Expert Group on R&D Tax Incentives Evaluation

Comparing Practices in R&D Tax Incentives Evaluation

Final Report

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Executive Summary

The Expert Group on R&D Tax Incentives Evaluation was established to suggest ways of improving the evaluation of R&D tax incentives in practice, and to help increase coherence among the evaluation methods used by European Union member countries. To do this the Expert Group reviewed recent evaluations, and wrote a series of discussion papers with an aim of identifying good practices. The main recommendations of the group are summarised below.

The decision to evaluate is too often based on an ex-post policy need and too rarely on an upfront commitment. Having an upfront commitment to evaluate provides an opportunity to think about evaluation requirements ex-ante, and in particular to ensure that the necessary data are collected.

An example of committing to evaluate ex-ante is Norway. The government decided that the evaluation would be carried out in tandem with the introduction of the tax incentives. Most evaluations, however, are carried out ex-post spurred by a policy need to evaluate. An example is Canada’s 2007 evaluation, which initiated stakeholder consultations on the federal Scientific Research and Experimental Development (SR&ED) tax incentive program.

The data available for an evaluation will influence significantly the methods used, the quality and relevance of the results, and the timing of the evaluation, which has implications for the extent to which the evaluation feeds directly into policy.

To illustrate, in order to carry out a before-after study of the impact of the introduction of an R&D tax credit, longitudinal data including the period before the start of the policy are crucial. The availability of a long time series of administrative data versus a single cross section of survey data will affect the empirical methods that can be used. In order to look at impacts on innovation and productivity, the data will need to include wider range of information.

The UK carried out a feasibility study into whether an econometric analysis was possible using existing administrative databases. A survey was also was conducted in 2005 to gauge the extent to which the tax credits were used and issues involved in take-up. Countries such as France, Norway and the Netherlands have used administrative data extensively in evaluation. The Netherlands and Norway were able to include an assessment of the impact of tax incentives on firms’ innovative behaviour.

Assessing R&D additionality is an essential component of an evaluation. Innovation additionality, and productivity and economic growth additionality are conditional on the tax incentive generating additional R&D.

Investigating additionality, (how many units of additional R&D expenditure are generated by one unit of the tax subsidy) is common to all evaluations. But the precise calculations of cost-effectiveness are not always comparable. This is an area where greater coherence is possible, but comprehensive information will be needed as part of an evaluation on the magnitude of both the benefits and costs.

Structural econometric approaches are an effective methodology for estimating R&D additionality. They can be usefully complemented by quasi-experimental approaches and other more descriptive econometric exercises, and by survey evidence.

In practice structural methods are not straightforward to implement and have some limitations. They may not for example, be able to address all policy questions such as predicting the future effectiveness of a dramatic R&D tax incentive policy reform. The extent to which a country has experienced policy changes may also influence the evaluation techniques used, for example, whether quasi-experimental methods can be used to exploit policy reforms to identify the impact of R&D tax incentives on R&D expenditure.

Linking evaluation criteria to the specific aims of the policy is important. Evaluations of specific elements of an R&D tax credit can be useful in this context.

For example, the Norwegian evaluation looked at a range of outcomes including the impact of the policy on firms' decisions to start conducting R&D and to start conducting R&D with universities, in addition to considering additionality. If, as in France, an aim is to attract internationally mobile R&D then this should be included in the evaluation.

Assessing the precise magnitude of R&D spillovers and welfare gains, although it should be ideally part of all general evaluations, is much too difficult and uncertain in practice to be used to inform specific policy recommendations.

The presence of R&D spillovers, (the external rate of return to R&D through which knowledge generated from the research and discovery process benefits society), justifies the use of R&D tax incentive schemes. To carry out a full welfare calculation of the effect of R&D tax credits, estimates of the magnitude of spillover benefits would be needed. However, the existing range of estimates is much too wide to provide a basis for targeted policy decisions. The Canadian 2007 evaluation has included estimates of spillovers in a cost-benefit calculation as a useful illustration of this issue. It is also worth noting that the magnitude of spillovers generated by subsidised R&D may differ from those generated by unsubsidised R&D activity.

To conclude, comparability across country evaluations is important for learning about the relative impact of different policy designs. But in practice evaluations have used a range of methods, metrics and data sources, as well as having different objectives. In part this is driven by the policy context in different countries as well as data availability. Not all evaluations will be able to answer all the policy questions.

1. Introduction

Because of the high social rate of return to research and development (R&D), the conviction that R&D contributes to economic growth or the perceived need to do R&D to remain competitive, governments spend a non negligible amount of money to induce firms to invest in R&D. A popular measure is the use of R&D tax incentives, reducing the cost of R&D through the tax system. This policy has the virtue of being neutral, i.e. giving a tax relief to any kind of R&D expenditure (that is covered by the definition of qualifying R&D), although some governments give for instance special credits to environmental R&D or research done in collaboration with universities.

The current decade has witnessed a significant increase in reliance on R&D tax incentives. In this regard, the European Commission and European Union Scientific and Research Committee (CREST) have invested resources to explore in greater detail the issues pertaining to the effective design and application of R&D tax incentives.[1] As R&D tax incentives represent tax revenue forgone or resources that could have been diverted to other activities of state support, there is an increasing need to justify such expenditure among the European states.

The European Commission believes that systematic and consistent evaluation of the impact of R&D tax incentives, both at the firm level and on the economy at large, is crucial for a more effective use of R&D tax incentives. The overarching objective of the European Commission in supporting the comparative evaluation work is to increase coherence among the methodologies used for evaluating the effectiveness of R&D tax incentives in Europe. It is expected that such work would facilitate the comparison of evaluation results and foster mutual policy learning among member states.

About the Expert Group

The Expert Group on R&D Tax Incentives Evaluation was established to address the aforementioned need and through identified good practices seek ways of improving the evaluation of R&D tax incentives in practice.

More specifically, the Expert Group was tasked with critically reviewing recent evaluations in the European Union member countries and abroad with a particular aim of identifying good practices. The group has focused on recent official evaluations.[2]

[1] *Evaluation and Design of R&D Tax Incentives*, Report of the CREST Expert Group on Fiscal Measures, European Commission, March 2006

[2] An official evaluation is an evaluation conducted by the government or on behalf of government by the third party.

Members

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Support

Members of the Expert Group were effectively supported by the team of professionals from EU Directorate General for Research. Richard Cawley, Tiit Jurimae, Fabienne Mollet and David Woolf, made valuable contributions to the work of the group and ensured that the workshop held on October 6, 2008 was a success. At the workshop, Expert Group members received important comments and suggestions on their discussion papers and final report from the discussants Isabel Busom and Benoit Mulkay, and the keynote speakers, Christian Hambro and Jan van den Biesen, as well as from other participants.

Tasks

Through a combination of collective and individual work punctuated by several meetings, the Expert Group was charged with the following three tasks.[3] (See box below.)

Tasks of the expert group on R&D tax incentives evaluation

Task 1: *Review up to 10 existing evaluations of R&D tax incentives worldwide* – including those recently performed in Canada, France, the Netherlands and the United Kingdom; assess the relevance of the methodologies used, identifying where appropriate major gaps and areas for improvement

Task 2: Identify and investigate up to 4 key topics which are not appropriately addressed in existing evaluation methodologies; develop discussion papers on said topics and present them at a seminar to be organised by the Commission

Task 3: Compare the methodologies used with the principles identified in the Commission's "Good practice guidance for the design, implementation and evaluation of R&D tax incentives" (SEC (2006)1515) and the Evaluation Handbook prepared by the CREST OMC Expert Group, and identify additional guidance that should be considered when preparing and performing evaluation.

[3] European Commission, *Terms of Reference for the Expert Group on R&D Tax Incentives Evaluation*, 2007

With regard to Task 1 and Task 3, the Expert Group reviewed twelve official or semi-official evaluations of R&D tax incentive programs in the following countries: Australia (2 evaluations), Canada (2), France (2), Netherlands (3), Norway (1) and the United Kingdom[4] (2). Table 1 describes the evaluations. Within each country the list is organized chronologically starting with the most recent evaluation. Where possible, a website link to the evaluation is provided.

With regard to Task 2, the group prepared four discussion papers on key issues affecting the evaluation of R&D tax incentives which were presented and discussed at the seminar organised by the Commission in October 2008. The final report discusses the findings from all these tasks.

[4] In the United Kingdom an initial survey and separate feasibility study were conducted

Table 1: Summary of evaluations reviewed

Country/evaluation	Description
Australia	
Australia 2007 An official evaluation of: *New Elements of the R&D Tax Concession: Evaluation Report*, The Australian Government, June 2007 http://www.innovation.gov.au/Programsandservices/RDTaxConcession/Pages/RDTaxConcessionNewElementsEvaluationReport.aspx	In 2001, *Backing Australia's Ability* introduced two new elements to the R&D tax concession: an R&D Tax Offset giving small firms in tax loss the option of receiving an early cash payment and a 175% Premium R&D Tax Concession on R&D expenditure above the average of a firm's previous three-year expenditure. A 2005 evaluation of the new elements' first full three years was overseen by government Steering Committee. A trendline analysis was the main methodology. The evaluation found the R&D Offset to be effective in enabling small tax loss firms to access the R&D Tax Concession. Data analysis found an average of 1,000 more firms a year than the trendline, for firms below the Offset caps; with an extra R&D spend of $310 million a year *above* the trendline, averaged over the three years. The pattern of change, ceasing abruptly at the $1 million R&D Offset threshold, appears directly related to the Offset threshold. The Offset (including Offset Premium) cost to Government is an average of $55 million a year according to Australian Tax Office figures. The R&D Premium was also found effective in inducing additional R&D. The increase *above* trendline in 2003–04 for Premium firms was $615 million and for the same year the estimate of the cost to Government above the cost of only the base 125% Concession is $136 million.
Australia 2003 An official evaluation of the standard 125% R&D Tax Concession, *Review of the R&D Tax Concession Program*, Centre for International Economics, Canberra, December 2003 (available in hard copy)	Based on a survey of firms, the independent evaluation found the R&D Tax Concession delivered an inducement rate of between 50 and 90 per cent (i.e. incrementality ratio of less than one per one dollar of subsidy). The evaluation noted that international literature suggests values of spillover effects from R&D to the rest of the economy range from 50 to 150 per cent of the expenditure on R&D. It concluded that the inducement rate, when combined with the typical spillover rates, was relatively effective at achieving its goal. Based on this assumption, the evaluation deemed the R&D Tax Concession to be appropriate and effective.

Canada	
Canada 2007 Second official evaluation: *An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development* (2007), Department of Finance, www.fin.gc.ca (need to request the publication)	The study represents a new practice for official evaluations in Canada – based on partial equilibrium model development and analysis The study relied on literature analysis of the estimates of the user cost of R&D capital, the opportunity cost of raising public funds and administrative and compliance costs - all based on available academic and official government evaluations No new administrative data or new survey data were created or used in arriving at the conclusions. The evaluation found that the federal R&D tax credit creates a net economic gain for the Canadian economy of 11 cents per dollar of subsidy Economic benefits are derived from the spillovers. Hence the size of the spillovers is relevant for the magnitude of gains.
Canada 1997 First official evaluation: *The Federal System of Income Tax Incentives for Scientific Research and Experimental Development: Evaluation Report* (1997), www.fin.gc.ca/toce/1998/resdev_e.html A joint Department of Finance – Revenue Canada evaluation	First evaluation since the program inception in 1985 A comprehensive evaluation of economic performance and administration performance, including incrementality ratios and cost-effectiveness estimates, as well as impact on the behaviour of firms and net welfare gain for Canada (through the static general equilibrium model) Largely survey based evaluation prepared by an independent consulting organization The study found that the federal R&D tax incentive program is cost-effective at 1.38 of additional R&D.
France	
France 2007 An Evaluation of the R&D Tax Credit Impact in France, Emmanuel Duguet (2007)	Evaluation calculates the main performance measure: the growth rate of private funding of R&D: Private funding = R&D Expenditures –Subsidies –R&D tax credit A negative effect means that the tax incentive would replace private funds, a zero effect that tax incentives would add to private funding, and a positive effect that tax credit would increase private funding Study Period: 1993-2003 during which the credit tax is equal to 50% of the increase of R&D over the average of three preceding years A independent evaluation prepared for Ministry of Higher Education and Research

France 2004 *The Effect of the R&D Tax Credit in France: A Panel Data Analysis 1978-2001*, Jacques Mairesse and B. Mulkay (2004)	Evaluation finds the R&D tax credit effective with multiplier effect of 1.8 for firms benefiting from the tax credit; a global effect is 0.9 for all firms In the long-run the credit induces a level of R&D spend between 1.8 to 5 times (within-firm) the cost to government Empirical analysis using panel data An independent evaluation
Netherlands	
Netherlands 2007 Second official evaluation: De Jong, J.P.J. and W.H.J. Verhoeven (2007), *Evaluatie WBSO 2001-2005. Effecten, doelgroepberiek en uitvoering*, Opdracht van het Ministerie van Economische Zaken, DG Innovatie.	Develops the Bang for the Buck (BFTB) measure. BFTB computed as difference in stream of additional R&D and additional costs to the government (but not including wage effects, administration costs, implementation costs, externalities, and opportunity costs) An independent evaluation: consultants, academics (EIM and UNU-MERIT), with a supervisory board composed of academics, civil servants from various government departments and stakeholders.
Netherlands 2005 Evaluation of the 2001 introduced changes in the WBSO: Cornet, M. and B. Vroomen (2005), *Hoe effectief is extra stimulering van speur- en ontwikkelingswerk?* CPB document No. 103.	On January 1, 2001, WBSO has been changed in two ways: higher rates for startups and increase of the first ceiling, i.e. the amount below which the R&D tax credit rate is more generous Comparison between 2000 and 2001 involves two cases: in one case, firms that qualify for starters against those that just missed at least one of the criteria; in the other case, firms that are between the old and the new first ceiling, vs those that just missed it. (more difficult to separate out experimental and control group)
Netherlands 2002 First official evaluation: Brouwer, E., P. den Hertog, T. Poot, and J. Segers (2002), *WBSO nader beschouwd. Onderzoek naar de effectiviteit van de WBSO*, Opdracht van het Ministerie van Economische Zaken, DG Innovatie	Develops a structural model of factor demand based on CES production, including price elasticities and incrementality ratio An independent evaluation - consultants and academics (PricewaterhouseCoopers, Dialogic and TU Delft) – with oversight by supervisory commission
Norway	
Norway 2007 Haegeland, Torbjørn and Jarle Møen, *Input additionality in the Norwegian R&D tax credit scheme*, Statistics	First official evaluation of the SkatteFUNN scheme introduced in 2002. Initially intended for SMEs only, in 2003 SkatteFUNN was extended to large firms with different rates of tax incentives in conformity with EU/EEA state aid rules: 18% tax credits for large firms, 20% for SMEs.

Norway, Report 2007/47 and *Evaluation of the SkatteFUNN Tax Credit to Support R&D: Summary and Proposals*, (translation of chapter 1 of the summary report Å. Cappelen, E. Fjærli, F. Foyn, T. Hægeland, J. Møen, A Raknerud og M. Rybalka, Evaluering av SkatteFUNN, Rapporter 2008/2, Statistics Norway, Oslo) http://www.ssb.no/skattefunn/rapp_200802_en.pdf	Among the most important results of the evaluation are the following: Significant input additionality: extra R&D that SkatteFUNN triggers per NOK in lost tax revenue varies between 1.3 and 2.9, with a point estimate of 2. This means that for every NOK in tax, the R&D activity would double. The estimated input additionality derives mainly from firms that did not invest very much in R&D before SkatteFUNN was introduced. The additionality appears to be strongest in small firms, firms in non-central areas, firms in which the employees have a relatively low level of education and firms in industries that are traditionally not research intensive. Firms that previously invested less than the cap increase their R&D more than firms that previously invested above the cap. Firms that previously did not invest in R&D are more likely to start investing in R&D after SkatteFUNN was introduced.
United Kingdom	
United Kingdom 2006 *Feasibility study for potential econometric assessment of the impact of R&D tax credits on R&D expenditure*, OXERA, 2006, HM Revenue & Customs Research Report 19. This comes in two parts, “Literature review” and “Matching R&D credit data” www.hmrc.gov.uk/research/literature-review.pdf www.hmrc.gov.uk/research/matching- report.pdf www.hmrc.gov.uk/research/non-technical-summary.pdf	Literature review: summary and analysis of empirical approaches to evaluation Assesses the feasibility of matching HMRC data on R&D tax credit claimants into ONS micro BERD data for use in an econometric analysis. An econometric study was considered infeasible at this stage due to data constraints
United Kingdom 2005 *Research and Development Tax Credits: Final Report*, British Market Research Bureau Social Research, 2005, HM Revenue & Customs Research Report 12 www.hmrc.gov.uk/randd/rand-taxcredits- final.pdf Executive summary www.hmrc.gov.uk/randd/rand-taxcredits-summary.pdf	Survey of users and potential users of R&D tax credits. Obtain information on awareness, take -up, claim process, effects etc.

CREST OMC Evaluation Principles

The 2005-06 work of the Other Methods of Coordination (OMC) Working Group performed under the auspices of the European Union Scientific and Technical Research Committee (CREST) served as a point of reference for the Expert Group.

The following principles were identified by the CREST group and recommended to policy makers involved in the design, implementation and evaluation of R&D tax incentives. These are largely drawn from the conclusions presented in the Evaluation Handbook:[5]

- The aims and objectives of R&D tax incentives should be very clearly defined, as a prerequisite to their proper evaluation.
- Evaluation of tax incentives should foremost:
    - Focus on ascertaining the direct additionality of tax incentives, i.e. the degree to which they induce more R&D activities (over and above what would have taken place otherwise) and improve economic performance of beneficiary firms.
    - Estimate behavioural additionality, i.e. the degree to which they induce changes in firms' strategic behaviour and internal decision-making with regards to R&D and innovation.
    - Test whether tax incentives have met their specific objectives and whether their delivery/administration mechanism was efficient.
- The wider societal effects of tax incentives should also be evaluated, but preferably in the broader context of the policy mix supporting investment in research and innovation, i.e. the combination and interaction of the range of policies affecting human resources in S&T; the science base; the performance of business R&D and innovation; and the overall economic and market development in each Member State.
- Tax incentives should be evaluated using a variety of different and complementary methods, aimed not only at estimating their impact but also at estimating their efficiency and administration costs.
- When designing R&D tax incentives, policy makers should already clearly identify which data will be needed for their evaluation, and how to collect these data. Particular attention is drawn to the fact that these data should allow *counterfactual* analysis when estimating direct and behavioural additionality, through the individual or combined use of historical data, data collected during discontinuities in the operation of the tax incentives and comparable data from other countries.

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[5] *Evaluation and design of R&D tax incentives*, Report of the CREST Expert Group on Fiscal Measures, European Commission, Brussels, March 2006. Also see, *Handbook on the Evaluation of R&D tax incentives*, 17 March 2006

- Careful attention should be given to the independence of evaluators and evaluation processes, whose results should be published and used to inform policy improvements.

The principles of an effective evaluation are summarized in the box below.

Summary of CREST OMC Principles

- Clarity of objectives
- Focus on direct additionality
- Consideration of behavioural additionality
- Assessment of macro effects – in the policy mix context
- Inclusion of delivery/administration tests
- Use of different/complementary evaluation tools
- Data identification and collection in advance of evaluation
- Independence of evaluators and evaluation processes

Source: E*valuation and design of R&D tax incentives*, 2006, pp. 12-13

The CREST principles are a yardstick against which the evaluations examined by the Expert Group can be measured. The group also had some leeway in selecting and establishing the criteria to be used in reviewing and comparing evaluations, and identifying good practices.

The group has come to the conclusion that it may not be possible to fit all evaluations into the theoretical framework of "good practices" as recommended by the handbook. This is because the evaluations reviewed are often driven by country-specific approaches. These vary with each country's own experience with tax incentives underpinned by its unique socio-economic needs and values.

General Approach

This report includes relevant background analysis and findings, and formulates concrete options for improving the methodologies and approaches for evaluating R&D tax incentives in Europe. The principal investigative methods employed were:

- Meetings – five meetings of the Expert Group were held to peer review each member's contribution and to design and construct the final report
- Review and comparison of evaluations – country evaluations were reviewed and compared within a common framework. The template used in this final report summarizes the main practices of country evaluations and compares them with CREST principles

- Discussion papers – four papers have been prepared by group members covering outstanding or not adequately addressed issues in evaluation, which could lead to the improvement of evaluation practices
- Seminar on tax incentives evaluation – the seminar was held on October 6, 2008 in Brussels to elicit feedback from the evaluation community on the discussion papers and on the final report.

Structure of the Report

The report covers the main areas of evaluation practices. Section 2 describes how evaluation objectives are formulated and how they affect the scope and content of the evaluation. Section 3 discusses the merits of building good databases for evaluation, and Section 4 describes the scientific methods and approaches applied in evaluations. Section 5 provides some conclusions and Section 6 outlines some directions for future research.

In addition, a template summarizing and comparing the evaluations reviewed against the recommended CREST principles of good practice was developed (see Appendix 1). The set of template tables generally adheres to CREST recommended principles. Also, for reference purposes Appendix 2 presents an overview of R&D tax incentives in evaluator countries.

A set of discussion papers referenced in this report follows in Appendix 3. The papers provide additional background on issues discussed in the main report. They contain technical information, formal model development and examples of practical applications. The four discussion papers are:

1. Jacques Mairesse and Damien Ientile "What can we learn from structural econometric models for the evaluation of R&D tax credit policies? An example and some comments."
2. Pierre Mohnen and Boris Lokshin "What does it take for an R&D tax incentive policy to be effective?"
3. Helen Simpson "Assessing the effect of R&D tax credits on R&D start-up and location decisions"
4. Jacek Warda "Measuring additionality of R&D tax credits: Can evaluation surveys be more effective?"

Finally, an official agenda for the workshop is provided in Appendix 4.

2. Setting Evaluation Objectives and Scope

The primary function of the tax system is to increase in a fair and efficient manner the revenues required to finance spending programs. The tax system also acts as an instrument to help achieve the government's economic and social policy objectives.

Any policy measures, including R&D tax incentives, are reviewed periodically for at least three reasons:

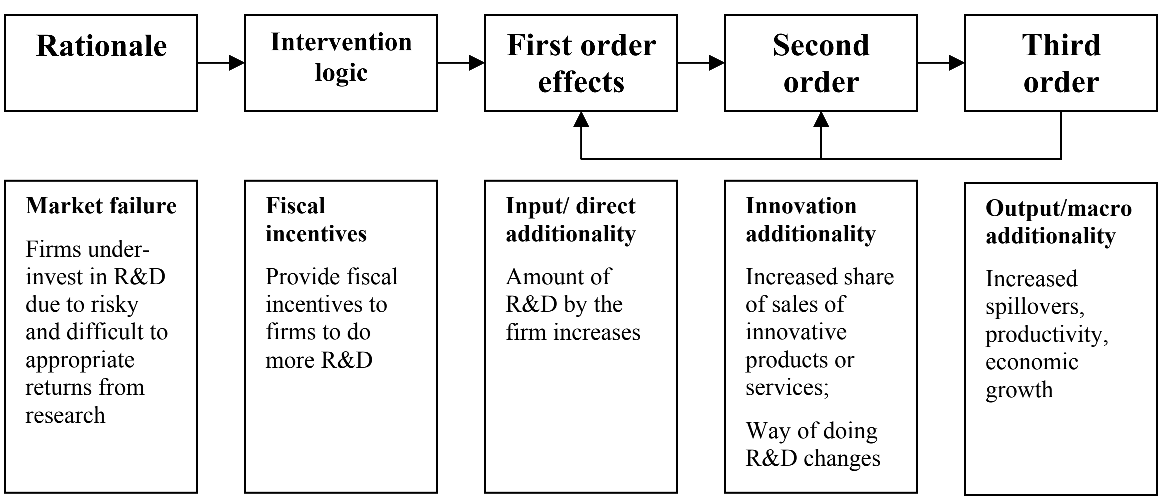
- To confirm that they continue to fill a policy need (relevance)
- To determine if they are achieving their objectives (success or effectiveness)
- To see if their cost-effectiveness, or efficiency, could be improved by changing program parameters or the mode of delivery

These reasons set an overall frame for the objectives of an evaluation of R&D tax incentives. Virtually all evaluations reviewed look into the relevance, effectiveness and efficiency of the tax incentive. The working objectives usually detail how these three issues will be addressed in the evaluation.

An Intervention Framework

Chart 1 presents a framework for analyzing the rationale behind R&D tax credits and the expected effects of the policy intervention. Three types of effects might be expected, of which "first order" and "second order" effects normally happen at the firm level followed by the ultimate "third order" effect to take place at the economy or international level. It has to be noted that the framework is highly stylized and probably depicts more theory than practice, as all these effects can reinforce each other through a feedback loop.

Chart 1: Intervention logic for fiscal R&D incentives



Source: Based on John Clark and Eric Arnold, *Evaluation of Fiscal R&D Incentives*, Report to CREST OMC Panel, Technopolis, September 2005, p.5

The intervention framework serves to identify the scope and content of the evaluation. Based on the Expert Group review, evaluations primarily cover direct (first-order or input) additionality, measuring incrementality and cost effectiveness i.e. they compare incrementality with the cost to government of delivering the tax incentive.

While measuring direct additionality remains the primary focus, evaluations tend to skim through the question of innovation (or behavioural) additionality. And only a few tackle the third order effect of impacts on society by estimating or second-guessing the size of spillovers (Canada 1997 and 2007, Australia 2003).

The methodologies used in evaluations range from econometric models to cost-benefit partial equilibrium models to general equilibrium models, the latter showing the impact of the tax incentive on factor prices and overall welfare of society. The choice is largely dictated by the evaluation objectives which are conditioned by the policy needs in the country. Table 2 summarizes the types of additionality estimates in the evaluations reviewed.

Table 2: Type of additionality calculations in R&D tax incentive evaluations

Country and year of evaluation	Direct additionality	Innovation additionality	Macro additionality
Australia 2007	yes	no	no
Australia 2003	yes	yes	no
Canada 2007	yes	no	yes
Canada 1997	yes	yes	yes
France 2007	yes	no	no
France 2004	yes	no	no
Netherlands 2007	yes	yes	yes
Netherlands 2005	yes	no	no
Netherlands 2002	yes	yes	no
Norway 2007	yes	yes	yes
United Kingdom 2006	no	no	no
United Kingdom 2005	no	yes	no

Source: European Commission, Expert Group on R&D Tax Incentives Evaluation, Brussels, 2008

Common Objectives

The objectives of the evaluations examined typically follow a common pattern. The main objective of R&D tax incentive schemes is generally similar across countries: to generate benefits for society by inducing an increased level of R&D investments, with returns exceeding the costs involved. Thus the detailed objectives of the evaluations are primarily defined as measuring the cost-effectiveness of the tax incentive. Producing a measure of incrementality (or additionality) appears to be an overarching focus of the evaluations, (i.e. calculating the numerator of the cost-effectiveness ratio that can be compared with the cost to government in the denominator). As already mentioned, some evaluations go further to estimate social effects including administrative costs of the scheme to both the firm and government.

Specific Objectives

The CREST OMC report notes that evaluations may have specific objective. This review finds that in several instances this is indeed the case. Additional explicit or implicit objectives include attracting internationally mobile R&D, inducing firms to start conducting R&D, and supporting firms to conduct R&D jointly with universities or other public research institutions. As discussed in discussion paper 3 in Appendix 3, policy makers may want to evaluate the effect of R&D tax credits on all these outcomes.

Examples are evaluations conducted in the Netherlands, Norway and Australia, and feasibility surveys in the United Kingdom. Moreover, in some countries and regions, an analysis of the impact of R&D tax credits on attracting R&D investment into the country or region is becoming increasingly important. For example, the specific objective of the France's 2008 R&D tax credit reform is seen as to attract foreign R&D investments and deter French firms from relocating their R&D to other countries.[6]

[6] Jacques Mairesse and Damien Ientile, *What can we learn from structural econometric models for the evaluation of R&D tax credit policies? An example and some thoughts,* Presentation to Expert Group Seminar on Evaluating RD Tax Incentives, European Commission, Brussels, October 6, 2008

3. Collecting Data for Evaluation

The CREST recommendations in the area of data collection point to pro-active and anticipatory identification of the type of data that will be needed for the evaluation, and how to collect these data. CREST encourages the use of data that will allow for counterfactual analysis. Counterfactual analysis could be performed by looking back into history of the R&D tax scheme and exploiting any policy changes or discontinuities, hence longitudinal data will be important. Before-after analysis can then be used to estimate the incrementality induced by the scheme or measure changes in the innovative performance of the firm, i.e. innovation additionality.

The CREST general principle is that evaluators should, as far as possible, use already available data to avoid any extra burden on companies and to be able to use a long time-series of data at a modest cost. It is suggested that after reviewing the possible data sources, in light of the questions to be evaluated, one should define what data is missing and how it can be remedied.

The main sources of data are national statistical agencies (e.g. Netherlands, France, and Norway) and administrative databases assembled by the operating agency for the tax incentive (e.g. Canada 1997, Australia 2007). For countries that have introduced tax incentives recently (e.g. United Kingdom) there is inevitably a lag before a sufficiently long time series of data becomes available. Alternatively, data may be collected through specialized surveys which have the advantage of providing the most current information on what companies think about the tax incentive (see box below). This information is typically supplemented by information about other factors that may influence the firm's decision to invest in R&D. Survey information augments existing microdata (firm-level) from administrative registers for evaluation purposes, but can be also a sole source of evaluation information (Canada 1997, Australia 2003, United Kingdom).

About the additionality survey

Surveys are probably the most common tool for policy evaluation. Benefits of the survey approach are numerous. Surveys help validate other methods of investigation such as econometric analysis. They make it possible to build relevant microdata and extend the available administrative databases. Surveys are also invaluable in helping to obtain – quickly and directly - contextual information containing respondents' views on the tax incentive scheme, appraisal of administrative complexity or other aspects of policy application.

Their main disadvantages include strategic answering, respondent bias and generally a high cost of design, implementation and analysis. Careful attention to sample design is particularly required. For example, samples that include claimants only may aggravate the selection bias. The question is open whether surveys should include non-claiming firms that do R&D and perhaps also non-R&D doing firms. There is also a trade-off in surveying: too many questions or too many surveys may produce less credible results.[7]

[7] Isabel Busom, Universitat Autonoma de Barcelona, *Comments to Jacek Warda's Measuring Additionality of R&D Tax Credits*, Expert Group Seminar on Evaluating R&D Tax Incentives, European Commission, Brussels, October 6, 2008

Surveys can be designed to diminish the bias by being focused and applying a number of different tests for measuring incrementality. A combination of direct-indirect questions could help to check whether the pattern of answering direct counterfactual 'absence' question corresponds to the pattern of responses to indirect questions. Some indirect questions may help reduce biases if a well thought out list of potential effects is provided. Thus asking more than one question on additionality in the evaluation survey may produce less biased answers. Having a range of additionality estimates can help evaluators to control for the extent of the bias and arrive at a more precise point estimate.

Source: Adapted from Jacek Warda, *Measuring Additionality of R&D Tax Credits Can Evaluation Surveys Be More Effective?* Discussion Paper, Expert Group Seminar on Evaluating RD Tax Incentives, European Commission, Brussels, October 6, 2008. Discussion paper 4, Appendix 3.

The availability of data influences the choice of evaluation methods. However, there are evaluations where statistical micro-data are not needed. The Canada 2007 evaluation, for example, uses a partial equilibrium model that gathers data on various variables such as incrementality ratios and external rates of return (spillovers) from a review of the literature. The Australia 2003 evaluation of the 125 per cent R&D tax concession uses a survey method that explores discontinuities in the scheme over time rather than making use of Australia's statistical databases. The Canada 1997 evaluation also relies on a survey method to derive its cost effectiveness ratio.

On the other hand, the Norway, France and Netherlands' evaluations make extensive use of existing statistical databases. For example, France's 2004 evaluation employs panel data for 1978-2001. The data include firms with more than 20 employees, mainly from manufacturing. Accounting data is matched with R&D survey data. In a similar vein, the Netherlands 2007 evaluation creates a panel of data, for the period 1996-2004 from multiple institutional sources. These include the Central Bureau of Statistics, Community Innovation Surveys, and SenterNovem, an agency that administers the WBSO tax incentive. Finally, Norway has developed a comprehensive evaluation database mainly from the registers of government monitoring agencies. From that database, evaluators were able to identify firms that are present in the R&D surveys and that have reported positive R&D in at least one year prior to the introduction of the SkatteFUNN tax incentive and that have never reported real R&D investments above 40 million NOK. The sample period is 1993 to 2005.

