillovers from the R & D induced by the subsidies, the cost of financing the subsidy with distortionary taxes, the cost of shifting resources from their market-determined uses, and administration and compliance costs. Novel features of the analysis include the determination within the model of the number of firms receiving assistance and the average amount of assistance received; the inclusion of marginal administration and compliance costs; and the ability to assess how program benefits could be optimized. The use of recent survey information on compliance costs for SR & ED and IRAP is another new feature of this analysis.

The SR & ED credit has two components: a regular 20 percent credit, reduced to 15 percent in the 2012 federal budget, and an enhanced 35 percent refundable credit for small Canadian-controlled firms. The regular credit generates a net economic benefit equal to 10 percent of the tax revenue forgone, but the enhanced credit fails a benefit-cost test, largely reflecting higher compliance costs, which have a substantial fixed component. The loss from the small firm credit amounts to almost 15 percent of the tax revenue forgone; this loss could be minimized by reducing the credit rate to 14.5 percent, but it would still be substantial.

IRAP supports R & D that is further upstream than the generally available SR & ED tax credit; as a result, the spillover benefits from IRAP-supported projects are estimated to be about one-third higher than those for SR & ED. In addition, the advice component of assistance is assumed to generate these same high spillovers, even though advice is provided on business management as well as on technical issues. Nevertheless, IRAP also fails a benefit-cost test owing to high administration and compliance costs, amounting to 25 percent and 11.6 percent, respectively, of the

TABLE 8 Net Benefit of Policy Options

	SR & ED			
	Regular credit	Enhanced credit	IRAP	Both programs
		$ millions		
Pre-budget base case	205	−185	−12	8
Post-budget				
Base case	165	−155	−18	−8
Single 20% rate/IRAP unchanged	195	−90	−12	93
Corporate income tax financing	−45 to −595	−310 to −650	−30 to −60	−385 to −1,305

subsidy provided. Cutting administration costs by a third and compliance costs by a quarter would be sufficient to get the welfare gain into positive territory.

Recognizing that government programs must be financed by taxes that harm economic performance plays an important role in the analysis. In the absence of this cost, the regular SR & ED credit would show a very large net benefit, and both the enhanced SR & ED credit and IRAP would easily pass a benefit-cost test. Further, if the source of financing were assumed to be corporate income tax revenues instead of a share-weighted average of the major taxes, both the regular and the enhanced credit would show large losses, and the loss associated with IRAP would also rise dramatically.

The results are also sensitive to changes in the spillover rate and price elasticity. Varying these parameters over plausible ranges suggests that there is just over a 10 percent probability that the true value of the net benefit arising from the enhanced credit is greater than or equal to zero; in the case of IRAP, the probability is approximately 20 percent.

Not all of the benefits and costs are included in the model, so some caution in drawing conclusions from the results is warranted. Missing elements include the negative impact of the indirect transfer of subsidy payments to foreigners and the positive indirect impacts of R & D subsidies on market failures associated with supporting innovative startups and environmental protection.

The analysis in this article supports a recommendation that the enhanced SR & ED tax credit rate be reduced to the same rate as the credit for large firms, while maintaining refundability in recognition of the financing constraints faced by smaller firms. Additional savings would be available by reducing compliance costs. There is also a need to assess the IRAP model of providing firms with a substantial amount of one-on-one advice and imposing relatively burdensome reporting requirements. High administration and compliance costs are the key constraint on IRAP's ability to generate a net economic benefit for Canadians.

The 2012 federal budget adopted a different approach than the one recommended in this article: the budget changes reduce the generosity of both the regular and enhanced SR & ED investment tax credits while making the preferential treatment of small business even more pronounced. The budget allocated part of the savings from the SR & ED cutbacks to an increase in IRAP funding. The combined effect of these budget changes will be to reduce the net economic benefit from the two programs.

