This paper aims to discuss the use of tax incentives for the promotion of business expenditures on Research and Development. In the 1980s, only a few countries, including Canada, the United States and France, were implementing tax breaks for R&D. By the 2000s, however, many countries from both the developed and the developing world had adopted policy packages that included a version of tax breaks for R&D activity. In view of this trend, the question of the effectiveness of R&D tax incentive schemes in generating additional privately funded R&D has become ever more important.

1. INTRODUCTION

In recent years, the number of countries that offer R&D tax breaks has increased, and many governments have made existing schemes more attractive. Within the OECD, the number of countries offering R&D tax breaks rose from 18 in 2004 to 26 in 2011. France has moved from an incremental scheme to a much more generous volume-based scheme, while the United Kingdom has increased incentives, especially for small and medium-sized firms (SMEs). Finland announced the launch of its first R&D tax break scheme to supplement direct subsidies. Japan and Korea included R&D tax incentives in their policy responses to the global financial crisis. Similar trends have emerged in other middle-income countries (MICs), where existing schemes have undergone reforms or new schemes designed to boost R&D have been introduced. Croatia introduced new tax incentive schemes in 2007, followed by Turkey and Brazil in 2008 and India in 2010. There is substantial evidence to support R&D tax incentives, although some countries still achieve high R&D intensities by focusing only on direct subsidies. Some R&D-intensive countries, such as Sweden and Germany, currently offer no tax incentives for R&D.

The economic rationale for providing tax breaks for R&D is based on the idea of subsidizing private R&D in order to lower the cost of carrying out R&D in the private sector. This rationale follows from Arrow’s idea that the social returns from R&D are higher than the private returns (Arrow, 1962). Because of spillovers and imitation, firms that invest in R&D cannot fully reap the benefits of this activity; thus, they invest at a level that is lower than the social optimum.

Private sector R&D investment behavior can be modeled in a profit maximization framework, as initially

---

1 OECD Science and Technology Scoreboard 2011.
introduced by Howe and McFetridge (1976). Acting as rational profit maximizers, firms invest in R&D until the additional cost of investing one more unit (marginal cost of R&D) is equal to its marginal rate of return (MRR), or the expected net benefit from engaging in the additional project. The marginal cost can be interpreted as the opportunity cost of using the funds for R&D activities instead of exploiting other investment possibilities. The marginal rate of return depends on the range of R&D projects that are available to the firm, that is, to the projects that constitute the firm’s “innovation possibility set” (David, Hall, & Toole, 2000). The MRR schedule is downward sloping to reflect the fact that the projects are sequenced in descending order of profitability for the firm.

An R&D tax credit induces a reduction in the marginal cost of investing in R&D capital for the firm, which can be depicted as an exogenous outward shift of the marginal cost curve (MC curves in Figure 1). This shift means a reduction in the cost of the previously unprofitable project (or the “marginal” project), making it profitable for the firm to engage in the project once the tax incentive is in place. Through this mechanism, the R&D tax credit may trigger a rise in R&D investment performed by the firm, the degree of which depends on the slope of the marginal rate of return.

Tax breaks offer an indirect means of supporting firms that engage in R&D activities. As distinct from direct support policies such as grants and loans provided by public bodies or other funding programs, tax breaks allow companies to choose the more profitable projects for themselves, which are generally also those that have a higher probability of success. This is plausible

---

2 The assumption underlying the continuous marginal rate of return curve in Figure 1 is that all of the R&D projects that the firm can invest in are continuous in value and are divisible into smaller pieces. This is for expositional convenience, but some authors present a more realistic stepwise function. See, for example, (Czarnitzki, Hanel, & Rosa, 2011).
since companies are in most cases better informed than public agencies about their own capabilities.

From an efficiency point of view, tax breaks offer a better alternative to the government, as they leave the task of selecting the projects on which firms will focus their R&D efforts to the firms themselves. On the other hand, with a view to addressing the well-known externality problem of innovation and R&D, it is socially more desirable for the government to make this decision. When the selection is left to the firm, the firm chooses to maximize its private returns, which can be shown to remain below the social returns (Arrow, 1962).

Governments are increasingly relying on tax breaks to support R&D projects, due to the ease of administration compared to direct funding programs, which require project evaluation and rigorous monitoring. Thus, tax incentives are purported to reduce the amount of red tape caused by the detailed monitoring procedures associated with direct subsidies.

Tax breaks reduce red tape relative to other support policies, although a different issue arises with tax incentives. Verifying whether an activity is eligible for the R&D tax break is relatively problematic for the tax authority, since the task of creating specialized R&D units is outside the purview of these institutions. Over the years, however, tax authorities have been adapting to such systems by building capacity to assess the eligibility of R&D activities for the tax incentives in an efficient manner. This is discussed later in this paper.

The next section presents the key characteristics of R&D tax incentive schemes. The third section touches on how the tax treatment of R&D is measured in the literature, followed by a critical discussion of various evaluation techniques. Recent international examples, illustrating ways that the burden of administering tax credits is being addressed, and new trends, such as patent box policies, are discussed in the fourth section. The fifth section sets forth some outstanding issues surrounding the availability and quality of data for effective policymaking. The sixth section concludes with the note’s key findings.

