Annex 3

The Evaluation of Fiscal R&D Incentives

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1 Introduction

In this paper we present the context of, and suggest approaches to, the evaluation of fiscal incentives for R&D[1]. The focus is on measures that use reductions in the taxes that companies have to pay as an incentive for performing R&D. This is not intended as a 'handbook' or procedures manual with step-by-step guidance on how to set up and evaluate a tax credit scheme, but is rather a high-level overview of issues that need to be addressed in the process of evaluation of such a scheme. Specifics of such schemes vary, but the key assumptions on which they are based, and which require examination and evaluation, are that

- there is underinvestment in R&D
- fiscal incentives lead to more R&D
- economic benefits follow.

The broad structure of this paper reflects these issues and is arranged as follows

- The rationale and context of fiscal R&D incentive schemes
- Alternative scheme structures
- Evaluation questions
- Evaluation methodologies
- Evaluation results
- Policy Issues
- Conclusions

2 Background - Rationale and Context of Fiscal R&D Schemes

2.1 Rationale

Over the past fifty years, the principal rationale for state support for R&D has been the idea of 'market failure': namely, that companies tend to invest less in R&D than would be necessary to produce some optimum amount of wealth and 'welfare'. The

[1] We are grateful for comments made on earlier versions of this report at OMC Group Fiscal Measures meetings, and particularly the comments at the 6th September meeting by invited experts Luke Georghiou and Bruno van Pottelsberghe

idea of market failure involves three barriers to greater R&D investment by companies[2]

1 Indivisibility: especially larger and more fundamental research projects cannot easily be split into small pieces, each of which can be expected to deliver useful results
2 Uncertainty: to the extent that research involves venturing into the unknown, it is hard to make a rational calculation of risk – no-one knows whether the needed new knowledge is near at hand or far away, or simply nowhere to be found; or whether markets will exist for new products or processes resulting from R&D. In short R&D requires a risk premium
3 Inappropriability: to the extent that R&D produces information, it is difficult to monopolise[3] and hence for those who invest in R&D to sustain an advantage over imitators for long enough to give them an attractive return on their R&D investment.

For all of these reasons, companies tend especially to avoid more fundamental kinds of research.

The coin of inappropriability has another side, namely spillovers. Since the benefits or R&D are hard to appropriate, many of them spill over to other firms and to consumers. Estimates differ, but there is a general consensus in the research literature (a) that private rates of return to R&D performers themselves are high (generally in the range 15-25%) compared with other forms of investment; and (b) that the social rates or return arising from spillovers are perhaps 2-4 times as big as the private ones. The taxpayer therefore has a strong incentive to invest, in order to obtain[4] the social returns.

2.2 Context

More recent literature emphasises the need for all parts of the national system of innovation to be working well in order to generate wealth, and especially the importance of technological capabilities – not only to do R&D but also to benefit from spillovers (whether from industrial or academic research). Key ideas are that

- R&D has two 'faces' – one that seeks outside knowledge and internalises it for the benefit of the company and the other that generates new knowledge and developments[5]
- 'Absorptive capacity' more generally – in the sense of "the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends"[6] is essential to both innovation and imitation

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2 Kenneth Arrow, 'Economic welfare and the allocation of resources for invention,' in RR Nelson (ed), *The Rate and Direction of Inventive Activity*, Princeton University Press, 1962

3 Patents, of course, give inventors temporary monopolies, but do not necessarily give sufficient protection to give confidence to R&D investors that they will see a return

4 A little-discussed complication in modern. open economies and in the context of globalisation is the extent to which the taxpayers who invest obtain a reasonable proportion of the benefits, or whether these migrate abroad

5 W Cohen and D Levinthal, 'Innovation and learning; the two faces of R&D,' *Economic Journal*, Vol 99, 1989, pp 569 - 596

High levels of technological capability, including the ability to do R&D, are therefore important for reaping both private and social returns from R&D within the economy. Both the traditional 'market failure' view and more recent thinking about capabilities and innovation systems therefore support the idea that inducing companies to increase their R&D expenditures is likely to bring economic benefits both for the companies themselves and for society more widely.

In Europe, interest in providing fiscal R&D incentives has increased in recent years, especially since the Council of Ministers set the 'Barcelona Goal' of spending 3% of European GDP on R&D. Such incentives appear to offer a way quickly to raise private R&D investment without the need for the state to incur the administrative costs involved in traditional project-based or competitive R&D subsidies and without the need for the state to 'pick winners' in running competitions among potential beneficiaries. Fiscal incentives have the political benefit, too, that they involve reductions in tax income rather than increases in public spending, so they can side-step limits on public spending or borrowing and bypass the normal competition for funds among spending ministries. Naturally, finance ministries are becoming concerned about losing tax revenues and becoming increasingly interested in evaluation, partly in order to quantify these losses.

The design of a tax credit scheme needs to take account of aspects of the 'national innovation system' and broad national interests. General corporate tax structures, for example, will influence the extent to which companies benefit from credits. Also, the choice of scheme will be influenced by industrial policy objectives of, for example, encouraging particular types of R&D activity or supporting particular company types such as SMEs. Consideration is also required of possible interactions with other schemes such as direct grants.