Table 3 summarizes the use of various databases in the evaluations. Administrative registers and statistical information are the most frequently employed and are used mainly in econometric evaluations. Survey databases are less common and usually complement the administrative data. Literature-based data are sometimes used, but this source is generally not well exploited. Similarly for data obtained by direct interviews or focus groups, which typically address a specific issue (e.g., administration and compliance costs.)

Table 3: Data sources used in R&D tax incentive evaluations

Country and year of evaluation	Administrative database	Survey database	Other databases
Australia 2007	yes	no	focus groups
Australia 2003	no	yes	literature
Canada 2007	no	no	literature
Canada 1997	yes	yes	focus groups, interviews
France 2007	yes	no	no
France 2004	yes	no	no
Netherlands 2007	yes	yes	no
Netherlands 2005	yes	no	no
Netherlands 2002	yes	yes	no
Norway 2007	yes	yes	no
United Kingdom 2006	yes	no	no
United Kingdom 2005	yes	yes	no

Source: European Commission, Expert Group on R&D Tax Incentives Evaluation, Brussels, 2008

4. Selecting Methods and Approaches [8]

Relevant questions

Public policies have many effects on society through various channels. The researcher whose objective is to evaluate the R&D tax credit should in principle consider (at least) two related questions, the first at a level of operational efficiency and the second at a level of general economic relevance:

- Does the tax credit effectively stimulate R&D expenditures?
- Does the tax credit increase social welfare?

Input or direct additionality

The first question is largely addressed by calculating input or direct additionality. R&D tax incentives are aimed at making private enterprises spend more on R&D than they receive in tax bonuses. It is what in economics is termed additionality as opposed to crowding out of R&D. If firms simply substitute government tax support for private R&D financing, the policy is clearly ineffective. If firms substitute part of their own funding by government money, there is partial crowding out. If they spend in excess of the amount of tax incentives they receive from the government then the policy is said to lead to additional R&D. A first way to verify the effectiveness of an R&D tax incentive policy is to test for R&D additionality. This can be done in various ways, but amounts to comparing the tax expenditures with the additional amount of R&D spent by private firms.

Comprehensive additionality

The second question refers to comprehensive additionality, where the efficiency criterion is social welfare. Answering this question is much more demanding as analyses must take into account a wider range of criteria for assessing the effectiveness of R&D tax incentives. These consist of analysing innovation output additionality (i.e., innovation or behavioural additionality), and macroeconomic effects (measures of economic performance such as productivity growth, profitability, employment or trade). The methods applicable here would include a general equilibrium analysis and full cost-benefit analysis, including capturing administrative and compliance costs and the costs of raising taxes to fund the policy.

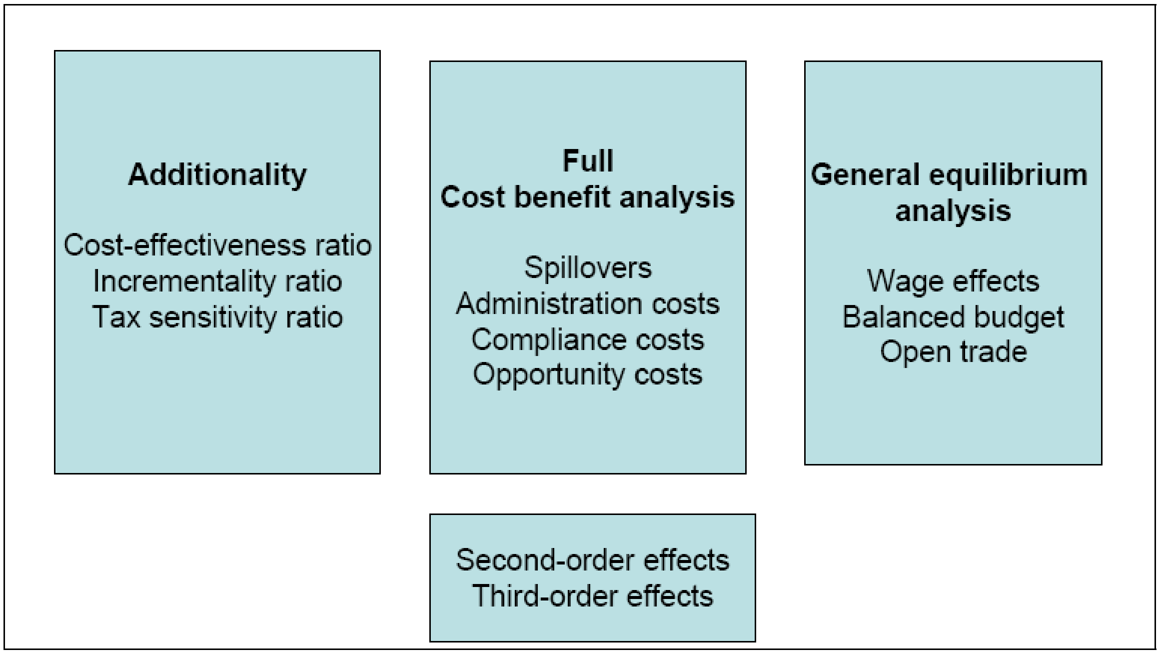
Assessing direct additionality

The objective of the evaluation is to demonstrate and quantify a causal effect (or its absence) between the tax credit and an increase in R&D expenditure. Testing for

[8] This section draws on Discussion papers 1 and 2 in Appendix 3.

additionality generally involves the computation of the "bang for the buck" (BFTB). It is measured by dividing the amount of R&D generated by the R&D tax incentives by the net tax revenue loss (tax expenditures or taxes forgone). The BFTB is also known in the literature as the "incrementality ratio", "cost effectiveness ratio", "inducement rate" or "tax sensitivity ratio" (see, Chart 2).

Chart 2: Reconciling evaluation notions



Source: Pierre Mohnen and Boris Lokshin, *What does it take for an R&D tax incentive policy to be effective?* Presentation to the Expert Group Seminar on Evaluating RD Tax Incentives, European Commission, Brussels, October 6, 2008

There are variations in how these ratios are calculated.[9] Some authors have added up all credits claimed without considering the change in the firms' tax positions because of the tax credit. For instance, in the Netherlands the tax credits proportional to R&D labour costs that can be deducted from the firm's social security contributions are themselves taxable. Other studies have calculated the tax credits claimed taking an average firm and ignoring firm heterogeneity in the type of R&D they do, combined with differences in the rates of R&D tax credits depending on size or the particular type of R&D. Finally, it needs to be noted that, unlike a true cost benefit ratio, an additionality ratio that is greater than one is not sufficient to conclude that the program is worthwhile.[10]

[9] As reported in Hall, B. and J. van Reenen, "How effective are fiscal incentives for R&D? A review of the evidence", *Research Policy*, 29, 449-469

[10] Parsons, M. and N. Phillips, 2007, p.3.

Approaches and methods

There are two broad econometric approaches used to isolate the effect of R&D tax incentives on R&D: the structural modelling approach and the treatment or quasi-experimental econometric evaluation approach. In addition survey-based methods represent a third way to evaluate a policy.[11] While surveys may be designed to reduce respondent bias, there is an overall consensus that econometric techniques represent a more objective way to estimate the extent of additionality.

Structural approach

This relies on the so-called structural econometric model, which involves the conjunction of a theoretical model and a statistical model, both largely based on a priori economic and statistical considerations, as well as on previous accumulated knowledge and practical experience. The approach allows for the evaluation of future tax reforms and of separate short term from long term effects. The approach does not directly estimate the effect of the tax credit on R&D expenditures but involves the two following steps:

- Computation of the impact of the tax credit on the "effective price of R&D" faced by the firm, or more generally on the "user cost of R&D capital" for the firm.
- Specification and estimation of an econometric model, which relates changes in the firm's R&D expenditures or its R&D capital to changes in the R&D effective price or user cost of capital.

The structural approach estimates an R&D demand equation (in terms of stocks or flows, but preferably stocks if there are enough data observations to construct them) on its typical determinants, including the user cost of R&D.[12] It is important to recognise the endogeneity of the tax credit, as it generally depends on the amount of R&D, as firms may for fear of being audited, ignorance or compliance costs decide not to apply for R&D tax credits.[13] Handling this endogeneity calls for good instruments.

It is also important to allow for the fact that any induced R&D may take time to show up because of adjustment costs in R&D (finding scientists and engineers, setting up a lab, devising projects). Therefore a distinction should be made between short-term and long-term effects. Finally, when comparing studies one should be careful not to compare elasticities, with semi-elasticities or absolute derivatives for the price effect on R&D.

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[11] See Discussion paper 4, Appendix 3.

[12] The user cost of R&D would typically include a quantification of the tax incentives via what has come to be known as the B-index. The B-index is defined as the ratio of the net cost of a Euro spent on R&D, after all quantifiable tax incentives have been accounted for, to the net income from one Euro of revenue. In other words, the B-index indicates the marginal income before taxes needed for the marginal R&D investment to break even. See, McFetridge, D.G. and J.P. Warda, *Canadian R&D Incentives: Their Adequacy and Impact*, Canadian Tax Paper No. 70, Canadian Tax Foundation, Toronto, 1983

[13] The latest 2007 evaluation of the R&D tax incentives in the Netherlands reports that for firms with less than 10 employees only one firm out of 3 applies for R&D tax credits. See, de Jong, J.P.J. and W.H.J. Verhoeven (2007), *Evaluatierapport WBSO 2001-2005: Effecten, doelgroepbereik en uitvoering*, Opdracht van het Ministerie van Economische Zaken, DG Innovatie, Den Haag, Netherlands, 2007

Treatment or quasi-experimental methods

Treatment evaluation methods consist of exploiting quasi-experiments in the shape of policy reforms, and constructing counterfactuals. These methods are relatively straightforward to apply but also suffer from weaknesses. They can provide convincing ex-post additionality estimates, but unlike the structural approach they do not allow for the simulation of the impact of changes in the features of the tax credit. Furthermore, they often make no distinction between short term and long term effects.

This approach exploits discontinuities or reforms to the design of R&D tax incentives. A simple application is to use data on firms' R&D activity before and after the initial introduction of an R&D tax incentive scheme, in order to assess whether the introduction of scheme has an impact on their R&D expenditure. However, if all firms are affected in the same way by the introduction of the scheme, (e.g. all firms are eligible and all face the same credit rate), then it is difficult to separately identify the impact of the introduction of the R&D tax credit scheme from a general shock affecting firms' R&D expenditures at the same point in time.

Exploiting variation in the extent to which firms are affected by a policy reform (i.e. using control groups) can help to identify the impact. For example, it may be possible to conduct a difference-in-differences analysis, i.e. compare the growth rate of R&D expenditure from before to after the policy reform, for firms just below and just above an eligibility ceiling. The Norwegian 2007 evaluation is an example.[14] This approach assumes that, conditional on observable characteristics, any difference in the growth rate of R&D between the two groups can be attributed to the R&D tax incentive. It requires accurate data on firms' characteristics and precise information on the tax rules in order to isolate the groups of eligible versus non-eligible firms.

The reason for comparing firms either side of an eligibility ceiling or threshold is that, other than in terms of eligibility they are likely to be very similar, hence the evaluator will be comparing like-with-like. Matching techniques can also be used in a differences-in-differences framework in order to identify a control group, (of non-eligible firms, or firms facing a different credit rate to the main group of interest), that have very similar observable characteristics to the set of eligible firms. One weakness is that there may remain unobservable time-varying differences between the two groups which affect R&D expenditure.

In sum, the difference between intuitive, quasi-experimental approaches and structural models is blurring as the former are growing more accurate (consideration of the dependent variable, and using precise details of the tax credit rules to pin-point groups of firms that are more or less affected) and structural methods are becoming not completely

[14] The ceiling is set at 4 million NOK of R&D intramural expenditures. For details, see Norway's R&D tax treatment profile in Appendix 2 and Haegeland, T. and J. Moen, *Input additionality in the Norwegian R&D tax credit scheme*, Report 2007/47, Statistics Norway 2007

structural.[15] This indicates that there is more of a *continuum* rather than a strict dividing line between the two approaches.

Testing for higher-order additionality

Beyond the induced R&D remains the question whether this additional R&D is efficient in generating innovation output (innovation additionality) and ultimately improves economic performance and net welfare (macro additionality).

Innovation additionality

The second-order effect of the intervention framework – innovation (behavioural) additionality – measures the effect of R&D spending induced by the tax incentive on the innovation performance of the firm. Of the twelve evaluations examined, only six have attempted to inquire about the innovation additionality (see Table 2).

The most consistent in this area are the Netherlands' evaluations – virtually all ask about innovation impacts, using an indicator of the proportion of innovative sales in total turnover of the firm. For example, a 2002 study estimates the sales effect due to a 1 per cent increase in the Dutch R&D tax incentive (WBSO). The short-run result is staggering – a 19 per cent higher share of innovative sales. The 2007 Netherlands' evaluation confirms the positive relationship, estimating that a 1 per cent increase in R&D increases the share of innovative sales by 0.11 percentage points. Also the telephone survey finds that the WBSO leads to more risky R&D, faster implementation and improved planning of R&D.

According to the Norwegian evaluation, the SkatteFUNN tax credit has the strongest impact on the behaviour of firms with no or limited previous R&D activity. The evaluation results show that firms with limited experience of R&D at the start-up of a SkatteFUNN project have changed their innovation behaviour most. Overall, Norway's tax credit scheme has been found to contribute to an increase in the rate of innovation in firms. It helps develop new production processes and to some extent new products for the firm.

The Canada 1997 evaluation also devotes a piece of the survey to innovation additionality. The analysis, supported by statistical regressions, finds no significant impacts on the behaviour of firms in the areas of imitation and competitiveness. The Australian 2003 evaluation (of the standard 125 per cent R&D tax concession) measures, via a mail-out survey, the role of intellectual property rights, the contribution of R&D to future sales and profits and access to capital and finance. Finally, the United Kingdom's R&D survey asks firms about elements of innovation additionality, for example, whether R&D tax credits lead them to undertake more risky R&D projects or longer-term projects, and whether they affect the international location of R&D.

[15] The choice of the dependent variable (level, log-level, difference, rate of growth of R&D expenditures) or the computation method for the explanatory variables, such as the rate of return, are scarcely completely structural.

Overall, it can be argued that, unlike direct additionality, the evaluations of innovation additionality do not have a well identified or coherent and comparable analytical method such as a structural model or cost-benefit analysis. The analysis of innovation additionality is either based on survey responses or *ad hoc* statistical models.

Macro additionality

Macro or output or third-order additionality has been addressed even less frequently than innovation additionality. However, governments are increasingly keen to know the total impact of an intervention on the economy and society. Estimating macro additionality is largely done by including spillovers.

A comprehensive computation of the effectiveness of R&D tax incentives generally requires a *full* cost-benefit analysis that would compute the total (direct and indirect) costs and benefits related to the R&D tax incentive.

On the benefit side, it would mean not just computing the amount of additional R&D but also the return on that R&D. The return on the marginal R&D may be lower since the R&D would not have been undertaken without the tax incentive. That requires looking into the existence of higher-order additionality, i.e. the effects on an economic performance measure like productivity or profitability. A proper social cost-benefit analysis would also require incorporating R&D spillovers, which can be positive (rent or knowledge externalities) or negative (market stealing or obsolescence). Another possibility is that domestic R&D tax incentives could benefit foreign firms and decrease the domestic firms' competitive position or conversely make domestic firms more receptive to international R&D spillovers.

On the cost side of the assessment should be included implementation costs, such as hiring consultants, accountants, financial experts; administration costs such as hiring auditors, tax officers; the existence of wage effects diluting the quantity effects, inter-temporal differences in the timing of costs and benefits, as well as the opportunity costs of alternative uses of the government funds allocated to support R&D (e.g. for enjoyment of the arts, care of the sick, the homeless and the elderly, a lowering of income tax rates, etc.).

The Canada 2007 evaluation presents the various issues to be considered, providing a good illustration of steps involved in full cost-benefit analysis.[16] These include, on the cost side, loss in producer surplus, opportunity cost of raising public funds (marginal excess burden) and, cost of compliance and administration and, on the benefit side, the external return to R&D (spillovers).

This approach shows that high input additionality *per se* is not a must for having an effective R&D tax incentive policy. In the Canada 2007 evaluation for the policy to have

[16] Parsons, M. and N. Phillips, *An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development*, Department of Finance Canada, Working paper, 2007

a positive economic impact there must be a high enough spillover parameter in order to overcome the negative effect of policy costs (see, Table 4). Thus it is not sufficient to show additionality in R&D. The additional R&D should also result in an overall welfare gain.

Table 4: Canada Evaluation 2007: Net economic (welfare) per unit of tax subsidy

Economic impact of the Scientific Research and Experimental Development (SR&ED) Tax Credit (per euro of tax expenditure)	
Base case efficiency loss (producer surplus)	-0.02
Adjustments	
Financing by distortionary taxes (opportunity cost)	-0.24
Compliance costs (incurred by business)	-0.08
Administration costs (incurred by government)	-0.02
Spillovers (domestic external rate of return)	+0.46
Net impact	**+0.11**

Source: John Lester, Department of Finance, Presentation to the OECD Workshop, Paris, December 10, 2007

5. Conclusions

There is no single good way to conduct an evaluation of a tax incentive policy. Much depends on the country context with its specific economic structure, social values, and political environment. It also depends on the evaluation tradition and accumulated evaluation expertise. It is interesting to note that not many countries have conducted official evaluations of their R&D tax incentive policies. This is despite the fact that over twenty countries in the OECD and a similar number in the European Union have implemented such policies. At some point these schemes, like any other, should be evaluated to check that they meet their objectives, and to uncover any weaknesses in implementation that could be improved on to make them more effective.

Considering evaluation early on in the policy process is important. In particular it helps to formulate a clear set of evaluation objectives, and to ensure that the data necessary for an evaluation are collected. The data available will influence the issues that can be addressed, the evaluation methods that can be used and the quality of the evaluation results. For example, in order to conduct a before-after study of the impact of the introduction of an R&D incentive scheme, data on R&D activity before the start of the program are required. The availability of data will also affect the timing of the evaluation, which is important if the evaluation results are to make a contribution to future policy formation.

It is difficult to include every interesting issue in one evaluation. Focusing the evaluation on the most relevant questions is important. A complex tax credit scheme (a hybrid volume-incremental system, special treatment of SMEs, separate incentives for university-industry R&D collaborations etc.) may require a separate evaluation of each element, not just one general evaluation that does not distinguish between the specific building blocks of the tax incentive program. The efficiency of the administration and delivery system for tax incentives, for example, could also render itself to a separate assessment. While the scope of individual country evaluations may not go so far as considering the impact of R&D tax credits on R&D location decisions across a wide range of countries, this is an issue that can be investigated at a European or global level.

A central element in all evaluations is the computation of additionality (how many units of additional R&D expenditure are generated per unit of tax subsidy). But for comparability across studies, the items included on the tax expenditure side should be harmonized (e.g. including or not including, R&D expensing, present and future outlays, government support net of corporate tax receipts). The calculation of additionality is an area where greater coherence across evaluations is possible.

Different evaluation methods can be used to assess the effectiveness of an R&D tax incentive scheme. Structural econometric approaches are an effective methodology for estimating R&D additionality. But applying this approach in practice is not always straightforward and may have some limitations. The approach estimates a price elasticity and therefore requires detailed data on the magnitude and precise design of the tax incentive. In principle this method should allow the evaluator to simulate the effect of an increase in the rate of the tax credit, but the method may not be able to predict the future impact of a dramatic R&D tax incentive policy reform. The extent to which a country has experienced policy changes may also influence the evaluation techniques used. For example, quasi-experimental methods can be used to exploit policy reforms in order to identify the impact of R&D tax incentives on R&D expenditure. This may also require good data to be able to pin-point the set of firms specifically affected by a change to the rules of the tax incentive.

Although it should ideally form part of an evaluation, assessing the precise magnitude of R&D spillovers and welfare gains is difficult in practice. To carry out a full welfare calculation of the effect of R&D tax credits estimates of the magnitude of spillover benefits would be needed. However, the existing range of estimates is much too wide to provide a basis for specific policy decisions. As much has been done in estimating spillovers to date, an interesting new direction would be to better understand the channels of externality transmission.

Finally, if it were possible to directly compare evaluations from different countries, using similar data, the same evaluation methods, and the same metrics for calculating additionality and net welfare gains, this would be extremely useful for making inferences about the relative effectiveness of different R&D tax incentive designs and hence improve policy design and implementation.

6. Future Directions

Following on from the conclusions we have identified some areas which may benefit from additional future research. They include:

1. Estimation of the magnitude of spillovers and the extent to which they cross industry, regional and international boundaries.

2. Extending the scope of evaluations to include analysis of the impact of R&D tax credits on higher order effects – innovation behaviour and productivity.

3. Understanding the impact of different designs of R&D tax credits on firms' decisions to start doing R&D. This could include the decision to start conducting collaborative R&D with universities. In both cases it may be important to assess the impact of R&D tax credits in the context of other incentive schemes such as direct subsidies.

4. Assessing the impact of R&D tax incentives on location decisions, and assessing the impact of these location decisions on innovation. This will link to the issue of the extent to which R&D spillovers are international.

5. Actively encouraging international collaboration on evaluation using comparable data and comparable methods. This is important for assessing which designs of R&D tax credits work best in practice, by drawing on comparable evidence from countries operating different schemes.

Appendix 1: Templates for Comparisons of Country Evaluations

The CREST Evaluation Handbook[17] has identified and recommended the following good practices:

- Clarity of objectives
- Focus on direct additionality
- Consideration of behavioural additionality
- Assessment of macro effects – in the policy mix context
- Inclusion of delivery/administration tests
- Use of different/complementary evaluation tools
- Data identification and collection in advance of evaluation
- Independence of evaluators and evaluation processes

Based on these recommendations and in accordance to terms of reference, the expert group developed the template to compare and summarize the evaluations (see Table 1).

Table 1: Summary Template for Comparisons of Country Evaluations

Country evaluation	**Objectives of the incentive and evaluation**	**Evaluation Coverage**				**Methods used**	**Data**
		Direct additionality (1st order)	**Behavioural additionality** (2nd order)	**Macro/welfare effects** (3rd order)	**Specific goals**		
1							
2							
Etc.							

The Expert Group reviewed twelve official or semi-official evaluations of R&D tax incentive programs in the following countries: Australia (2), Canada (2), France (2), Netherlands (3), Norway (1) and the United Kingdom (2). The set of three summary tables presented below broadly adheres to the above generic summary table:

- Table 1 provides information on evaluation objectives.
- Table 2 details the content of the evaluation including additionality and administration/compliance.
- Table 3 presents the methodologies and databases used in the evaluation

[17] *Handbook on the Evaluation of R&D tax incentives*, 17 March 2006

Table 1: Evaluation Objectives

Country/evaluation	Evaluation Objectives
Australia	
New Elements of the R&D Tax Concession: Evaluation Report, The Australian Government, June 2007 http://www.innovation.gov.au/Programsandservices/RDTaxConcession/Pages/RDTaxConcessionNewElementsEvaluationReport.aspx In September 2005, a government Steering Committee oversaw an evaluation of the new elements first full three years of operation. The committee comprised representatives from the Department of Industry, Tourism and Resources (DITR), the Australian Taxation Office (ATO), the Department of Finance and Administration (DOFA), the Department of the Treasury (Treasury), and a representative of the Industry Research and Development Board (IR&D Board).	Assess the effectiveness and the efficiency of the new elements of the R&D Tax Concession program—the Tax Offset and the 175% Premium. In doing this, the evaluation considers: • The inducement effect (behaviour additionality and activity generated by industry sector and size of firm); and • The benefit to cost ratios by inducement and spill over rates
An official evaluation of the standard 125% R&D Tax Concession, *Review of the R&D Tax Concession Program*, Centre for International Economics, Canberra, December 2003 (available in hard copy)	Review the 125% R&D Tax Concession against the three criteria: • Appropriateness: spillovers analysis from literature • Effectiveness: direct additionality - inducement ratio • Efficiency: cost-benefit framework
Canada	
Second official evaluation: *An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development* (2007), www.fin.gc.ca	To provide an *update* of the 1997 SR&ED evaluation What is the welfare effect? Role of domestic spillovers Role of tax distortions (marginal excess burden)
First official evaluation: *The Federal System of Income Tax Incentives for Scientific Research and Experimental Development: Evaluation Report*	What is the cost-effectiveness (incrementality ratio) of the assistance?

(1997), www.fin.gc.ca/toce/1998/resdev_e.html	On what and where is the tax credit being spent? What is the impact on the level of economic activity in Canada? What is the effectiveness of administration: goals, processes and delivery?
France	
The Effect of the R&D Tax Credit in France: A Panel Data Analysis 1978-2001, Jacques Mairesse and B. Mulkay (2004)	Calculate the effect of the R&D tax credit on the user cost of R&D capital and additional R&D spending by the private sector
An Evaluation of the R&D Tax Credit Impact in France, Emmanuel Duguet (2007)	Estimate the impact of R&D tax credit on business R&D expenditure
Netherlands	
First official evaluation: Brouwer, E., P. den Hertog, T. Poot, and J. Segers (2002), *WBSO nader beschouwd. Onderzoek naar de effectiviteit van de WBSO*, Opdracht van het Ministerie van Economische Zaken, DG Innovatie	Additionality effect on R&D expenditure due to WBSO wage tax credit Target group penetration Perception of the implementation (use of intermediaries/subsidy advisors) and users' desired changes to the design of the WBSO Is WBSO still needed?
Second official evaluation: De Jong, J.P.J. and W.H.J. Verhoeven (2007), *Evaluatie WBSO 2001-2005. Effecten, doelgroepbereik en uitvoering*, Opdracht van het Ministerie van Economische Zaken, DG Innovatie.	Estimates additionality effect on R&D expenditure due to WBSO wage tax credit Econometric evaluation complemented by a telephone interview. Quick-scan of administrative costs Analysis of target group penetration
Evaluation of the 2001 introduced changes in the WBSO: Cornet, M. and B. Vroomen (2005), *Hoe effectief is extra stimulering van speur- en ontwikkelingswerk?* CPB document No. 103.	Estimate and compare the WBSO impact on business R&D pre and post changes
Norway	
Haegeland, Torbjørn and Jarle Møen, *Input additionality in the Norwegian R&D tax credit scheme*, Statistics Norway, Report 2007/47	Multiple goals: • The scheme's ability to stimulate extra R&D effort and change firms' R&D

	behaviour • Effects on innovation and value creation in firms • User-friendliness • Administrative costs for users, tax authorities, the Research Council and other public agencies • Effect on R&D cooperation between firms and research institutes • Relation between the R&D tax credit scheme and other R&D incentives • How the Norwegian scheme compares to R&D tax credit schemes in other countries • The quality of the projects supported under the scheme and the extent to which they are tax motivated (including reclassification of other costs)
United Kingdom	
Research and Development Tax Credits: Final Report, British Market Research Bureau Social Research, 2005, HM Revenue & Customs Research Report 12 www.hmrc.gov.uk/randd/rand-taxcredits- final.pdf Executive summary www.hmrc.gov.uk/randd/rand-taxcredits-summary.pdf	Survey of users and potential users of R&D tax credits
Feasibility study for potential econometric assessment of the impact of R&D tax credits on R&D expenditure, OXERA, 2006, HM Revenue & Customs Research Report 19. This comes in two parts, “Literature review” and “Matching R&D credit data” www.hmrc.gov.uk/research/literature-review.pdf www.hmrc.gov.uk/research/matching- report.pdf www.hmrc.gov.uk/research/non-technical-summary.pdf	Feasibility study for econometric evaluation. Assess whether a matched sample of R&D data and tax data could be used for econometric evaluation.