2. KEY CHARACTERISTICS

R&D tax credits, enhanced deductions, cash credits, special depreciation allowances for capital goods, loss carrybacks and carryforwards, and similar policies reduce the cost of undertaking R&D for firms by alleviating their tax liability. Often, the term “R&D tax credit” is used to refer to this general class of fiscal incentives provided to R&D-intensive firms. Governments select one or more of these tools in formulating their own R&D tax incentive schemes, giving rise to large cross-country heterogeneity in terms of policy design. Table 1 (next page) presents various country examples where R&D tax incentive mechanisms are a combination of the various instruments described in this section. All of the countries listed in the table use more than one instrument to support firms’ R&D activity.

A tax credit, in the strictest sense of the term, allows firms to directly deduct from their tax liability an amount equivalent to a proportion of the base R&D expenditure performed by the firm, where this proportion depends on the statutory credit rate. The calculation of the base amount of R&D is defined clearly in the design of the scheme, along with definitions of eligible expenditures. The tax credit itself may or may not be taxed. The schemes in effect in the United States (Research and Experimentation Tax Credit) and France (Crédit d’impôt recherche) are examples of this kind of direct tax credits.

An enhanced deduction allows the firm to deduct from its taxable income an amount larger than the total of its eligible R&D expenditures. This leads to a maximum tax gain that is at a rate equal to the product of the tax rate and the deduction rate that applies to the firm. To make the distinction between a tax credit and an enhanced deduction scheme clearer, one may consider the following: (i) a credit scheme with a statutory credit rate of 25 percent, and (ii) a deduction scheme with a deduction rate of 25 percent. The tax savings of a firm under a tax credit scheme is 25 percent of its total eligible R&D expenditures. Under an...

3 The discussion in this section does not take into account the economic gains from R&D as an investment with future returns. Only the accounting definition of R&D expenditure and the related tax gain are considered.
TABLE 1 Examples of R&D Tax Incentive Systems

<table>
<thead>
<tr>
<th>Country</th>
<th>General Corporation Tax Rate</th>
<th>Eligible Expenditures</th>
<th>Enhanced Deductions</th>
<th>Tax Credit</th>
<th>Allowances for Capital Goods</th>
<th>Carry-Forward or Paid Out as Negative Tax</th>
<th>Other Relevant Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada  (federal)²</td>
<td>General: 15% Small business: 11%</td>
<td>Salaries, materials, overheads, lease, subcontracting expenses used in experimental development to achieve technological advancement to create new materials, devices, products, or processes; applied research with a specific practical application in view; basic research to advance scientific knowledge; support work, only if the work directly supports the eligible experimental development, or applied basic research.</td>
<td>20% federal tax credit, 35% for small firms (on first $3 million) + Provincial credits</td>
<td>100% immediate expensing for machinery and equipment (not buildings)</td>
<td>100% refundable for expenses and 40% refundable for capital expenditures</td>
<td>100% immediate expensing for machinery and equipment (not buildings)</td>
<td>20% federal tax credit, 35% for small firms (on first $3 million) + Provincial credits</td>
</tr>
<tr>
<td>France³</td>
<td>General: 34% Small business: 15%</td>
<td>Staff costs for researchers and technicians, operating expenses, spending on R&amp;D performed by government agencies, universities, NGOs and other organizations approved by the Ministry of Research, depreciation and amortization of property and buildings used directly in R&amp;D; R&amp;D includes activity that aims at significant technological advancement, requires scientific methods and specialized personnel.</td>
<td>30% up to €100 million, above that 5%.</td>
<td>100% immediate expensing of R&amp;D equipment.</td>
<td>Unused tax credits can be carried forward or refunded after three years</td>
<td>Some new applicants may receive tax credit at rates of 40% in the first year, 35% in the second year, then the standard rate. Different caps apply to in-house and outsourced R&amp;D. Income from intellectual property is subject to lower tax rate.</td>
<td>30% up to €100 million, above that 5%.</td>
</tr>
<tr>
<td>Spain⁴</td>
<td>General: 30% Small business: 25% (or 20%)</td>
<td>Salaries of R&amp;D&amp;I personnel, cost of capital goods that are dedicated to R&amp;D; R&amp;D includes investigation with the purpose of acquiring new knowledge and its application. Technological improvement of materials, products, processes.</td>
<td>25% volume, 42% incremental, with base as the mean of the two prior years. 12% for technological innovation. 17% on cost of qualified personnel assigned exclusively for R&amp;D. + Regional incentives</td>
<td>Additional 8% credit for amounts invested in fixed capital, except real estate.</td>
<td>Carry-forward for 15 years</td>
<td>40% discount in Social Security contributions for staff employed to perform R&amp;D&amp;I activities. Different caps apply to different tax credits. Income from intellectual property is subject to lower tax rate.</td>
<td>25% volume, 42% incremental, with base as the mean of the two prior years. 12% for technological innovation. 17% on cost of qualified personnel assigned exclusively for R&amp;D. + Regional incentives</td>
</tr>
<tr>
<td>United Kingdom⁵</td>
<td>General: 24% Small business: 20%</td>
<td>Employee costs for staff who are actively engaged in carrying out R&amp;D itself, staff providers, materials, payments to clinical trials volunteers, utilities, software used directly in the R&amp;D.</td>
<td>130% for large firms 225% for SMEs</td>
<td>100% immediate expensing for capital used in R&amp;D</td>
<td>Carry-forward and cash credit for SMEs up to 12.5% of unrebursable losses.</td>
<td>Minimum R&amp;D spend of £10K required. Subcontracted work is subject to special provisions. A cap applies to cash credits. Income from intellectual property is subject to lower tax rate.</td>
<td>130% for large firms 225% for SMEs</td>
</tr>
</tbody>
</table>

Source: Relevant government institutions; see footnotes. Some summary information obtained from ERAWATCH and Deloitte 2012 Global Survey of R&D Tax Incentives, February 2012.