Against the background of these contextual considerations, Exhibit 1 shows a generic intervention logic for fiscal R&D incentives. It proposes that incentives will lead

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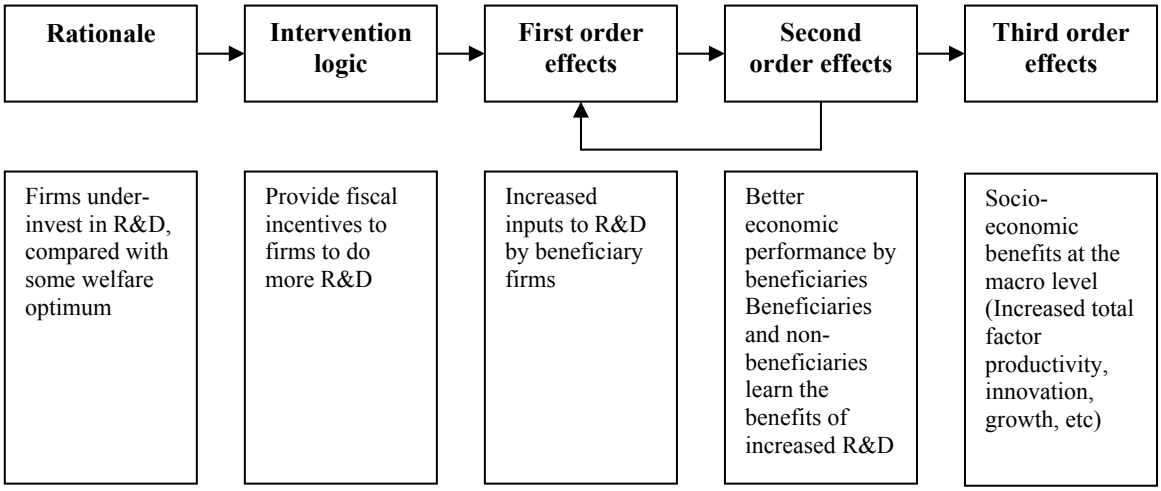
[6] Wesley M Cohen and Daniel A Levinthal, 'Absorptive capacity: a new perspective on learning and innovation,' *Administrative Science Quarterly*, Vol 35 (1), March 1990, pp128-152

Exhibit 1 Generic Intervention Logic for Fiscal R&D Incentives



companies to invest more in R&D if they are given a fiscal incentive to do so and that these investments will set in chain two processes. First, the increased investments will improve the performance of those who invest, resulting both in private benefits and in spillovers, and these together will help increase overall economic performance. Second, the demonstration that investing more in R&D improves performance teaches beneficiaries (and, hopefully, also other firms) that greater investment in R&D is rational, even in the absence of an incentive. This is the feedback from second to additional 'first-order' effects shown in the Exhibit. This should allow the incentives eventually to be reduced or eliminated. In other words, the incentives provide input and output additionality (they induce firms to invest more and to obtain greater benefits from R&D than they otherwise would) but they also provide behavioural additionality (companies change their behaviour in response to learning) so that the rationality of the innovation system itself changes.

3 Alternative Scheme Structures

3.1 Volume and incremental schemes

In practice, there is wide variation in the way fiscal incentives are implemented. There are at least three categories

- Volume-based incentives, where companies get a benefit either on all the R&D they do, or on all R&D up to a specific limit (so that the incentive is likely to cover a greater proportion of smaller firms' than larger firms' R&D)
- Incremental, where the amount of the incentive depends on how much companies increase their R&D expenditure compared with some earlier period. Here, too, a ceiling can be imposed so that the incentive favours smaller firms. Normally, the incentive to the individual firm is short-lived, since it gets the incentive only when it increases R&D expenditure
- Project-specific, where companies have to apply to the authorities in order to get the incentive in relation to a specific project. This is more like traditional R&D

project subsidy, except that the benefit is provided through foregone tax income rather than a cash transfer.

More countries now go for volume. The disadvantage of this is that all R&D is supported, including that which a firm would have done anyway, in the absence of a concession. As a result, there is the risk of greater 'deadweight' expenditure than might be incurred in the case of incremental schemes.

Incremental schemes suffer from the difficulty of defining a base period from which the increment is measured, which can produce perverse incentives and penalise heavy R&D spenders. They can also be complex and costly to administer for both companies and authorities. There is a very large number of ways to structure an incremental scheme (particularly in relation to how the base against which the increment is measured is defined). Each variant is likely to have different effects and evaluation can play a role in understanding these differences.

3.2 Other aspects of system design

Rules for tax credits differ from country to country, are often subject to local variations within countries, and are frequently complex. The latter features make inter-country comparisons difficult, but it is worth highlighting a few areas where there are major differences in practice.

Dimensions affecting whether, and to what extent, there is entitlement to tax credit include the following

- *Eligibility of various categories of R&D*. The 'Frascati' definition of R&D (OECD, 1980) is widely used as the definition of R&D for tax credit purposes. This definition includes basic research, applied research and experimental development, the latter broadly covering the development, improvement and testing of new products and processes. More 'routine' areas of commercial activity such as market research, mineral or gas exploration, and direct commercial production, are normally excluded. Some particular areas of work, such as software development, are sometimes included, sometimes not. A lack of clarity and visibility can lay a system open to abuse, an area appropriate for inclusion in an evaluation system
- *Expenditures covered* may or may not include the following categories: wages and salaries, capital equipment and other kinds of capital expenditures, materials, overheads, and sub-contracted research
- *Firm size* may influence eligibility, with preferential terms frequently being offered to smaller companies
- *Taxes to which credits are applied.* Credits are normally applied to corporation taxes, and this means that companies (such as start-ups) that do not make enough profit to pay corporation tax cannot benefit. To get round this difficulty, in the Dutch case the application is to taxes on wages, while the Norwegian Skattefunn scheme provides an incentive in the form of negative corporation tax, allowing companies not paying tax to receive money
- *Rates* of allowances for similar types of organisation may vary considerably between countries/regions. Rates of allowances may also be subject to bandings,

and total relief subject to a specified maximum. There may be an 'optimum' level of support where stimulation of R&D is maximised, which is potentially open to testing and evaluation. Timing issues, such as whether carry-forward of unused credits is allowed, are also important

Another key consideration is the overall taxation strategy. Some countries – especially new EU member states, which favour radical 'flat' tax schemes – try to maintain a broad taxation base, so that the rates of tax levied are low. Others prefer more selective taxation strategies, involving narrower tax bases and therefore higher rates of tax. The value of concessions under the second sort of strategy can clearly be larger than under the first.