Table 2: Evaluation Content and Coverage

Country/evaluation	**Direct additionality** (1st order)	**Behavioural additionality** (2nd order)	**Macro/welfare effects** (3rd order)	**Administration**
Australia				
New Elements of the R&D Tax Concession (2007)	The main method to determine additionality is to compare total R&D expenditures before policy change (pre 2001-02 data) with data after policy change.	Additional behavioural benefits not addressed	Additional value generated for the economy from spillovers of the knowledge generated by R&D undertaken through the new elements not examined	Compliance costs examined through focus groups – found to be not of issue for R&D Offset and R&D Premium claimants
An official evaluation of the standard 125% R&D Tax Concession, *Review of the R&D Tax Concession Program*, 2003	Additionality measured by the inducement (incrementality) rate A structural model developed to estimate firm responsiveness to various R&D costs changes Sensitivity tests: Consistent estimates in 50 to 90% range i.e., below 1:1	Measured through mail-out survey: • Primary cost drivers for R&D (e.g., skilled labour) • Role of IPRs • Contribution of R&D to future sales and profits • Access to capital and financing	Examines efficiency of R&D tax concession through comprehensive cost-benefit analysis Costs considered: Tax revenue forgone Administration/compliance Economic efficiency cost (marginal excess burden) Rent-seeking cost Benefits considered: Inducement rate Spillovers rate Both ambiguous and no point estimate provided	Includes administrative cost for the government and compliance cost to firms as parameters based on other studies No administrative or compliance evaluation undertaken

Canada				
An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development (2007), www.fin.gc.ca	Based on a literature review, estimates the median R&D incrementality ratio then used as an input to net welfare effect equation	Not addressed	Estimates net welfare gain at 11 cents per dollar of subsidy (gross gain of $1.11) Spillovers are the benefits less the costs such as: the cost of financing by distortionary taxes, administration and compliance costs and losses in producer surplus (base case efficiency cost)	Estimates as parameter the administration cost (2 cents) and compliance cost (8 cents) for a total of 10 cents per dollar of subsidy
The Federal System of Income Tax Incentives for Scientific Research and Experimental Development: Evaluation Report (1997), www.fin.gc.ca/toce/1998/resdev_e.html	Estimates cost-effectiveness ratio (CE) at 1.38 $CE = \frac{\text{Incremental SR\&ED}}{\text{Tax Cost of Incentives}}$ Measures impact on firm R&D with the tax credit, and in its absence (counterfactual)	Econometric analysis of survey responses into behaviour of firms in the areas of innovation, imitation and competitiveness	Static computable general equilibrium (CGE) approach modeled with and in the absence of the R&D tax credit Net gain in real income estimated at $20-$55 million	Provides a detailed review of the administration and delivery system
France				
The Effect of the R&D Tax Credit in France: A Panel Data Analysis 1978-2001, Jacques Mairesse and B. Mulkay (2004)	Uses a standard CES production function (log-linear form) to estimate the optimal demand for R&D capital based on its components – value added and nominal cost of capital Introduces the R&D tax credit into the user cost of capital of the model	Not addressed	Not addressed	Not included
An Evaluation of the R&D Tax Credit Impact in France,	Uses a descriptive analysis and matching methods to arrive at	Not addressed	Not addressed	Not addressed

Emmanuel Duguet (2007)	additionality estimates. Descriptive analysis: addition effect ranges from 2.5% to 12.2% when comparing recipients with other firms and between 0 to 10% when including tax credit dummy in the OLS regression Matching method: additionality effect ranges from 6% on positive growth rates of R&D sample to 13% on full sample			
Netherlands				
First official evaluation (Brouwer et al., 2002)	One euro of WBSO yields in the short run 1.02 R&D expenditures, independently of size class and sector. A specification estimating a price elasticity of R&D labour costs (estimated at 0.11) yields an increase of 0.61 Euro per Euro of WBSO (below the confidence interval of the 1.02 estimate) Marginal effect of WBSO is lower for large firms	1% higher WBSO leads to 19 % higher share of innovative sales in the short-run	Not addressed - not enough variables to use as controls and not enough observations in the time dimension.	Technology startups and service firms have more complaints about the administration of WBSO, along with small firms. Compliance: on average, it takes 6.4 days to apply for WBSO. 50% of respondents to a telephone survey say they would diminish R&D without WBSO (especially small firms) WBSO influences the location of R&D in a globalized world and the riskiness of R&D undertaken

Second official evaluation (de Jong and Verhoeven, 2007)	Price elasticity of R&D, short-run and long-run Bang for the buck (BFTB), short-run and long-run Variations across firm size, industry Results include: BFTB>1 in the short run (around 1.75 per Euro of WBSO, but with a large confidence interval – from 0.35 to 3.15 Euro), <1 in long run (0.51 on average with a confidence interval from 0.03 to 0.99) BFTB higher for SMEs Telephone interviews confirm results from econometric analysis: 2/3 of the respondents declare an additionality effect, more so among SMEs	Execution of R&D, type of R&D, share of innovative sales, Rough estimates find that a 1% increase in R&D leads to an increase in the share of innovative sales of 0.11 percentage points. But no direct estimate of the effect of WBSO on product innovation. Telephone survey found that WBSO leads to more risky R&D, faster implementation of R&D, an improved planning of R&D, and overall higher qualitative effects for SMEs	Evaluation found that 10% of the WBSO goes into R&D wages No significant effect was found of the share of innovative sales on labor productivity	Implementation costs for government: 0.02 eurocents per Euro of WBSO Administration costs for the firms: 0.07 eurocents per Euro of WBSO Potential improvements according to users: decrease in administration costs, more flexibility in application , extension to innovation expenditures Steady increase in WBSO users: 80% of firms with more than 10 employees use it. More users among large companies
Evaluation of the 2001 changes to the WBSO (Cornet and Vroomen, 2005)	Startups facility has a significant effect of the order of 10-20% on R&D. The BFTB is .50 to 0.80 (extra R&D wage costs/extra reductions in social security taxes) The lengthening of the first slice of firms (increase in the first ceiling) leads to 2.5 to 3% more R&D. The BFTB is between 0.10 to 0.20	Not addressed	Not addressed	Not addressed

Norway				
Haegeland, Torbjørn and Jarle Møen evaluation (2007)	Probability of starting to do R&D: firms that previously did not invest in R&D are more likely to start investing after SkatteFUNN was introduced Short-term additionality: increase in R&D man-years and increased use of skilled labor for given output level Firms that previously invested less than the cap increase their R&D more than firms that invested above the cap (but both for firms that applied and those that did not apply for SkatteFUNN) No clear indication that additionality is stronger in the long run Additionality is strongest in small, low-tech, and relatively low-skilled firms, i.e., firms with traditionally little R&D Calculation of the "bang for the buck"	SkatteFUNN has not had a strong impact on R&D co-operation with universities, colleges and research institutes SkatteFUNN contributes to an increase in the rate of innovation in firms, in particular to the development of new production processes and to some extent to new products for the firm	Effect of R&D on productivity for firms that receive R&D tax credits is positive but about the same as for other R&D activity. In SMEs there is a wage effect of R&D tax incentives	Separate survey conducted on the compliance cost for firms The total of compliance cost for firms and administration cost for government estimated at about 7 per cent per total tax relief
United Kingdom				
"Research and Development Tax Credits: Final Report", British Market Research Bureau Social Research, 2005,	Claimants asked how R&D tax credits had impacted on their R&D expenditure	Claimants asked whether R&D tax credits had lead them to undertake more risky R&D projects, longer-	Not addressed	Claimants asked about the claim process. Non-claimants asked

HM Revenue & Customs Research Report 12		term projects, whether R&D tax credits had affected the international location of R&D.		why they hadn't claimed (awareness, compliance costs etc.)
"Feasibility study for potential econometric assessment of the impact of R&D tax credits on R&D expenditure" OXERA, 2006, HM Revenue & Customs Research Report 19.	Not applicable	Not applicable	Not applicable	Not applicable

Table 3: Methods and databases

Country/evaluation	Methods	Data
Australia		
New Elements of the R&D Tax Concession (2007)	The evaluation included: conducting focus groups with stakeholders (November and December 2005), accepting written submissions, analyzing tax concession registration data, examining relevant reports, including an international study comparing R&D tax concessions and a 2005 study on the impact of the concession on firms To assess additionality trendlines for pre policy changes were estimated and differences between post policy data and trendline data calculated to arrive at the additionality estimate. A multivariate analysis of the R&D tax concession registration data was also performed to determine the size of inducement but not included in the evaluation.	The data comprise six years of R&D Tax Concession registration—three immediately before the elements were introduced and the three immediately after. Data is self-reported by firms and may vary from the amount of R&D expenditure allowed by the ATO. Different tax deduction rates were less well predicted by firms when they registered. Therefore, the evaluation measured increases in R&D expenditure for each firm and the cost to Government using the more reliable Treasury Tax Expenditures Statement estimates and ATO data, which is only available for the total cost of each element for each year.
An official evaluation of the standard 125% R&D Tax Concession, *Review of the R&D Tax Concession Program*, 2003	Survey-based approach Structural model developed to derive the inducement rate Sensitivity tests of the estimated inducement rate (various levels of R&D, turnover, various long-run scenarios)	Main data source: survey of 744 responding firms (response rate of 30%) Estimates taken from the literature on spillovers, MEB and administration and compliance costs
Canada		
An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development (2007), www.fin.gc.ca	Technical point of view, fully grounded in cost-benefit principles Develops partial equilibrium (PE) model to estimate net welfare gain Relies on parameters determined through literature review	No need for large database Data primarily obtained from literature review and used in calculations of parameters that enter net welfare gain

		model
The Federal System of Income Tax Incentives for Scientific Research and Experimental Development: Evaluation Report (1997), www.fin.gc.ca/toce/1998/resdev_e.html	Surveys by telephone: a representative sample of 1400 SR&ED users, with 501 responses Limited econometric analysis of regressions of survey results Interviews and case studies Computational general equilibrium model Evaluates administration and compliance burden through survey and interviews	Revenue Canada SR&ED company claimants database Database augmented by survey data
France		
The Effect of the R&D Tax Credit in France: A Panel Data Analysis 1978-2001, Jacques Mairesse and B. Mulkay (2004)	An econometric approach using three dynamic panel data estimation methods: • Within-firms estimates with time dummies, • Generalized Method of Moments (GMM) estimates in first differences with instruments in levels, and • GMM estimates combining first difference and level equations	Panel data for 1978-2001 Data include firms with more than 20 employees, mainly from manufacturing Accounting data matched with R&D survey data Estimation period 1981-2000
An Evaluation of the R&D Tax Credit Impact in France, Emmanuel Duguet (2007)	Employs descriptive analysis and matching methods supported by econometric regressions Descriptive counterfactual analysis: • Compares the growth rate of private funding of R&D between recipients and non-recipients • It was possible to restrict the comparison to the firms that have positive growth rates of R&D – one-third without tax credit and two-thirds with tax credit) • Matching methods - comparing similar firms, those that have the same estimated propensity to get the R&D tax credit	Two-year samples are used in order to calculate growth rates and to avoid the use of balanced samples throughout the study period (1993-2003) as this would exclude many of the firms that reported unevenly Samples vary between 1133 and 1645 firms
Netherlands		
First official evaluation	Multiple lines of inquiry: econometric analysis and telephone survey and semi-	Company data from the Dutch Central Bureau of Statistic (production statistics and

(Brouwer et al., 2002)	structured interviews of WBSO users (500 respondents, 20 minutes interviews) Econometric analysis – structural model of factor demand based on CES production function: R&D labour cost in 1998 regressed on the R&D labour cost of 1997 and the WBSO received in 1996 (and its square) while controlling for other factors (business characteristics, market structure, sector characteristics)	CIS data) and from SenterNovem (SN), the agency in charge of the WBSO policy. Limitation to structural WBSO applicants, i.e. those that applied in every year from 1996 to 1998.
Second official evaluation (de Jong and Verhoeven, 2007)	Structural model of factor demand (CES production function, with lags, user cost of R&D is firm and year specific) Telephone interview (1000 users) Computation of administrative costs related to WBSO	Data from CBS on production statistics, R&D and CIS surveys and data for 1995-2004 from SenterNovem (SN). SN data used are positive users of WBSO instead of assuming that every R&D performer uses it Panel data, period 1996-2004
Evaluation of the 2001 changes to the WBSO (Cornet and Vroomen, 2005)	Econometric analysis: difference in difference model and first difference model	Merging of data from tax authorities (1994-2003) and SenterNovem (1998-2003). Fiscal units: 28 134 observations
Norway		
Haegeland, Torbjørn and Jarle Møen evaluation (2007)	Econometric analysis: Difference-in-difference method comparing the R&D growth of firms below and above the cap The assumption made is that the difference in the growth of R&D investment between the two groups, conditional on observables, is due to the fact that one group benefits from tax incentives and the other does not. Apart from this, there should be no difference in the growth of R&D investment between the two groups *(strong assumption)* Excludes firms that did not previously report R&D	Final dataset used firms that are present in the R&D surveys and that have reported positive R&D in at least one year prior to the introduction of SkatteFUNN and that never have reported real R&D investments above 40 million NOK. Observations with R&D intensity (R&D/sales) above 5, and observations with zero R&D in the R&D surveys, but a positive R&D tax credit in the tax record are excluded. Observations that lack variables used in the analysis are also excluded. The sample period is 1993 to 2005 amounting to 8233 observations.

United Kingdom		
Research and Development Tax Credits: Final Report, BMRB Social Research, 2005, HM Revenue & Customs Research Report 12	Telephone survey interviews with eligible (R&D-doing, incorporated) companies	Survey data: 968 firms responded (response rate 51%).
Feasibility study for potential econometric assessment of the impact of R&D tax credits on R&D expenditure, OXERA, 2006, HM Revenue & Customs Research Report 19.	Literature review Match HMRC R&D tax credit claim data to ONS micro-level BERD data. Matching via company reference numbers and names	Matched data, but matching rate poor, only 10% of claimants match. Data contain poor coverage of small firms over time.Pre-R&D tax credit R&D expenditure data less comprehensive. Hence econometric analysis currently infeasible. Might be feasible at a later stage for large firms.

Appendix 2: Overview of R&D Tax Incentives in Selected Evaluator Countries

Australia: R&D Tax Concession

Summary

- *A 125 per cent tax concession (allowed from taxable income) applicable on the volume of R&D expenditures*
- *A 175 per cent tax concession (allowed from taxable income) applicable to the increase in the level of R&D expenditures over the 3 preceding years base*
- *An R&D Tax Offset (refund) for tax-loss small companies*
- *There is no ceiling on the amount of R&D tax concession claimed.*

The objective of the R&D Tax Concession program is to provide a tax incentive, in the form of a deduction, to make eligible companies more internationally competitive by:

- Encouraging the development of innovative products, processes and services;
- Increasing investment in defined research and development activities;
- Promoting technological advancement through a focus on innovation or high technical risk in defined research and development activities;
- Encouraging the use of strategic research and development planning; and
- Creating an environment that is conducive to increased commercialization of new processes and product technologies developed by eligible companies.

The R&D Tax Concession program was initially introduced in 1985 and underwent several changes over the past 20 years. Prior to the 1996–97 budget firms were eligible for a 150 per cent R&D tax concession. Today, the concession provides a basic 125 per cent deduction for eligible R&D expenditure, claimed against taxable income.

On June 1, 2001, Australia boosted the generosity of its tax concession by adding a 175 premium on the incremental increase in current R&D expenditures. The base period for the calculation of the increase is the average of R&D expenditures incurred over the three preceding tax years. It also introduced an R&D Tax Offset (refund) on the earned concession for tax-loss small companies (those with sales of up to AUS $5 million and having R&D expenditures not exceeding AUS $1 million).[18]

Australia requires eligible companies to *register* with the Industry Research and Development Board (IRDB) government authorities in order to claim the concession. Registration is required for each year of income in which the R&D expenditure is incurred. The formal stated purpose of registering is ‘to reduce the incidence of companies being required to reimburse tax benefits subsequent to a tax audit’. However,

[18] See, www.ausindustry.gov.au and ATO Research and Development Tax Concession Schedule and Instructions

a more practical purpose of registration is to provide government with the source of statistical information which then can be used for program performance evaluation.

In 2001, following the government's *Backing Australia's Ability* initiative[19], a requirement for companies to prepare R&D plans was introduced. This plan is not submitted with registration, but is a requirement of being an 'eligible company' and claiming the concession.

Canada: SR&ED Tax Incentives

Summary

Federal:

- *An SR&ED tax credit: 20 per cent for large and small non-CCPC companies (non-refundable)*
- *35 per cent (refundable) for small Canadian Controlled Private Corporations (CCPC)*
- *Incentive depreciation: 100 per cent capital cost allowance (CCA) for R&D machinery and equipment*

Provinces:

- *R&D tax credits range between 10 to 20 per cent on the top what the federal government offers*

Federal Level

The basic structure of the current federal system of income tax incentives for Scientific Research and Experimental Development (SR&ED) was put in place between 1983 and 1985. The policy objectives underlying these incentives were also introduced in 1983. While adjustments have been made to the SR&ED tax incentives since 1983, the policy objectives remain the same. (See box below.)

Goals and Objectives of SR&ED Program

- Encourage SR&ED to be performed in Canada by the private sector through broadly based support;
- Assist small businesses to perform SR&ED;
- Provide incentives that are, as much as possible, of immediate benefit;
- Provide incentives that are as simple to understand and comply with and as certain in application as possible; and
- Promote SR&ED that conforms to sound business practices.[20]

The SR&ED program allows a 100 per cent deduction for qualifying current R&D expenditures, as well as for qualifying capital expenditures made on R&D machinery and equipment. Most importantly, the program allows an investment tax credit on qualifying

[19] Commonwealth of Australia, *Backing Australia's Ability - Building our Future through Science and Innovation* 2001, http://backingaus.innovation.gov.au

[20] The Department of Finance, *Evaluation Report*, Ottawa, 1997

SR&ED expenses incurred in Canada. The qualifying expenses are generally the same as for the current deduction. For large companies and for companies other than small Canadian Controlled Private Corporations (CCPCs), the rate of the credit is 20 per cent of qualifying R&D expenditures. The rate of SR&ED tax credit for companies eligible for the small business deduction - the CCPCs - is 35 per cent. Both current expenses and expenditures on machinery and equipment qualify for the credit. The SR&ED tax credit is taxable, however, in the sense that it must be deducted in calculating the base for current and capital expenses eligible for the 100 per cent deduction from business income. The federal SR&ED tax credit and current deduction are based on qualifying expenditures net of government assistance. For CCPCs in a non-taxpaying position, the credit is refundable.

Provincial level

Canada's corporate income tax system is a *combination* of federal and provincial income taxes. All provinces generally follow federal rules with respect to the deductibility of current and capital expenditures on R&D. Ontario, Quebec, British Columbia, Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Newfoundland, and most recently Alberta, each provide investment tax credits for R&D. Provincial rules generally conform to federal rules relating to the definitions of qualifying work and expenditures, and the treatment of government assistance, non-government assistance and the federal SR&ED tax credits. The definitions of eligible work and expenditures for purposes of these provinces' R&D tax credits are generally the same as for the federal SR&ED tax credits. Under federal regulations, provincial investment tax credits are considered to be government assistance and reduce the amount of expenditures eligible for the federal SR&ED tax credits and deduction in the year in which the provincial credits are receivable.

France: Credit d'Impot Recherche (1983)

Summary

Previous system*:*

- *A 40 per cent tax credit applicable to an increase in the level of R&D expenditures over the 2 preceding years base*
- *A 10 per cent volume tax credit applicable to the level of current year R&D*
- *Ceiling – 16 million euro per enterprise per year*

New system (from 2008 with first credits to be paid in 2009):

- *Volume tax credit only available*
- *A 30 per cent credit on first 100 million euro of R&D expenditure*
- *A 5 per cent credit on R&D expenditure above 100 million euro*
- *A 50 per cent credit for companies declaring R&D expenditure first time (only in first year)*
- *Ceiling eliminated*

Since 1983 France has offered the Credit d'Impot Recherche (CIR) – a tax credit for company research expenditures. As a horizontal and non-discriminatory measure across sectors of activity, the CIR is considered key in the support of R&D investments in both small and large companies.

France's experience with R&D tax credits indicates a number of experimentations with the design. Over the past four years, France moved from offering a combination of incremental and volume tax credit rates to a completely volume based design.

The 2004 tax reform increased the generosity of the tax credit and made a few important changes to the operation of the system.[21] France moved from a purely incremental tax credit to a hybrid approach that used a mix of incremental and volume-based tax credits. The modified CIR consisted of the following two parts: a 45 per cent of the excess of R&D expenditures incurred in the current year over the average expenditure during the preceding 2 years; and a 5 per cent volume-based calculation of the current year R&D expenditure.

In 2006 France again modified the CIR by increasing the volume component of the tax credit to 10 per cent and a decreasing the incremental component to 40 per cent. And in 2008 France abandoned the incremental system by introducing differential rates of volume tax credit depending on the size of company annual R&D expenditure. The following rates are currently available: a 30 per cent tax credit on the first 100 million euro of R&D expenditure; a 5 per cent credit on R&D expenditure above 100 million euro; and a special provision of a 50 per cent tax credit for companies declaring R&D expenditure for the first time. Unused tax credits are refunded after three years and for "young" companies they are paid immediately.

There is no particular incentive provision for capital R&D assets in France. Machinery and equipment employed in R&D would normally be depreciated on a declining balance basis as regular capital assets.

Netherlands: WBSO R&D Tax Incentive (1994)

Summary

- *An R&D wage tax credit:*
- *42 per cent for small companies (with additional 20 per cent for technostarters)*
- *14 per cent large companies*
- *Self employed can claim up to 11, 608 euro per year and technostarters 5,805 additional euro*

WBSO (Wet bevordering speur- en ontwikkelingswerk) is the main fiscal instrument that the Dutch government uses to stimulate private R&D expenditures and compensate firms for the relatively high wage costs of researchers in the Netherlands. WBSO was introduced in 1994 and it works through providing reductions in wage taxes and in social

[21] http://www.enseignementsup-recherche.gouv.fr/cid20358/le-credit-d-impot-recherche-cir.html

security payments paid by a firm on its R&D salaries. In 2005 the Dutch government spent close to 400 million Euros on WBSO (see Table 1).

Table 1: Evolution of WBSO Tax Incentive: Selected Statistics

Year	Budget (million euro)	1st bracket (euro)	WBSO rates 1st bracket (%)	WBSO rates 2nd bracket (%)	Ceiling (million euro)	No of firms applying	No of projects
1996	204	68.067	40	12,05	4,5	6.800	39750
1998	281	68.067	40	17,5	6,8	8.900	53220
2000	302	68.067	40	13	6,8	10.000	59585
2002	367	90.756	40 or 70 (s)	13	7,9	10.500	63110
2004	365	110.000	40 or 60 (s)	14	7,9	10.200	63153
2005	381	110.000	40 or 60 (s)	14	7,9	10.600	65123

Source: Netherlands Ministry of Economics Affairs (2007) Note: s=technostarters

There are four types of R&D projects that can be accommodated by WBSO in under the current scheme:

- technical scientific research
- development of technically new physical products, processes or programming
- feasibility studies of own potential future R&D
- research into improvement of production processes

The target group of the WBSO incentive includes all R&D performing enterprises in the Netherlands, in particular SMEs and young firms. Approximately 70 per cent of the WBSO budget goes to SMEs.

Currently, for the lower (1st bracket) level of R&D expenditure typically incurred by small businesses, the applicable incentive is a 40 per cent reduction of the research wage costs of R&D employees. For the higher level of R&D spending (2nd bracket) typically performed by larger businesses the applicable incentive is 14 per cent of wage costs. Qualifying activities must be systematically organised in the Netherlands and be directly and exclusively aimed at technical and scientific research leading to new products and services. The Dutch government treats the reduction as an important policy instrument, varying its level from time to time depending on policy objectives. The scheme applies to both intramural and extramural (i.e., encouraging university-industry research collaboration, for example) R&D wage costs.

Capital assets must be depreciated in the Netherlands. However, no general rulings with regard to depreciation have been issued. The taxpayer is free to choose depreciation periods and the corresponding rates. They will be accepted by the tax administration unless they are clearly excessive. In general, the rates should reflect the normal (economic) period of use by the taxpayer.[22]

Norway: SkatteFUNN R&D Tax Credit (2002)

Summary

- *An R&D tax credit of 20 per cent – applicable to small firms only*
- *An R&D tax credit of 18 per cent – applicable to large firms*
- *Ceiling imposed*

SkatteFUNN was introduced in 2002 as part of a major restructuring of Norwegian innovation policies. Initially intended for SMEs only, in 2003 it was extended to large firms with different rates of tax incentives in conformity with EU/EEA state aid rules: 18 per cent tax credit for large firms and 20 per cent for SMEs. The credit is volume based and non-taxable. [23]

Norway imposes a ceiling of 4 million NOK (approximately 500,000 Euro) of company intramural R&D and of total R&D. The ceiling is doubled to 8 million NOK for co-operative R&D with approved R&D institutions (e.g., universities and research institutes). Any R&D amount above those ceilings is not supported.

SkatteFUNN payments are made when the tax authorities have made their assessment, i.e. one year after expenses have been incurred. If a firm has insufficient taxable profits the tax credit is paid out as a grant. There were 2,600 applications in 2006. It is important to note that the SkatteFUNN incentive is awarded on a project basis – projects must be approved by the Research Council of Norway prior to applying for tax benefits. SkatteFUNN projects are evaluated for eligibility *ex-ante* to the R&D activity occurring rather than ex-post as is the case for other countries' R&D tax incentive programs. The program has been designed to boost the innovativeness of small firms and remains popular with small firms: roughly 85 per cent of the approved projects are by firms with less than 50 employees. The average subsidy is sizable: 1,000 Euro per employee compared to the average tax per employee of 2,300 Euro.

There is no incentive depreciation for capital R&D assets in Norway. These assets are depreciated as other assets on a declining balance basis.

[22] See web site of the tax credit scheme www.senternovem.nl/wbso/english.asp

[23] See web site of the tax credit scheme www.skattefunn.no

United Kingdom: R&D Tax Credit (2000)

Summary

- *A 175 per cent (up from 150 per cent as of April 1, 2008) R&D tax credit (deductible from taxable income) for small and medium sized companies.*
- *Payable credit for small and medium sized firms with tax losses*
- *A 130 per cent (up from 125 per cent as of April 1, 2008) R&D tax credit (deductible from taxable income) for large companies.*
- *No ceiling on the tax credit claimed*
- *Incentive depreciation: 100 per cent write-off for capital R&D assets*

The United Kingdom's R&D tax credit represents a company tax relief which can either reduce a company's tax bill or, for some small or medium sized companies, provide a cash sum. The aim of the tax credit, introduced in 2000 for small and medium sized companies (SMEs) initially, is to encourage greater R&D spending in order to promote investment in innovation. In 2002, the credit was extended to large companies.

The R&D tax credit works by allowing companies to deduct 175 per cent (under the current SME scheme) or 130 per cent (under the current large company scheme) of qualifying expenditure on R&D activities when calculating their profit for tax purposes. SMEs with tax losses can surrender their enhanced relief in return for a payable tax credit equal to 24 per cent of the qualifying R&D expenditure.[24]

In addition, the United Kingdom maintains a generous system of writing down allowances for capital assets. It allows a 100 per cent write-off for capital R&D expenditures (machinery and equipment and plant) in the year capital expenditures are incurred.

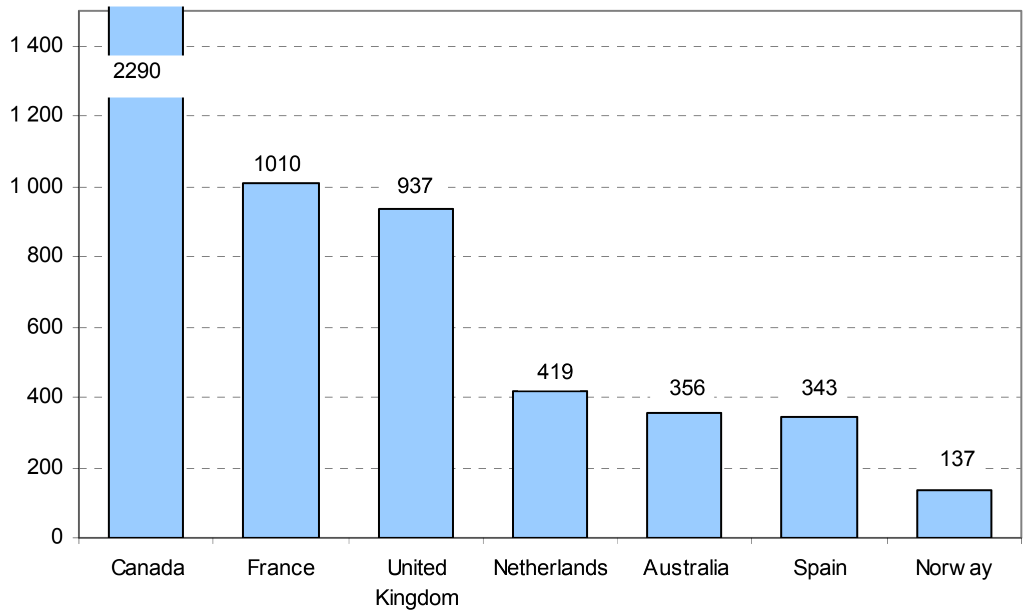
All fiscal policies are operated by HM Revenue and Customs (HMRC) and are designed to "change the climate for investment across the economy, changing the risk/cost ratio for investment in research and development."

Tax Cost Indicators

Chart 1 presents preliminary estimates of taxes forgone for all seven evaluator countries. In absolute terms, Canada spends the most on R&D tax incentives while Norway the least. This is also confirmed in relative terms: as a percentage of GDP, Canada channels the highest proportion of its total private sector R&D assistance via tax incentives, and Norway the lowest (see Chart 2). Those countries that spend heavily on tax incentives (Canada, Netherlands and Australia) devote a commensurably lower proportion of GDP to direct assistance. On the other hand, in France, Norway and the UK where direct assistance is of more importance, tax incentives play a relatively smaller role.

[24] For details, see http://www.inlandrevenue.gov.uk/randd/index.htm

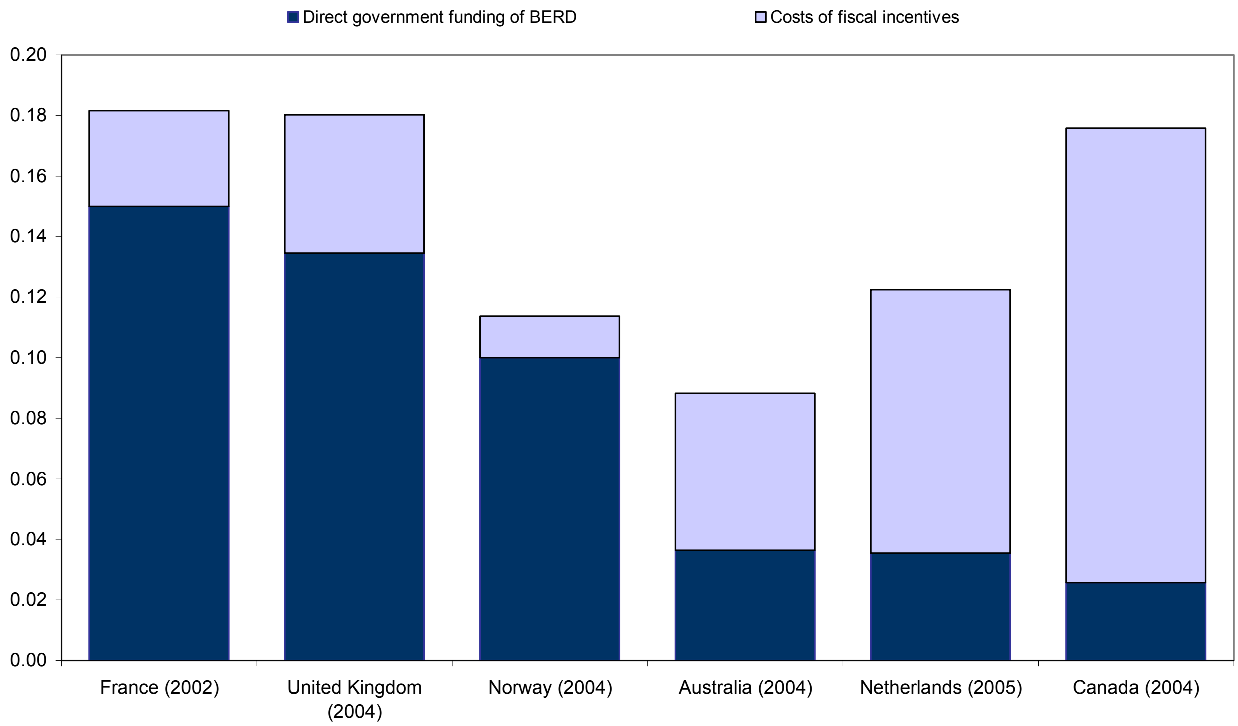
Chart 1: Costs of R&D tax incentives: Estimates of revenue losses due to R&D tax incentives[25] (2005, USD millions in PPP)



Source: OECD Scoreboard 2007, Statlink: http://dx.doi.org/10.1787/117566660733

[25] OECD, based on national estimates (NESTI R&D tax incentives questionnaire), some of which may be preliminary. The estimates cover the federal research tax credit for the United States; the SR&ED tax credit for Canada; the mixed volume and incremental incentive for France; the tax credit consisting in a reduction of taxes on R&D wages as well as the allowance on profits of R&D self-employed for the Netherlands; the volume measure for the United Kingdom and Norway; the mixed volume and incremental measure for Spain (now being phased out); and standard R&D tax concession, tax offset and incentive incremental premium for Australia.

Chart 2: Direct government funding of business R&D and tax incentives for R&D
(Percentage of GDP)



Source*: OECD Science, Technology and Industry Outlook 2006*, Paris, p. 25 (based on national estimates, some of which may be preliminary)

StatLink: *http://dx.doi.org/10.1787/*108314226461

Summary Table: An Overview of R&D Tax Incentives (2008 or most recent year)

Country/ Tax Incentive	Description of Tax Incentive			Refund	Ceilings	Cost of tax incentives vs. cost of direct funding (% of GDP, 2004)	Cost to government (US million PPP, 2005)
	Rates	Expense base	Deducted from				
Australia R&D Tax Concession (year of introduction 1985)	125% on volume plus 175% on increment over past 3 years average	Current and machinery & equipment (M&E) depreciation	Taxable income	Small firms in tax loss position can claim an R&D tax refund (offset) equal to tax savings from Tax Concession	No ceiling	0.03 vs 0.15	356
Canada SR&ED Tax Credit (1985) Incentive R&D depreciation	20% for large firms and 35% for small firms (CCPC) 100%	Current and M&E R&D M&E	Tax payable (benefit is taxable) Taxable income	Cash refund for small firms (CCPC)	Generally no ceiling but small firms get 35% credit on first 3 million CAD$	0.15 vs 0.03	2,290
France Research tax credit (CIR, 1983)	As of 2008, 30% on first 100 million euro and 5 % on amount above increment over 2 past years; first time applicants receive 50% in the first year only	Current plus depreciation of capital assets	Tax payable	Young firms – immediate refund Other firms – after 3 years	No ceiling	0.03 vs 0.15	1,010
Netherlands R&D wage tax credit (1994)	14% on volume; 42% for small firms	Research wages	Reduction of withholding tax on wages	Works like refund	For small firms, limit for 42% credit is 110,000 euro of R&D wages	0.09 vs 0.04	419
Norway R&D tax credit (2002)	18% on volume; 20% for small firms	Current costs	Tax payable	Refundable as cash grant	Up to NOK 4 million; if joint project with approved R&D institution – up to NOK 8 million	0.01 vs 0.10	137

Summary Table: An Overview of R&D Tax Incentives (2008 or most recent year)

Country/ Tax Incentive	Description of Tax Incentive			Refund	Ceilings	Cost of tax incentives vs. cost of direct funding (% of GDP, 2004)	Cost to government (US million PPP, 2005)
	Rates	Expense base	Deducted from				
United Kingdom R&D allowance (2000) Incentive R&D depreciation	175% for small firms; 130% for large firms; volume based 100%	Current cost R&D plant & equipment	Taxable income Taxable income	Refund for small firms - 24% of the cash cost of the qualifying R&D	No ceiling	0.05 vs 0.13	937

Source: Adapted (and updated) from Alessandra Colecchia, *R&D tax incentives and R&D statistics: What next?* Directorate for Science, Technology and Industry, OECD, Paris, May 2007

Appendix 3: Discussion Papers

Draft November 5, 2008

Expert Group Seminar on Evaluating R&D Tax Incentives

In Search of Good Practices in Evaluating R&D Tax Incentives

Brussels, 7 November 2008

What Can we Learn from Structural Econometric Models for the Evaluation of R&D Tax Credit Policies? An Example and Some Thoughts

By Jacques Mairesse and Damien Ientile

1. Introduction

Although economic liberalism is gaining momentum, government intervention in the economy is more than ever necessary in growing international competition. Many public policies that aim at supporting domestic firms and at fostering high value-added activities are implemented in industrial countries, from public ownership of firms to direct subsidies and fiscal incentives. International comparisons are increasingly used to design and justify public policies, particularly on the basis of the data published by Eurostat and the Organization for Economic Cooperation and Development (OECD). The main objective is to keep up with the leaders in every area: this is true for innovation, which is considered as one of the major determinants of growth in what is known as the knowledge-based economy. The Lisbon strategy was defined by the European Council in March 2000, to make the European Union 'the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010'. As far as R&D is concerned, the objective is to reach an intensity of 3% by 2010 with the following decomposition: two-thirds for the private sector (2% of GDP) and one-third for the public sector (1% of GDP)[26]. The R&D intensity for the EU27 was 1.84% in 2005, with 1.17% for the private sector and 0.65% for the public sector; the R&D intensity for France was 2.13% in 2005, with 1.37% for the private sector and 0.79% for the public sector. Therefore an additional effort should be made to fulfil the objective defined by the Lisbon strategy. The implementation of R&D tax credit policies among most industrial countries, aimed at increasing the private R&D expenditures, is part of the effort.