¹ OECD Tax Database, corporate income tax tables. For a more detailed presentation of exceptions, refer to the source.


⁴ Spain Ministry of Economy and Competitiveness; http://www.idi.mineco.gob.es/portal/site/MICINN; Spain Ministry of Science and Innovation Análisis comparativo sobre el diseño, configuración y aplicabilidad de Incentivos Fiscales a la Innovación empresarial, 2011.

⁵ HM Revenue and Customs; http://www.hmrc.gov.uk/ct/forms-rates/claims/randd.htm
enhanced deduction scheme, the firm will first deduct 125 percent of its eligible R&D expenditure, rather than 100 percent, from taxable income; then, the net profit is taxed at a rate τ, leading to a tax gain of 25%×τ. Examples of enhanced deduction schemes can be found in Hungary, Brazil, Austria, and the United Kingdom.

Loss-making firms cannot fully benefit from these schemes, but governments have other ways of compensating them for their R&D efforts. One such tool is credits payable to firms for the excess amount of the credit, or unconditional cash refunds. For instance, in Ireland, companies can claim a tax refund to be paid in cash if the company is in a loss-making position. Ireland also allows firms to carry back unused tax credits to alleviate the previous period’s tax liability. Many countries allow carry forward options for firms to claim their earned tax credits in a given financial year in future periods. This is possible in many countries, including Poland, the United States, Spain, China, the Czech Republic, and India. In the United States, the Research and Experimentation Tax Credit allows firms to carry forward the tax credit for 20 years. This means that a loss-making firm, which does not have corporate tax liability and hence cannot fully benefit from the tax credit in a given accounting year, can use its earned right to a tax credit in a future accounting period in which the company has made a profit.

Depreciation allowances also provide fiscal incentives for R&D-intensive firms. R&D, in economic terms, is a type of investment which generates future income; hence, R&D expenditures could be treated economically as capital goods. In accounting terms, though, many regimes allow current expenses on R&D to be deducted 100 percent against taxable income, but not capital expenses: these may be subject to special depreciation allowances, such as an immediate 100 percent deduction from gross income, or accelerated depreciation at higher rates than determined for other types of capital goods. In the United Kingdom, for example, Research and Development Allowances grant a 100 percent immediate deduction from taxable income of capital expenditure that is used for performing R&D activities.4

For most of these fiscal incentives, the design of the scheme defines a base amount of R&D on which the tax credit5 applies, depending on the eligible expenditures incurred by the firm. Eligible expenditures are generally significantly lower than the firm’s total R&D expenditure. A large number of schemes use the OECD Frascati Manual6 definition of R&D to distinguish between eligible and non-eligible expenditures, but there are usually additional restrictions specific to each country. Some regimes limit the eligibility criteria further to a specific field of research, such as clean technology, or a particular kind of expenditure, such as researcher salaries.

The base also depends on the broad policy design, which may be either: (i) volume-based, or: (ii) incremental. In volume-based schemes, the tax incentive applies to the total amount of eligible R&D undertaken by the firm in the most recent fiscal year. If the scheme is an incremental tax credit, then the incentive applies only to the increase in R&D, if any, above the base amount determined by the policy. The base may be an average of the spending across several previous fiscal years, or it may be a single reference year, but the firm cannot benefit from the scheme unless it demonstrates positive growth between the expenditure in the reference period and the most recent fiscal year.

Volume-based schemes are costlier in terms of the foregone tax revenue, but they prevent firms from modifying their R&D investment strategically each year in an effort to maximize the tax gain. Incremental tax credit schemes induce firms to experiment with stop-and-go strategies, since an increase in the current year R&D expenditure reduces any future benefits to the firm by raising the reference level of R&D on which the increase is rewarded. The aim of incremental schemes is to generate a higher additionality impact, but such stop-and-go strategies may diminish the additionality effect

4 The scheme is called “Scientific Research Allowance”.
5 The term “tax credit” used here is comprehensive of other tax incentives listed earlier.
6 OECD (2002).
and impose a higher administrative burden on both the tax authority and the firms themselves.

R&D tax incentive schemes impose *an administrative burden* on all applicants (although to a lesser extent than direct subsidies), but SMEs suffer the most from the procedural requirements. The extent of red tape varies significantly across countries but, in general, tax authorities require considerable paperwork from applicants for the tax incentive schemes. The main obstacle in this context is the cost to firms of filing an application, which usually involves hiring a consultant and requires time and effort of the managers or employees to which the task is delegated. This is especially burdensome for SMEs since they are financially constrained and may not be able to afford to pay consultants. Some of the ways in which countries have addressed these issues are discussed in Section 4.

Tax breaks may be more generous for SMEs, but not always. This depends on the government’s aim in introducing the tax break, that is, whether to increase the number of firms engaged in R&D or to increase the overall volume of R&D performed by firms already in the market. Since startups and younger firms usually need time to achieve their break-even point and switch to a profit-making position, policymakers may find it more beneficial to support such firms via direct grants while providing tax incentives to large-scale R&D performers. As mentioned above, there are ways to provide tax breaks to loss-making firms, and some governments use a mix of these means as well as direct subsidies to support R&D activities of SMEs.