Issues of system design were covered by a previous (2003) EU Task Force.[7] In outline, their recommendations were for

- Volume-based rather than increment-based schemes
- Cash refunds of tax credits where companies make losses
- A clear definition of R&D
- Improved visibility and transparency
- Simplicity, with low administrative and compliance costs
- Reliability and long term stability

They also recommended formal evaluation practices of the effectiveness of fiscal incentives, including comparison of fiscal incentives with other types of policy instrument. We would concur with this proposal and expect that a 'tailor made' evaluation system, following principles suggested in this paper, would be embedded in the design of the scheme.

4 Evaluation Questions

Normally, evaluation of an intervention is done both in order to test whether taxpayers' money is being used in an appropriate way and to allow learning, and asks three kinds of questions:

- Appropriateness: Are we doing the right thing?
- Effectiveness: What happens as a result?
- Implementation efficiency: How well are we operating the intervention?

4.1 Appropriateness

Regarding appropriateness, the evidence that increasing R&D intensity is a sound policy objective is already rather strong (even if the questions of how best to achieve this and whether R&D can be treated as a homogeneous entity in this context, are more open – we return to these issues below). The relevant evaluation questions are therefore mostly about how effective alternative approaches are in raising R&D

[7] 'Raising EU R&D Intensity – Fiscal Measures', report to the European Commission by an Independent Expert Group, European Communities, 2003

intensity and generating wealth, and how best to manage and administer incentive schemes. Raising these questions is important not only at the national level but also internationally, since comparing evaluations is in some cases the most promising route to understanding the implications of alternative ways to implement fiscal measures.

4.2 Effectiveness

In line with our intervention logic (Exhibit 1) key questions about *effectiveness* include

- *How big is the increase in company R&D expenditure (first-order effects, input additionality) triggered by the scheme, and what is its cost in tax foregone?*
- *How big is the change in firm performance induced (second order effects, private output additionality)? What are its effects on productivity, value-added, employment, competitiveness, etc?*
- *What are the socio-economic benefits (third-order effects, public output additionality), for example on industry productivity, value-added, employment, competitiveness, etc?*

As suggested above, the first of these is perhaps the key issue according to which the degree of success of a tax credit scheme is usually assessed. A conceptually simple question is whether businesses overall have at least matched their tax savings by a corresponding increase in R&D. This question is of interest in itself for system evaluation, and is also relevant to the issue of which forms of state support are most effective in stimulating private R&D. In particular, how do tax credits compare with targeted state subsidies in terms of R&D impact?[8] In the case of subsidies the additional R&D should at least be equal to the subsidy. If a firm is given money directly for R&D it would be expected to spend it on R&D. Is the corresponding effect greater or lesser in the case of tax credits?

The first-order effect on R&D tends to be regarded as the primary evaluation issue, although the higher-order impacts are more fundamental, in the sense of representing ultimate objectives of policy intervention. It can, however, be argued that the extent to which R&D is stimulated by the scheme is the only question that needs to be addressed in an evaluation, since the connection between R&D and higher-order effects is well established – R&D is necessarily 'good for you'. However, the question of whether 'marginal' R&D induced by tax incentives is as productive as R&D overall has not been answered in the evaluation literature. It might be more or less effective in particular cases or situations. We would like to compare the nature of the R&D induced by the scheme with activities the company would in any case finance itself (in terms of, for example, risk, scale, partnerships). Does incentive-driven R&D 'crowd out' other R&D? Does it 'crowd in' additional effort? Does it induce learning, thereby raising firms' propensity to conduct R&D, their rate of innovation and so on (behavioural additionality)?

Another factor is the effect of introducing fiscal measures on the supply of R&D workers and other key resources. A large increase in (apparent) R&D expenditure

[8] The latter in particular may, of course, have other objectives.

requires big increases in the availability of R&D resources, especially people, and it is not clear how quickly their supply can be increased (whether by reallocating them from other work or by educating additional people).

Finally, there is the question of *persistence* – does the impact on R&D remain constant, or does it decay (or grow) over time?

4.3 Implementation efficiency

Key questions about *implementation efficiency* include:

- Are there differences in effectiveness between volume, incremental and project-specific schemes?
  - In terms of their input and output additionality
  - In terms of behavioural additionality
- Are these kinds of differences also visible between specific R&D subsidy and fiscal incentive schemes?
- How does the incentive scheme interact with other policy instruments?
- Does the generosity of the scheme influence its input additionality? (For example, do more generous schemes induce disproportionately more additional R&D activity than less generous ones?)
- What are the relative administrative costs (in money, time and trouble) of the different types of scheme?
  - For the authorities
  - For companies
- How susceptible are different types of scheme to abuse (in particular, the phenomenon of 'relabelling', the re-description of non-R&D activity as R&D)?
- How can the administration and implementation of individual schemes be improved? Is it 'user-friendly'?
- Is it stable?
- Is it reversible?

These questions are typically more qualitative than those relating to effectiveness, indicating the need for different evaluation approaches, as we discuss below.