The movement of international comparison of data and policies was accompanied by the development of public policy evaluation. Indeed the role of the government has been strongly challenged since the 1980s: in particular it has been argued that the private sector can do better for cheaper, that public money is often wasted by inefficient and bureaucratic administrations (and government-owned firms) and that the numerous taxes are a burden for the firms, which prevents the economy from reaching its potential growth. Citizens also demand more and more accountability and want to know how the public money is used. Governments launched audits and 'modernization' programs to reduce the cost of administration and public policies, and to increase service quality. The evaluation of public policies is logically considered necessary today: public policies must prove efficient to be maintained; otherwise they have to be modified, improved or stopped. This ensures that public money is used efficiently and allows reducing

[26] R&D intensity is defined as the ratio of R&D expenditures to Gross Domestic Product (GDP). All R&D intensity figures are taken from Eurostat (2008). The private sector R&D corresponds to the business enterprise sector, and the public sector R&D corresponds to the government and higher education sectors. This is a simplification since higher education is largely private in some countries.

ineffective expenses. Of course there are different kinds of evaluations. Indeed one can evaluate waiting periods, meeting of deadlines, cost optimization or transparency of public policies by building indices or by applying audit methods (implementation evaluation); but one can also concentrate on outcome variables (outcome evaluation). This latter kind of evaluation is the most difficult since the effect of a policy on outcome variables can be a long-term effect and can be hard to measure. Although various outcomes may be selected for the evaluation of the tax credit, we follow here the vast majority of tax-credit-related articles and concentrate on R&D expenditures. Therefore the objective of the evaluation is to demonstrate and quantify a causal effect (or the absence of causal effect) between the tax credit and an increase in R&D expenses.

Remarkable progress has been made in this field of evaluation, like in many others, thanks to the availability and proper investigation of firm-level data and specifically to the use of firm panel data. Indeed country and industry-level panel data lead to imprecise estimations of the effect of tax incentives that cannot really be distinguished from other changes and macroeconomic shocks. Firm-level panel data can provide an important degree of variability, which allows taking into account unobserved heterogeneity and hopefully obtaining more precise and reliable estimations. Several methods have been used to evaluate the effect of tax incentives on private R&D since the 1980s, and a significant international literature has developed. Yet no consensus on a 'best approach' has been reached.

The aim of this discussion paper is to provide a presentation of the various evaluation methods applied to the R&D tax credit with a main focus on the so called econometric structural methods. Section 2 recalls on the one hand the basic characteristics of the R&D tax credit, and on the other hand the general framework of evaluation in which specific evaluations are embedded and which should always be kept in mind. Section 3 presents the structural econometric approach in general, while Section 4 goes into more details by giving an example of its application to the case of the French R&D tax credit. In Section 5, we briefly compare this approach with other classes of econometric methods, which we pull together here under the label of "intuitive econometric methods". Respective advantages and drawbacks of the various methods are discussed. In Section 6, we consider four specific questions, two of a more technical nature, two raising broader issues.

2. Background Considerations on the R&D Tax Credit and Framework of Evaluation

The first subsection gives a brief description of the R&D tax credit general features, which are necessary to recall for an understanding of the evaluation methods presented in the following sections, while the second subsection put these methods in the broader context of the economic evaluation of public policy and the rationalisation of budgeting choices, which is also useful to have in mind.

General Features of the R&D Tax Credit

The R&D tax credit relies on a very simple idea: it gives firms incentives to increase their R&D expenses by allowing them to deduct a share of their expenses from their corporate taxes. Here we concentrate on the common features of the design of R&D tax credit across industrialized countries, but one should notice that there exist numerous variations in details, which in practice can matter importantly[27].

The R&D tax credit slightly differs from direct subsidies for two main reasons:

- Since any firm can apply for the tax credit and benefit from it, provided that it incurs R&D expenses, it is universal. On the contrary the direct subsidies are granted to selected projects and therefore to selected firms. As a consequence, the tax credit allows the firms to decide freely what projects they want to carry out[28].
- Since the firms first invest in R&D and then apply for the tax credit, it can be considered an ex-post incentive. This is not the case of subsidies, which are attributed to projects before or while they are carried out.

The tax credit is equal to the product of a base times a statutory rate. For example if the base is equal to the current R&D expenditures and the rate is equal to 20%, then the firm can deduct an amount equal to 20% from its R&D expenditures from its taxes. Three general types of tax credit can be distinguished:

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[27] These variations come from differences in statutory rates, ceilings, definition of eligible R&D expenditures, special rules for specific areas of R&D, carryforward rules, and other practical details.

[28] In some countries however (Norway), the tax credit is only attributed to projects that were accepted by the administration.

- ***Volume tax credit*** The base is the current amount of R&D expenditures. Denote θ the statutory rate, R the volume of R&D (in constant price of a base year) and P_{RD} the price of R&D (as an index of price change between the current year and the base year). The tax credit TC is equal to:

  $$TC = \theta\, P_{RD}\, R$$

  A firm can always benefit from the volume tax credit, irrespective of whether its R&D expenditures are decreasing or increasing.

- ***Incremental tax credit*** The base is the difference between current expenses and a reference level. The reference level is usually an average of past expenses. Denote θ the statutory rate, R the R&D and P_{RD} the price of R&D. In the simple setting where the base level is the previous period level of expenses, the tax credit TC is equal to:

  $$TC = \theta\, (P_{RD,t}\, R_t - P_{RD,t-1}\, R_{t-1})$$

  Only firms that increase their R&D expenditures can apply for and obtain the incremental tax credit. This type of tax credit is the most difficult to analyze because its effect is intertemporal: it is reduced by the fact that additional expenditures increase the reference level of the subsequent year.

- ***Mixed tax credit*** It is composed of both a volume and an incremental part: in this case two statutory rates must be defined. Denote θ_1 the volume rate and θ_2 the incremental rate. The tax credit TC is equal to:

  $$TC = \theta_1\, P_{RD,t}\, R_t + \theta_2\, (P_{RD,t}\, R_t - P_{RD,t-1}\, R_{t-1})$$

Firms have to declare their eligible expenses only. R&D eligibility is usually defined by law and varies across countries and has also changed over time in most countries. In general it is somewhat different from Frascati's definition of R&D, which is used in R&D surveys, even if several countries seek harmonization by adopting this definition.[29]

The definition of the tax credit includes specific rules regarding the timing of taxation. When a firm's tax credit is higher than its corporate taxes, it may carry forward the

[29] For lack of access to detailed fiscal data, most studies which have analysed the R&D tax credit have usually considered that eligible expenses are a fixed share of total R&D expenditures across firms.

remaining tax credit for several subsequent years and deduct it from its future corporate taxes. For instance, French firms can carry forward their tax credit for three years, and they receive the tax credit as a monetary transfer if they still do not pay taxes at that time. The frequency of this situation indirectly depends on the loss carryback and loss carryforward rules, which allow the firms suffering losses to carry their losses back or forward to optimize their taxation.

With the incremental tax credit, a firm that reduces its expenditures accumulates negative tax credit. This negative tax credit is deducted from the tax credits of future periods, but the firm never pays this negative credit, even if it keeps decreasing its R&D expenditures. Furthermore, the tax credit cannot exceed a ceiling, which is either defined as a maximum amount of tax credit or as a maximum amount of declared R&D.

Assessing Public Policy Efficiency

Public policies have many effects on society through various channels. The researcher whose objective is to evaluate the R&D tax credit should in principle consider (at least) two related questions, the first at the level of operational efficiency and the second at the level of general economic relevance:

- Does the tax credit effectively stimulate R&D expenditures?
- Does the tax credit increase social welfare?

The effect of the tax credit on R&D expenditures The first question addresses the issue of input additionality, with the amount of additional R&D generated by the tax credit used as the efficiency criterion. R&D policies are aimed at encouraging firms to spend more than one Euro of additional R&D per Euro of tax credit forgone by the government. If the amount of R&D spent by the firms is the same with and without the tax credit, then no additional R&D is be generated and the policy is completely ineffective. If one Euro of tax credit generates between 0 and 1 Euro of additional R&D, then the effect of the R&D tax credit is positive albeit weak. If one Euro of tax credit generates more than one additional Euro of R&D, then the tax credit can be deemed efficient - for example more than direct financing of public research, other things being equal.

Two multipliers M1 and M2 are generally used to assess additionality, respectively with respect to forgone taxes (i.e. to the amount of tax credit), and with respect to 'R&D expenditures without the policy'. Denote R_1 the R&D expenditures when the firm benefits from the tax credit and R_0 the counterfactual R&D expenditures (i.e. what they would have been in the absence of the tax credit), and TC the amount of tax credit received by the firm:

$$M1 = (R_1 - R_0) / TC \qquad \text{and} \qquad M2 = R_1 / R_0$$

Thus, if M1=0 the tax credit has no effect and if 0<M1<1 its effect is weak. If M=1 then one euro of tax credit generates one euro of additional R&D. If 1<M1 its effect is strong: one euro of tax credit generates more than one euro of R&D. The second multiplier indicates whether the tax credit has an effect or not, but it does not allow to compare this effect with forgone taxes. These multipliers are usually computed at the national level and used as a summary of the evaluation results. Notice that M1 is known as 'bang for the buck' (e.g. Hægeland and Møen [2007], Lokshin and Mohnen [2007]) because it indicates what one gets for one's money.[30]

Multipliers are often considered a convenient way to present the results because they allow international comparisons, even if the tax credit policies and the methods applied to evaluate them are different. Although the multipliers can be obtained as primary results of survey or questionnaire methods[31], they are often derived from econometric estimates that cannot be directly interpreted as multipliers. These estimates usually stem from models with a function of R&D as the dependent variable and a variable accounting for the tax credit among the explanatory variables. Depending on the data and the specifications, some models make it possible to distinguish between the long-term and the short-term effects of the tax credit on R&D[32].

Most methods only try to answer the question of whether the R&D tax credit policy, considered as a binary treatment, has been effective. Yet, some methods allow an evaluation of the effects of future policy changes: their primary results are usually elasticities measuring the responsiveness of R&D to changes in the policy's features. Thus they make simulations possible under different scenarios of policy change[33].

The effect of the tax credit on social welfare The efficiency criterion underlying the second question is social welfare. This approach is much more demanding because it requires taking into account the economy as a whole and running a complete cost-benefit analysis. Parsons and Phillips [2007] present the various issues to be considered,

[30] Many other multipliers can be defined, for example, $M3 = ((R_1 - R_0) / TC) - 1$. It is useful that evaluation studies report their results in the form of multipliers, and when they do so it is important that they specify clearly which multiplier(s) they use. See P. Mohnen discussion paper in this workshop.

[31] See for example Mansfield and Switzer (1985) or Hægeland and Møen (2007).

[32] See Discussion paper by Pierre Mohnen for further details.

[33] One of the limits of most analyses is that they are centred on the impact of the tax credit on R&D expenses, but do not take into account the effect of the policy on R&D prices. If the tax credit is efficient at a large scale, demand for R&D will significantly increase, which might result also in raising its price. This argument has been developed by Goolsbee [1998], but it does not seem that in fact the price effect matters much.

providing a good illustration with the evaluation of the Canadian R&D tax credit. They also address the question of the 'optimal' rate of tax credit, which becomes meaningful in their framework.

In Parsons and Phillips' model, the implementation of the tax credit impacts social welfare through four main channels. Each of them can be quantified in cents per dollar spent on the policy, and their algebraic sum corresponds to the global effect of the policy on social welfare, measured in cents per dollar spent on the policy:

- The tax credit increases the producer surplus because it acts as a subsidy, but it has a direct social cost equal to the amount of the credit.
- The tax credit gives firms incentives to increase their R&D expenditures and thus to reach a socially more efficient level of R&D[34]. Indeed, R&D has both an internal (or private) return and an external return. The external return is due to positive externalities (or spillovers) and other firms in the economy can benefit from it, which increases social welfare.
- The money spent on the tax credit has an opportunity cost, since the forgone tax revenue could have been used to finance other public expenses (e.g. public education, social spending) or a lump-sum tax cut. A complete cost-benefit analysis requires evaluating the opportunity cost of the tax credit. For the sake of clarity, consider that in the absence of the tax credit, a lump-sum tax cut would be implemented thus increasing social welfare by reducing distortions. The opportunity cost is therefore the marginal excess burden (MEB), defined as the welfare loss associated with a one-dollar increase in tax revenues. Figure 1 relies on three assumptions on the value of the MEB.
- The compliance and administration costs of the tax credit affect both the firms and the tax administration, and thus reduce social welfare.

Parsons and Phillips try to provide a complete cost-benefit analysis by quantifying the effect of each channel for one dollar spent on the tax credit. The loss or benefits components induced by each channel on total social welfare are taken from a survey of estimates found in previous studies. The limits of the approach are thus mainly due to very imprecise or even conflicting estimations of these various components. All in all, the median increase in social welfare would be around 10 cents per dollar of tax credit. The authors illustrate the overall uncertainty of such a result and its sensitivity to the underlying estimates in figure 1, which shows that it could be positive or negative. In particular, the opportunity cost of public resources is not accurately estimated: indeed the authors decided to simulate a lump-sum tax cut instead of the tax credit, but they could have decided to allocate the money elsewhere (for example to education). More

[34] In the absence of the tax credit, the level of R&D investment is defined by the equality of the private return and the marginal cost of R&D. The optimal R&D tax credit gives firms incentives to invest as long as the sum of the internal return plus the external return of R&D is higher than its marginal cost.

generally, this approach is as ambitious as it is difficult to implement. It is stimulating because it is aimed at providing the most complete possible evaluation of a public policy, but the results are too uncertain and ambiguous to be useful to policy-makers.

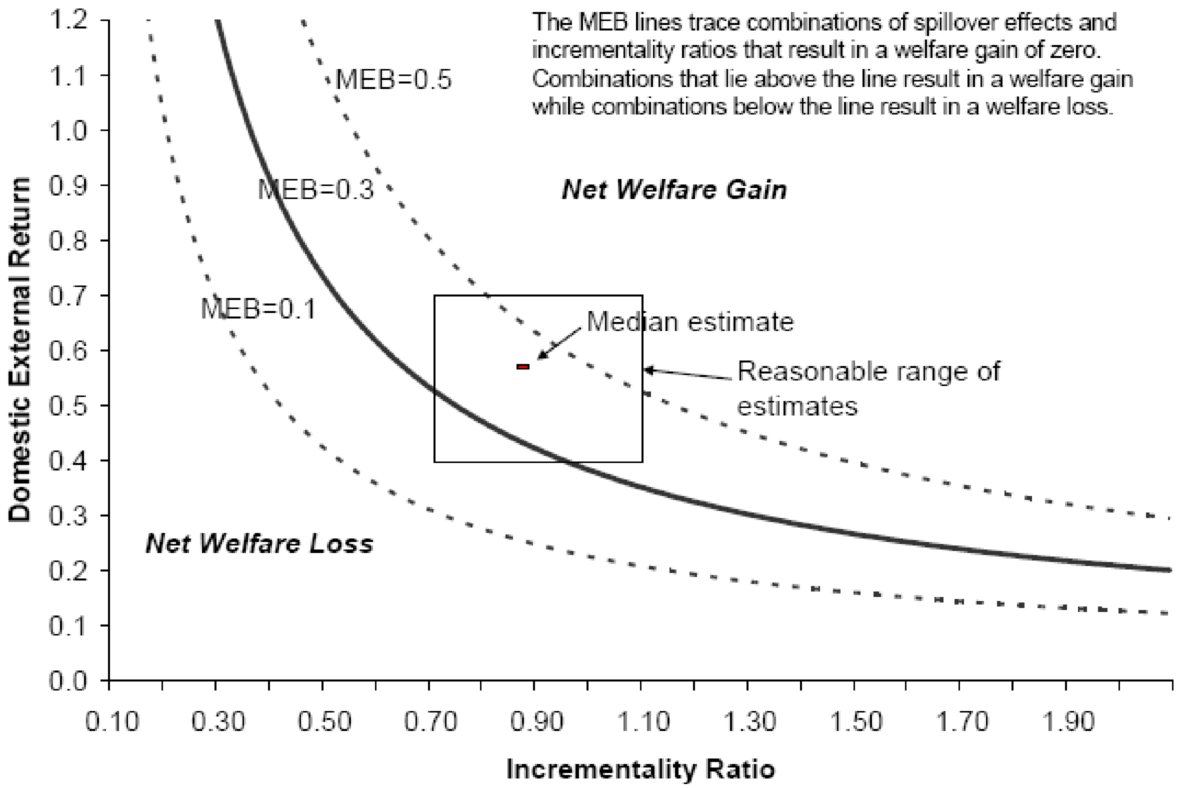

Figure 1[35]: Sensitivity of the Tax Credit Welfare Effects to Illustrative Changes in the Marginal Excess Burden (from Parsons and Phillips 2007)

3. The Structural Econometric Approach

The structural approach has been adopted by institutions such as the U.S. Government Accounting Office [GAO 1989] and the OECD [1997], and it has been developed by several authors such as B. Hall [1993], Mairesse and Mulkay [2004, 2008] and Lokshin and Mohnen [2007]. It relies on a so-called structural econometric model that involves the conjunction of a theoretical and a statistical model, both largely based on *a priori* economic and statistical considerations, as well as on previous accumulated knowledge

[35] The incrementality ratio is equivalent to the multiplier M1. The domestic external return corresponds to the spillover effect: it is equal to the return the domestic firms as a whole benefit from when one firm increases its private R&D by one unit.

and practical experience. It allows evaluating future reforms and separating short-term from long-term effects. The approach does not directly estimate the effect of the tax credit on R&D expenditures and involves two main steps, namely:

- The computation of the impact of the tax credit on the 'effective price of R&D' faced by the firm, or more generally on the 'user cost of R&D capital' for the firm;
- The specification and estimation of an econometric model that relates the changes in the firm's R&D to changes in the effective price of R&D or in the user cost of R&D capital.

The general specification of the econometric model can be summarized in a regression equation of the following form:

$$g(R\&D) = \sigma\, C(EP_{RD}(\theta), X_c) + X\,\beta + \epsilon \qquad (1)$$

in which the dependent variable is a function g(.) of R&D (such as the expenditures, the capital or the rate of growth of R&D). The explanatory variables are:

- A function C(.) of the effective price R&D EP_{RD} (itself a function of the statutory rate of the tax credit θ) and a vector of other variables X_c. C(.) is usually the user cost of R&D capital.
- A vector X of other explanatory variables.

In what follows, we tend to favour regression (1) in terms of the user cost of R&D capital, which we view as very structural. More descriptive specification can be obtained by replacing C(.) by the effective rate of credit (denoted ERC thereafter) or the effective price of R&D[36]. We call these specifications 'agnostic' since they do not rely on any explicit underlying model:

$$g(R\&D) = \sigma\, EP_{RD}(\theta) + X\,\beta + \epsilon$$

Such models allow evaluating the response of R&D to changes in its effective price EP_{RD} or in its user cost (i.e. the actual price, or user cost, faced by the firm when it makes the R&D investment decision). The parameter of interest in regression (1) is σ, which is often an elasticity since it is usually more appropriate to take the main variables in log-levels.

[36] We consider that the vector X_c is included in the vector X.

From a consistently estimated σ, and knowing the functions g(.), EP_{RD}(.) and C(.), we can derive the marginal effect of a change in θ on the studied R&D outcome.

If the effect of the R&D tax credit on the R&D price or user cost is properly computed (step 1), and if the reaction of R&D to its price or user cost is correctly specified and estimated (step 2), it is thus possible to measure the effect of the tax credit (and also the effect of prospective changes in its features) on the firm's R&D. Of course this method requires addressing thorny econometric issues such as endogeneity and errors in measurement of explanatory variables, in particular as regards the R&D effective price and user cost (or some of their components). Exogenous variability in the R&D effective price and user cost is needed to deal with these problems and to identify and estimate the parameter of interest σ properly, i.e. consistently, precisely and robustly enough. Such variability may originate from firm-specific characteristics that vary across firms and over time, from the precise features and general design of the tax credit differing across various categories of firms and from changes over time.

We shall first present the computation of the effective price of R&D, and then show how it is included in the more general formulation of the user cost of R&D capital, which enters an economically grounded structural relation. We shall finally show briefly how this equation can be further specified as an econometric regression and estimated, before giving more details in Section 4 with the example of the study by Mairesse and Mulkay [2004, 2008] on the French tax credit.

The Effective Price of R&D

Denote P_{RD} the market price of one unit of R&D capital and θ the statutory rate of tax credit, and consider a simple setting in which the tax credit is equal to a share θ of the firm's R&D expenditures. The most elementary formula of the R&D effective price EP_{RD} is thus:

$$EP_{RD} = P_{RD}\,(1 - \theta)$$

For each unit of R&D investment at price P_{RD} the firm receives a tax credit equal to θP_{RD}, as if the price it faced was EP_{RD}. This simple formula becomes more realistic when fiscal depreciation allowances are taken into account: if fiscal rules state that the entire R&D investments are depreciated immediately (as part of government R&D policy), then the firm can subtract the value of these R&D investments from its taxable benefits. If the tax rate is τ, the firm reduces its taxes by $\tau\ P_{RD}$ for each unit of R&D investment. The formula thus becomes:

$$EP_{RD} = P_{RD}\,(1 - \tau - \theta)$$

The effective price of R&D, EP_{RD}, is also known as the 'after-tax price' or the 'tax price' of R&D.

The OECD [1997] has defined an index (B-index) that corresponds to the initial income needed to invest one dollar in R&D and that is commonly used to compare the effective price of R&D across countries. As already stated, firms need to generate an income of $P_{RD}\,(1 - \tau - \theta)$ in order to finance one unit of R&D. But since firms are taxed on their income at rate τ, they actually need to generate a higher pre-tax income (the B-index does not include the price):

$$\text{B-index} = (1 - \tau - \theta) / (1 - \tau)$$

Thus the cost of an investment in one unit of R&D requires $(P_{RD}\,(1 - \tau - \theta)) / (1 - \tau)$. More generally, if firms cannot depreciate immediately all their R&D expenditures but have to comply with specific rules of depreciation allowances (declining balance, straight line), this can be taken into account through an adjustment factor A (smaller than τ) in the slightly more general formula:

$$\text{B-index} = (1 - A - \theta) / (1 - \tau)$$

Yet, this formula does not exactly fit the incremental tax credit because it does not take into account the intertemporal effect of this policy. Indeed, when a firm invests one additional dollar of R&D at time t, it mechanically raises the base level of t+1. Therefore it reduces the potential amount of tax credit it will receive in t+1, which corresponds to an implicit increase in the effective price of R&D in t: since it is anticipated and due to the current level of expenses in R&D, the increase in the effective price of future R&D units should be embedded in the effective price of current units.

The 1989 GAO report, followed by B. Hall [1993], argues that the incremental nature of the tax credit is equivalent to an adjustment of the statutory rate θ in the formula. Instead of θ, an effective rate of credit (ERC) must be computed for each firm depending on its expenses for several years and on its rate of return ρ. In the simple case where the base level is defined as the previous year expenditures, a firm earns θ (in the form of a reduction of its taxes) when it increases R&D by one unit in the current year t, but will loose θ the year after (i.e. in t+1) since the base level increases by one. This anticipated loss must be discounted at rate ρ and finally the effective price of R&D should be:

$$ERC = \theta - \theta / (1 + \rho) = (\theta\, \rho) / (1 + \rho) \qquad (2)$$

For a firm that decreases its R&D expenditures in t+1, the ERC is zero because the tax credit does not apply to it.

The GAO and B. Hall propose further refinements. First, they generalize the ERC to other base levels (in particular when this level is equal to the average of the n previous periods' R&D expenditures). Second they include carryforward rules in the ERC: when a firm cannot receive the total amount of its tax credit because its overall taxes are lower than the tax credit it is entitled to, it receives it the subsequent years. Thus the tax credit earned in t (but effectively received in t+1) is discounted at rate ρ. Therefore (2) becomes:

$$ERC = \theta / (1 + \rho) - \theta / (1 + \rho) = 0$$

B. Hall also takes into account the fact that not all R&D expenditures are eligible to the tax credit: eligible R&D usually has a narrower definition than R&D as it is reported in the firms' books. The previous analysis leads to a more complete specification of the effective price of R&D where η is the share of eligible R&D:

$$EP_{RD} = P_{RD}\, (1 - A - \eta\, ERC) / (1 - \tau)$$

Because of the many situations of the firms (EP_{RD} is partly firm-specific) and of the variations in the features of the tax credit scheme (reference level, statutory rate, ceiling), a significant variability of the effective price of R&D can be obtained, which is required to estimate the reaction of R&D expenditures to changes in their price.

The User Cost of R&D Capital

It is important to highlight the fact that the effective price of R&D (EP_{RD}), as we just defined it, is a marginal price (i.e. the price of the last unit of R&D invested by the firm), which is largely different from the average cost in the case of an incremental tax rate (since only the units above the base benefit from the tax credit). Although we introduced this definition mostly on intuitive grounds, it is also important to see that it is consistent with a formal economic analysis from which a completely specified model of firm production and investment behaviour can be derived. It is not necessary to develop fully this analysis here, but we must nonetheless go one step in this direction by showing briefly how the effective price of R&D must be embedded in the more formal notion of user cost of R&D capital.

Precisely, we show that the user cost of R&D capital can be derived from a (more or less) fully specified structural model, and that it is directly related to the effective price of R&D, as already defined, as well as to other time-varying or firm-specific variables. In the next section, we also show that the user cost of R&D capital can be decomposed into several components, of different variability across firms and over time, that can be more or less affected by severe errors in measurement. Thus in practice, it may make sense to isolate the component of the effective R&D price as more variable and immune to measurement errors (Mairesse and Mulkay [2004, 2008]).

The underlying economic model assumes that the firm optimizes its intertemporal value (defined as the sum of its discounted income flows or dividends). The first-order conditions for the optimum lead to the equilibrium equality between the marginal productivity of R&D capital and its user cost C. Denoting P the price of output, P_{RD} the market price of R&D, F the production function and K the R&D capital stock computed assuming a constant geometric depreciation at rate δ, and without going into the derivation, we obtain the following equation:

$$P_{t+1}\frac{\partial F_{t+1}(K_t, X_{t+1})}{\partial K_t} = C_{t+1} \qquad (3)$$

with the user cost C defined as:

$$C = P_{RD}(\frac{1 - A - ERC}{1 - \tau})(\rho + \delta - \pi)$$

where ρ is the firm-specific rate of return, τ the corporate tax rate, π the inflation rate of R&D, A the fiscal depreciation rate and ERC the effective rate of the tax credit.[37]

How to interpret this formula? Consider that the firm uses a unit of R&D capital for one year: it buys it at the beginning of the year and sells it back at the end of the year. The cost can be interpreted as the 'minimum income' that the marginal unit of R&D has to generate so as to be profitable. It must generate its own market price P_{RD} times the price

[37] The rate of return ρ is firm-specific. More complete formulas take into account the fact that a share of the firm's investments is financed through debt at interest rate r. In this case the interest rate r and the share of indebtedness are added to the computation of the user cost and increase variability. See Mairesse and Mulkay [2004] for explicit derivation.

of borrowing money to the shareholders ρ, plus the depreciation rate δ, minus the increase in its price (when π is positive). In other words, the user cost of R&D is both the cost incurred by a firm when it uses one unit of R&D for one year, and the minimum amount of income the marginal unit of R&D has to generate in order to be profitable. This 'minimum income' is reduced by R&D tax incentives (1 – A – ERC), and thus the higher the effective rate of tax credit ERC, the higher the effect of the tax credit and the lower the user cost of R&D. The user cost can also be seen as the cost incurred by a firm when it rents one unit of R&D capital for one year.

The effective rate of tax credit (ERC) is also deduced from the model and is equal to the ERC as defined previously. In the simple case of an incremental tax credit based on the previous period's expenditures, the ERC of a firm below the ceiling is equal to:

$$ERC = \theta - \theta / (1 + \rho) = (\theta\, \rho) / (1 + \rho) \quad (4a)$$

where θ is the statutory rate of the incremental tax credit.[38] When the tax credit is a volume tax credit, there is no intertemporal effect and the ERC is simply equal to θ. It is also possible to compute ERC for tax credits that have a volume component and an incremental one:

$$ERC = (\theta_1 + \rho\, (\theta_1 + \theta_2)) / (1 + \rho) \qquad (4b)$$

with θ_1 the volume rate and θ_2 the incremental rate[39].

Econometric Specification and Estimation Strategy

In order to proceed further, we have to specify the form of the production function F. Assuming a CES production function (where CES stands for Constant Elasticity of Substitution) of R&D capital and of the other factors of production (i.e. labour, physical capital) supposedly lumped together, we obtain the following relation:

$$\ln K_t = \Omega + \beta \ln Q_{t+1} - \sigma\, (\ln C_{t+1} - \ln P_{t+1})$$

[38] In an incremental setting, the computation of the ERC is only possible for firms that increase their R&D. Firms that decrease their R&D expenditures do not benefit from the tax credit and their ERC equals zero.

[39] The ERC can be adapted to the firms that are above the ceiling. See Mairesse and Mulkay [2004] for further details.

where K is the firm's R&D capital, Q its production in volume (i.e. constant price of a base year), C the R&D cost and P the production price (i.e. the price index with reference to the base year).[40]

Since Q and P are not observed at the firm level, it is useful to transform this equation so as to replace Q and P by the production value V=P.Q, which is available at the firm level. To proceed we have to make an assumption about the functional specification of the firm's demand function. Considering, as it is usual, that the demand price elasticity is approximately constant (i.e. $Q = D_0 P^{-\epsilon}$, where ϵ is the demand price elasticity and D_0 stands for the other demand shifters), and using now for simplicity small letters for the log variables, we obtain:

$$k = \alpha + \omega\, v - \sigma\, c \qquad (5)$$

where k, v and c are respectively the log-levels of R&D capital, production value and R&D cost. The parameter of interest is σ, which is the elasticity of substitution between R&D and other factors; ω is equal to $[\sigma + (1 - \sigma)(\mu / \nu)]$ where μ is the mark-up coefficient and ν the return to scale. The econometric estimation of σ is an estimate of the elasticity of R&D capital demand with respect to the user cost.

As shown in Section 4, equation (5) can be refined in order to take into account the length of the decision process. When panel data are available, fixed effect may also be added in order to correct for unobserved heterogeneity. One econometric issue stems from the fact that when the tax credit is incremental, the cost of R&D depends on the level of R&D expenses: therefore it is endogenous in equation (5).

4. Practical Application of the Structural Approach

This section illustrates the use of structural econometric methods with the evaluation carried out by Mairesse and Mulkay [2008] on the French tax credit.

The French Tax Credit

At the initiative of the Ministry of Research, the tax administration and the Parliament, the tax credit scheme has been modified several times since its introduction in 1983. From 1983 to 2003 the tax credit was incremental, but from 1993 on the number of firms

[40] The functional form assumption of a CES assumes that the elasticity of substitution between R&D capital and an aggregate of other factors is approximately constant.

asking for the tax credit sharply decreased (as can be seen in figure 2), which became a growing concern for the government. There are several reasons for this decrease: in particular since the tax credit was purely incremental many firms reached their maximum R&D, and many firms accumulated so much negative tax credit that they gave up.