What is the best policy design for the tax treatment of R&D?

Given the rich variety of tools, such as tax credits, enhanced deductions, and depreciation allowances under volume-based or incremental regimes, no single mechanism has proven to be the best. Experience has shown that a clear and simple design helps to increase the take-up rate, which is essential to achieve the intended outcomes of the policy. In 2006, the European Commission issued some guiding principles for the design of R&D tax breaks, which emphasized transparency and ease of access by a broad range of firms to maximize take-up and hence increase overall R&D and innovation activity. Lower administrative and compliance costs are components of a simple design, which is especially important in enabling SMEs and startups to benefit from these schemes.

### 3. MEASUREMENT AND EVALUATION OF TAX INCENTIVES

In an effort to measure the economic effects of R&D tax incentives, researchers and tax authorities have looked at a wide variety of metrics, ranging from cost measures based on foregone tax revenues to indicators of the economic benefits to society, using economic theory and econometric techniques to test the theory. Due to the cross-country heterogeneity of tax incentives, harmonizing these metrics and measuring the generosity of schemes across countries at a given point in time have been difficult. Many countries have been changing their R&D tax incentive structures frequently, rendering the task of making comparisons within a given country over time even more challenging. Over the years, methods have been developed to tackle these measurement issues.

In addition to cross-country heterogeneities, the greatest difficulty in policy evaluation is that the counterfactual outcome is never observed. Once the policy is in place, the evaluator does not know how much R&D would have been performed by firms in the absence of the policy, and when there is no tax incentive, it cannot be known how much R&D would be generated additionally because of the policy. This is a common policy evaluation problem, but there are further complications in the context of corporate taxation: randomized trials, which can be conducted in fields related to social policy, cannot be undertaken for tax policy. Such an experiment would introduce unfair competition to the treatment group, and with the control group at a disadvantage, the true impact could not be identified.

---

Measurement in Terms of ‘Foregone Tax Revenue’

Perhaps the most obvious of the methods available for comparison and the one most relevant to tax authorities is the amount of foregone tax revenues due to fiscal incentives for R&D. As an example, Box 1 presents the cost of the United Kingdom’s R&D Tax Relief to the tax authority.

The OECD presents cross-country comparisons of foregone tax revenues in its MSTI indicators both as a share of GDP to enable a fair comparison across countries and in constant prices to observe trends over time. Figure 2 shows the change in the real cost to the tax authority of implementing the tax incentive scheme between 2004 and 2008.
and 2008. Many governments have been increasing the amount of tax credits, provided by changing the structure of the scheme (from incremental to volume, as in the example of France), endeavoring to reduce red tape through simplification of paperwork and procedures, or introducing a new tax incentive scheme. OECD data in Figure 2 show this real increase in the amount of R&D support provided through some form of tax incentive mechanism in several countries.

The OECD’s STI Scoreboard (2011) provides a ranking of countries in terms of the volume of indirect and direct incentives as a share of their GDP, and in absolute real volumes of foregone tax revenues as a result of fiscal incentives. Since these figures relate to 2008–09 as the latest observation, the very recent trends of even more generous tax incentives are not fully reflected in Figure 3.

**The B-index Measure**

Another commonly used comparison tool to measure the relative generosity of different regimes is the

"B-index" formulated by McFetridge and Warda (1983) which calculates the “minimum present value of before-tax income necessary to pay the cost of R&D and to pay the corporate income taxes, so that it becomes profitable for the firm to conduct R&D (Warda, 2005, p. 5).” One may adapt the main formula to account for the different tax treatment regimes for R&D. Formulations of the B-index for different kinds of depreciation allowances and other tax incentive structures can be found in the OECD STI Review No. 27 (2001). Users should note that the B-index model assumes away tax exhaustion and caps on the use of the incentives and it does not offer a full structural explanation of the relationship between the firm’s R&D expenditure and the cost of R&D to the firm.

Annex I presents a cross-country comparison of tax incentive schemes according to a B-index ranking.

**Structural Models**

Economic theory is frequently used to provide a basis for the econometric study of the impact of policies. The general class of models that are based on the theoretical ‘structure’ are called structural models. They aim to measure the impact of the policy on the beneficiary through the beneficiary’s lens by modeling their optimization problem. In the case of R&D tax credits, the aim is to measure the impact of the policy on the firm’s optimization problem (profit or value maximization) and estimate how the firm adjusts its R&D expenditure in response to the tax credit.

8 In terms of notation, this corresponds to: $B = \frac{1-\frac{A}{1-t}}{1-\frac{A}{1-t}}$, where $A$ represents the proxy for the tax credit rate (including any depreciation allowances and other incentives) and $t$ is the statutory corporate income tax rate. The calculation of $A$ here depends on both the tax credit rate and the structure of the scheme.
Structural models of R&D tax credits are inspired by the literature on tax policy and investment behavior, which is based on the optimal capital allocation framework of Jorgenson (1963) and developed by Hall and Jorgenson (Hall & Jorgenson, 1967). This model proposes that firms choose the level of capital which equates marginal product of capital to its “user cost”, which is the cost of using one unit of capital for the firm. This literature is based on the accumulation of physical capital, but the same ideas can be used to quantify the effects of tax on R&D capital (Griliches, 1979).

The user cost of R&D capital is a function of the tax rate and the tax credit rates faced by the firm, as well as the relative price of R&D, the firm’s discount rate, the interest rate, and the depreciation rate. In this setup, the tax credit rate affects the user cost negatively, with more generous tax credits inducing a decrease in the user cost of capital.