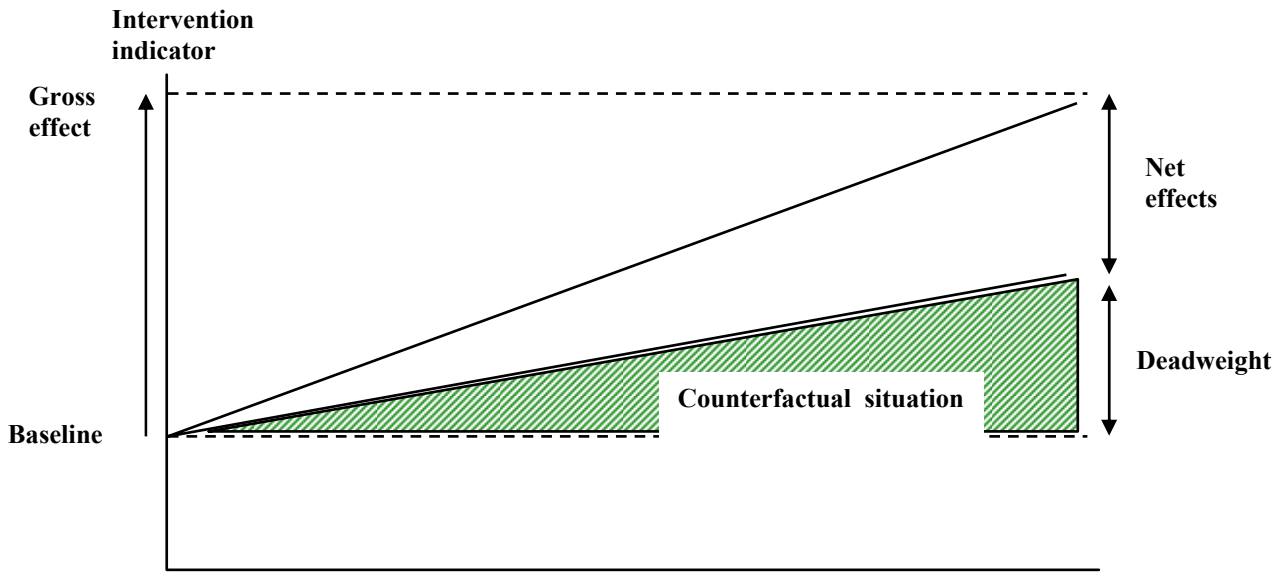
5 Evaluation Methodologies

5.1 Introduction

The evaluation questions set out above are very demanding; some of them stretching the limits of what is possible with current methods. The methods that can be used are individually not all that reliable, or give only partial insights. It is therefore important to use combinations of different methods in evaluation and to look for convergence among the findings that emerge, in order to have a good degree of confidence in evaluation conclusions.

As Exhibit 2 illustrates, interventions are normally made in the context of existing activities and trends. Some changes would have happened in any case without the intervention. These changes in the 'counterfactual' situation (that is the imaginary situation where there is no intervention) give rise to 'deadweight'. Often, the trickiest part of an evaluation of effects is to find a way to separate out the deadweight from the total changes observed so as to identify the net effect actually caused by the intervention. As with a great deal of social research, it is difficult to use a control group as a way to estimate deadweight. One can hardly decide to deny a fiscal incentive to one group of firms solely in order to create an 'untreated' control group whose performance can be compared with that of the 'treatment group' that benefits from the incentive.

Exhibit 2 Identifying the Net Effects of Intervention



This difficulty can to some degree be overcome by quasi-experiments and comparisons:

- Before/after studies of the introduction of schemes
- Using discontinuities, such as changes in scheme conditions or the type of scheme in use
- Inter-scheme (and, therefore, generally international) comparisons

Enabling such studies – and, indeed, evaluation studies more generally – to be done requires the systematic creation and management of large data sets. These need to have long time horizons – much longer than the period of the incentive(s) studied – partly so that it is possible to use synthetic data for a control group. Panel data are needed on companies with detailed information over time about R&D activity, inputs, outputs, employment data (including about education levels) and company financials. Particular efforts may be needed to collect data about firms that fall below the size threshold to be included in the normal R&D and innovation surveys.

The methods used need to tackle evaluation questions at multiple levels (**Exhibit 3**) or units of analysis. This further argues for a mix of methods.

Exhibit 3 Levels at which Evaluation Questions Should be Tackled

Evaluation Questions	Firm Level	Beneficiaries	Innovation System
Effectiveness			
Increase in firm R&D expenditures	X	X	
Changes in firm performance	X	X	
Socio-economic benefits		X	X
Learning, behavioural additionality	X	X	X
Effects on supplies of R&D inputs	X	X	X
Nature of R&D induced	X	X	X
Implementation efficiency			
Differences among scheme types	X	X	
Differences between fiscal and subsidy schemes	X	X	X
Effects of generosity	X	X	X
Administrative costs		X	
Susceptibility to abuse	X	X	
Process improvements in scheme administration	X	X	

5.2 Econometrics and first-order effects

Methodologically, estimates of impacts on R&D have overwhelmingly been based on econometric studies. Those that tackle the question 'how much additional R&D is induced by the incentive' are of two main types:[9]

- In the first, an equation is estimated with level of R&D (r(i,t)) expressed as a function of variables like lagged R&D, output, expected demand, and, characteristically, a dummy set to one or zero depending on whether the tax credit scheme is in operation. The coefficient of the dummy gives the R&D induced by the credit. An advantage of this approach is simplicity – there is no need to calculate the actual subsidy to each firm. The downside is that there is the implicit assumption that all firms are subject to similar R&D costs, irrespective of individual circumstances, which is not empirically valid
- The second type of econometric estimation involves inclusion of a price variable (the user cost of R&D) in the equation, capturing the marginal cost of R&D. The response to this price variable gives the price elasticity of R&D. The elasticity provides the response induced by a given tax reduction. Multiplication by the reduction in user price of R&D caused by the tax initiative gives the extra R&D induced

Econometrics is the central methodology for investigating the incentive effects of tax credit schemes, and is valuable for this. But it does have limitations, for example in its demands for much good quality data, and the need to make sometimes rather arbitrary assumptions. In addition, all results are both temporal and cross-sectional (firm, sector, country) *averages,* and qualitative support frequently needs to be sought to avoid misinterpretation.