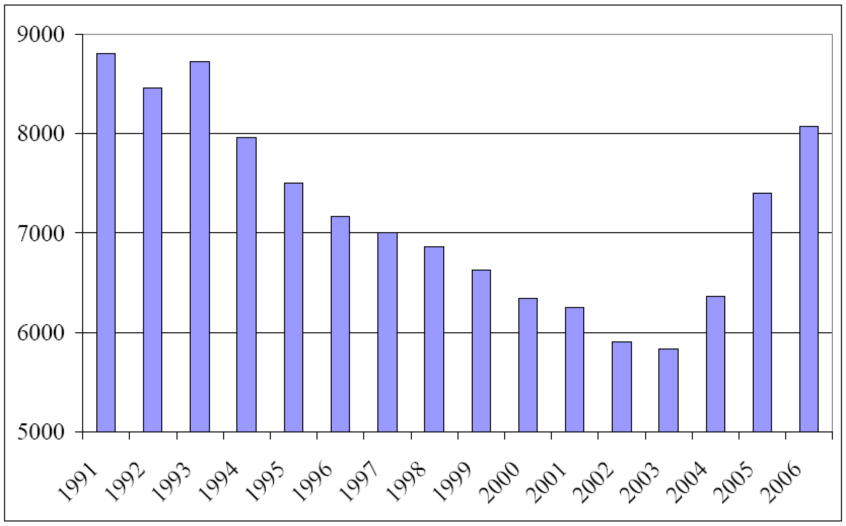

Figure 2: Number of French Firms asking for the Tax Credit[41]

For fear that this situation might entail relocation in other countries and reduce FDIs into France, and because they wanted to foster French private R&D, the Ministry of Research and the French tax administration supported the introduction of a volume component in the tax credit (the volume tax credit was considered more simple and more profitable, and it cannot lead to negative tax credit[42]). As a consequence, the incremental tax credit became a mixed tax credit in 2004. In 2008, the incremental part was completely removed, as well as the ceiling. The current government strategy is to grant more tax credit and to reduce direct project-based subsidies in order to let the firm free to decide how they use the money, and to help small firms more.

The following tables summarize the evolution of the French tax credit's rate and ceiling[43]. From 1983 to 1990, the reference level was the preceding year's R&D, and from 1991 on it was the average of the two preceding years' expenses. In 2004 a volume part was added to the tax credit, and the incremental part was removed in 2008. When the

[41] One may notice that only a share of the declaring firms effectively receive the tax credit. For instance in 2006, 8,071 firms applied for the R&D tax credit but only 5,961 effectively benefited from it. Data from the French Ministry of Research.

[42] When the tax credit includes both a volume part and an incremental part, the negative tax credit is deducted only from the incremental part of future tax credits. Therefore the firms receive the volume part of the tax credit, even if they reduce their expenditures.

[43] From 1998 to 1990, an additional special tax credit was implemented. It is not presented in details here.

tax credit was mixed, the ceiling applied to both the volume part and the incremental part as a whole.

Rate	Ceiling	Year
25%	457 K€	1983-1984
50%	762 K€	1985-1987
50%	1 524 K€	1988-1990
50%	6 100 K€	1991-2003
45%	8 000 K€	2004-2005
40%	10 000 K€	2006
40%	16 000 K€	2007
Removed		2008

Table 1. Incremental tax credit

Rate	Ceiling	Year
5%	8 000 K€	2004-2005
10%	10 000 K€	2006
10%	16 000 K€	2007
		2008
30% up to 100M€ of R&D		
5% above 100M€ of R&D		

Table 2. Volume tax credit

Main Estimation Results

The study by Mairesse and Mulkay [2004, 2008] is conducted over an unbalanced panel of 2,431 French firms (more than 20 employees, mainly in the manufacturing sector) from 1979 to 2003 (25,071 observations). The authors only kept the firms that did R&D for six years or more. The authors have matched accounting data with R&D surveys, but since they do not use tax data they do not know which firm effectively asked for and received the tax credit.

The model they derive was presented in Section 2.2. The following table reports the effective rate of credit (ERC) for fully recipient firms at different time periods. As explained previously, the ERC corresponds to the effect of the tax credit and can be interpreted as a percentage reduction in the cost of R&D: the higher the ERC, the lower the user cost of R&D. The figures clearly show that the change in the base level in 1991 had strong effect on the ERC, which was multiplied by 1.5. The transition towards the volume tax credit had a huge effect on the ERC, corresponding to an important reduction in the user cost of R&D capital.

Year	Effective Rate of Credit (ERC)
1983-1990	1.42%
1991-2003	2.10%
2004-2005	6.89%
2006-2007	11,68%
2008	30% if R&D < 100M€ 5% + (25 / R&D) if R&D > 100M€

Table 3. Average Effective Rate of Tax Credit

They adopt a dynamic specification by adding three lags to each variable of equation (4), so as to provide a more realistic dynamic adjustment mechanism and to take into account the fact that R&D is a long-term process. Instead of differentiating this expression to obtain an accelerator, they rearrange it to obtain an error correction model ECM(3,3). The estimation equation finally writes[44]:

$$\Delta k_{it} = \alpha_i + \chi_1\, \Delta k_{it-1} + \chi_2\, \Delta k_{it-2} + \omega_1\, \Delta v_{it+1} + \omega_2\, \Delta v_{it} + \omega_3\, \Delta v_{it-1} + \sigma_1\, \Delta c_{it+1} + \sigma_2\, \Delta c_{it} + \sigma_3\, \Delta c_{it-1} + \varphi\, (k_{it-1} - v_{it} - c_{it}) + \lambda\, v_{it} + \lambda'\, c_{it} + \varsigma_t + \varepsilon_{it}$$

This choice relies on three reasons: the ECM is an exact deduction of the ADL model (same structure), the ECM allows to estimate long-term effects in addition to short-term effects (the accelerator specification does not allow to do so), and its equilibrium is defined in levels and not in growth rate. This specification allows them to obtain long-term and short-term estimations of σ and ω. Since they use panel data the authors add fixed effects α_i. They also include time effects ς_t to capture the autonomous demand. The long-term value of the effect of the user cost c on the R&D capital k, denoted σ, can be obtained by considering that in the long-term equilibrium, all differences are equal to zero: $\sigma = 1 - (\lambda' / \varphi)$.

The authors discuss the respective assets and liabilities of two estimation methods, the GMM and the within estimator. The GMM allow correcting for the endogeneity of the explanatory variables but it yields too imprecise estimates. The within estimator yields more precise estimates and corrects for the endogeneity of the lagged dependent variables, but it does not correct for the endogeneity of the other variables and in

[44] Δx_t denotes the first difference of log(X) from t to t-1.

particular the user cost. The authors present the results obtained through the within estimator method, which are the most reliable.

They decompose the user cost of R&D into four components in order to correct for the error-in-measurement bias. The first part accounts for financing resources (c_1), the second one for corporate taxes (c_2), the third one for tax depreciation (c_3) and the last one for the effect of the tax credit (c_4). Thus equation (5) rewrites as follows (before transformation into ADL and ECM):

$$k = \alpha + \omega\, v - \sigma_1 c_1 - \sigma_2 c_2 - \sigma_3 c_3 - \sigma_4 c_4 \qquad (6)$$

This allows evaluating separately the effect of the fourth components. This decomposition is useful because the coefficient of the tax credit part of the user cost, c_4, is the more significant.

The long-term elasticity of R&D capital with respect to sales ω^{LT} is significantly estimated at 0.5, and the long-term elasticity of R&D capital with respect to the tax credit component of R&D user cost, σ_4^{LT}, is very significantly estimated at -5.5. The following figure concentrates on the short-term effects of the tax credit and displays the adjustment dynamics.

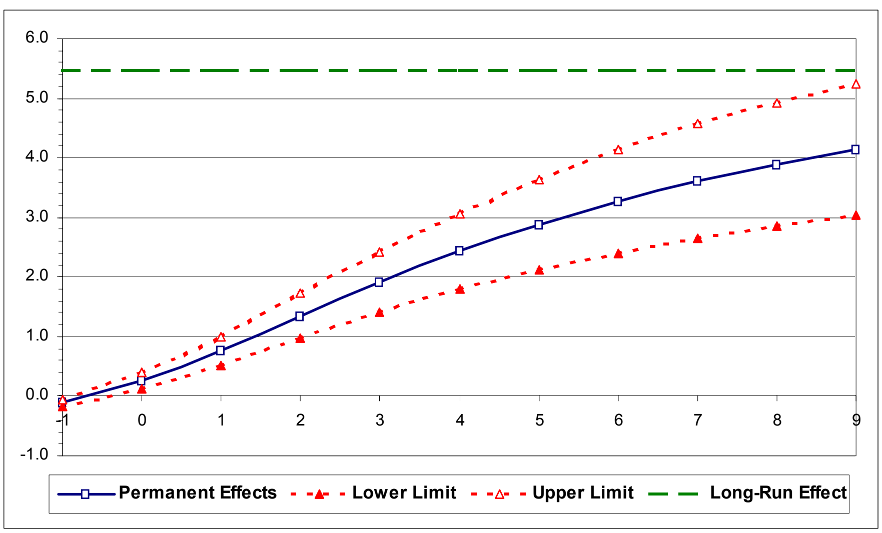

Figure 3. Adjustment Dynamics

The short-term elasticity of R&D capital demand with respect to its cost is plotted on the Y-axis while time is plotted on the X-axis. This figure shows that the effect of the tax credit on the R&D capital is very progressive.

To illustrate these results the authors make a policy simulation for 2003. They simulate the effect of an increase in the statutory rate of the incremental tax credit from 50% to 60%, which corresponds to an increase by 20%. They correspondingly increase the ceiling by 20%. Such a policy change would have provoked an augmentation of government spending on the tax credit by 20%, i.e. an additional 86M€. The elasticity of R&D capital with respect to the statutory rate θ can be computed with this formula:

$$\frac{\partial K}{\partial \theta} = \frac{\partial K}{\partial C_4}\frac{\partial C_4}{\partial ERC}\frac{\partial ERC}{\partial \theta} = \sigma_4^{LT}\frac{\partial C_4}{\partial ERC}\frac{\partial ERC}{\partial \theta}$$

It is equal to 0.24 for the firms that receive the tax credit. Since a share of firms could not receive the tax credit because they reduced their R&D expenses, the global long-term effect would be an increase by 1.2% in the R&D capital, corresponding to 136M€. The multiplier M1[45] is thus 1.6. Therefore the long run multiplier is larger than one and translates an important effect of the tax credit on private R&D expenses. This result is original because most international studies on the tax credit find a multiplier close to one.

5. Comparison with Intuitive Econometric Methods

This section presents the various intuitive econometric methods that have been applied to the evaluation of the tax credit and compares them with the structural methods.

These methods are straightforward but suffer from several weaknesses. They provide convincing ex-post multipliers but they do not allow evaluating future policies (in particular future changes in the features of the tax credit). Furthermore they usually make no distinction between short-term and long-term effects. Above all, they do not use the information provided by the changes in the tax credit features because they usually consider the tax credit as a binary treatment (a firm benefits from the tax credit or not).

In addition to the structural and the intuitive methods, survey or questionnaire methods represent a third way to evaluate a policy[46].

[45] M1 = $(R_1 - R_0)$ / TC.

[46] See discussion paper by Jacek Warda.

5.1 Discontinuity and Difference-in-Difference Analyses

The most natural idea is to compare the R&D (expenditures or rate of growth) of similar firms, ideally the same, before and after the introduction of the tax credit. If their R&D dramatically increases, then it can be argued that such a change can only be explained by the implementation of this policy. Yet, this before-after analysis does not allow separating the effect of the tax credit from macroeconomic shocks or generalized microeconomic changes. Indeed one could make the realistic assumption that the government and the firms understand the importance of R&D in a knowledge-based economy at the same moment, inducing the former to launch the tax credit and the latter to increase R&D. In this case the before-after analysis would indicate that the tax credit has a significant effect on R&D, even if it does not. Therefore it is necessary to implement a difference-in-difference analysis, which is possible thanks to the ceiling of the tax credit.

The ceiling of the tax credit generates a discontinuity between similar firms and it can be considered that the firms are randomly distributed below and above the ceiling, as long as the two groups do not encompass firms that are too far from it. Hægeland and Møen [2007] do so for the Norwegian tax credit, which is limited by a ceiling[47]. They argue that the firms whose expenses would have been above the ceiling in the absence of the tax credit are not affected by the tax credit because the cost of their marginal unit of R&D is not reduced, whereas the cost of the marginal unit of the firms whose R&D expenses would have been under the ceiling in the absence of the tax credit is reduced by the tax credit. The latter have stronger incentives than the former, and the effect of the tax credit on their R&D expenses should be higher. In other words, this framework can be considered as quasi-experimental because the treatment is randomly applied to a group of firm while the other is considered as a counterfactual.

The authors need to determine which firm would have been above or under the ceiling in the absence of the tax credit, so they simply build two groups of firms according to their expenses before the introduction of the tax credit in 2002 (one group for the firms below the ceiling and one for the firms above the ceiling in 2001).

To estimate the effect of the policy on R&D expenditures, the authors concentrate on the rates of growth of R&D between 2001 and 2003, which is equivalent to a difference-in-difference analysis. Under the strong assumptions that the ceiling is exogenous and can be considered as random, that the firms are comparable and that the expenses of the firms are stable across time, the between-group difference in the R&D growth rate between

[47] The Norwegian tax credit is a 20% volume tax credit. Its ceiling is defined by the maximum of R&D expenses that can be declared, i.e. 4 million Norwegian Krones.

2001 and 2003 can be interpreted as evidence of the effect of the tax credit. Another underlying assumption is that the marginal cost of R&D effectively determines the level of R&D expenditures[48].

From a practical point of view, one should notice that an issue may stem from the construction of the two groups. Because of the limited number of observations, the authors face a trade-off between too wide and too narrow a sample below and above the discontinuity. When the sample is the sample is too wide the comparability of the firms across the two groups is weak; when it is too narrow a larger share of firms is likely to be classified in the wrong group (the firms just below the ceiling in t might have been above the ceiling in t+1 even in the absence of the tax credit, and vice versa), hence the importance of the assumption about the stability of R&D expenses.

The results of the article clearly show that the firms of the 'below group' have a higher rate of growth of R&D, which seems to indicate that the tax credit stimulates additional R&D, without providing a reliable measure of its effect.

5.2 Matching Method

E. Duguet [2007] applies the matching method to the evaluation of the tax credit, which is original in this research area. He uses French data on R&D firms over a period (1993-2003) in which the rate of the tax credit did not change (50%). Thus this method does not rely on the variability of the tax credit's features but rather considers the tax credit as a binary treatment.

When two firms have the same probability to obtain the tax credit but only one asks for it and effectively receives it, then the author assumes that the tax credit was randomly attributed. This is an artificial way to create the ideal experiment in which the tax credit is randomly attributed to the firms. The fact that some firms do not benefit from the tax credit is considered a quasi-experiment and these firms are used as counterfactuals.

[48] If the marginal cost of R&D is not the only determinant of the firms' level of R&D, this method does not provide a reliable measure of the effect of the tax credit. For instance, if the firms have a global budget dedicated to R&D then they rather take into account the average cost of R&D. In this case the tax credit also generates incentives for firms above the ceiling. Indeed, the tax credit reduces the average cost of R&D (even if the cost of the marginal units is not reduced by the policy) because the cost of the units below the ceiling is reduced. So the firms above the ceiling spend more than what they would have done in the absence of the tax credit. Therefore both groups have incentives to raise their R&D; but since the 'below-group' has stronger incentives (all its units of R&D are subsidized), there is a difference in R&D rates of growth. As a consequence this method shows that the tax credit has an effect, but it does not allow to measure it (because the 'above-group' is not a good counterfactual).

Thus this method relies on the comparison between the firms that benefit from the tax credit (group 1) and the firms that do not benefit from the tax credit (group 2). The probability to receive the tax credit (propensity score) is estimated for each observation with a Probit model. The main determinants of the tax credit are the lagged status with regard to the tax credit (a firm that received the tax credit in t-1 has a high probability to receive it in t) and the ratio of R&D to sales. The propensity scores are then used to match 'similar' firms: each firm that receives the tax credit is matched with a firm that has the same propensity score but does not receive the tax credit. The difference between their R&D rates of growth reflects the effect of the tax credit on this specific type of firm. When they are averaged over the whole sample, these differences yield an estimate of the average effect of the tax credit.

In Duguet (2007), two different groups are used as counterfactuals. The first one (group 2a) gathers all the firms that do not receive the tax credit, whereas the second one (group 2b) gathers only the firms that do not receive the tax credit *and* increase their R&D expenditures. Using these two counterfactual groups, two estimates of the effect of the tax credit can be computed: one on the full sample and one on the subsample of firms with positive rates of growth of R&D expenditures.

The latter estimate requires that some firms could obtain the tax credit (because they increase their R&D) but do not obtain it, and the author does not discuss the reasons why such firms do not receive it. This paves the way for a major criticism, though. Can these firms convincingly be compared to the firms that receive the tax credit?

In group 2a, many firms do not benefit from the tax credit simply because they do not increase their R&D expenditures[49]. But in this case, their probability to receive the tax credit should be zero. The construction of group 2b requires that some firms in the sample do not ask for the tax credit while they increase their R&D expenditures. As far as these firms are concerned, the explanation could be that:

- Their R&D expenses are not eligible to the credit.
- They ignore the existence of the policy.
- They forget to ask for the credit.
- They fear that asking for the tax credit might provoke a tax audit.

Thus there may be unobserved differences between the two groups, such as interest for research and innovation or excessive fear of tax audits (revealing an unobserved weakness). In this case, the matching method yields a biased estimator since it relies on the strong assumption that all explanatory variables are observed and that the selection

[49] The tax credit being incremental, they cannot obtain it.

into the tax credit is random conditional on observed variables. The main criticism is thus the lack of comparability of the matched firms.

This method also shares the drawbacks of the ones previously discussed: no long-term effect can be estimated, no evaluation of future changes can be made. Furthermore this method does not really use the fact that the data are panel data, whereas the same firms are observed over 10 years.

The effect of the tax credit is presented in the form of a multiplier M1. It is equal to 3.33 with group 2a and to 1 with group 2b. Therefore, this method indicates that the tax credit is more efficient than direct public funding of R&D (i.e. generates more than one euro of R&D per euro of tax credit forgone by the government) only if the firms that benefit from it are compared to the whole sample of firms, including firms decreasing their R&D expenditures.

5.3 Descriptive Econometric Methods with Dummy Variables

Simple econometric methods can be applied to the evaluation of the R&D tax credit when firm-level data are available. We call them agnostic because they rely on no explicit assumption concerning the underlying model. One may simply regress firm-level R&D on a set of variables X and a dummy TC indicating whether the firm benefited from the tax credit or not (of course this method requires knowing whether a firm benefits from the tax credit or not):

$$R\&D = \alpha\, TC + X\beta + \epsilon$$

This set of methods is limited by several econometric and theoretical weaknesses:

- First, the classical omitted-variable bias occurs in the estimation of α whenever a variable correlated with TC is unobservable or is omitted in the analysis, which is all the more likely since these regressions do not rely on a theoretical model.

- Second, these methods rely on the strong assumptions that the tax credit has the same effect on all firms in the sample (or in a given industry), and that this effect is linear and additive. In particular it does not take into account the possibility of a firm-specific effect nor the changes in the features of the tax credit across time. Here again the policy is considered a binary treatment, so future policy cannot be evaluated.

- Third, this method requires that many firms in the sample do not benefit from the tax credit. Since it is universal, firms observed before its launching are needed. But they are not sufficient because if the only source of identification stems from the difference between firms before and after the introduction of the tax credit (as in the time-discontinuity analysis) the estimation of the tax credit effect will be biased by macroeconomic evolutions. It is therefore necessary to observe firms that do not benefit from the tax credit while others do so at the same moment.

- Finally, the lack of underlying model makes the results hard to interpret: the most striking example of this issue is the choice of the dependent variable. Hall and Van Reenen [1999] present a model in which the dependent variable is the level of R&D expenses, Hægeland and Møen [2007] present a similar model where the dependent variable is the rate of growth of R&D, while Duguet [2007] chooses the annual firm-level rate of growth of R&D. As a whole, these various specifications are not coherent. This underlines an issue that is often downplayed or simply ignored by the authors: they do not explicitly say why they choose the level of R&D expenses, their log-level or their rate of growth as the dependent variable, which results in a lack of coherence and makes comparability difficult.

More complex specifications can be implemented by adding time dummies, dummies indicating whether a firm is above the ceiling, and product of variables[50]. Some articles also feature attempts to correct various biases including selection, endogeneity and unobserved heterogeneity. In sum, the difference between intuitive methods and structural methods is blurring as intuitive methods are growing more accurate and structural methods are not completely structural and leave several aspects of the models in the black box[51]. This seems to indicate that there is more of a *continuum* rather than a dividing line between complex intuitive methods and structural methods.

6. In guise of Conclusion: Some Thoughts on Improving Evaluation

This section outlines several thoughts about remaining issues. They aim at providing avenues for improvements in the evaluation of the tax credit as well as a wider insight of this public policy.

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[50] Hægeland and Møen [2007] estimate many specifications with dummy variables. In particular they try to separate short term from long term effects, and they try to address selection. They also multiply dummies indicating position with respect to the ceiling and dummies indicating that the firm benefit from the tax credit, which corresponds to a difference-in-difference method.

[51] For instance, the choice of the dependent variable (level, log-level, difference, rate of growth) or the computation method for the explanatory variables, such as the rate of return, are scarcely completely structural.

Is it Better to Know which Firms Effectively Receive the Tax Credit?

Most econometric methods previously presented require tax data since they rely on dummy variables indicating whether the observed firms effectively benefit from the tax credit. Yet structural econometric methods do not require such data because they rely on the simulated user cost of R&D, which corresponds to the cost faced by the firm if it behaves rationally. This implies that the simulated user cost of a firm that could ask for the tax credit is reduced by the tax credit, even if the firm does not ask for the tax credit.

However, a significant share of the firms theoretically entitled to benefit from the tax credit does not receive it in practice. One may argue that this is a weakness of structural methods, since the R&D user cost of the firms that *could* have the credit but do not have it is *equal* to the user cost of the firms that effectively receive the credit. In fact this is rather an advantage of structural methods[52].

Indeed, the structural methods previously presented provide an evaluation of the *average effect of the policy on the firm that should benefit from it.* The fact that a share of firms do not ask for the tax credit (i.e. do not participate in the public policy while they should do so) is embedded in the evaluation. What is estimated is the *average effect* of a decrease in the potential cost of R&D, provided that among the firms that could obtain the tax credit some effectively receive it and others do not.

If fiscal data were used to compute an effective user cost of R&D, taking into account the effective status of the firms vis-à-vis the tax credit, then:

- The user cost of the firms that effectively benefit from the tax credit would be reduced by the tax credit.
- The user cost of the firms that could benefit from the tax credit but do not do so would not be affected by the tax credit.
- The user cost of the firms that cannot benefit from the tax credit[53] would not be affected by the tax credit.

This could lead to an overestimation of the effect of the tax credit on the firms that should take advantage of it. Indeed, if one believes that the tax credit is efficient, then *ceteris paribus* the firms that could obtain the tax credit but do not ask for it have lower

[52] From a practical point of view, it might often be easier for the researcher to obtain data on R&D than tax data.

[53] For instance, the firms that reduce their R&D expenses in the incremental tax credit.

expenses. As a consequence the negative correlation between the level of R&D expenses and the user cost would be higher than in the previous setting in which a reduced user cost is simulated for all the firms that could obtain the tax credit. Therefore the estimated effect of the tax credit on the expenses would be biased upwards.

Issues in Evaluating the Effect of the Tax Credit on the Decision to do R&D

Evaluations of the R&D tax credit usually concentrate on R&D firms only, which is a very specific sample. As outlined in the previous paragraph, some authors estimate the effect of the tax credit on the firms that effectively benefit from it, and some of them estimate its effect on the firms that should benefit from it. But generally the data only include R&D firms, which is likely to generate a selection bias. Furthermore, several studies are restricted to firms that have long spells of R&D. Once more, the question is to know if one is seeking to evaluate the effect of the policy on a specific sample of firms (those doing R&D) or on a wider population of firms.

Indeed, the R&D tax credit might have an effect on the firms that do not perform R&D. Since the tax credit reduces the potential cost of R&D, it should induce some firms to start R&D. This could be included in the structural methods by adding a selection step with the user cost of R&D as an explanatory variable.[54] The result would be an evaluation of the effect of the tax credit both on the level of expenses and on the decision to perform R&D, which is a way to extend the scope of the analysis.[55]

The selection process should be included in the global structural model, otherwise the analysis would only be half-structural. In practice, the addition of a selection step in the model raises difficult theoretical and econometric issues. First, the selection process should include a firm-specific fixed cost of entry into R&D in addition to the marginal user cost of R&D. Such a cost is difficult to estimate. Yet it is necessary because otherwise the estimates will lead to the conclusion that the tax credit deter the firms from starting R&D, because all of them could benefit from the tax credit while a vast majority does not start R&D.[56] Second, the selection model should be dynamic since R&D is highly autocorrelated: the decision to perform R&D at time t is strongly determined by

[54] Corchuelo [2004] adds a selection step, but is model is not structural and the user cost he uses is different from the one previously presented. Indeed it is an average user cost rather than a marginal user cost. The decision to start R&D has also been studied *per se* by Hægeland and Møen [2007], but since they only rely on year dummies, their results are hardly convincing.

[55] Furthermore the selection step would allow to correct for selection in the estimation of the tax credit's effect on the level of expenses.

[56] When the tax credit is incremental, the firms that start doing R&D benefit from the tax credit because their expenses increase.

the R&D status at time t-1. This autocorrelation is partly due to the existence of fixed costs and to the long-term scope of R&D. Third, from a purely practical point of view, the selection process should include fixed effects so as to take advantage of panel data, which implies heavy computations when the sample is large.

Incremental versus Volume Tax Credit

The representative firm invests in R&D as long as the private marginal productivity of R&D is higher than its marginal cost. Since the private marginal productivity of R&D is believed to be lower than its social productivity due to positive externalities, the government is encouraged to subsidize marginal units until they get to the point where the social marginal productivity of R&D equals its cost.

The first best policy would be to subsidize only the units that exceed the level of expenditures without the tax credit. But the amount of R&D expenditures a firm would incur in the absence of the tax credit is private information and is not observed by the tax administration. In this setting of asymmetric information, an assumption must be made to design the incremental tax credit: for instance, 'in the absence of the tax credit, the firm-level R&D expenses are stable'. This way, the tax credit does not subsidize too many units that would have been purchased by the firm anyway. The incremental tax credit is thus a second best.

On the contrary, the volume tax credit subsidizes all units of R&D and firms can capitalize on it without increasing their R&D. In this case it can be considered a windfall by some firms. Here again, the question of the objective of the policy is very important. This point may be illustrated by the French example. When it was introduced in 1983, the French tax credit was aimed at increasing R&D expenses. Today its objective is more complex since it is considered a fiscal incentive that attracts foreign investments and deters French firms from relocating in other countries. The transition from an incremental to a volume tax credit is thus a way to protect domestic industry.

The real-world comparison between the volume tax credit and the incremental tax credit also involves arguments that are not taken into account in the basic model. First, the incremental tax credit is deemed more costly for the firms because it is more complex. It is also criticized because of the deterring effect of the negative tax credit mechanism. If a firm suffers from an exogenous shock at time t that forces it to reduce its R&D expenditures, it will not have incentives to increase its R&D at time t+1 because of the negative tax credit. This criticism shows that, rather than the transition to a volume tax credit, another policy change could have been implemented in France: the removal of the negative tax credit mechanism. Yet one might argue that the negative tax credit mechanism could not be removed lest the firms declare zero expenditure every other year so as to maximize their incremental tax credit.

Figures 3 and 4 illustrate the differences between the incremental and the volume tax credit. As can be seen, the volume tax credit is far more expensive than the incremental tax credit, since it subsidizes all units of R&D instead of subsidizing the marginal units only.

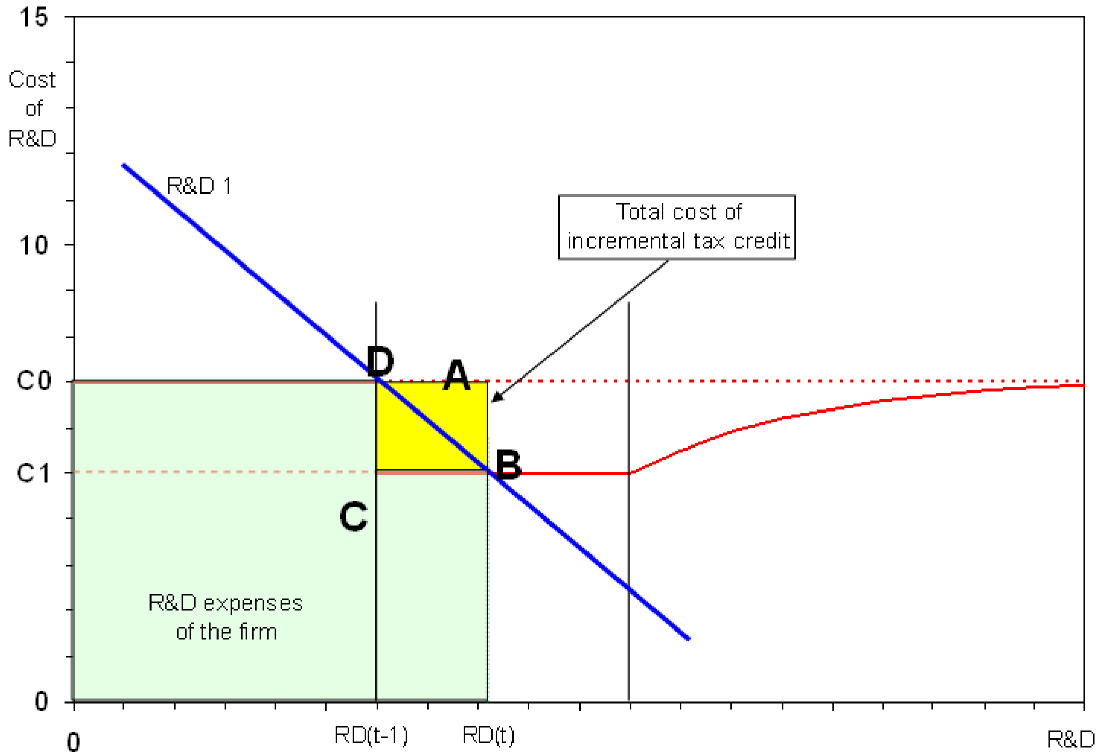

Figure 3: Incremental Tax Credit

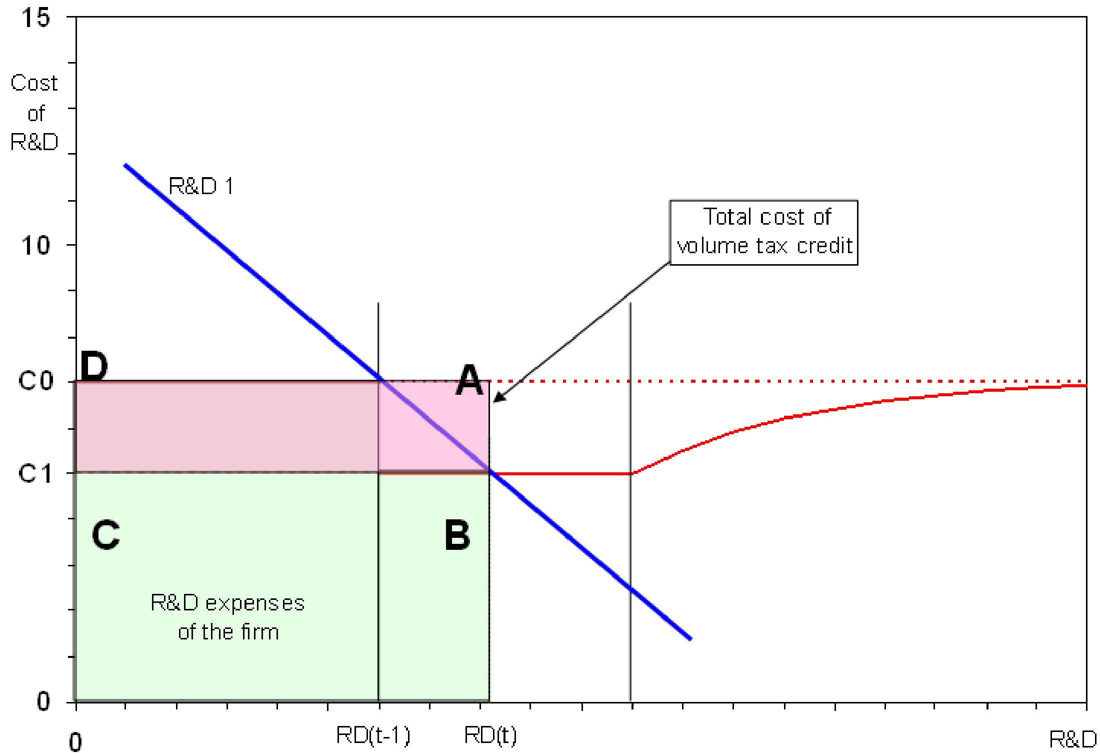

Figure 4: Volume Tax Credit

Can Structural Models Resist Dramatic Policy Changes?