In evaluating R&D tax breaks, structural models associate the tax incentives with the user cost of R&D capital, and then the user cost with R&D intensity at the firm level, sub-national level, or country level. The exact form of the estimation equation depends on the model’s assumptions, but in general terms, the user cost of R&D enters as an independent variable, along with a host of firm/state/country controls, and R&D intensity is the dependent variable, which may be measured by R&D as a share of output or some other scaling factor. Long-run effects can also be traced if the model includes a lagged dependent variable.

The literature generally finds a significant positive association between the introduction or generosity of tax credits and R&D intensity. A common finding of structural estimation studies is the negative and significant user cost coefficient, with the magnitudes varying considerably. Mairesse and Mulkay (2011) present a structural model to estimate the effect of the then-incremental French R&D tax credit system. Using firm-level data over the period 2000–07, they find a price elasticity of −0.4, indicating that a 1 percent reduction in user cost induces a 0.4 percent rise in the accumulation of R&D capital. Another example of a structural estimation study is that of Lokshin and Mohnen (2012) on the tax incentive scheme in place in the Netherlands, which finds a short-run elasticity of −0.4 and a long-run elasticity of −0.8 in their firm-level study covering the period 1996–2004. The cross-country study conducted by Bloom, Griffith, and van Reenen (2002) finds a long-run elasticity of negative unity.

The literature also finds long adjustment periods before the effect of the subsidy on R&D investments kicks in; hence, the expected increase in R&D is generally observed with some lag. This is mainly because R&D investment requires specialized training of new and existing personnel, installation of new equipment and learning how to use it, and adaptation issues. In short, an adjustment period is required to increase the firm’s R&D capacity. The study by Mairesse and Mulkay (2011) simulates the effects of the change in the regime in France from an incremental tax credit10 to a fully volume-based one in 2008. According to their model, the increase in R&D as a result of the reform kicks in around the fifth year after its implementation, then it gradually reaches its long-run equilibrium level, which is higher than the starting value in 2008. Many studies find that the new long-run equilibrium is reached in 10–15 years after the launch of the tax incentive scheme.

Other Evaluation Methods
Well-known policy impact evaluation methods can be used and, if needed, adapted to the R&D tax credit context. Randomized trials are not possible due to discrimination and competition concerns, but quasi-experimental designs can be used where policy discontinuities exist. In the literature, difference-in-differences, propensity score matching methods, propensity score matching methods,

---

9 The economic depreciation rate depends on the assets being included in the user cost. As an example, in Bloom et al. (2002), these are taken as 30% for current expenses, 3.61% for buildings and 12.64% for plant and machinery.

10 The tax credit scheme in France had a small volume-based component until 2008, but this share was very small and the switch to the fully volume-based scheme in 2008 increased the generosity of the French scheme to a large extent.
and other regression discontinuity designs have been utilized to measure the effects of R&D policy.

Studies that use other methods than structural estimation, such as surveys and regression discontinuity designs, generally agree with the positive and significant effects of fiscal incentives for R&D and innovative activity. A recent study by Czarnitzki, Hanel, and Rosa (2011) using nonparametric matching methods looks at the Canadian R&D tax credit system. The study finds that the policy has been useful in generating, on average, additional outputs, and an increased share of new and improved products in their overall sales. Haegeland and Moen (2007) use difference-in-differences to calculate the total additional R&D stimulated by the Norwegian tax credit. They make use of the discontinuity at the 4 million krone tax credit cap and identify the firms that are above this threshold as the control group. They find that the firms which benefited from the credit experienced stronger growth in their R&D expenditures.

In quasi-experimental evaluation studies, researchers and policymakers should pay attention to endogeneity concerns to avoid overestimating the effects of the policy. In such studies, the treatment and control groups are selected based on how the policy determines which firms are eligible for the tax credits. The selection into treatment may well be endogenous to the outcome variable. For example, if the researcher categorizes the firms that use tax credits as the treatment group and those that do not as the control group, then the more productive firms may be better able to complete the necessary paperwork and prove to tax authority that their R&D expenditures qualify for the tax credits. Methods are available in the econometric literature to address such issues.

“Bang-for-the-buck” (BFTB) multipliers are used to measure the additional R&D generated per dollar of foregone tax revenue (and other costs where applicable). This multiplier is calculated by dividing the total additional R&D expenditure that is generated thanks to the tax credit by the total amount of the tax credit used by the firm. This metric can be calculated after the estimation of the additionality effect. The estimation can be carried out using any method outlined above, and then the estimate can be divided by the amount of foregone tax revenue for the tax authority.

In his study of the French R&D tax credit, Duguet (2012) uses the information on whether or not firms have ever benefited from the tax credit to identify the treatment and control groups. In the paper, he uses least squares and propensity score matching methods to trace the variation in R&D across firms that benefit from the tax credit and those that do not. He finds that a Euro of tax credit generates a little more than a Euro of R&D, and also increases the number of researchers.

**Caveats**

Some studies suggest that the positive effect of tax breaks on R&D is merely a result of relocation of R&D into the jurisdiction where tax breaks are available. Wilson (2009) examines the R&D flows between states in the United States as a result of the variation in state-level R&D tax credits. He finds that a 1 percent reduction in in-state user cost induces a 2.5 percent rise in in-state R&D spending in the long run. He finds the opposite effect for R&D leaving the state due to a reduction in the out-of-state user cost. When the out-of-state user cost is reduced by 1 percent (as other states introduce tax credits), R&D undertaken within the state decreases by about 2.5 percent, suggesting no aggregate benefit.