[9] Hall, B.H. and van Reenen, J. (2000), 'How Effective are Fiscal Incentives for R&D? A Review of the Evidence', *Research Policy,* 29, pp. 449-469. These authors discuss advantages and disadvantages of alternative specifications.

5.3 Higher-order effects

Econometric analyses of higher-order impacts involve regressing measures of output or total-factor productivity, or their growth rates, against measures of R&D 'capital', possibly including terms for 'spillovers' from other firms, industries or countries (depending on the level of analysis). Griffith et al.,[10] for example, in their representation of productivity growth in countries behind the technological 'frontier', include, as well as R&D expenditure, terms representing technology transfer and 'absorptive capacity', the latter itself depending on domestic R&D.

Exhibit 4 Impacts of R&D support

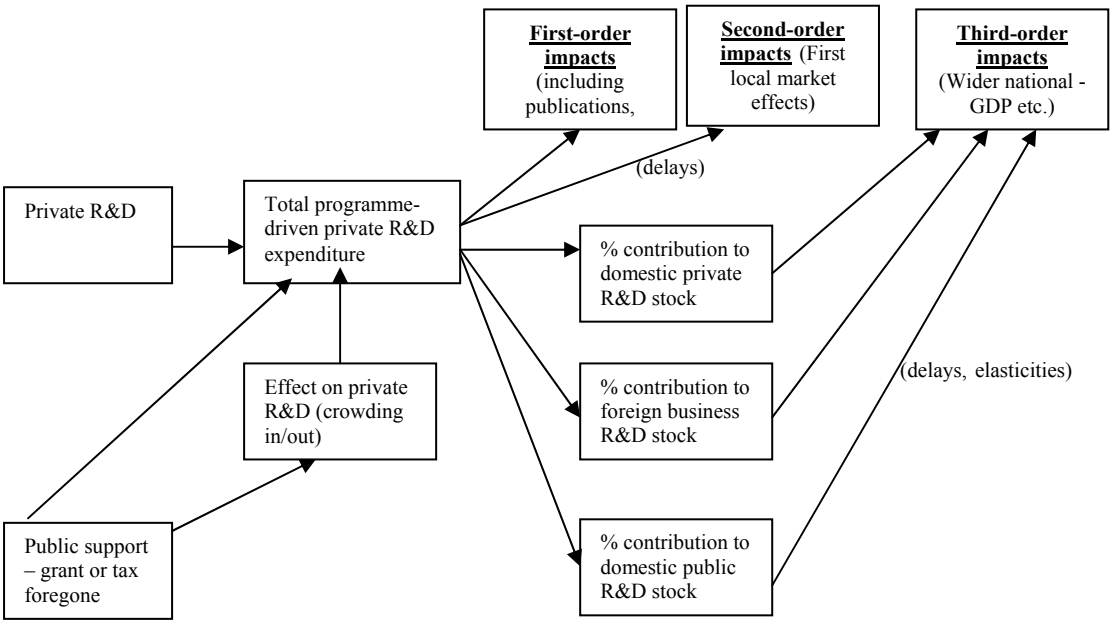


Exhibit 4 shows a model capturing impacts of R&D support programmes along the lines of that suggested by Guellec and von Pottelsberghe[11], who have attempted to assess the impact of R&D from different sources on the growth of total factor productivity of industry across OECD countries. Three sources of productivity growth are considered: the stock of business R&D, the stock of public (government and HEI) R&D, and the stock of 'foreign business' R&D. For each of these, 'elasticities' (the percentage effect on productivity of 1% increases) are estimated. Overall effects on the growth of total factor productivity, and hence on industrial output and GDP, can then be estimated, providing the link to the macroeconomy.

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[10] Griffith, R. et al., 'Measuring the Cost-Effectiveness of an R&D Tax Credit for the UK', *Fiscal Studies,* vol. 22, 3, pp. 375-399

[11] D Guellec and B von Pottelsberghe (2001) 'R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries', OECD.

There are question marks with such methodologies, including issues like the specification of R&D stocks and their depreciation, treatment of spillovers from other countries, variations between countries, representations of particular schemes. There seems to be potential for a lot more to be done in this area, but the implication is that direct subsidies for R&D *or* tax incentives may repay themselves many times over in terms of the eventual overall effect on national output.

An alternative means of estimating macroeconomic effects would be through a large scale macroeconomic model, as used by Governmental finance departments (e.g. the Treasury model in the UK). Such models do not generally contain R&D as an explicit variable, a seeming weakness in view of its recognised importance for economic development. The ability to track the effects of R&D tax incentives through such models would, for example, allow the interesting question of whether tax foregone in the short term was likely to be at least recouped in the longer term, via stimulus to the economy.

However, these econometric approaches fail to generate an understanding of company behaviour and learning or of the processes involved in defining, so other complementary methods should be used to capture these important dimensions, as well as to cross-check the plausibility of the estimates generated by econometric means.

5.4 Case studies

Evaluation of fiscal incentives should include case studies at the level of individual firms (and, potentially, clusters of firms), to provide a qualitative description and understanding of how and why individual firms take up the incentive and what the effects are in terms of the various forms of additionality. This is an important test of the intervention logic: to see whether and how the intervention designers' intentions are borne out in practice. Case studies have the additional benefit of providing explanations of how the intervention works that are intelligible to non-economists, especially among decision makers and the media.