The structural methods should allow predicting the effect of future policy changes, which is a major advantage. It is possible to simulate the effect of an increase in the statutory rate of the tax credit, which is a minor change in the policy.[57] Could the structural model adapt to a major policy change? The French tax credit has undergone a major reform in 2008 with the complete removal of the incremental part of the tax credit. This transition can be simulated by using the elasticities estimated with the incremental tax credit, but the results are unrealistically high and may not be reliable.

Indeed, the model was estimated locally, i.e. with small variations of the effective rate of the tax credit. But the transition to the volume tax credit corresponds to a dramatic increase in the effective rate of the tax credit and in the user cost of capital. Therefore, the local elasticity might not be used to simulate such a change. This is a practical limitation of structural methods: even if they can theoretically adapt to dramatic policy changes, the estimates obtained on data before the change might not be appropriate to predict the future impact of the policy.

[57] For such a simulation, see for instance Mairesse and Mulkay [2008].

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What does it take for an R&D tax incentive policy to be effective?

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1. Introduction

Because of the conviction that R&D (research and development) earns a high social rate of return, contributes to economic growth or assures competitiveness, governments spend a non negligible amount of money to induce firms to invest in R&D. A popular measure in this regards is the policy of R&D tax incentives. It reduces the corporate income taxes or the employer's social security contributions in proportion to the R&D effort and thereby decreases the cost of doing R&D so that firms move closer to the R&D level that would be socially optimal. This policy has the virtue of being neutral, i.e. giving a tax relief to any kind of R&D expenditure, although some governments give special credits to for instance environmental R&D or R&D done in collaboration with universities.

The policy of R&D tax incentives has been in place for many years in countries like the U.S., France or Canada. It was adopted in the UK a few years ago and is presently being considered to be introduced in Germany. France, Canada, Norway, Australia and the Netherlands re-evaluate the usefulness and the effectiveness of their R&D tax incentives on a regular basis, because of its ever increasing importance in the science and technology budget. France and Spain recently reformed their policy of R&D tax credits.

This paper has two objectives. The first is to review how the effectiveness of R&D tax incentives has been assessed in previous evaluations, trying in this way to build up a comprehensive evaluation scheme, which would encompass previous evaluation approaches, and to sort out and harmonize various notions and measurements. How do cost effectiveness, additionality, and net welfare gain relate to each other? Is cost effectiveness the same thing as the bang for the buck? Where do econometric evaluations enter the cost/benefit analysis? This is the object of section 2. The second objective is to assess the sensitivity of the evaluation outcome to the magnitude of certain parameters. Is additionality a must for having an effective R&D tax incentive policy? How high must the externality parameter be to overcome the negative effect of administration costs or the costs of distortionary taxation? This is the object of section 3. In section 4 we report on the success of a past policy changes in the Netherlands, and we simulate the effect of various parameter changes in the existing Dutch R&D tax incentive scheme.

2. Reconciling notions and evaluation methods

2.1 The notion of additionality

The R&D tax incentive policy is aimed at making private enterprises spend more on R&D to get closer to the social optimum. The most common way to verify whether a tax incentive policy is effective is to test for additionality as opposed to crowding out of R&D. If firms do nothing but substitute private R&D financing by tax support, then there is full crowding out, and the policy is clearly ineffective. If firms substitute part of their own funding by government funding, there is partial crowding out. If they spend an amount of R&D in excess of the amount of tax incentives they get from government then the policy is said to lead to additional R&D.

Testing for additionality somehow amounts to comparing the tax expenditures with the additional amount of R&D spent by private firms. It involves the computation of the "bang for the buck" (BFTB), which, as noted by Parsons and Phillips (2007), is also known in the literature as "incrementality ratio", "cost effectiveness ratio" or "tax sensitivity ratio". It is measured by dividing the amount of R&D generated by the R&D tax incentives by the net tax revenue loss (also called tax expenditures). It has not always been done correctly, as reported by Hall and van Reenen (2000). Some authors have added up all credits claimed without considering the change in the firms' tax positions because of the tax credit. For instance, in the Netherlands the tax credits that can be deducted from the firm's social security contributions are themselves taxable. Other studies have calculated the tax credits claimed taking an average firm and ignoring the firms' heterogeneity in the type of R&D they do and in their sensitivity to the tax credits.

The R&D tax credits may be based on the level of R&D and or the incremental R&D with respect to a reference. The amount claimed by a firm may depend on the revenue position of the firm and the possibility to carry forward or backward, or to claim for refundability of, unused tax credits. The rates may vary depending on the size of the firm or its amount of R&D. In principle, everything should be quantifiable but the researcher might not have all the information on hand to compute the claimable tax credits correctly. Moreover, there may be a difference between the tax credits computed on the basis of the reported expenditures and the statutory tax rates, the actually claimed tax credits or those finally approved by the tax authorities. And there may a timing problem between the date the credits are claimed and the date they are received. The ideal would be to have access to the administrative data of whatever governmental agency hands out the R&D tax credits, and the data from the tax offices that collect the corporate income taxes.

One way to estimate the additional R&D generated by the R&D tax incentives is to ask firms directly whether tax incentives make a difference to their R&D expenditures. There is at least the suspicion that either firms do not know how much R&D they would have done in the absence of R&D tax credits, or that they are biased in their responses so as to be able to continue benefiting from it. It should, however, be noted that the Australian evaluation by the Bureau of Industry Economics (1993) reports consistency between declarations by firms and econometric evidence of additionality.

A more objective way to estimate the extent of additionality is to use econometric techniques. There are two broad approaches to isolate the effect of R&D tax incentives on R&D: the structural modelling approach and the treatment evaluation method. The structural modelling approach consists in regressing an R&D demand equation (in terms of stocks or flows, but preferably stocks if enough observations are available to construct them) on its typical determinants, among which the user cost of R&D incorporating the R&D tax parameters. A dummy taking the value one for R&D tax credit as opposed to firms or periods without tax credits would also be feasible, but then the foregone tax revenue would be more difficult to calculate. In contrast, the user cost of R&D includes a quantification of the tax incentives via what has come to be known as the B-index. The B-index, introduced by Warda and McFetridge (1983), is defined as the ratio of the net cost of a Euro spent on R&D, after all quantifiable tax incentives have been accounted for, to the net income from one Euro of revenue. In other words, the B-index indicates the marginal income before taxes needed for the marginal R&D investment to break even. This method has been used by Hall (1993), Bloom, Griffith and van Reenen (2002), Dagenais, Mohnen and Therrien (2004) and Mairesse and Mulkay (2004).

It is important here to recognize the endogeneity of the tax credit, as the rates generally vary with the amount of R&D. Likewise the dummy that tax credits have been claimed is endogenous, because firms may, for fear of being audited, sheer ignorance or compliance costs, decide not to apply for R&D tax credits.[58]Handling this endogeneity calls for good instruments. It is important to allow for the fact that the induced R&D may take time to show up because of adjustment costs in R&D (finding scientists and engineers, setting up a lab, devising projects). Therefore a difference should be made between short-term and long-term effects. Finally, when comparing studies one should be careful not to compare elasticities, with semi-elasticities or absolute derivatives for the price effect on R&D.

The treatment evaluation methods consist in running quasi-experiments or constructing counterfactuals. Matching estimators compare the average R&D effort of firms that receive R&D tax credits with the average R&D of firms that do not but that are otherwise similar, for instance in having the same likelihood of receiving R&D tax credits but prefering not to apply for them (Czarnitzki, Hanel and Rosa, 2004; Corchuelo and Martínez-Ros, 2008, Duguet, 2007).[59] The difference-in-differences estimator compare the R&D of firms in the control and treated groups before and after a policy change, in this case a new feature in R&D tax incentives (Cornet and Vroomen, 2005). In regression discontinuity design one compares the R&D of firms that are affected with those that are unaffected by an exogenous discontinuity in the treatment function, for example firms just below and just above a ceiling in the conditions for being eligible to receive R&D tax credits (Haegeland and Moen, 2007).

[58] The latest evaluation of the R&D tax incentives in the Netherlands (de Jong and Verhoeven, 2007) reports that for firms with less than 10 employees only one firm out of 3 applies for R&D tax credits.

[59] In this particular instance, the matching estimator is perhaps not the most appropriate method because the choice of being in the treatment or in the control group is not quite exogenous.

2.2 Cost-benefit calculations or net welfare effects

A more comprehensive computation of the effectiveness of R&D tax incentives would require a full cost-benefit analysis. It would require computing the total (direct and indirect) costs and benefits related to the R&D tax incentive. On the benefit side, it would mean not just computing the amount of additional R&D but also the return on that R&D. The return on the marginal R&D may be lower since the R&D would not have been undertaken without the tax incentive. That requires looking into the existence of second-order and third-order effects, as explained in the following section, i.e. the effects on innovation behaviour and on an economic performance measure like productivity or profitability. Another kind of secondary effect is the R&D induced by increased output stemming from the additional R&D (see Bernstein, 1986). There could also be a return from making firms become R&D performers[60] and from attracting footloose investors (multinational companies attracted by tax incentives). A proper social cost-benefit analysis would also require incorporating R&D spillovers, which can be positive (rent or knowledge externalities) or negative (market stealing or obsolescence).

On the cost side of the assessment should be included implementation costs, such as hiring consultants, accountants, financial experts; administration costs such as hiring auditors, tax officers; the existence of wage effects diluting the quantity effects, inter-temporal differences in the timing of costs and benefits, as well as the opportunity costs of having to raise income taxes to finance the tax incentives. A somewhat more remote possibility is that domestic R&D tax incentives could benefit foreign firms and decrease the domestic firms' competitive position or conversely make domestic firms more receptive to international R&D spillovers.

2.3 Second-order and third-order effects

It is not sufficient to show additionality in R&D, the additional R&D should also yield a positive rate of return for there to be a private benefit. A number of studies have examined the effects of tax incentives on various measures or aspects of innovation (patents, the share of innovative products in total sales, the propensity to come up with new products, new to the firm or new to the market). These phenomena are referred to as behavioural innovations, i.e. the way firms behave differently in terms of innovation output. They are also often referred to as second-order effects as opposed to first-order effects (on R&D) and third-order effects (on firm performance measures such as productivity or profitability).

[60] Hægeland and Møen (2007) report that firms that previously did not invest in R&D are more likely to start doing so as a result of SkatteFUNN, the Norwegian R&D tax credit system.

Second- and third-order effects can be estimated within some version of the Crépon-Duguet-Mairesse (CDM) model. It consists in modelling R&D intensity, innovation output (INNO) and productivity (PROD) as a system of simultaneous equations. In a first equation, firm's R&D is explained by the R&D tax credits (TC) and other controls; in the second equation firm's share of innovative products in total sales is explained by the R&D intensity; and in a third equation total factor productivity (level or growth) is explained by the share of innovative sales:

$$\begin{cases} R\&D_{it} = \mathbf{Z}_{it}\beta + X_{it}\delta + \alpha TC_{it} + \theta_i + u_{it} \\ INNO_{it} = \Pi_{it}\varphi + \psi \widehat{R\&D}_{it} + \gamma_2\theta_i + \varepsilon_{it} \\ PROD_{it} = \mathbf{W}_{it}\eta + \kappa \widehat{INNO}_{it} + \gamma_3\theta_i + \upsilon_{it} \end{cases} \quad (1)$$

where each equation has a random error component and θ_i is an individual effect that plays out differently in each equation (in the case of panel data). The system of simultaneous equations (1) can be estimated by asymptotic least squares or instrumental variable methods and allows estimating the second- and third-order effects of the fiscal incentives. If estimated in logs, the coefficient ψ can be interpreted as the elasticity of the innovative output with respect to R&D, which in turn is a function of the fiscal incentives and other covariates. The second-order effect of the tax credits can be computed as the product of the partial effects (elasticities if variables are in logs):

$$\frac{\partial INNO}{\partial TC} = \frac{\partial R\&D}{\partial TC} \cdot \frac{\partial INNO}{\partial R\&D} = \alpha \cdot \psi \,. \quad (2)$$

Similarly, a third-order effect of the fiscal incentives on firm productivity can be computed as the product of the three partial effects (elasticities):

$$\frac{\partial PROD}{\partial TC} = \frac{\partial R\&D}{\partial TC} \cdot \frac{\partial INNO}{\partial R\&D} \cdot \frac{\partial PROD}{\partial INNO} = \alpha \cdot \psi \cdot \kappa \,. \quad (3)$$

Lokshin and Mohnen (2007a) report for the Netherlands a short-run elasticity of R&D to the user cost of R&D 0.77, an elasticity of the share of innovative sales to the R&D intensity of 0.52 and an elasticity of total factor productivity growth to the share of innovative sales of 0.07. The total elasticity of PROD with respect to TC is thus equal to 0.028, implying that a 10% increase in tax credits would increase (labour) productivity by 0.28%. The advantage of the simultaneous-equations model over reduced form models is that it allows todisentangle the effects of tax incentives on innovation input, innovation output and productivity.

Another approach would be to estimate directly a reduced form of innovation or economic performance on the user cost of R&D. This approach is attractive for its simplicity. It was used by Brouwer et al. (2002) in the first official evaluation of the R&D tax incentive for the Netherlands. They regressed various innovation output measures such as the share in total sales of innovative products on received tax credits and found that a 1% higher amount of tax credits leads to a 19 % higher share of innovative sales in the short-run. Similarly, Cappelen et al (2008) use this approach on two cross-sections of Norwegian firms for 2001 and 2004 to study the effects of the Norwegian SkatteFUNN R&D support scheme on firm innovation activities and patenting. They find that the SkatteFUNN credits have a positive impact on the new (or improved) product for the firm, but not the new (or improved) product for the market.

Parsons and Phillips (2007) calculate the net welfare gain of R&D tax incentives following the cost-benefit framework suggested by Lattimore (1997). From a comprehensive survey of estimates reported in the literature, they take the median values of the R&D incrementality ratio (0.86) and of the domestic external rate of return to R&D (0.56), and they compute an average marginal excess burden of taxation of 0.27. The compliance and administration costs in proportion of the tax incentives provided are set at 8% and 2% respectively.[61] For these parameter values, they estimate a net welfare effect per dollar of tax expenditure of 10.9%.

3. Sensitivity analysis

It is a daunting task to assess the exact magnitudes of all the elements that enter a proper cost-benefit analysis. It involves parameter estimates with more or less high standard errors. An alternative would be to perform a sensitivity analysis by simulating the benefit-cost ratio using ranges of reasonable estimates of R&D responsiveness, opportunity costs, externalities, administration and implementation costs, rates of time preference, differential responsiveness by firm size, or possible differences in the rates of return on marginal R&D projects stimulated by the tax incentives compared to the rates of returns earned on already performed R&D projects, to see what patterns of estimates of the various determinants would produce a positive net welfare gain. An exercise of this kind is conducted by Parsons and Phillips (2007) for Canada. They report for instance that the domestic external return would have to fall to 0.45 or the incrementality ratio to 0.71, all other things equal, to produce a net welfare loss per dollar of R&D tax incentive.

[61] The recent Dutch evaluation of its R&D tax incentive system (de Jong and Verhoeven, 2007) reports compliance and administration costs of 7% and 2%, figures that are very close to those reported for Canada (Parsons and Phillips, 2007).

Nevertheless they conclude that for a reasonable range of estimates the net welfare gain of R&D tax incentives is positive.

Instead of comparing the costs and benefits in the period just after the introduction of a new policy or at the new long-run equilibrium (assuming it gets reached in one shot), we argue that it is more appropriate to compare the whole sequence of costs and benefits, in discounted present value terms, before and after the introduction, the removal or the modification of R&D tax incentives. The timing at which costs and benefits occur may make a difference. Costs and benefits may be spread out over time because of adjustment costs in R&D, delays in getting the R&D tax credits, or intertemporal connections between tax credits as in the case of incremental R&D tax credits. This type of reasoning has been applied in Dagenais, Mohnen, Therrien (2004) and Lokshin and Mohnen (2007b). We propose to measure the bang for the buck by the following expression:

$$BFTB = \frac{\sum_i \sum_{t=1}^{\infty} (\widetilde{R}_{it} - R_{it})/(1+r)^{t-1}}{\sum_i \sum_{t=1}^{\infty} (\widetilde{W}_{it} - W_{it})/(1+r)^{t-1}}. \tag{4}$$

where R_{it} is the R&D expenditure of firm i in period t that the firm would have incurred in the absence of a change in the R&D tax credit and $\widetilde{R}_{it}$ the corresponding R&D expenditure after the change in the R&D tax credit; W_{it} and $\widetilde{W}_{it}$ are the respective R&D cost of firm i supported by government.

To illustrate our proposed measure of cost effectiveness and its sensitivity to the incorporation of costs and benefits other than those directly related to changes in the R&D tax incentives, we simulate a set of 1000 observations, replicating the composition of the Dutch population of R&D performers. The Dutch R&D tax incentive scheme, known as WBSO, allows firms to deduct from their social security contributions 40% of their R&D labour costs up to €110,000 and 14% of the remainder with a cap on total tax incentives of €7.9 million. We assume that the R&D stock adjusts to its desired level by a partial adjustment mechanism, whereby in every period a fraction λ of the desired adjustment is accomplished. We use the estimated R&D price elasticities and adjustment speeds of R&D estimated in Lokshin and Mohnen (2007b) for Dutch firms: an estimated λ of 0.58 for large firms and 0.51 for small firms, a short-run price elasticity of R&D stock of 0.11 for large firms and 0.31 for small firms, and a long-run price elasticity of 0.20 for large firms and 0.61 for small firms.

Our simulated data set is constructed as follows: in the first step we draw a random sample of 1000 observations on R&D from a uniform distribution with a minimum of €500 and a maximum corresponding to the first bracket ceiling of €110,000. This subsample represents a cohort of small firms and starters whose R&D expenditures fall entirely in the first bracket. In the second step, we similarly draw another sample of 1000 observations on R&D from a uniform distribution with a minimum of 110,001 Euro and a maximum that corresponds to a total of tax support set at €7.9 million. This sub-sample represents a cohort of larger firms whose R&D expenditures span over the two brackets. Our final sample on which we perform simulation experiments corresponds to 75% of observations randomly drawn from the first cohort and 25% observations randomly drawn from the second cohort.[62] The mean R&D of the small- and big-firm cohorts are €56,000 and €3,907,000, respectively, with an overall sample mean of €956,000.

In addition to the random sample, and in order to increase the variation in the subsequently constructed user cost, we randomly draw a number of other parameters. We draw the share of labour R&D expenditures from a normal distribution with a mean of 0.7 and a standard deviation of 0.18. We truncate the maximum of the wage share to unity. We then create the remaining R&D expenditure shares mimicking the actual data values (share of R&D spent on equipment, buildings and other R&D expenditures), ensuring that all the shares sum up to unity.

In the final step, we construct the user cost of R&D using the simulated R&D data as:

$$u_{Ri} = P_R(r+\delta)\frac{1}{1-\tau}\left\{1-(1-\tau)w_i^{L}\gamma_i(R_i)-\tau\kappa_i\right\} \tag{5}$$

where P_R is the R&D deflator, r is the real interest rate, δ is the depreciation rate of the stock of knowledge assumed to be 15%, τ is the corporate income tax rate, w_i^L is the percentage of labour costs in total R&D, $\gamma_i(R_i)$ is the fraction of private R&D supported by the tax incentive program, itself taxable, and κ_i is the fraction of total R&D expenditures that can be immediately expensed.[63] $\gamma_i(.)$ depends on R_i because firms that fall in the second bracket of R&D expenditures benefit from a lower rate of R&D tax credit. κ_i is different from one because the capital expenditures part of R&D cannot be immediately expensed.

Table 1 Components for the computation of the bang for the buck (equation (4))

[62] In the Netherlands SMEs make up about 75% of all firms (see de Jong and Verhoeven, 2007).

[63] For more details on the construction of the user cost of R&D for the Netherlands, see Lokshin and Mohnen (2007b).

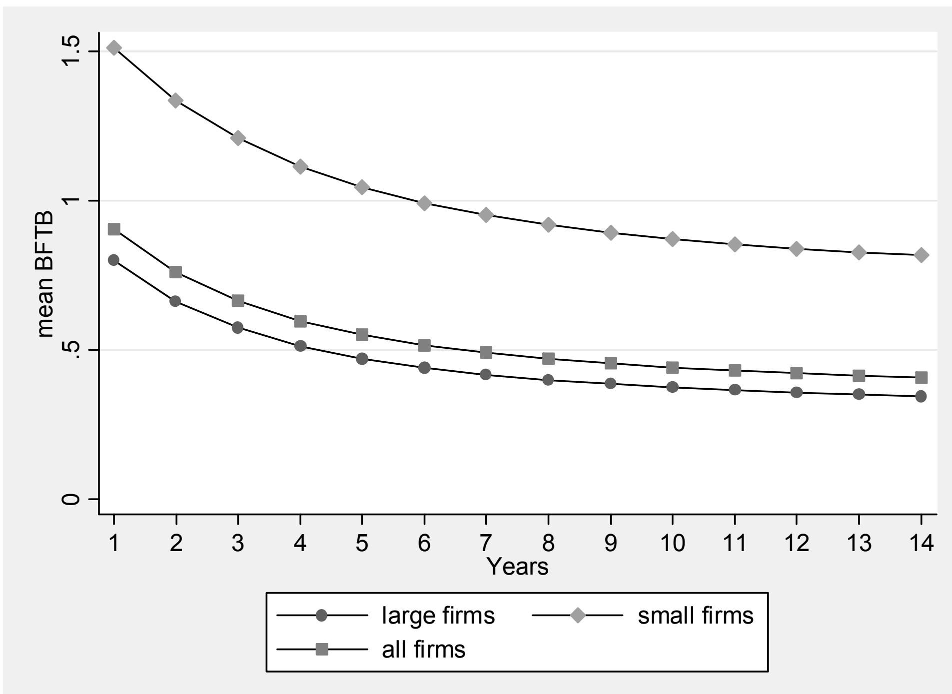
time	Change in R&D expenditures ($\widetilde{R}_t - R_t$)	Change in foregone tax revenues ($\widetilde{W}_t - W_t$)
1	$(\partial K_1 / \partial u_R^1)\Delta u_R^1$	$(1-\tau)w^L[\widetilde{\gamma}(\widetilde{R}_1)\widetilde{R}_1 - \gamma(R_1)R_1] - \tau\kappa(\widetilde{R}_1 - R_1)$
2	$\delta(\partial K_1 / \partial u_R^1)\Delta u_R^1 + (\partial K_2 / \partial u_R^1)\Delta u_R^1$	$(1-\tau)w^L[\widetilde{\gamma}(\widetilde{R}_2)\widetilde{R}_2 - \gamma(R_2)R_2] - \tau\kappa(\widetilde{R}_2 - R_2)$
3	$\delta(\partial K_1 / \partial u_R^1 + \partial K_2 / \partial u_R^1)\Delta u_R^1$ $+ (\partial K_3 / \partial u_R^1)\Delta u_R^1$	$(1-\tau)w^L[\widetilde{\gamma}(\widetilde{R}_3)\widetilde{R}_3 - \gamma(R_3)R_3] - \tau\kappa(\widetilde{R}_3 - R_3)$
.	.	.
t	$\delta(\partial K_1 / \partial u_R^1 + \partial K_2 / \partial u_R^1 + \ldots + \partial K_{t-1} / \partial u_R^1)\Delta u_R^1$ $+ (\partial K_t / \partial u_R^1)\Delta u_R^1$	$(1-\tau)w^L[\widetilde{\gamma}(\widetilde{R}_t)\widetilde{R}_t - \gamma(R_t)R_t] - \tau\kappa(\widetilde{R}_t - R_t)$

Notes: R stands for R&D expenditures, K for R&D stock, δ is the depreciation rate of the R&D stock, the subscripts correspond to time periods starting with period 1 when the policy shock takes place, superscript ~ denotes values after the policy shock. The derivative $\partial K_j / \partial u_R^1$ represents the change in desired R&D stock in period j after the change in the user cost of R&D due to a change in R&D tax incentives in period 1 (Δu_R^1). In Lokshin and Mohnen's (2007b) model, it is given by $\frac{\partial K_i}{\partial u_1^R} = -\sigma\lambda(1-\lambda)^{t-1}\frac{\widetilde{K}_t}{u_1^R}$.

In our base experiment we assess the costs and benefits of a complete removal of R&D tax credits, i.e. setting $\widetilde{\gamma}(.) = 0$. This policy shock leads to an increase in the user cost of R&D and a consequent decrease of the optimal R&D stock. Firms, from whatever position they are in (it need not be a steady state equilibrium), strive to adjust to the new steady state corresponding to the change in the user cost of R&D. To arrive at the new steady-state R&D stock firms decrease their R&D investment and hence government saves on foregone tax revenues by no longer supporting the R&D incentive scheme. Table 1 summarizes the old and the new trajectory of R&D flows for a particular firm (for ease of notation the index i has been removed) and the tax revenues foregone by government from period 1 onwards. As we assume a geometric adjustment towards the new steady state, it will theoretically take for forever to reach the new desired stock, although it is essentially reached after 15 to 20 periods. In order to estimate the BFTB we compute the ratio of the accumulated discounted differences in R&D expenditures from period 1 onwards till infinity between the two scenarios (with and without the R&D tax credits) to the accumulated discounted government savings due to the scheme's removal.

Since the tax support is more generous towards small and medium sized enterprises, it is of interest to compare the effectiveness of the tax credit policy for SMEs and large enterprises. To illustrate the impact of the removal of the R&D tax scheme, Figure 1 plots the estimated BFTB for small firms (whose R&D falls entirely in the first bracket of the Dutch R&D tax incentive scheme) and for bigger firms (whose R&D spans over the two brackets of the scheme). The BFTB after one period is above unity only for smaller firms. But, it declines rapidly and converges to a point slightly below unity for small firms and well below unity for large firms. Although our sample is created so as to mimic the actual population of scheme's users, the overall BFTB line is closer to the one that pertains to large firms, the total R&D of which dominates the sample.

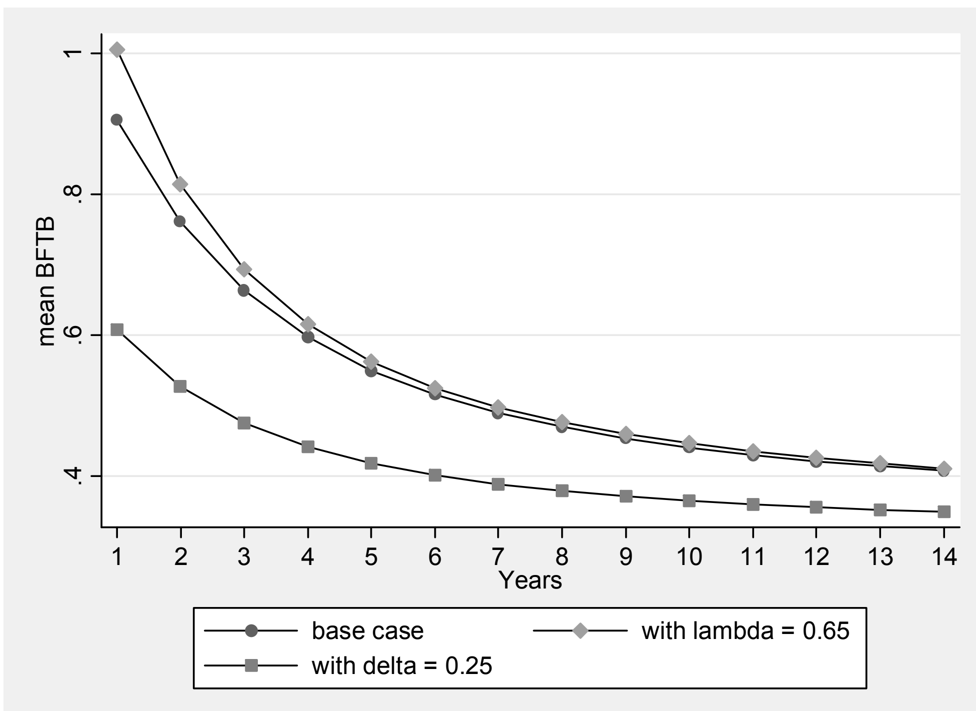
Figure 1: Mean BFTB after t years: all, large, and small firms



The rapid decline of the BFTB is due to the transfer cost (or deadweight loss) caused by the level-based nature of the fiscal incentive scheme. Intuitively, government supports any increment in R&D to the extent that it allows this R&D to be immediately expensed (in some countries, but not in the Netherlands, it also provides an increment-based R&D tax credit), but by introducing the level-based WBSO the Dutch government also supports the level of R&D that existed at the time the policy was introduced, i.e. an amount of R&D that would have been performed in the absence of the tax credits. The support of the latter is a deadweight loss from the social planner's perspective. The transfer cost amounts to 88% of the total cost accruing to the government for supporting the tax incentive scheme. The latter is computed by adding the first terms in the second column of table 1 and dividing it by the sum of the total elements of column 2 (summing over all firms and appropriately discounting).

Given our modelling assumptions, the curvature of the evolution of the BFTB curve and the behaviour of R&D investment can be shown to depend on the R&D stock depreciation rate δ, the partial adjustment coefficient λ and the discount rate $(1+r)^{-1}$. The increase in adjustment coefficient leads to a steeper BFTB curve and an upward shift of the curve. The increase in depreciation rate δ leads to flatter curve and downward shift in the curve. Figure 2 illustrates the difference in the cumulative bang for the buck for three scenarios: the baseline case, reproducing the middle curve in Fig.1, and the curves that correspond to a higher speed in the adjustment of R&D stock (0.65 instead of 0.5) and a higher depreciation rate for the R&D stock (0.25 instead of 0.15).

Figure 2: Mean BFTB after t years, all firms



In all our experiments so far we observe that firms respond to the removal of R&D tax credits by decreasing their R&D investment in the first period following the policy change; however their R&D behaviour in the subsequent periods depends on the relative magnitudes of δ and λ. It can be shown (the proof is available from authors upon request) that in the model of Lokshin and Mohnen (2007b) an initial drop in R&D expenditures due to the removal of the level-based R&D tax credit will be followed by a lower drop (compared to the initial level of R&D expenditures) in the subsequent periods when $\delta < \lambda$. When $\delta > \lambda$, R&D levels will keep declining more and more until a new steady state is reached. We observe that small firms are quite responsive to the shock. The initial drop (from t=1 to t=2) in average R&D spending is steeper for smaller firms compared to large firms: it is about 55% for small firms and 7.5% for large firms. The total drop from the initial shock to the point of convergence some 10 periods later is about 16% for the small firms and is only 2.0% for the large firms.

To do a more accurate cost-benefit analysis we shall follow the example of Parsons and Phillips (2007) and compute a net welfare gain including the BTFB, the social return to R&D, administration and compliance costs, and the cost of distortionary taxes. Accounting for the social rate of return to R&D, i.e. including the effects of R&D spillovers, amounts to multiplying the numerator of equation (4) by $(1+\varphi)$ where φ is the social rate of return to R&D and subtracting the taxes paid on the social returns to R&D from the tax revenues foregone in the denominator. Accounting for administration and compliance costs (c) amounts to multiplying that part of the denominator of (4) that relates to the R&D tax credit (the first terms in column 2 of table 1) by (1+c). Accounting for the costs of distortionary taxes (d) amounts to multiplying the whole denominator of (4) by (1+d).