Another caveat is the relabeling of ordinary expenses as R&D, which is ignored by many studies, leading to an inflated positive effect of the fiscal incentive. After the implementation of a tax incentive regime, some firms have the capacity to mimic a large portion of their usual expenditures as qualified R&D in order to benefit from the scheme. Some studies on the United States observe an increase in “qualifying R&D” for the tax break, but none in other R&D, which seems to support the “relabeling” argument (Hall & van Reenen, 2000). Better administration and monitoring through R&D units coupled with fines for any deliberate relabeling have been useful (US GAO, 2009).
The increase in expenditures may point to a rise in the salaries of researchers rather than the employment of more researchers or more vibrant R&D activity. Goolsbee (1998) argues that the increased R&D spending generated as a result of tax incentive schemes mostly goes to current expenses, specifically to researchers’ salaries. This is because the supply of scientific and technical personnel and engineers is highly inelastic. Goolsbee then suggests that in the existing literature, the overestimation of the benefits of tax incentive schemes in the form of higher R&D investments is in the range of 30–50 percent.

4. RECENT INTERNATIONAL TRENDS
Countries have recently been moving toward simpler designs, with a tendency to implement volume-based schemes that are easier to administer. Over the years, it has been observed that incremental schemes cause firms to act strategically to maximize the use of tax incentives, which created an additional social cost. The current trend toward simpler, more volume-based schemes translates to higher take-up ratios by firms, which also means larger impact. The trend towards simpler mechanisms demonstrate countries’ understanding of the fact that the success of R&D tax credits relies on an efficient design, with complexity and red tape reduced to the lowest possible degree.

Tax breaks for R&D appear to be easier to administer than direct subsidies for R&D, as the latter require the government to spend a large amount of resources on identifying and monitoring the most beneficial projects. Regardless of the relative ease of administration, with tax incentives the tax authorities still have the task of correctly identifying which expenditures qualify for the tax credits and which do not. This imposes a burden on the tax authority, which is usually inexperienced in the field of R&D and innovation. Box 2 presents some of the ways developed by the more established schemes to alleviate the administrative difficulties associated with R&D tax breaks.

Economic policy packages during the recent global financial crisis put considerable emphasis on supporting innovative activity. Tax breaks have been used to boost growth through innovation in the wake of the global recession. Many countries increased the generosity of their R&D tax incentive schemes starting in 2008. The United Kingdom, for instance, increased the enhanced deduction rate available for SMEs from 150 to 175 percent in 2008, then to 200 percent in 2011 and to 225 percent in 2012. In addition to introducing a new tax incentive for 2008–2012, Japan loosened the carryforward provisions from one year to three years in the 2009–2010 accounting period, then reduced it back down to two years in the accounting period that followed (2010–2011).

The number of countries implementing tax incentives has been rising, but the policy mix is varied, with many countries using a combination of tax credits or...
deductions for current expenditures and depreciation allowances for capital goods. The number of OECD countries that implement an R&D tax incentive scheme has risen from 18 in 2004 to 26 in 2011. These consist mostly of volume-based schemes involving some form of enhanced deduction or tax credit (OECD, 2011). Now the question is how these governments intend to evaluate and adapt the policy to better meet the needs of society.

Patent box policies, which offer very low corporate tax rates on profits arising from patents registered in a given country, have begun to be used in some countries, including Belgium, Luxembourg, the Netherlands, Spain, and the United Kingdom. The main purpose of these policies is to attract intellectual property and broaden the tax base while encouraging innovative activity and licensing. The benefits and costs of such policies to the host countries are yet to be studied, and researchers have not yet been able to find a significant potential increase in tax revenues or any growth effects through innovation (Griffith, Miller, & O’Connell, 2010) as a result of patent boxes.

5. QUESTIONS TO ASK WHEN ASSESSING TAX INCENTIVE SCHEMES

Availability of data on R&D and innovation:
Evaluating tax incentive schemes for R&D requires data on innovation and R&D, which is usually scarce at the firm level. Moreover, the analysis of the incentives is more accurate when there is information on both pre- and post-intervention outcomes, which requires data collection prior to policy implementation. Data availability on an outcome measure for R&D or innovation is important for evaluation, whether at the firm, sub-national, or national level. Depending on the availability of data, the evaluator should examine the effect of policy on both R&D inputs and R&D outputs. R&D inputs include the intensity of R&D investment by the firm (as a share of output), the number of R&D personnel, and the accumulation of R&D capital. Examples of R&D outputs are an increase in intellectual property ownership, the number of new products, sales of new products, and originality of innovation.11

Survey data on R&D and innovation are more easily and reliably available for larger firms, while administrative data are not always easily accessible, especially in developing countries. SMEs are more financially constrained and are more likely to benefit from these schemes, but it is difficult to find SMEs that formally undertake R&D activities (usually SMEs do not have to report R&D in their annual accounts) or to detect innovative activity by SMEs, which is often informal. Such activity by SMEs usually comes in the form of incremental innovations and adjustments to existing products and processes. Innovation data, such as the Community Innovation Surveys undertaken in the EU Member States and candidate countries, help in identifying this type of activity.