Case studies are therefore particularly appropriate for the examination of the *nature* of the incremental R&D induced by tax incentives – questions such as

- How do companies in practice allocate the additional resources provided by the incentive? Do they, for example, conduct 'marginal' projects that just fall below their normal return on investment criteria or do they find additional R&D opportunities that are at least as likely to bear fruit as the R&D they routinely perform?
- How does the induced R&D fit into firms' overall research portfolio? For example, is it in a core area of their work, or is it peripheral, undertaken for special reasons of some kind?
- To what extent have additional R&D resources been deployed, and from where were they obtained or redeployed?
- Is there evidence of 'relabelling' of non-R&D activity for the purpose of (illegitimately) claiming tax credits?

5.5 Longitudinal and Other Studies

Longitudinal studies, at both the case level and with sample populations of beneficiaries, are needed, particularly to understand behavioural additionality and the interplay between the impulse for change provided by the fiscal incentive and by other factors. They will also help us understand how rapidly companies can react to altered incentives and the processes involved in reacting.

5.6 Evaluation of direct subsidy schemes

There are well-established traditions in the evaluation of direct R&D subsidies of using a combination of surveys, interviews and analysis of programmes to produce evaluations that typically focus on first and second-order effects. Partly because the populations of assisted firms tend to be modestly sized, the forms of assistance tend to be diverse and data suitable for econometric analysis are hard to obtain, this tradition has tended to be rather qualitative. Nonetheless, the large body of such evidence means there are good opportunities to compare fiscal incentives with direct R&D subsidy programmes by using established methods from the direct subsidy evaluation tradition.

The direct subsidy evaluation tradition also has a strong history of using beneficiary surveys, process mapping (and to some degree benchmarking) to do process evaluation of interventions. These should be undertaken both in order to identify process opportunities and so that the costs of different types of intervention can be compared.

6 Evaluation Results from the Literature

We can conclude that there are some things that can be said with some confidence from the available evidence, and other things that are important and on which there is evidence but which at the moment are rather speculative and uncertain.

6.1 Appropriateness

On appropriateness, the evidence does seem very strong that there is a real and large gap between social costs and social returns to R&D, i.e. that spillovers are significant. This may not mean that there is not enough R&D. It may be that any incremental R&D stimulated by a tax credit does not necessarily tend to close the gap. The R&D stimulated may be of the 'wrong sort', in the sense that, for example, it does not match scheme objectives. But there does seem to be justification for state intervention.

6.2 Tax incentives and R&D expenditure

The main body of evidence about fiscal incentives, using more or less simple cost-benefit analysis, looks at the first-order effect (input additionality): How much additional R&D will firms perform for a given fiscal incentive? The broad answer so

far seems to be that a $1 tax concession triggers $1 in additional R&D expenditure[12]. If the additional (marginal) R&D induced is as good an investment as R&D in general, we can infer from research on the economics of R&D investment that a $1 fiscal incentive generates a private return on investment of 15-25% and a social rate of return of 30-100%. However, there is no real evaluation evidence that confirms this, because of the difficulty of disentangling the effects of the fiscally induced R&D from the effects of other R&D. Policy has to work on the assumption that second and third order impacts (output additionality) of incentives are large, but that **is** an assumption. It remains unclear whether the R&D induced by fiscal incentives is riskier than the R&D firms normally do (which means that it could potentially produce bigger returns) or whether it is less financially attractive than the work firms do without subsidy, and whether the poorer potential return on investment is the reason the work is not prioritised. (The same questions, of course, arise about direct R&D subsidy.)

6.3 Behavioural Changes and the Nature of Induced R&D

Learning effects (behavioural additionality) are also poorly understood. On the face of it, the general finding that a $1 concession triggers $1 in additional R&D suggests there is no behavioural change. However, behavioural effects are difficult to capture without large amounts of time-series data at the firm level as well as some qualitative data and this question needs a lot more investigation before it can be regarded as resolved.

Thus, we have good evidence that it is possible to convert tax revenue into company R&D expenditure and good grounds for believing that doing so will bring both public and private benefits, but the jury is still out on whether fiscal incentives change behaviour or whether firms revert to their former, lower levels of R&D expenditure when the incentives are taken away.

There are several other issues related to behavioural changes and induced R&D. The issue of elasticity of supply of R&D resources seems an important one. One study[13] suggests that a major effect of a fiscal incentive may be to raise R&D workers' wages, rather than to increase the amount of R&D work actually done. Goolsbee has suggested that a large proportion of Government R&D assistance goes merely to increase the wages of scientists and engineers – an inflationary rather than a real effect. He regresses real income against total R&D expenditure as a proportion of GDP, and growth rate of GDP, and several dummies reflecting the attributes of individuals, and concludes that a 10% increase in R&D expenditure increases incomes by about 3%. Overall, he suggests that conventional estimates of the effectiveness of R&D policy may be 30%-50% too high. In his words, 'a major component of Government R&D spending is windfall gains to R&D workers'.[14]

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[12] Bronwyn Hall and John van Reenen, 'How effective are fiscal incentives for R&D? A review of the evidence,' *Research Policy*, 29 (2000), pp449-469

[13] A Goolsbee, 'Does R&D policy mainly benefit scientists and engineers?' American Bar Foundation and NBER, 1998

[14] On the positive side, higher R&D salaries may, in the longer term, promote an increased flow of workers to R&D activity.

6.4 R&D and the Macroeconomy

On macroeconomic effects, such evidence as there is suggests that R&D stimulates economic growth to the extent that the national economy gets back many times its investment in R&D.

As well as discussing rates of return, Griffith et al.[15] consider the effects of tax credits on productivity growth. As indicated above, they relate growth in total factor productivity not only to R&D expenditure and control variables, but include terms representing technology transfer and 'absorptive capacity'.

The impact on the growth of manufacturing value-added is estimated at around 0.32%.. The cost to the exchequer is estimated to be greater than the value of additional output in the first year, but the effects on output subsequently become very positive for the national economy.