APPENDIX MODEL DESCRIPTION AND PARAMETER VALUES

The Model

Net welfare gain = Spillover + Net producer surplus − Financing cost − AF − CF

Spillover = $Re * \varepsilon * (s - mcc) * I/(1 + (s - mcc) * \varepsilon)$

Net producer surplus = $I/(1 + (s - mcc) * \varepsilon) * ((s - mcc) + 0.5 * (s - mcc)^2 * \varepsilon - (s + mac) * (1 + (s - mcc) * \varepsilon))$

Financing cost = $MEB * (s * I + A - t *$ (Spillover + Net producer surplus))

Administration and compliance costs:

$A = AV_f * Nf + AF$

$AF = Nf * af_f * (1 - (Nf - \overline{Nf}))/\overline{Nf} * (1 - \varepsilon_A))$

$AV_f = I_f * mac$

$CF = Nf * cf_f$

$mcc = CCVShare * ACC * s$

$mac = ACVShare * AAC * s$

If $[(s - mcc + 0.5 * (s - mcc)^2 * \varepsilon)/(1 + (s - mcc) * \varepsilon * I_f) \leq cf_f$, then $Nf = 0$, else $Nf = Nf^s = 0 * (1 + (s - mcc) * \varepsilon)^{\alpha}]$,

$I_f = I_f^{s=0} * (1 + (s - mcc) * \varepsilon)^{1-\alpha}$, where $I_f^{s=0}$ is an estimate of R & D investment per firm in the base year with s equal to zero.

$I = Nf * I_f$

Note: Variables with a bar denote base case values.
Expenses and costs are in millions of dollars.

Variable Definitions

A = Administration expenses

AF = Fixed administration expenses

AV_f = Variable administration expenses per firm

CF = Fixed compliance costs

I = Amount of investment in R & D benefiting from government assistance

I_f = I per firm

$I_f^{s=0}$ = An estimate of investment per firm when s = zero; calculated as (Amount of subsidized investment per firm in base year)/$(1 + (\bar{s} - mcc) * \varepsilon)^{1-\alpha}$

mac = Marginal administration cost per dollar of investment supported

mcc = Marginal cost of compliance per dollar of investment supported

Nf = Number of firms receiving assistance

Parameter Definitions

α	=	Parameter to capture the sensitivity of the number of firms to changes in the subsidy rate
ε_A	=	Elasticity of fixed administration costs to the number of clients
ε	=	Absolute value of the price elasticity of demand for R & D
af_f	=	Fixed administration expenses per firm
AAC	=	Average administration expenses per dollar of subsidy paid
ACC	=	Average compliance cost per dollar of subsidy received
$ACVShare$	=	Share of variable administration costs in total administrative costs (Nf constant)
$CCVShare$	=	Share of variable compliance costs in total compliance costs
cf_f	=	Fixed compliance costs per firm
MEB	=	Marginal excess burden of taxation (proportion of taxes raised)
$Nf^{s=0}$	=	(Number of firms receiving subsidies in base year)/ $(1 + (\bar{s} - mcc) * \varepsilon)^{\alpha}$
Re	=	External rate of return on R & D
s	=	Effective subsidy rate on R & D investment
t	=	Marginal tax rate on gross domestic product

TABLE A1 Base Case Values

	SR & ED		
	Small firms	Large firms	IRAP
Parameters			
α	0.5	0.5	0.5
ε	1.0	1.0	1.0
εA	0.75	0.75	0.75
af_f	0.001437	0.003598	0.009618
AV_f	0.000359	0.002399	0.004737
AAC	0.025	0.012	0.247
ACC	0.142	0.047	0.116
$ACVShare$	0.34	0.34	0.4
$CCVShare$	0.34	0.34	0.54
cf_f	0.008086	0.014093	0.003102
mac	0.0028	0.0007	0.0236
mcc	0.0161	0.0026	0.0113
MEB	0.26	0.26	0.26
Re	0.56	0.56	0.76
s	0.357	0.172	0.239
t	0.264	0.264	0.264
Base year values			
Number of firms/projects	18,071	3,918	1,604
Subsidy payments ($ millions)	1,298.0	1,958.0	93.3[a]
Administrative costs ($ millions)	32.5	23.5	23.0
Compliance costs ($ millions)	184.3	92.0	8.2

[a] Including $22.7 million in the cost of advice provided.