For the evaluator, it would help to observe the recipients of the R&D tax incentive, but these data are usually either unavailable or the tax authority may not be willing to allow the data to be matched with firm characteristics due to confidentiality concerns. Ideally, information would be available on recipients in cases where take-up rates are low, or in order to undertake an assessment using matching techniques or policy experiment-type analyses involving beneficiaries and non-beneficiaries of the policy. If there is a size threshold or a cap on the amount of benefits that can be used, the assessor might exploit such discontinuities in the design of the scheme to make comparisons of the outcome measures between beneficiaries and non-beneficiaries around the threshold. Many of the evaluation techniques outlined here do not rely on knowing which firms benefited from the tax incentive. Under certain assumptions, cost-minimizing firms are expected to make full use of an incentive mechanism that is offered to them, if the true costs of the policy (including, for example, the administrative burden) do not exceed the benefits.

Red tape associated with access to tax incentives:
In many cases, simplification of access procedures generates higher returns than increasing the generosity of the scheme. Cumbersome paperwork or a narrow definition of eligible expenditures usually causes

11 as in Czarnitzki et al. (2011)
difficulties for smaller firms and requires them to hire expensive consultancy services in order to be able to take advantage of the schemes. In these regimes, take-up rates are severely affected, as administrative procedures increase the costs of the scheme beyond the value of any benefit that could be derived from it. The assessor may find it useful to undertake a step-by-step analysis of the procedures for accessing R&D tax breaks and make comparisons across regimes in order to be able to comment on the relative bureaucratic burden of the scheme.

**Do targeted policies hinder competition?** In practice, this aspect is difficult to quantify. An analysis should be conducted to assess whether the policy benefits certain groups of companies more than others. This may be the case if, for example, a size threshold is an eligibility criterion for the tax credit. If SMEs are at an advantage, policymakers should ask whether this places firms that are slightly above the size threshold at an unfair competitive disadvantage. The EU tries to eliminate discriminatory policies through its state aid regulations. It is important to note that these policies are usually targeted to certain groups of firms from which governments expect to generate high social returns, in which case such discrimination may be justified.

**What are the difficulties in quantifying the impact?** In many countries, reliable and consistent data collection for R&D-performing firms starts only after the tax breaks have been implemented, and in some countries, no data are collected. Data availability for policy evaluation is therefore especially limited for the pre-treatment periods. Another obstacle is the long adjustment period associated with R&D investments in response to the change in policy, which makes it difficult to reliably evaluate the short-run effects of tax incentives on R&D intensity. These problems can be resolved by collecting good pre-treatment data on R&D-performing firms.

**Governments should be encouraged to collect good and reliable data on R&D and on firms that benefit from tax incentives.** Making administrative data available for research is an important step in paving the way for a better assessment of the schemes currently in effect. Despite the 30-year history of R&D tax credit evaluation studies, the literature does not report consistent results, which makes the task of policymakers more complex. At times, studies of the same scheme for the same time period yield different results only because they use different datasets. This is mainly due to the paucity of good data on eligible R&D, which dates back a sufficient number of years and uses a large enough sample size to study the effects. Given the current data and research, publication bias in existing evaluation studies is also cause for concern.

### 6. CONCLUSION

Around the world, an increasing number of countries have been implementing R&D tax incentive schemes, and new instruments have been formulated to support not only innovation input, which is R&D expenditure, but also R&D output, such as patents and sales of innovation. The impact of the policy has yet to be evaluated in many of the countries that have recently implemented tax incentives, but the policy is gaining in popularity internationally. This paper outlined the rationale, main aspects, and evaluation methods of R&D tax incentive schemes that are implemented globally, with a view to informing policy making and designing systematic evaluations of the policy.

There are different tax instruments available to policymakers. The design of the schemes can be volume-based or incremental. There is no single best design, but the discussion in the paper reveals that the simpler designs increase overall welfare by alleviating the administrative burden on the tax authority.

Among the questions that are asked when implementing R&D tax incentive schemes, administrative issues by the tax authorities arise most frequently, as most tax authorities have no expertise in R&D, and knowing which expenses to classify as R&D is challenging. In countries that have been implementing R&D tax incentives for a long time and where tax authorities had been burdened by this task in the past, specialized units have been set up to build expertise in R&D. The accumulation of knowledge in the field has
also helped reduce the amount of red tape faced by the beneficiaries.

Regarding evaluation, there are established methodologies that can be used to assess the impact of existing R&D tax incentive schemes. Building on the results of these studies, policymakers can modify the policy design by iterative learning. However, evaluators and policymakers should be aware of the drawbacks of each methodology so as not to overstate the additionality effects.

Studies that have evaluated tax incentives for R&D usually find positive and significant effects of the policies in stimulating R&D and innovative outputs. The finding is not without caveats: evaluators need to be careful to avoid tracking increased salaries for researchers or R&D that merely moves from one state to another with sub-national schemes. Studies that find positive effects are usually conducted on the older and more established schemes in developed countries that collect data of acceptable quality on R&D and innovation. In addition, these countries have developed specialized units to monitor and support the administration of R&D tax breaks over the years, lowering the risk of detecting the relabeling of ordinary expenses as R&D. Recently, there has been a global trend toward implementing tax incentive schemes, but these schemes need to be carefully monitored and evaluated. It will be important for tax authorities to establish mechanisms to systematically monitor the success of the policies, using objective benchmark indicators and adjusting the policies through iterative learning when changes are warranted.