Table 2 we summarize the outcomes of various sensitivity analyses on the short-run and long run net welfare gains. Introducing a 10 percent administration and compliance cost decreases even further the benefit/cost ratio, although its effect on the long-run welfare gain appears minimal. Adding a 30 percent additional cost of distortionary taxation reduces the benefit/cost ratio even further down to 0.28 in the long run. When we express the benefits in terms of social returns assuming a 10% social rate of return on R&D, we obtain a net welfare gain of 7 percent in the short run and of 3 percent in the long run. If we allow for a 30% social rate of return the net welfare gain rises to 22 percent in the short run and 9 percent in the long run. If we put the social rate of return to 50% (which is close to the median return reported by Parsons and Phillips (2007) the net welfare gain rises to 38 percent in the short run and 16 percent in the long run. The long-run outcomes are always smaller than the short-run outcomes because of the deadweight loss. The 16 percent net welfare gain from R&D tax incentives in the Netherlands is close to the 11 percent figure reported by Parsons and Phillips (2007).

Table 2 Benefit/cost analysis from a removal of level-based R&D tax credits

	Scenarios	Short run net welfare gain	Long run net welfare gain
	Base case		
1	Bang for the buck	0.91	0.37
	Adding to the base case		
2	10 cent administration and compliance cost	0.84	0.34
3	10 cent administration and compliance cost, and 30% cost of distortionary taxation	0.65	0.26
4	10 cent administration and compliance cost, 30% cost of distortionary taxation and 10% social rate of return	0.07	0.03
5	10 cent administration and compliance cost, 30% cost of distortionary taxation and 30% social rate of return	0.21	0.09
6	10 cent administration and compliance cost, 30% cost of distortionary taxation and 50% social rate of return	0.36	0.15
	BFTB for different size distributions		
7	43% of small firms	0.94	0.40
8	23% of small firms	0.83	0.34

4. Policy experiments

Parameters of the fiscal incentive schemes rarely stay constant over time. Governments may wish to give an additional boost to R&D or increase the stimulus for a particular target group (e.g., starting firms, small and medium sized enterprises, etc.). For example, the Dutch scheme parameters have varied a number of times since 1994. The first bracket ceiling was extended from €45,000 to €68,000 (in 1996), later to €90,000 (in 2001) and most recently to €110,000 (in 2004). The first bracket rate was increased from 25% to 40% in 1996 and most recently to 42% (in 2004). The second bracket rate was increased most recently from 13% to 14% (in 2004). A special first bracket rate exceeding the normal first bracket rate by 20% was introduced for starting firms in 2001. A question that naturally arises is how sensitive firms are to marginal changes in the fiscal incentive scheme parameters. In order to answer this question, we performed some additional experiments in which we simulated the effect of a marginal change in a parameter of the tax scheme holding all other parameters constant.

Changes in the scheme's parameters lead to changes in the user cost and may thus affect a firm's R&D decisions. From our experiments we conclude, however, that the impact on the user cost is not substantial when the changes in the tax scheme's parameters are small. For example, an increase in the first bracket rate of 2% results in a change of the B-index from 0.71 to 0.73 in our simulated sample and a decrease of the user cost of 0.2% on average for firms which are in the first bracket and has practically no impact on the larger firms. The decrease in the user cost prompts a modest response in terms of the increased R&D spending of about 2.5% in the first period (for small firms), which gradually declines to about 1.3% in the long run. The results also suggest that the response for large firms to changes in the first bracket rate in terms of additional R&D is negligible.

When the first bracket length is extended by €20,000 or the second bracket rate is increased by 1% we observe very little change in the user cost (magnitudes of the order of 0.1%). The increase in R&D levels due to the extension of the first bracket, even for small firms, is about 0.3% in the short run. The increase in R&D levels for large firms due to the increase in the second bracket rate is about 0.5% in the short run. This latter experiment is of course not relevant for small firms, whose R&D by definition lies entirely in the first bracket.

Our experiments with introducing marginal changes in the scheme's parameters show that in terms of the increased R&D spending the impact of marginal changes in the fiscal incentive scheme are limited. The most promising change from the policy perspective is the increase in the first bracket rate which prompts almost a proportional increase in the R&D spending in small firms, but this effect declines as firms adjust to the new steady state. We find minimal impact of the marginal changes in the scheme's parameters in terms of the R&D spending for large firms.

It is often the case that fiscal incentive schemes' aim a particular target group. This could be small and medium size enterprises, young firms or firms in a particular (technological) sector. The policy of preferential treatment of small firms is justified from the point of view of government because SMEs are likely to be more reactive to the changes in R&D tax incentives. On the one hand, this is due to their relatively greater difficulty in financing their R&D as a result of having little collateral; on the other hand, they may be young firms with little to show in terms of success, they may not even have patents to signal their capability to innovate.

The simulation experiments that we carried out so far suggest that the preferential treatment of smaller firms for R&D tax credits is justified. R&D tax credits are more effective in stimulating R&D investment in small firms and are quite wasteful in terms of cost-benefit for large firms. As a final experiment we investigate the impact in terms of the cost-benefit of a compositional change in the population of users. We do this by drawing a sample of 1000 observations from a uniform distribution with a minimum of R&D expenditures of €500 and a maximum set equal to €250,000 in one case, which corresponds to an R&D department of about 5 people and to €500,000 in the second case.

When the maximum R&D is set at €250,000 the share of small firms in our sample is 43% and the share of their R&D in the total is 20%. The results of these experiments are summarized in Table 2. The initial BFTB for the whole sample is close to unity, and it is well below unity in the long run. Increasing the maximum R&D to €500,000 reduces the share of small firms to 23% and the share of their R&D to 5%, while the BFTB for the whole sample becomes even smaller. Increasing the share of small firms (which, as before, are defined as those with an R&D that falls entirely in the first bracket) increases the overall BFTB, but not by a substantial amount.

Cornet and Vroomen (2005) is one of the few studies that have evaluated the effectiveness of changes in the R&D incentive scheme. They examined the result of two changes in the Dutch WBSO system that were introduced in 2001: the increase of the ceiling of the first bracket from €68,067 to €90,756 and the introduction of the starter's facility that provides an extra 20 percent tax credit for firms in the first bracket. Using counterfactuals analyses, the authors find that the increase of the first bracket ceiling yields a BFTB of only 10 to 20 cent and the introduction of the starter's facility a BFTB of 50 to 80 cent. The low estimates could in part be due to difficulties in identifying the respective effects, but are also in line with the results of our simulation.

5. Conclusion

In this paper we have tried to demystify the conventional wisdom that an effective tax incentive policy should lead to a cost effectiveness ratio, or bang for the buck, greater than one. With level-based tax incentives, it is inevitable that this ratio is smaller than one because of a transfer cost, or deadweight loss, resulting from supporting R&D that would be done anyway. In this sense, level-based tax incentives are akin to R&D subsidies. A cost-effectiveness ratio smaller than one is, however, not sufficient to condemn the R&D tax incentive policy for being inefficient. What matters is the net welfare gain of such a policy, i.e. whether the social return of the additional R&D exceeds the net compliance, administration, and opportunity costs of public funding.

In the presence of adjustment costs in R&D, administrative delays in paying the tax incentives, or other reasons for irregular and asymmetric distributions of costs and benefits over time, it is important to consider the time path of the realizations of the social costs and benefits, as we have illustrated in section 3.

Using reasonable estimates of the various components of the net welfare gains and simulated data representative of the Dutch population of R&D performers, we conclude that the Dutch WBSO R&D tax incentive scheme leads to a positive net welfare gain. Changing the value of the tax parameters does not make a great difference in terms of net welfare gains.

In designing a fiscal incentive scheme an important choice to be made by policymakers is between a level-based and an increment-based R&D tax credit system. With a level-based system (volume regulation) any R&D performed is eligible for tax credits, whereas with a increment-based system only R&D that exceeds a base level is eligible for R&D tax credits. The reference point in the incremental scheme can be the amount of R&D in a reference year or the average expenditures over a number of years. Most countries that have a fiscal incentive scheme opt for a volume-based regulation. Few countries implement the incremental system, e.g. Spain, Ireland, Portugal and up to recently, France (Nill, 2005).

There are good reasons for it. First, increment-based schemes are more difficult and costly to administer. Second, they lead to market distortions and uncertainty among firms. Indeed they encourage firms to have a cycling R&D behaviour to maximize the benefits of tax incentives (see Hollander, Haurie and L'Ecuyer, 1987 and Lemaire, 1996). Third, they are limited in their effects as any increase in R&D in a given year reduces the possibility to claim tax credits in future years (when the reference base is a moving base). However, as we have shown, volume-based schemes are inefficient because they involve large transfer costs by supporting pre-existing R&D that would have been done even in the absence of R&D tax credits, a weakness not shared by incremental R&D tax credit schemes. While previous research acknowledges the transfer cost in the volume-based schemes (e.g. Russo, 2004), which quite naturally leads to a bang for the buck below one, the value of one is still largely considered as the sign of an effective tax incentive policy.

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Assessing the effect of R&D tax credits on R&D start-up and location decisions

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1. Introduction

In addition to increasing the overall amount of R&D activity R&D tax credits may have other explicit or implicit objectives such as attracting regionally or internationally mobile R&D investment, encouraging firms to start R&D activities for the first time and encouraging firms to conduct R&D in conjunction with universities. Policy makers may want to evaluate how R&D tax credits affect these outcomes and how the precise design of an R&D tax credit system impacts on these elements of firm behaviour.

R&D activity is becoming increasingly international. For example, in the UK highly mobile multinational firms (both UK and foreign-owned) account for the majority of R&D expenditure as shown in Table 1 using data for the year 2000. In 2006 US owned businesses carried out 20% of UK intramural R&D expenditure with French, Japanese and German businesses accounting for a further 6%, 2% and 2% respectively.[64] Figure 1 illustrates the proportion of R&D expenditure that is financed from abroad for the EU-15 countries, France, Germany and the UK. The figures for the EU-15 and the UK show a clear increase over time in the proportion of R&D expenditure financed overseas, pointing to increasing internationalisation of R&D activity. Finally Figure 2 illustrates trends in trade in R&D (which involves the transfer of intellectual property rights) for the UK, and shows an increase in R&D exports over time.

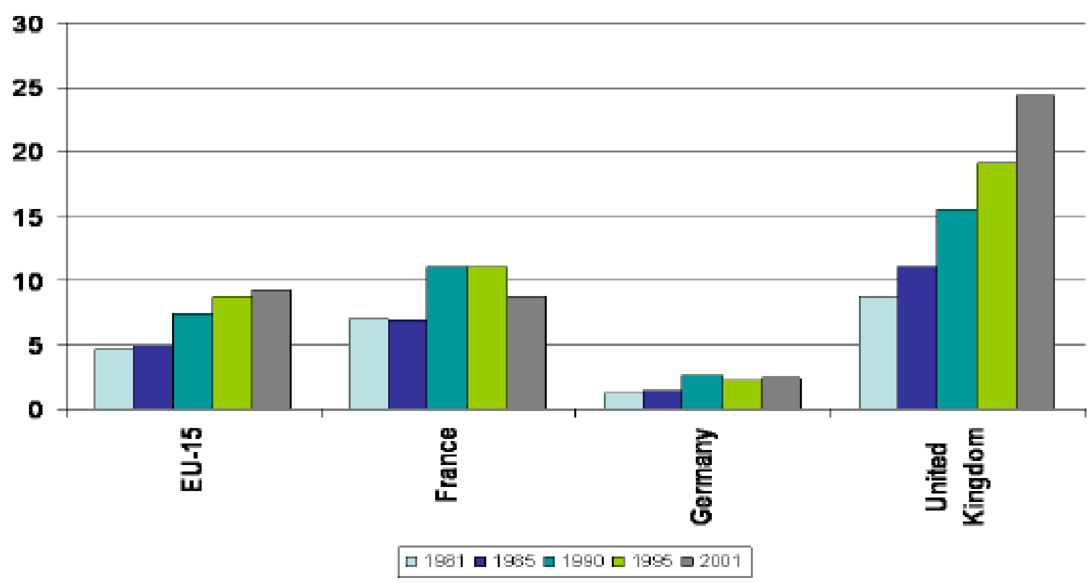
[64] ONS (2008).

Table 1: R&D Activity and Ownership

R&D Product Group	Intramural R&D 2000	% Intramural R&D expenditure accounted for by		
		Domestic	UK-MNEs	Foreign-MNEs
Pharmaceuticals and Chemicals	£3.42 billion	16%	52%	32%
Mechanical Engineering and Electrical Machinery	£2.36 billion	16%	36%	48%
Transport Equipment and Aerospace	£1.85 billion	10%	52%	38%
Other Manufacturing	£1.08 billion	42%	38%	21%
Services	£2.25 billion	39%	43%	17%

Source: Griffith, Redding and Simpson (2005).

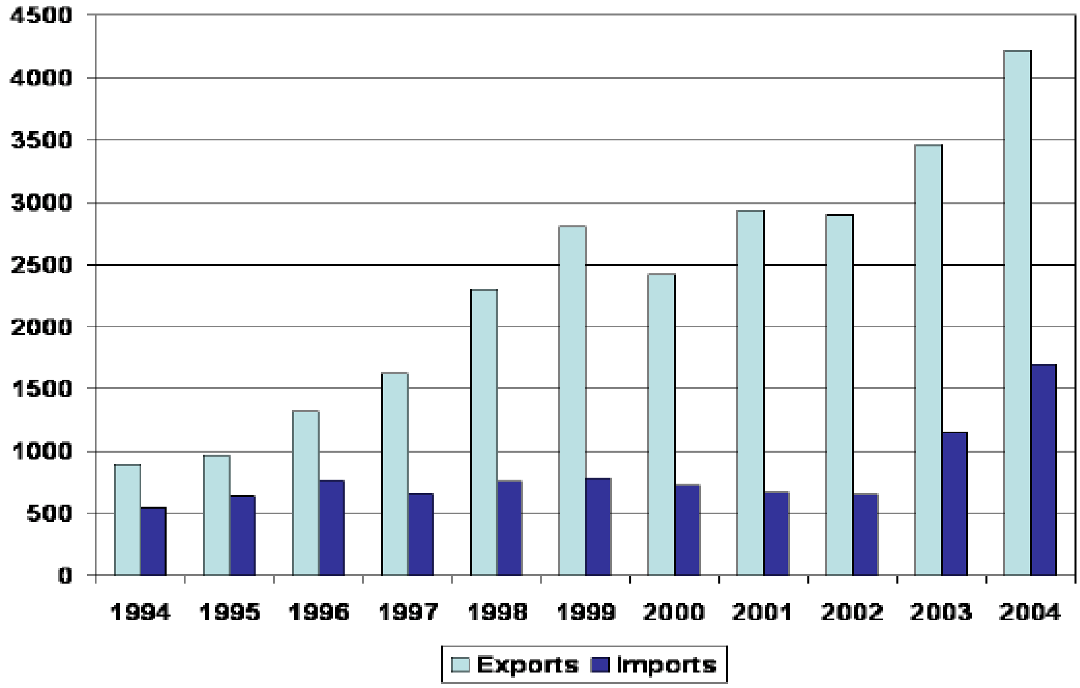
Figure 1: Proportion of R&D expenditure financed from abroad



Source: OECD Main Science and Technology Indicators 2004, reported in Abramovsky, Griffith and Harrison (2005).

Given a rise in the international mobility of R&D and given that large multinational firms are likely to conduct a significant amount of R&D, one way for an individual country to increase its own aggregate R&D expenditure is to ensure that it is an attractive location for footloose R&D activity. While skilled labour, high quality scientific institutions and market access may be key factors determining where firms choose to locate their R&D activity, R&D tax credits and the (corporate) tax system more broadly may also have a role to play.

Figure 2: Imports and Exports of R&D, £ million



Source: Table 3.9 in ONS, The Pink Book, 2005, reported in Abramovsky, Griffith and Harrison (2005).

Other mechanisms which may also have an impact on a country's aggregate R&D activity, although very likely on a smaller scale than attracting large multinationals, are inducing firms to start conducting R&D, or inducing firms to start conducting R&D in conjunction with universities or other research institutions. Again R&D tax credits may have an effect on these decisions. Unlike the choice by a firm with a long R&D track record of whether to increase R&D expenditure at the margin, these decisions of where to locate R&D, whether to start carrying out R&D, and whether to start carrying out R&D with a university partner can be characterised as discrete choices.

The discussion above suggests that R&D tax credits may have differential effects on different types of firms. Small or new domestic firms may be induced to start conducting R&D. Large multinational firms may be making decisions about where to locate their R&D investment across countries or across regions within a country. The remainder of this discussion paper considers these potential heterogeneous effects of R&D tax credits on different types of firms, and how these might vary with alternative scheme designs. It considers econometric evaluation methods that might be used to address these questions with examples from existing evaluations and the academic literature. Section 2 discusses location decisions and Section 3 R&D start-up decisions. Section 4 briefly discusses survey evidence and Section 5 provides some concluding remarks.

2. Do R&D tax credits affect the location of R&D?

This section outlines econometric approaches to analysing the effects of R&D tax credits on the location of R&D activity. First I briefly discuss some issues around the influence of the design of the R&D tax credit scheme.

In addition to considering whether R&D tax credits affect R&D location decisions a second question is how the precise design of the credit impacts on this decision. A primary aim of evaluating the effectiveness of R&D tax credits is to isolate causal effects of the credit on R&D expenditure. Often the focus is on marginal R&D investment decisions of already R&D active firms, where marginal R&D investment decisions would be expected to be affected by the effective marginal tax rate on R&D expenditure. As discussed above the decision of where to locate a new R&D facility can be characterised as a discrete investment decision. The literature suggests that such investment decisions are likely to be affected by the effective average tax rate applying to R&D expenditure across potential locations (see Devereux and Griffith, 1998). If this is the case then the design of the R&D tax credit scheme, incremental versus volume, might affect the impact of the credit on these marginal and discrete decisions, (for a given cost of the credit). In addition the extent to which companies can claim R&D tax credits domestically on R&D activity carried out abroad, and the tax treatment of foreign source income may also play a role. If attracting footloose R&D is a specific aim of R&D tax credits then these consideration merit further theoretical and empirical investigation.

Econometric evaluation of the effect of R&D tax credits on the location of R&D

To analyse new location decisions micro data would be needed on where firms locate their new R&D facilities either across countries or within a country where the generosity of R&D tax credits varies across locations, (e.g. Canada or the US). An alternative is to use more aggregate data on R&D expenditure over time across each of these locations, e.g. expenditure at the industry-level in each location over time, or a expenditure at the location-level over time, although this would encompass changes in R&D expenditure due to entry and exit and due to surviving firms increasing or decreasing their R&D activity.

Ideally econometric analysis would exploit both cross-section variation in the generosity and/or design of R&D tax credits across geographic locations and time-series variation in the generosity within geographic locations. Analysis could relate location choices to differential variation in the generosity of R&D tax credits across locations over time. The key will be to separately identify the impact of R&D tax credits on location choices from other area-time varying characteristics that might affect R&D activity. It will therefore be important to control for area-time varying characteristics such as wages, land costs, universities and other infrastructure etc. In an analysis using micro-level data firm characteristics are also likely to be important. Defever (2006) analyses the location of different functions within multinational firms across Europe. His study emphasises that firms' R&D facilities and production facilities exhibit co-location.

Specific details of the R&D tax credit scheme which imply differential impacts across firms could to be taken into consideration and potentially be used to aid identification of effects. An increase in the generosity of R&D tax credits in a location might have a very different effect on the attractiveness of that location for mobile R&D activity depending on the tax treatment of firms incorporated versus not incorporated in the area, for example whether or not firms that were incorporated outside the location were eligible to claim R&D credits on R&D in that location. Similarly, an increase in the generosity of R&D tax credits might be expected to have a differential effect on location decisions depending on other area characteristics which determine the attractiveness of the area as a location for R&D, such as the strength of the science base and the supply of skilled workers.

Boxes 1 and 2 provide two examples of studies from the academic literature that examine whether R&D tax credits have an impact on the location of R&D, and which ask whether there is any evidence of "R&D tax competition" for mobile R&D activity. Box 1 provides a cross-country example (Bloom and Griffith, 2001), and Box 2 provides a within-country example (Wilson, 2007). In both cases data on aggregate (either country-year level, or US State-year level) on R&D expenditure is used. This means that the analysis cannot distinguish between changes at the extensive margin (firms setting up new R&D facilities at particular locations) and changes at the intensive margin (firms increasing their R&D activity at locations where they have already established facilities). Both studies find evidence suggesting that locations are engaged in a form of tax competition for mobile R&D activity.

Box 1. Bloom and Griffith (2001)

Bloom and Griffith (2001) show that R&D in one country responds to a change in the tax price of R&D in another "competitor" country. A multinational considering where to locate new R&D activity will consider the domestic user cost of R&D and the user cost in alternative locations, and may be able to shift R&D activity between locations relatively easily if it has already established R&D facilities in a number of countries.

Bloom and Griffith use panel data for 8 countries (i) over 19 years (t) 1979-97 to estimate the following model:

$$rd_{it} = \beta_0 y_{it} + \beta_1 \rho^d_{it} + \beta_2 \rho^f_{it} + d_i + t_t + e_{it}$$

Where rd_{it} is log R&D, y_{it} is log output, ρ^d_{it} is the domestic user cost of R&D and ρ^f_{it} is the foreign user cost of R&D which is calculated as a weighted average of the other countries where the weights are the average amount of FDI investment into each country over the period 1982-92. The expectation is that $\beta_1 < 0$ and $\beta_2 > 0$. The authors present IV results due to concerns about omitted variable bias. The table below shows their results. The second column includes lagged R&D and the third column excludes the US. The results suggest that domestic R&D increases in response to a reduction in the domestic user cost of R&D, and increases in response to an increase in the foreign user cost of R&D, with long run elasticity estimates exceeding the short run estimates. This implies a role for R&D tax credits in influencing the international location of R&D activity.

TABLE 9

Relocation of R&D for Tax Reasons

Dependent variable: ln(R&D)	*(1)*	*(2)*	*(3)*
Lagged ln(R&D)	—	0.885	0.854
		0.044	*0.052*
Ln(domestic user cost)	–0.429	–0.135	–0.153
	0.133	*0.059*	*0.067*
Ln(foreign user cost)	1.054	0.364	0.775
	0.524	*0.223*	*0.330*
Ln(output)	1.213	0.016	–0.016
	0.337	*0.162*	*0.174*
Long-run elasticity — domestic user cost		–1.180	–1.050
(P value from Wald test)		(0.057)	(0.029)
Long-run elasticity — foreign user cost		3.176	5.300
(P value from Wald test)		(0.161)	(0.023)
Country dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Number of observations	139	139	122

Notes: Countries included in sample are Australia, Canada, France, Germany, Italy, Japan, the UK and the USA; the USA is excluded in column 3. The data run from 1979 to 1997. Instruments are current and lagged tax price of domestic R&D, current and lagged foreign user cost of R&D and once- and twice-lagged output; columns 2 and 3 use once- and twice-lagged R&D in addition.

Source: Table 9, Bloom and Griffith (2001).

Box 2. Wilson (2007)

Wilson (2007) provides evidence of a zero-sum game among US States competing for mobile R&D. He finds that in-state R&D tax incentives are effective in increasing R&D, but that the majority of this increase is due to attracting R&D away from other US states.

He specifies an R&D demand model using state-level panel data over the period 1981-2004 to estimate elasticities of R&D with respect to the in-state and out-of-state user cost of R&D. Wilson (2007) estimates a similar model to Bloom and Griffith (2001) including lagged R&D. He measures the out-of-state user cost as an inverse distance-weighted average of the closest 5 or 10 states, or of all other US states. He also experiments with weights based on industry and technology proximity (the latter using information on patent shares across technology classes).

Wilson finds a long-run elasticity of in-state R&D with respect to the in-state user cost of around -2.5, and a long run elasticity with respect to out-of-state user cost of around +2.5, which implies an aggregate cost elasticity (the sum of the in-state and out-of state elasticities) of around zero.

3. Do R&D tax credits affect firms' decisions to start conducting R&D? Or to start conducting R&D with universities?

As before, policy variation will offer the best opportunities for identifying the effect of R&D tax credits or changes in their design on decisions to start conducting R&D or to carry out joint research with universities. In these cases analysing changes to specific parts of the tax code may be particularly important. Some countries have specific provisions in the design of their R&D tax credits to encourage collaboration with universities. For example under the UK large firms R&D tax credit, only R&D *conducted* by the firm, rather than simply *financed* by the firm is eligible for the credit, apart from R&D conducted by universities. Other provisions may affect the extent to which firms start conducting R&D for the first time. For example, the ability of firms to claim R&D tax credits when they are in a tax-loss position (i.e. do not have taxable profits against which to offset an R&D tax credit) may affect the impact that R&D tax credits have on new (potentially initially loss-making firms) to begin to engage in R&D. A further example might be exactly how an incremental scheme is implemented for firms with no R&D track record.

Consider a case where a country chooses to introduce an R&D tax credit for the first time, or makes a substantial change to the design of their R&D tax credit. A before-after comparison could potentially be carried out to evaluate whether the introduction or change to the scheme affected the likelihood that firms started conducting R&D.

If data were available on all firms in an economy over a suitably long period of time and on whether or not they carry out R&D it would be possible to compare the proportion of firms in the economy (or the proportion of small firms in the economy) that carry out

R&D before and after the change to the R&D tax credit regime conditional on firm, industry and wider economy characteristics. One difficulty is identifying the effect of the introduction or change to the R&D tax credit separately from other unobservable contemporaneous effects that might impact on firms' propensity to conduct R&D. Box 3 provides an example of this type of approach that has been used in the 2007 evaluation of the R&D tax credit in Norway.

An alternative might be to use data on the population of R&D-doing firms and examine the rate of entry into this population before and after the policy change. Exploiting variation in the extent to which individual firms or groups of firms are affected by the tax change, for example the extent to which it affects firms around a particular size threshold, might further help to isolate the impact of the tax change.

A similar approach could be used to assess whether R&D tax credits affect the likelihood that firms engage in co-operative R&D with universities. This will require data on this very specific type of behaviour, and might be available in survey data such as the Community Innovation Survey. It might also be available in tax return data if it is a required element of tax reporting in order to benefit from a specific provision in the R&D tax credit scheme for collaborative R&D with universities. An example of a study that tries to estimate the effect of R&D tax credits on this decision is provided in Box 4 from the 2007 evaluation of SkatteFUNN in Norway.

Box 3. Norway 2007 evaluation of SkatteFUNN

This evaluation finds that after the introduction of SkatteFUNN firms are more likely to start conducting R&D.

The authors run two regressions: one looking at the probability of starting to conduct R&D given that a firm was not conducting R&D in the two years previously; and one looking at the probability of continuing to conduct R&D given that the firm was conducting R&D two years previously. The samples therefore change in each year, and consist of firms that either were, or were not conducting R&D in t-2. The data run from 1995 to 2005.

They regress a 0/1 indicator of each of these outcomes on dummy variables for the years SkatteFUNN was in operation compared to a before period (pre-2002), and measures of ln(sales). The table below shows that the estimated marginal effects on the 2003 and 2004 dummy variables are positive and significant indicating that these two groups of firms were more likely to start doing R&D and to continue doing R&D in the post-SkatteFUNN period.

In the regression for starting to conduct R&D the marginal effect is negative and insignificant in 2005, potentially due to the way that the sample has been selected. The 2005 dummy is estimated on a group of firms that were not doing R&D two years previously, i.e. in 2003 – this is therefore a potentially selected group that were not induced to conduct R&D by SkatteFUNN in 2003 and which may be slower to move into R&D activity.

Table 6.6. The probability of starting or continuing R&D

	Intramural $R\&D_{t-2}=0$	Intramural $R\&D_{t-2}>0$
ln(sales)	0,036***	0,045***
	(0,008)	(0,014)
$\ln(sales)_{t-2}$	-0,004	-0,004
	(0,008)	(0,013)
Dummy for 2003†	0,104***	0,133***
	(0,014)	(0,015)
Dummy for 2004†	0,073***	0,160***
	(0,016)	(0,014)
Dummy for 2005†	-0,017	0,072***
	(0,011)	(0,015)
Pseudo R-sq	0,088	0,087
No. of obs.	7286	3851

† Marginal effect for discrete change of the dummy variable from 0 to 1. The years 1995-2001 is absorbed by the constant term and not reported.

* Significant at the 10 percent level** Significant at the 5 percent level*** Significant at the 1 percent level.

Source: Table 6.6. Hægeland and Møen (2007)

Box 4. Norway 2007 evaluation of SkatteFUNN

The evaluation looked at the effect of SkatteFUNN on the probability of cooperating with universities, but found no substantial effect.

The authors look at the probability of starting to conduct co-operative R&D with a university given that a firm did not do so 2 years earlier, and the probability of continuing to conduct co-operative R&D with a university given that a firm was doing so 2 years earlier. Hence the sample of firms used in estimation changes in each year in each case. Each outcome indicator is regressed on post-SkatteFUNN year dummies and measures of ln(sales).

The table below shows that there is some evidence that firms were more likely to start conducting R&D in conjunction with universities in 2003 and 2004 (an increase of 1-2 ppts), but those firms that were not conducting co-operative R&D in 2003, were less likely to start in 2005 than was typical in the pre-SkatteFUNN period. There is no evidence of a positive impact on the probability of continuing to engage in R&D with universities.

Table 6.7. Effects on R&D cooperation

	Extramural R&D from research institutions $R\&D_{t-2}=0$	Extramural R&D from research institutions $R\&D_{t-2}>0$
ln(sales)	0,023***	0,051**
	(0,004)	(0,026)
$\ln(\text{sales})_{t-2}$	-0,002	0,008
	(0,004)	(0,025)
Dummy for 2003†	0,024***	-0,017
	(0,007)	(0,043)
Dummy for 2004†	0,012*	0,014
	(0,007)	(0,045)
Dummy for 2005†	-0,010**	-0,085**
	(0,005)	(0,038)
Pseudo R-sq	0,106	0,072
No. of obs.	9795	1316

† Marginal effect for discrete change of the dummy

Source: Table 6.7. Hægeland and Møen (2007)

4. Gathering evidence from survey data

Surveys of R&D tax credit users and potential users can ask directly about these types of behaviour, and potentially elicit quite precise information on the features of R&D tax credit schemes that matter for these decisions. Survey evidence might also be helpful in informing econometric analysis. For example, asking firms to rank a range of factors, including R&D tax credits, that might affect their decision to start conducting R&D or where to locate their R&D, might provide useful information on explanatory variables that should be included in an econometric analysis. In isolation this type of information might be potentially useful for making improvements to very specific elements of the design of R&D tax credits, but is unlikely to be useful for quantifying the effects of R&D tax credits on these types of behaviours.

It will be important to consider which groups of firms to survey in order to ensure an unbiased response to these behavioural questions. Potential groups include R&D-doing firms (both R&D tax credit claimants and non-claimants) and non-R&D doing firms. When investigating any effects of R&D tax credits on the decision to start conducting R&D it is unlikely to be sufficient to only survey firms that have taken up R&D tax credits, as this selected sample would very likely result in an over-estimate of any effect. When considering the effects of R&D tax credits on firms' decisions of where to locate R&D, a survey could potentially include multinational firms not currently carrying out R&D in the country of interest as well as those that are located there.

Questions could ask directly about the influence of R&D tax credits on the decision to start doing R&D. In the same way questions could be asked on the effects of R&D tax credits on collaboration with universities relative to the influence of other factors. Hypothetical questions could also be asked about schemes of different design and different generosity.

Questions could ask about the influence of R&D tax credits on the decision of where to locate R&D. This could be relative to other factors (such as locating R&D near production facilities, markets, supply of skilled labour, access to cutting edge technological expertise such as universities, clusters of R&D intensive firms etc.). Hypothetical questions could also be asked, for example what would happen if country X increased the generosity of its R&D tax credit? What would be the effect if this country abandoned its R&D tax credit?

Box 5 contains examples of questions that were used in the BMRB (2005) UK survey and information on the responses.

Box 5. Examples of survey questions, UK (2005) BMRB Survey

The survey asked questions about the impact of R&D tax credits on the international location of R&D projects.

Successful claimants were asked:

"Are you aware of any instances where the existence of the R&D tax credits has enabled your UK R&D facilities to attract R&D projects from R&D facilities abroad?"

"Are you aware of any instances where the existence of the R&D tax credits has prevented R&D projects in the UK from migrating overseas?"

These questions were answered: Yes, No, Don't know/not aware.

A summary of the percentage of "Yes" responses is given in Table 8.3

	All	SME scheme claimants	Large firm scheme claimants
No. observations	333	238	70
Attracted R&D projects from abroad	10%	9%	16%
Prevented UK projects from migrating to overseas facilities	10%	10%	11%

Source: Table 8.3 BMRB (2005).