Guellec and Van Pottelsberge[16] have also estimated macroeconomic effects. They attempt to measure the impact of R&D on the growth of total factor productivity of industry. Three sources of R&D impacting on productivity growth are considered

- The stock of business R&D a 1% increase in which is estimated to increase productivity by .13%
- Stock of public R&D
- Stock of foreign business' R&D, to capture imitation.

We used this work to try to estimate the effect on the UK of the R&D carried out or stimulated by the Framework Programme, and the figures were very impressive indeed; the contribution to UK industrial output came out at an order of magnitude greater than UK *expenditure* on the Framework Programme[17].

6.5 Volume and Incremental Schemes

Arguments for and against volume and incremental methods are well known, but there seems to be little literature on quantitative assessment of their relative impacts.

However, there is an interesting recent study by Canadian and American researchers comparing the impact of the systems in the two countries.[18] Canada uses a volume system, the US an incremental system, which has periodically been suspended and then reintroduced. The study uses a matched sample of Canadian and US firms, and regresses R&D expenditures on proxies for tax incentives for R&D and various control variables like lagged levels of R&D.

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[15] Griffith, R. et al., 'Measuring the Cost-Effectiveness of an R&D Tax Credit for the UK', *Fiscal Studies,* vol. 22, 3, pp. 375-399

[16] Guellec, D. and van Pottelsberghe, B: 'From R&D to Productivity Growth: Do the Institutional Settings and the Source of Funds of R&D Matter?' Oxford Bulletin of Economics and Statistics, 2004

[17] Clark, J.: 'Returns to Publicly-Supported Research and Development', forthcoming

[18] Klassen K.J. et al. (2004) 'A Cross-National Comparison of R&D Expenditure Decisions: Tax Incentives and Financial Constraints', mimeo.

They find that the estimated responses of R&D expenditures to the tax credit are very similar in the two countries, but because the Canadian system is more generous the R&D stimulated *per tax dollar foregone* is considerably less in Canada than in the US (1:30 per dollar as opposed to 2:96 in US)

It is perhaps intuitively reasonable to suppose that incremental schemes such as those in the US are more efficient in this sense. However, it is not clear whether volume or incremental schemes are more effective in inducing changes in firm behaviour. What does seem clear is that opinion in general is turning in favour of volume schemes despite their higher cost and risk of greater deadweight, in view of the greater complexity, risk of distortion, and administrative difficulties associated with incremental schemes.

6.6 Tax Credits vs. Subsidies

There is a great deal of ambivalence on whether tax credits or subsidies are more effective in stimulating R&D. The following quotes, from the New Zealand and Canadian governments, respectively, sum up the opposite attitudes.

The NZ government stated in its 2000 budget: 'grants are a *better, safer* and *fairer* option than tax breaks'. They were unconvinced of the level of market failure or of the effectiveness of tax concessions and did not regard increased spending on R&D as necessarily providing a positive impact on welfare (OECD 2002).

In contrast, a Canadian Federal Budget document in the 1980s put that Government's view as follows[19]

> The private sector is in the best position to determine the amount and type of industrial R&D it should undertake. Any firm's R&D projects have to make business sense, and the results need to be marketable.. Thus the incentive structure for R&D should contain general measures, such as R&D tax incentives that leave day-to-day decisions on R&D projects in the hands of the private sector.

The hard statistical evidence does not seem to give either side a clear victory. The choice of scheme seems to come down to a weighing of advantages and disadvantages of alternatives in a particular national situation, and particular objectives – tax credits may be a favoured means of enhancing R&D generally, leaving the market to determine the nature of the additional R&D, while subsidies/grants can be used to promote a particular area or type of R&D.

7 Policy Issues

Tax incentives and direct subsidies are not therefore direct substitutes. The fiscal approach is inherently *general*, while subsidies can be used much more selectively to address specific classes of problem, such as the need to catch up with foreign levels of effort in specific technologies or find technologies to help solve particular social problems.

[19] Klassen K.J. et al. (2004) 'A Cross-National Comparison of R&D Expenditure Decisions: Tax Incentives and Financial Constraints', mimeo.

It is axiomatic that the effects of a policy intervention depend not only upon the intervention itself but also upon its context, and the value of a given fiscal incentive depends upon the way the wider tax system works. There is some degree of competition among countries to offer attractive fiscal R&D incentives, as part of their wider activities to attract and retain mobile R&D investments. Work under OECD auspices has tried to compare the attractiveness of fiscal incentives in their context via the so-called Beta-index.[20] Whether it is sensible to offer fiscal incentives also depends upon the wider taxation strategy. It is inconsistent with the 'flat tax' approach, for example, which by definition tries to create a wide tax base with no exemptions but a low overall tax rate. Here, R&D subsidy or other direct measures are likely to be more appropriate. However, there is no good evaluation evidence that tells us how differences among incentive regimes affect either the relative attractiveness of locating R&D in different places or whether they induce difference amounts of R&D per unit of tax foregone.

Given the limitations of the available evidence, policy making on fiscal incentives needs to be pragmatic, and certainly has to be shaped in the context of other national policies as well as in ways that minimise administrative and regulatory burdens.

In effect, the existing body of evaluation studies leaves quite a number of policy-relevant questions unanswered – in large part because it builds upon a neoclassical rather than an innovation systems perspective. We need a much clearer differentiation between short term, incentive-induced changes in activity and performance and longer term and sustainable changes in what companies understand and how they behave. For example, in choosing between incremental and volume based schemes, it is important to understand whether the short term incentive created by incremental schemes can be sufficient to alter behaviour. Alternatively, if firms do not learn more R&D-intensive behaviours while benefiting from R&D incentives, permanent, volume-based schemes will be needed.