7. ADDITIONAL INFORMATION

Data Sources

- International macro data on business expenditures in R&D (BERD) is compiled by the OECD Structural Analysis (STAN) Database, and other relevant information on government financing of R&D can be found in the OECD Main Science and Technology Indicators (MSTI).
- The ERAWATCH database, prepared and published by the Institute for Prospective Technological Studies (IPTS) under the European Commission’s Joint Research Center (JRC), collects information on the research and innovation policies of 48 countries.
- Tax databases are compiled by the European Commission, OECD, and tax policy research institutes (mostly based in universities or established as independent think tanks).
- Firm-level data collected by national statistics institutes following the Frascati Manual, (OECD, 2002) can be analyzed in countries where researchers are allowed to work with the microdata.
- Studies on EU Member States and candidate countries can make use of the Community Innovation Surveys and European Patent Office (EPO) data on innovation outputs at the firm level.
- The World Bank’s World Development Indicators compiles a host of indicators on science and technology, while Enterprise Surveys offer publicly available firm-level data.
- Reports are prepared by tax consultants such as Deloitte, KPMG, PriceWaterhouseCoopers, and other individual consultants.

Useful References for Practitioners:

A good literature review by Hall and van Reenen was published in 2000, before many evaluation studies were available and prior to the rapid increase in tax incentives for R&D, which took place in the subsequent decade. More recently, lentile and Mairesse (2009) provide a more policy-oriented discussion of R&D tax breaks and evaluation studies that can be beneficial for practitioners.

Tax policy research centers attached to academic institutions, such as the Office of Tax Policy Research at the University of Michigan and the University of Oxford Centre for Business Taxation, and think tanks, such as the Institute for Fiscal Studies based in London or the Tax Policy Center of the Brookings Institution, offer data and a wide range of research papers on tax-related topics, including the tax treatment of R&D.
ANNEX II: USER COST OF R&D CAPITAL

The exact formulation of the user cost variable depends on the assumptions of the model, but an example may help in demonstrating the basic idea: Bloom et al. (2002) formulate the user cost of R&D as

\[ 1 - (AC + AD) / r + \delta \]

where \( AC \) represents the net present value of the tax credit and \( AD \) represents the net present value of depreciation allowances. Understandably, this formula will be different for different types of assets, and the authors differentiate between current expenditures in R&D, machinery and equipment, and buildings. The authors take a weighted average of these different user cost calculations for each asset to arrive at the final user cost variable. Note that \( AC \) is calculated differently for volume-based, incremental credits, enhanced deductions, and depreciation allowances should also be accounted for in this calculation.

France, followed by Croatia and then Spain, seem to offer the most generous tax systems for R&D, according to a ranking based on B-indices (Figure 4). Countries with a B-index of unity are at the rightmost section of the scale. A B-index of unity may translate to a 100 percent immediate deduction of R&D expenses and no special incentives. Examples are Sweden, Germany, Israel, and Chile. The World Bank (2012) provides a detailed discussion of the B-index comparisons across countries as a snapshot in 2009, based on the most recent data available.

---

**ANNEX I: B-INDEX**

It is possible to incorporate the different types of schemes, such as tax credits, enhanced deductions, or depreciation allowances, in the B-index formulation. For example, to account for a non-taxable volume-based tax credit in the B-index, the numerator is calculated as \( 1 - (\tau + \alpha) \) where \( \alpha \) is the tax credit rate, whereas a taxable tax credit would render the numerator to be calculated as \( 1 - (\tau + \alpha - \tau\alpha) \). For an enhanced deduction at rate \( \gamma \), \( A = \tau\gamma \) can be used (supposing that firms can deduct 125 percent of their R&D expenditures, then \( \gamma = 1.2 \)). Depreciation allowances should also be accounted for in this calculation.

France, followed by Croatia and then Spain, seem to offer the most generous tax systems for R&D, according to a ranking based on B-indices (Figure 4). Countries with a B-index of unity are at the rightmost section of the scale. A B-index of unity may translate to a 100 percent immediate deduction of R&D expenses and no special incentives. Examples are Sweden, Germany, Israel, and Chile. The World Bank (2012) provides a detailed discussion of the B-index comparisons across countries as a snapshot in 2009, based on the most recent data available.

---

12 For an incremental scheme, the calculation is based on the assumption that R&D expenditures will be constant in real terms. Taking the base as the previous year expenditure, OECD (Warda, 2001, p. 204) provides the explanation as follows: “tax credits based on increases in nominal R&D spending over the previous period […] represents the tax saving resulting from investing one dollar in R&D in year \( m \) less the present value of the tax saving foregone over the next \( n \) years as a consequence of investing in year \( m \).” For a non-taxable incremental tax credit, the B-index is calculated as:

\[ \frac{1}{1-(1+r)^{-n}} \]

where \( c \) is the credit rate, and \( r \) the discount rate.
FIGURE 5 Change in the User Cost of R&D in the United Kingdom Over Time

Source: Bond & Guceri, 2012.

For example, the introduction of the United Kingdom’s large-firm R&D tax credit in 2002 prompted a substantial decline in the user cost, as depicted in Figure 5. In addition to the introduction of a tax credit or generous depreciation allowances, a reduction in tax rates or a rise in the relative price of R&D may also induce a drop in the user cost. The non-tax incentive-related changes in the United Kingdom can be observed in Figure 5 through the fluctuations in other years than the launch of the tax credit (2000 and 2002).

BIBLIOGRAPHY