Non claimants were asked:

"In your opinion, how likely is it that receiving R&D tax credits would enable companies to attract R&D projects to the UK from R&D facilities abroad?"

"How likely is it that receiving R&D tax credits would prevent R&D projects at UK facilities from migrating to overseas facilities?"

Each question was answered using the following scale: Very likely, Fairly likely, Not very likely, Not at all likely, Don't know.

A summary of the responses is given in Table 8.8.

	All	Aware of R&D tax credits?		Spend on R&D	
		Yes	No	<£125k	£125k +
No. observations	549	375	169	252	141
Attract R&D from abroad					
Likely	41%	35%	56%	44%	35%
Unlikely	45%	51%	33%	43%	59%
Prevented UK projects from migrating abroad					
Likely	40%	37%	49%	42%	37%
Unlikely	44%	48%	37%	41%	56%

Source: Table 8.8 BMRB (2005).

5. Final comments

In some countries R&D tax credits have implicit or explicit objectives to attract internationally mobile R&D, to encourage firms to start conducting R&D for the first time and to encourage firms to engage in collaborative R&D with universities. Evaluating the impact of R&D tax credits on these elements of firm behaviour is important in terms of understanding the overall impact of the policy. In addition, it is important to understand how the precise design of R&D tax credits affects these outcomes.

R&D activity is becoming increasingly mobile. While the scope of individual country evaluations may not go so far as considering the impact of R&D tax credits on R&D location decisions across a wide range of countries, this may be an issue that can be investigated at a European or global level. For policy purposes it would be extremely useful to know whether R&D tax credits are acting to increase overall activity within Europe, or simply acting to shift the location of R&D activity across European countries. In some countries the tax price of R&D will vary across locations, hence it may be feasible to address this question within a single country context. More generally it would be interesting to examine the impact of the tax system in general on R&D location decisions.

Examining the impact of R&D tax credits on firms' incentives to start conducting R&D and to start joint research with universities is of policy interest, but the magnitude of the impact of such changes in behaviour in terms of the additionality of R&D tax credits on overall R&D expenditure may be relatively small, since the majority of R&D expenditure is conducted in-house by large firms. Examining the effectiveness of other policy tools such as grants in influencing these decisions (relative to the impact of R&D tax credits) is also important in terms of understanding the appropriate policy mix.

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Expert Group Seminar on Evaluating R&D Tax Incentives
European Commission

Measuring Additionality of R&D Tax Credits Can Evaluation Surveys Be More Effective?

Discussion Paper

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Introduction

A significant increase in the number of countries using R&D tax incentive schemes has triggered an interest in the evaluation of R&D tax incentives. It is expected that evaluation activities will be on the rise in the near future, especially in European countries new to R&D tax incentives, and the use of surveys as a tool of evaluation will intensify.

This paper discusses the role of surveys in conducting evaluations of the R&D tax incentives. The discussion is based on country evaluation experiences for the on-going review of the evaluations by the Expert Group. It is intended as an overview of survey design issues that need to be addressed in the process of evaluation of R&D tax breaks.

The objective is to provide policy makers with the information on areas that are not appropriately addressed in existing evaluation methodologies and where practices may be improved or sharpened for the benefit of the evaluation. It is hoped that by informing the policy makers about the recent developments, views and experiences in using the survey instrument, this paper will contribute to improving the practice of future R&D tax incentive evaluations.

A proposition advanced in this paper is that the primary objective of an R&D tax incentive evaluation survey is to inquire about additionality. Other issues that may pertain tightly or loosely to the evaluation should be addressed in separate projects that may or may not accompany the evaluation.

This discussion paper focuses on the issue of addressing additionality. It attempts to ask the following questions: How can survey data be collected and used to measure additionality when econometric analysis of administrative data is infeasible? And more generally: How can one get the most out of a survey by focusing it on the right questions of additionality and minimizing the subjective bias?

Organization

The paper consists of the four sections:

- Identify challenges in measuring additionality via surveys
- Review practices to measure additionality in surveys
- Focus the survey on key additionality questions to ask
- Outline possible good practices for survey improvement

Challenges of the Survey Instrument

Surveys of companies remain an important tool for estimating additionality of R&D tax incentive schemes. Based on the initial findings from the review of official evaluations, surveys have been carried out in Australia,[65] Canada[66] and Netherlands.[67] Norway evaluation[68] does not employ the survey instrument directly to measure additionality but relies on surveys prepared earlier, for example, to estimate the administration and compliance cost of the SkatteFUNN incentive. The United Kingdom survey[69] represents a part of the feasibility project on conducting an evaluation of the R&D tax credit in the near future.

Survey benefits

Surveys are important if only for these benefits:

- Surveys are typically used to validate other methods of investigation such as econometric analysis. In several cases, surveys are the only method of conducting the empirical analysis (e.g., Australian evaluation 2003, Canadian evaluation 1997).

- Surveys allow for extending the available administrative databases and building of relevant microdata. They are particularly valuable when historical data is missing.

- Surveys are an important tool for assessing respondents' views or perspectives on a scheme, for example, whether they understand the scheme and how easy they find it to claim support. Such evaluation questions can only be tackled by survey or direct interview methods.[70]

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Problems with surveys

Depending entirely on the survey instrument needs to be considered with caution for the following reasons:

Response bias: Survey participants may be inclined to behave in a way that maximizes their benefit from the R&D tax credit. Thus surveys may provide biased results as the respondents may answer strategically to questions, in particular those addressing the aspects of additionality.

High cost: Surveys tend to be an expensive way of examining additionality. We already see a departure from using surveys as a principal method, e.g., the Canadian evaluation 2007 which is based on the partial equilibrium model that uses data established in literature, or Australian evaluation 2007 which bases on trendline analysis of aggregate R&D expenditures.

Multiplicity of issues: Surveys evaluating R&D tax incentive schemes tend to be very broad in scope, covering many issues not necessarily related to additionality. Addressing multiple issues may not be as useful as surveys that focus on one or two issues only. There is temptation to include in evaluation surveys everything from incrementality tests to problems that cannot be directly tested by econometric analysis, such as behavioural aspects, and compliance and administration costs. In other words, R&D tax incentive evaluation surveys can become repositories of any kind of business R&D/innovation information that government wishes to collect but has not done so through other surveys or other statistical means. This may be a positive feature, as surveys are able to address intricate areas of inquiry which econometric models are unable to provide for. But broad surveys may be a detriment to the *primary* evaluation focus – measuring additionality/incrementality.

Status of survey respondents: The quality of survey answers may depend on the respondent's status and position within the organization. For example, Chief Technology Officers may provide different answers from those by Chief Financial Officers. Likewise, different responses may come from a junior respondent. An R&D manager or tax manager's estimates of the R&D elasticity with regard to the tax incentive many not be the same as their bosses'. Although survey investigators define whom they want to ask questions, they often have to contend with a variety of respondents including executives in other functions e.g., business development, public affairs, corporate secretary – each with different level of knowledge about R&D performed in the company. Thus a possibility of a systematic bias in the results due to the status or position of the respondent on the company ladder cannot be ruled out. Increasing the sample size will not work to cancel out systematic bias and in itself may be constrained by the availability of valid observations. Polling several company staff members knowledgeable of R&D and then coming up with a point estimate of R&D additionality per company may reduce the bias. This is an expensive proposition, however, that can only be practiced in direct interviews rather than through impersonal surveys.

Choice of firms: There are several groups of companies that can be surveyed with regard to R&D additionality. At the broadest level, companies can be grouped into two categories: those which do R&D and those which don't do R&D. Those companies doing R&D can be further divided into those who claim and those who do not claim R&D tax credits. The latter category is interesting as it may include companies that do not know that they do R&D or find their opportunity cost of claiming an R&D tax credit to be higher than the marginal benefit from receiving the credit.

The population of claimants can be further divided into successful claimants and those whose applications have been rejected, meaning that they likely do not do R&D. Most of the surveys of R&D additionality utilize the population of the successful claimants. Such are the surveys conducted in Canada in 1997 and Australia 2003. In Canada, for example, official government statistics (e.g., Statistics Canada) on R&D performing companies include only successful claimants. No other companies are counted as R&D spenders or performers.[71]

Using successful claimant responses, the surveys come up with the estimates of additional R&D stimulated by the scheme. However, it is quite possible that depending on successful claimants only would aggravate the answering bias – because this category of respondents will particularly be having a stake in answering strategically.

Review of Practices

A subjective nature of the questions and variety of roles and responsibilities of persons answering leaves open the possibility that some answers may be biased. Surveys can be designed to minimize the bias, however, by applying a number of different tests for incrementality. The Australian 2003 evaluation offers three different tests (in addition to econometric analysis of the survey database) embedded in the survey questionnaire in an attempt to ensure bias is reduced:

- *Direct question method* asks how much additional R&D a firm would undertake if the incentive were increased by a defined number of percentage points. This type of question is probably the easiest for survey respondents to inflate their individual estimates, which will likely provide an overestimate of the additionality level. Moreover, the nature of the survey question may lend itself to misinterpretation. According to the Australian evaluation, it was unclear how respondents calculated additionality and it was likely that some may have calculated an increase differently.[72]

[71] It is acknowledged that the system is not perfect because companies that perform research might not submit a tax credit claim and will thus be absent from the official records. However, these missing firms in Canada tend to be smaller companies spending small amounts on research, so it is believed their absence does not affect the overall spending results very much. See discussion in: Ron Freedman (ron@impactg.com), *Understanding Trends in Industrial Research Performance in Canada*, The Impact Group, July 2008, p. 2

[72] Centre for International Economics, 2003 pp. 40-41

- *Historical question method* exploits discontinuity and addresses changes in the level of the Australian R&D tax concession following the 1996 reform. It asks for impact on additionality of the R&D tax concession in the context of other factors such as different business environment today and 10 years ago and behavioural aspects of the firm. The historical method has fewer potential problems than the direct question method, as it applies the two factual pieces of information – the pre and after R&D expenditures.

- *Indirect question method* asks claimants how much more R&D the firm would do if its threshold required rate of return were lowered by 20 per cent. This is indirectly assumed to be equivalent to a reduction in R&D costs by 20 per cent. By asking this type of question, the approach is seen as potentially less susceptible to manipulation. However, the very choice and clarity of an indirect question is important. The one asked in the Australian example may not be realistic for many firms, especially small firms with more discrete R&D investment opportunities. The firms may also find it unclear what threshold rate of return is in their specific context. Hence while the idea of formulating the question indirectly is interesting in itself, the actual choice of the question is important and will much depend on the characteristics of companies the survey is designed for.

There is another approach - *induced projects method* – investigated in the Australian evaluation but not used due to difficulty in obtaining reliable project based data. It asked survey participants what consideration they give to the incentive when making their project decisions, for example, whether it changes their investment decisions per project.

The methods above vary in the degree of sensitivity to strategic answering, with the direct method being exposed the most and the other methods having gradually diminished potential to biased answering.

Not all evaluations include testing for errors in their surveys, which is often due to lack of discontinuities in the tax incentive. For example, Canada 1997evaluation when exploring incrementality asks one basic question – using what in the Australian terms would be a direct question method. The question exploits counterfactual approach by asking what would have happened in absence of the incentive. For firms indicating that their R&D expenditures would have been lower or higher in the absence of the federal R&D tax incentives, the survey asked by what percentage their spending on R&D would have been different.

The Canadian evaluation addresses many issues of many stakeholders, which may tip the focus from additionality to other areas. The Canadian information and communications technology industry, the largest performer of private R&D, and Revenue Canada[73] -

[73] Currently operating under the name of Canada Revenue Agency (CRA)

administrator of the R&D tax incentive program - had large portions of the survey devoted to their issues. In addition, the question asking for additionality estimates was one of the last questions asked in a telephone survey. This also brings a question whether the survey's end is a right place for asking a critical to the evaluation question of additionality.
The examples above show that practices to measure additionality through surveys are quite diverse. The remainder of the paper develops a possible approach for a more coherent and comparable approach to surveying the effectiveness or efficiency of R&D tax incentive programs.

Key Additionality Questions

Below provided are some examples of additionality-oriented survey questions from Australia, Canada, Netherlands, Norway and the United Kingdom. (See Table 1 for overview of questions.) What distinguishes the three countries is that they all have a different history of the R&D tax credits which influences the method and scope of questions asked.

Australia appears to have a pretty robust history of introducing important changes to its R&D tax concession. Hence it is possible to use the historical approach exploring discontinuities in providing the tax incentive. Canada and Netherlands have a relatively "smooth" history of providing their tax credits, with no major bumps or changes. Therefore, it seems that the use of counterfactual approaches (What would have happened in the absence of…?) is appropriate.

The remaining two countries are new to R&D tax incentives. Norway has only recently introduced the R&D tax credit but already advanced a comprehensive and multiyear program evaluating the SkatteFUNN incentive experimenting with various approaches to estimating direct additionality such as before-after and difference-in- difference methods. And for the United Kingdom, a relative newcomer in the field of R&D tax credits, it is possible to exploit a before-after approach to estimate incrementality. For now, the UK work focuses on sensing the range of possible questions. Indeed, the survey conducted there did not ask about additionality directly but focused rather on probing additionality through the use of indirect questions.

Australia

A 2003 evaluation of the Australia's R&D tax concession used the survey to create the database and estimate the additionality of the incentive. As discussed above, the survey applied three methods to measure additionality: a historical method, direct method and indirect method. By estimating direct additionality (incrementality) described by three different sets of questions, researchers were able to provide a range of additionality estimates from a most general (direct) approach where additionality was expected to be the largest to more focused approaches where additionality was smaller. This proved that asking a different question produces a different point estimate of additionality. Knowing the range of point estimates, it is possible to choose the most appropriate estimate or opt for a range of possible estimates.

Australian evaluators first started with the direct approach. A direct method was expected to provide the highest estimate of additionality as it is most prone to strategic answering because of its open-ended character. The question asked was:

If the tax concession were increased by 25 per cent, how would that influence the amount of R&D you would do? (As a percentage of your current R&D spending)

It is interesting to note that the question was formulated in a different manner than typical counterfactual question would take i.e., what would happen in the absence of the tax incentive. Here the approach was to explore what a positive change in the generosity of the tax incentive would do to the level of R&D spending by firms. The method has an advantage in making the respondent think how to convert the percentage increase in the level of tax incentive into the additional R&D spending. One could expect a more thoughtful and perhaps less strategic answer to such stated question than to all-or-nothing type of question.

Australian evaluators then followed with the historical approach, which explored a discontinuity in providing the incentive over time. In 1996, the government introduced several reforms to the R&D tax concession, including reducing the rate from 150 to 125 per cent. Researchers were thus able to ask question that was designed to determine the influence of those reforms on R&D. The question asked was:

How much has your R&D spending changed from 1995-96 to 2001-02 (+$, -$)?

A scale of 0-10 was used to rate the importance of the various impacts on company's decision to change the level of R&D. (An associated question asked to indicate the direction of each impact (+/-)). It needs to be noted that the impact of changes to the tax concession (discontinuity) was considered as one of many factors which could have influenced the private sector R&D spending over the specified period of time. Other factors listed included other changes to the tax concession (e.g., abolition of syndication), changes in technological opportunities, changes in market opportunities, changes in other government policies, changes in availability of labour, equipment and collaboration, and changes in profitability of R&D.

It is perfectly valid to explore discontinuity in the survey. The question pertains to the weighting system. Are weights of the level of importance good enough indicator for R&D additionality? Also will respondents be able to separate the impact of changes to the tax concession from other factors, especially those that are tax related?

Finally, Australian researchers followed with indirect method, asking:

If your threshold required rate of return were to be lowered by 20 per cent then approximately how much more (in per cent) R&D you would do?

The question implied an increase in the base rate of the R&D tax concession by a factor of 20 per cent. It was seen as the most focused and least vulnerable to strategic answering question - one that was expected to yield the most precise additionality of R&D estimate.

Based on the survey questions, researchers were able to provide the point estimates of additionality as a function of propensity to strategic answering. It appears that asking more than one question on additionality in the evaluation survey may produce but not eliminate a less biased answering. The questions should be designed to look unrelated in order to provide a check and balance system in the survey. Having a range of additionality estimates can help evaluators to arrive more precisely at the point estimate. Alternatively, researchers may decide on the range of estimates of additionality in case they are not sure about a precise value of the estimate.

Canada

A survey prepared for Canada1997 evaluation asked by telephone a single set of questions on direct additionality in an extensive questionnaire spanning about 30 other questions. The lead question applied the direct method and was as follows:

If there had been no federal R&D tax incentives, what effect would this have had on your firm's R&D expenditures? Do you think that it would have …reduced, increased, had no effect on expenditure or effect was unknown?

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If reduced, an auxiliary question was asked on the size of the reduction (in per cent of reported R&D expenditure) and on the form the reduction had taken. Forms of reduction included: cutting across-the-board R&D expenditure; canceling some R&D work; postponing the start of some R&D work; stretching out some R&D work; reducing the technological objectives; and shifting some R&D work outside Canada. It can be argued that asking about the forms was intended to not only provide more detail to the issue but indirectly validate a very broad type of question asked.

Alternatively, if R&D expenditures were reported as increased, a question was asked by what percentage the firm estimated its expenditure on R&D to have increased. Interestingly, the question stopped at that, without asking about forms the increase would assume. Judging from the Australian experience, the type of direct question asked will likely result in an overestimate of the additionality effect.

Netherlands

The Netherlands' telephone survey[74] included a number of questions on the additionality as *perceived* by WBSO tax incentive users. It noted that the survey results are less reliable than results based on econometric analysis. Nevertheless, the survey had an

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[74] Ministry of Economic Affairs, *WBSO Evaluation 2001-2005: Impacts, target group reach and implementation, March 2007*, pp. 44-47

advantage of covering the representative group of users and enabling comparisons between groups. The survey sought to provide answers to direct additionality question indirectly by asking about the positive impacts due to WBSO. These impacts included: more R&D expenditure generally, increase in feasibility of R&D becomes, more risky R&D projects, recruitment of R&D staff, higher quality R&D, business continuity or survival, more R&D done in the Netherlands rather than in other countries.

An alternative direct counterfactual question was also asked:

What the R&D expenditure would be if users were to be awarded no WBSO?

This question produced a positive incrementality result that there was an additional impact on R&D expenditure for two-thirds of WBSO users. Recall that a similar question was used in the Canadian 1996 survey. The main difference, however, is that the Canadian survey served as sole source to estimate additionality whereas the Netherlands' survey was part of a larger econometric study estimating the "bang-for-the-buck" effect.

Norway

Norwegian evaluation strikes as being very thorough and comprehensive. It should be noted, however, that the timeframe of the evaluation entailed some three years. Having such a timeframe it was possible to do not one but several evaluations that would feed into a final evaluation report. Thus a number of surveys and research papers were prepared within the timeframe. Norwegian surveys were conducted separately from the main econometric assessment.

Surveys focused mainly on supplementary aspects of the additionality and prevailingly on the administrative cost (for government) and compliance cost (for business) of the SkatteFUNN incentive scheme. Nevertheless, the surveys were able to shed light on some descriptive aspects of additionality, which then were used by the main econometric evaluation as a consistency guide for the econometric results.[75]

The purpose of the survey by Foyn and Kjesbu was primarily to map the business knowledge and experience with the administrative procedures of the scheme.[76] In addition, the survey asked about the effects of the scheme on the enterprise with regard to additionality, collaboration and profitability. The survey did not attempt to estimate direct additionality but to inform qualitatively whether such additionality exists. An update of the survey was conducted in 2007.[77]

[75] Torbjørn Hægeland and Jarle Møen, pp. 14-15

[76] Frank Foyn and Knut Arild Kjesbu, *Brukernes vurdering av SkatteFUNN-ordningen*, Statistics Norway, Oslo, Report 2006/7, www.ssb.no/emner/10/02/rapp_200607

[77] Frank Foyn and Guro Lien, *Administrativ gjennomføring og brukervurdering av SkatteFUNN*, Statistics Norway, Oslo, Report 2007/47

In order to detect direct additionality, researchers posed indirect questions that are quite similar to those discussed in the paper. Questions were asked whether the R&D projects were: abandoned, carried through fully, carried through in scaled down version, or delayed. They were posed to two groups of claimants: those whose claims were rejected and those whose tax credit claims were accepted. Successful claimants were then asked a counterfactual question of what would have happened without the tax subsidy.

United Kingdom

The United Kingdom survey explored *perceived impact* of R&D tax credits on business R&D expenditure while asking questions on additionality indirectly. The questions are interesting as a way of friendly but consistent probing about direct additionality. The questions were addressed to "successful" claimants, as was the case with the Canadian and Australian surveys. The system of additionality questions starts with a general lead question:

Does your company take into account the expected value of R&D tax credits when setting its R&D budget? (Yes/No/Don't know)

This is narrowed down by more probing, including questions about impacts similar to those in the Canadian survey. The next question focuses even more on additionality but without asking for estimates. A three-pronged question was asked whether the R&D tax credit had led the firm to (a) increase its R&D budget by more/less than (or equal to) the expected value of the tax credit, (b) maintain the R&D budget instead of cutting it or (c) reduce the R&D budget but by less than if there were no tax credit.

The additionality part in the survey ends with a seemingly counterfactual type of question which rounds up all other questions:

In your opinion, are R&D tax credits an incentive to undertake further R&D that would not otherwise be undertaken?

The question is then followed by an open-ended query asking for further elaboration on the impact of R&D tax incentives in undertaking further R&D.

Note that the question does not include any attempt at quantification of the additional R&D. Similar to Norwegian surveys, it only asks for a direction of additional R&D spending. It is interesting to note that the UK survey asked both claimants and non-claimants how much money they spent on R&D. This is unlike the other surveys which concentrated on the claimants and in the case of Australia and Canada on successful ones.

Table 1: An Overview of Direct Additionality Questions: Selected Surveys

Country	Historical questions	Direct questions	Indirect questions
Australia	How much has your R&D spending changed from 1995-96 to 2001-02 and due to what factors, including change in the R&D tax concession? (*explores discontinuity in the tax incentive*)	If the tax concession were increased by 25 per cent, how would that influence the amount of R&D you would do?	If your threshold required rate of return were to be lowered by 20 per cent then approximately how much more R&D you would do? (*explores changes in the incentive*)
Canada		If there had been *no* federal R&D tax incentives, what effect would this have had on your firm's R&D spending? (*counterfactual*)	
Netherlands		What the R&D expenditure would be if *users* were to be awarded no WBSO? (*counterfactual*)	
Norway		What would happen to the company's R&D without the tax subsidy? (*counterfactual*)	Was the R&D project: (a) abandoned, (b) carried through fully, (c) scaled down, or (d) delayed
United Kingdom		Has the R&D tax credit led you to... increase, reduce or maintain your R&D budget?	Does your company take into account the expected value of R&D tax credits when setting its R&D budget? In your opinion, are R&D tax credits an incentive to undertake further R&D that would not otherwise be undertaken?

Proposed Questions

Of the three types of questions – historical, direct and indirect – historical queries exploring discontinuity in the tax incentive scheme are perhaps better addressed by econometric modeling where differential approach can be applied and the sensitivity of R&D expenditure to tax incentive before and after examined. As shown in Table 1, there are not too many countries that actually apply historical method in their surveys. This is because many countries examined have not recorded any important changes to compare. For example, in Canada one would have to go back to pre Scientific Research and Experimental Development tax incentive program that is basically to pre-1985 period.[78]

[78] In Canada, it could be possible to use historical before-after approach in some provinces, which made changes to the level of their R&D tax credits relatively recently (e.g., Quebec). Moreover, in addition to

For surveys, it appears that the two latter types of questions – direct and indirect - are more applicable. The answers to these questions will likely be biased – the issue is how to reduce the bias. That is why a mix of direct-indirect questions is proposed. A survey or its section focusing on direct additionality can first start with a host of indirect questions followed by a direct question exploring what would have happened in the absence of a tax incentive.

The most reliable picture would emerge by putting the pieces together. A combination of indirect/direct questions could be quite effective in that indirect questions would help to check whether the pattern of answering to counterfactual 'absence' question actually corresponds to the pattern of responses to indirect questions. If the responses coincide/agree with the overall result to direct question then it can be assumed, of course with a certain dose of probability, that the bias is reduced. Examples of possible questions are outlined in Table 2. To some extent individual questions tend to paraphrase the questions in Table 1. This is because questions from the surveys reviewed for this paper are already pretty robust. Nevertheless, if kept as a set the proposed questions may contribute to obtaining more credible responses.

Australia, a good country to use such an approach would be France where many changes in the generosity of the R&D tax credit took place over the past 10 years.

Table 2: Possible Direct Additionality Questions

Type	Question
Indirect	1. Which, if any, of the following factors (including R&D tax credits) do you expect to have favourable/adverse effect on your R&D program? (*list the factors you want to examine and ask to rank on a Likert scale*) 2. How important is the R&D tax credit for the amount of R&D undertaken by your company? (*important, not important, not sure*) 3. Could you comment on how the R&D tax credit influences your company's R&D budget? (*open ended*) 4. What is the impact of the R&D tax credit on the company's R&D budget? (+/=/-) 5. Can you provide an estimate (in per cent) by how much your R&D budget has increased or decreased or stayed the same because of the R&D tax credit? 6. How did you/will you use the most recent R&D tax credit claimed? (*to do more R&D; to cover operating expenses; to repay investors; other*) 7. If the R&D tax credit program were to disappear this year, what would your company do? (*continue R&D as usual; stop doing R&D; go out of business; move business out of the country; reduce R&D; other*)
Direct (*counterfactual*)	1. If the tax concession were increased by *xx* per cent, how would that influence the amount of R&D you would do? **and/or** 2. What would be the amount of R&D the company would do without the R&D tax credit?

Questions outlined in Table 2 are a blend of all questions examined and some proposed. They are hypothetical and need not be applied all in the survey.

The additionality survey should contain basic descriptive information about the respondent, his/her R&D spending profile in total and by the source of funding (in per cent). The source of funding should include an R&D tax credit. A section asking a few questions on company R&D/innovation strategy could also be included. The core of the survey should be devoted to measuring direct additionality. The survey could follow the pattern as presented in Table 2.

- Questions 1-3 can be called warm-up questions. They ask for general climate for doing R&D in the company, the status of the R&D tax credit and the possible impact of the credit on the company's R&D budget. Question 3 looks for a descriptive open ended answer or comment to capture more insight on the role of the tax credit for company R&D that other questions cannot provide. The latter is rather an optional question that may or may not be included in the survey.

- Questions 4-5 examine the company's R&D budget. They are intended to elicit more precision in how the R&D tax credit influences the R&D budget. Note that the question on the budgetary impact does not ask for details (e.g., whether the impact is more than the tax credit awarded itself, etc.) as such a question would likely lead to strategic answer.

- Questions 6-7 seek information on company behaviour, in particular how the R&D tax credit is being spent in the company (Question 6) and what would happen qualitatively to company R&D if the credit were to be terminated (Question 7).

- The above questions are then complemented by a counterfactual question directly asking about the impact of the tax incentive on the level of R&D expenditures. Two types of questions can be applied are – a question asking what would happen if the generosity of the incentive were to be increased by a fixed percentage or a question inquiring what impact would be in the absence of the tax credit. These two questions are not mutually exclusive – they can be asked at the same time, but normally one would expect only one question to be selected.

Responses to direct additionality questions should be analyzed and assessed in the context of indirect questions. Such an assessment would make it possible to check whether responses are consistent. Based on this, a reliability of answers could be established. This is no panacea, however, for foolproof answering.
Studies show that surveying executives of companies leads to subjective and/or perceptual responses.[79] Therefore a combination of econometric and survey based analysis could be the best prescription available. One thing that could be done is perhaps not to cluster these questions but disperse them in a sensible way across the survey to make sure that strategic answering is even more reduced. However, in a focused survey with a limited number of questions, as recommended by this paper, dispersing the questions may not be possible and some clustering must take place.

[79] Van Pottelsberghe B., Nysten S. and Megally E., *Evaluation of current fiscal incentives for business R&D in Belgium*, June 2003, SSTC and CEB Working Paper, Solvay Business School, ULB

Conclusions

This paper discussed the role of surveys in conducting focused evaluations of direct additionality of the R&D tax incentives. The goal is to improve the practice of future R&D tax incentive evaluations.

A subjective nature of the questions and variety of roles and responsibilities of persons answering leaves any survey-based evaluation project vulnerable to answering bias. It is argued, however, that surveys can be designed to diminish the bias by being focused and applying a number of different tests for measuring incrementality.

The framework for this paper is based on the Australia 2003 evaluation and survey. The approach introduced three different tests (in addition to econometric analysis of the survey database) embedded in the survey questionnaire in an attempt to reduce the bias: direct, indirect and historical methods of determining the rate of additionality. The methods above vary in the degree of sensitivity to strategic answering, with the direct method being exposed the most and the other methods having gradually diminished potential to biased answering.

The paper has encountered a diversity of practices through which evaluations attempt to measure of additionality. It proposes a more coherent and comparable approach to surveying additionality.

It appears that asking more than one question on additionality in the evaluation survey may produce but not eliminate a less biased answering. Having a range of additionality estimates can help evaluators to control the extent of the bias and arrive more precisely at the estimate. A combination of direct-indirect questions is proposed – it would help to check whether the pattern of answering to counterfactual 'absence' question actually corresponds to the pattern of responses to indirect questions.

Overall, it is advisable to ask more than one question regarding estimates of additionality to check for errors in answering due to strategic behaviour and/or lack of information on the part of the respondents. Questions should be designed to provide a check-and-balance system in the survey.

Appendix 4: Official Agenda

Expert Group Seminar on Evaluating R&D Tax Incentives

In Search of Good Practices in Evaluating R&D Tax Incentives

Brussels, October 6, 2008

Introduction

Systematic and consistent evaluation of the impact of R&D tax incentives, both at the individual firm level and for the economy at large, is crucial for the more effective use of such measures. However, the relatively few evaluation studies that currently exist often use different methodologies, making their results difficult to compare. Increased coherence between the methodologies used for evaluating the effectiveness of R&D tax incentives in Europe would facilitate the comparison of evaluation results and foster mutual policy learning amongst Member States.

As more EU members introduce R&D tax incentives there is a growing need for the identification and informed analysis of best practices in evaluation. In addition, there is a need for international arrangements (e.g., networks, on-line databases etc.) through which evaluation practitioners could freely exchange ideas and gain insights from each other on how to improve evaluation practices. *The seminar will serve as a testing ground in this direction.*

The Expert Group has been established to address the need to improve the evaluation of R&D tax incentives building on identified best practices. In its final report, the group will provide insights for improving the methodologies and approaches for evaluating R&D tax incentives in Europe. *The seminar is intended to provide peer feedback to the group, to consider existing evaluation approaches and to generate new ideas for evaluation practices.*

The seminar is aimed at both innovation policy makers and R&D evaluation practitioners, including academic experts, who would contribute to and benefit from the presentations and mutual dialogue. Both groups would gain knowledge about the current state of the art in the area and identify new directions for improving evaluation practices that would contribute the to Expert Group's final report recommendations.

Programme

9:30 - 10:30	***Opening session***
	Introduction Tiit Jurimae (Head of Unit C.2, DG Research) Jacek Warda (Chair of tax incentives expert group; JPW Innovation Associates Inc.) *Designing and Evaluating R&D Tax Incentives: a CREST Report* Christian Hambro (Gram Hambro & Garman)
10:30 – 10:50	*Coffee Break*
10:50 - 13:00	***Experiences from business and evaluation practitioners***
	Company perspective Jan Van den Biesen (Philips Research) *Presentation of preliminary findings on evaluation practices* Jacek Warda
13:00 - 14:00	*Lunch Break*
14:00 - 17:00	***Issues in evaluation***
	Presentations of discussion papers prepared by Expert Group members: *Do R&D tax credits affect R&D start-up and location decisions?* Helen Simpson (CMPO, University of Bristol) *Measuring additionality in R&D tax incentive surveys* Jacek Warda *What can we learn from structural econometric models for evaluation of R&D tax credits? An example and some comments* Jacques Mairesse (INSEE) *What does it take for an R&D tax incentive policy to be effective?* Pierre Mohnen (MERIT, University of Maastricht) ***Response from discussants:*** Isabel Busom (Universitat Autònoma de Barcelona -Departament d'Economia Aplicada, Bellaterra) Benoit Mulkay (Faculté de Sciences Economiques, Université de Montpellier) ***Open discussion with participants***
17:00 - 17:30	**Wrap up session: What have we learned about good practices in evaluation? Can we identify new practices?**