Only once we have such an understanding, too, will it be possible to think about trade-offs and complementarities between fiscal incentives and other measures. Changes in companies' propensities to perform R&D are not simply automatic responses to external incentives, but depend upon capabilities and resources. No incentive on earth will increase a company's R&D spending if it cannot hire people competent to do the R&D work or if its management is unable to understand the importance of innovation. We have raised the issue of the elasticity of supply of R&D workers with respect to incentives, the extent to which incentive in practice generate wage inflation, rather than increased activity, and the differences between short- and long-run elasticities.

One of the key implications of the Innovation Systems heuristic is that economies really **are** complex systems, and they work well when all their components work well. So we need to know much more about the contextual conditions that allow fiscal incentives to be effective, and not just about the incentives themselves. There are other important gaps in our understanding about the operation of the incentives themselves, including whether incentives-induced R&D and innovations are in some

[20] J Warda, 'Measuring the value of R&D tax incentives in OECD countries,' *STI Review*, No 27, 2001

important way different from 'normal' R&D and innovation activities, and therefore whether we can legitimately extrapolate normal R&D behaviours to those behaviours induced by incentives.

8 Conclusions for Future Evaluations

Some of the issues and uncertainties raised by attempts to evaluate R&D tax incentives are rather fundamental. The evaluation client and the evaluator both need to be clear about the extent to which evaluations contain a research component. Trying to obtain genuinely new and general knowledge can make evaluation much more expensive than otherwise and reduce its timeliness. Given the complexity of the interplay between induced R&D investments and socio-economic benefits, it may be more appropriate to have a much simpler evaluation ambition of trying to understand whether the costs or the benefits of intervention are larger.

Some of the key issues for the conduct of evaluations emerging from the above discussion are

- Evaluations need to take careful account of specific scheme objectives and system design, and to be 'built in' as part of that design
- The national and regional context will be key to the effects of the scheme. They need to be explicitly stated and analysed
- Evaluation needs primarily to encompass estimates of 'first-order' effects on the induced volume of R&D, taking account of temporal effects (such as the possibility of a declining effect following an initial impetus) and cross-sectional variations (for example, examining differences between firm types and industrial sectors). It is quite likely that schemes will affect different segments of the company population in different ways, so that population needs to be understood in a number of ways, including company size, branch, absorptive capacity, profitability and so on
- The nature of the induced R&D requires examination – for example, is it economically marginal, does it change firms' risk profiles. In short, there is a need to 'get under' the 'raw' statistical R&D effects to examine more qualitative factors. A key issue here is whether or not the induced R&D is 'typical' and can therefore be expected to convey the large higher-order effects measured for R&D as a whole
- Issues of implementation efficiency (Section 4.3) should be included. These include
  - Differences between different types of scheme, where possible (eg volume based versus incremental schemes)
  - Comparison with specific R&D subsidy schemes
  - The effects of scheme generosity
  - Stability and reversibility of the scheme
- Administration and compliance costs – in money but also in other terms, such as the degree to which these deter companies from using tax incentives, need to be considered
- Perverse effects, relabelling and other ways to use schemes for tax evasion should be examined

- There is a need to explore the effects of schemes on the availability of inputs to R&D, especially scarce manpower. If schemes increase demand for these inputs too rapidly, they will tend to be inflationary. Implementing a tax incentive scheme may have implications for other areas of policy, such as education and training or the availability of foreign currency to pay for importing new instrumentation
- Improved understanding is needed of the extent to which costs and benefits of tax incentive schemes accrue at national level. In the EU, this has implications for subsidiarity and for the choice between tax incentives that can be applied only at the national level and specific subsidies that can be implemented Europe-wide (such as the Framework Programmes)

Given the complexity of the area and the limitations to which individual evaluation tools are liable, a 'holistic' approach to evaluation, involving a number of interlinked approaches, is important. Any new scheme should be accompanied by a data collection plan that makes the needed panel data available to future evaluators. How this is to be done varies nationally, as a result of differences in national systems. It may be necessary to take data protection legislation into account and to require companies to give permission for certain kinds of data to be collected and held as a condition for obtaining the tax incentive.

Evaluation customers and evaluators need to look for ways to 'build experiments' via comparisons, before/after studies and studies of changes in the conditions attached to individual schemes. This requires a greater degree of cooperation and planning than is normal in R&D evaluation.

The need for a variety of methods means that at least the following should be considered when designing an evaluation:

- The primary tool so far used has been econometric analysis of various kinds, and this will continue to be important. While the authors of most econometric studies warn that they should be complemented by more qualitative approaches that explore causality and behaviour, less of this kind of work has been done that would appear to be useful
- Case studies are therefore needed, to show the working of the incentives at the micro level, to help tease out how decisions are made and how behavioural additionality may arise
- Economic panel surveys are needed over long periods of time, to generate econometrically useful data sets. In some countries these can effectively be assembled from existing surveys by the statistical or tax authorities. In others, a special inquiry will be needed
- Simulations of behaviour, costs and benefits of the incentives for different industrial segments of the company population will help tune the design of incentives policy and enable a more intelligent choice to be made between tax incentives and specific subsidies in different segments
- Surveys and interviews should be done that specifically tackle the processes involved in administration and compliance and the associated costs. Comparisons will be needed among these, in order to establish good practice benchmarks and to understand systematic variations among different types of scheme

- Reapplying the fairly standardised survey techniques widely employed in evaluating specific R&D subsidies will allow qualitative comparison with tax incentives

Finally, international comparison is a key tool for creating some of the quasi-experiments and controls that are so difficult to implement in intra-national evaluations. It would be useful to establish an open international forum on fiscal R&D incentive evaluation. Potential host organisations include the European Evaluation Society and the European Commission.