briefing notes

RESPONSE TO CONSULTATIVE NOTE ‘DESIGNS FOR INNOVATION’

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1. Introduction

The government intends to introduce a new research and development (R&D) tax credit, which will be open to larger firms, in Budget 2002. It has issued a second consultative note, *Designs for Innovation*,[1] on the design of the new credit. This Briefing Note discusses which firms are likely to benefit from the new credit, and the likely costs and effectiveness of the designs under consideration.

There seem to be strong economic grounds for introducing a government subsidy to R&D, and tax credits have become a popular policy tool both in the UK and in other countries.[2] The divergence between private and social rates of return to R&D by private firms provides one of the main justifications for government subsidies to R&D.[3] In order to achieve the optimal level of R&D investment, government policy aims to bring private incentives in line with the social rate of return. An R&D tax credit does this by reducing the cost to the firm of doing R&D. Recent empirical evidence suggests that R&D tax credits are an effective instrument in stimulating additional R&D.[4] But in order to be desirable, a policy needs to be not only effective but also cost-effective and implementation needs to be feasible.

The government originally consulted on the design of the R&D tax credit for large firms in March 2001.[5] Both volume and incremental credit designs were considered. A volume credit is one that is payable on the total amount of R&D expenditure by a firm. An

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[1] HM Treasury and Inland Revenue, 2001b.

[2] There are a large range of other policy instruments that could affect the share of GDP that is invested in R&D. Indirect policies such as competition policy and regulation may be important. Direct policies include direct public funding of R&D, investment in human capital formation and patent protection.

[3] See Griliches (1994) and Hall (1996). Griffith (2000) provides a summary.

[4] See, *inter alia*, Hall and Van Reenen (1999) and Bloom, Griffith and Van Reenen (2000).

[5] HM Treasury and Inland Revenue, 2001a.

incremental credit is one that is payable only on eligible expenditure above some base (for example, last year's expenditure). In the original consultation document, the government proposed a specific design of incremental credit. The theoretical advantage of an incremental credit over a volume-based credit is that it only rewards additional expenditure, so that the deadweight cost of paying the credit on R&D expenditure that would have occurred in the absence of the credit is reduced. This may allow a higher credit rate and therefore, in theory, should give a greater R&D incentive for a given exchequer cost.

However, in practice, the cost-effectiveness and desirability of an incremental tax credit depend very much on the choice of base from which incremental expenditure is measured. In the March 2001 consultation paper, the government favoured a two-year rolling base, where the base would be calculated as average annual expenditure in the previous two years and the credit would be given on the increase in expenditure over that base. One of the problems with a rolling base is that it reduces the incentive to do additional R&D – by spending a pound today, the firm earns a tax credit, but because this raises its base, it reduces the tax credit it will receive tomorrow. This negates some of the benefits of targeting incremental expenditure, and can even lead to negative incentives if R&D expenditure is volatile.[6] Once these perverse incentives are taken into account, there may be little difference between the cost-effectiveness of an incremental tax credit with a rolling base and a volume-based credit.[7] A volume-based credit has a clear advantage in terms of simplicity, as the need to measure and update the base from year to year is almost certain to involve greater compliance costs for taxpayers and administrative costs for the Inland Revenue.

The responses to the first consultative document were 'overwhelmingly against an incremental credit and in favour of a volume-based one'.[8] An incremental credit was felt by many respondents to be too complex and was expected to lead to a great deal of uncertainty for companies. The latest consultation paper comes down firmly in favour of a volume-based credit.

In the next section, we discuss the design options proposed by the government. In Section 3, we discuss the cost-effectiveness of each option, and estimate the amount of R&D expenditure that is likely to be eligible for the new credit and how it is distributed across sectors and firms. In Section 4, we consider the compliance and other costs associated with each design which will affect their effectiveness in practice. Section 5 concludes.

2. Options for the design of the new credit

Designs for Innovation proposed three designs for a volume-based credit on current R&D expenditure. At present, current expenditure on R&D can be deducted from taxable

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[6] For a discussion of this, see the early literature in the USA starting with Eisner, Albert and Sullivan (1984).

[7] This depends on the assumptions that are made about a number of factors, including firms' discount rates. See Table 2 of Bloom, Griffith and Klemm (2001).

[8] Annex A, HM Treasury and Inland Revenue (2001b).

profits in the year that it is incurred.[9] The credit will operate as an additional deduction from taxable profits. The designs are:

Option 1: simple volume scheme – an extra deduction, applying to all qualifying R&D expenditure. This can be operated at the company rather than at the group level.

Option 2: two-tiered volume scheme – two rates of extra deduction, with a higher rate on R&D expenditure below some threshold. The consultation document gives an example threshold of £100 million. This scheme would operate at the group rather than the company level.

Option 3: baseline volume scheme – an extra deduction on R&D expenditure above some baseline level. The consultation document gives an example baseline of 50% of R&D expenditure in 2000. This would operate at the group rather than at the company level. Under this design, there is an implicit requirement to uprate the baseline level of R&D at some point.

As discussed in the consultation document, for a given exchequer cost, option 3 implies a higher headline credit rate (the rate of additional deduction) than option 1, because under option 1 the credit is payable on all qualifying R&D expenditure. Again compared with option 1, option 2 allows a higher headline credit rate for R&D expenditure below £100 million, but a lower headline credit rate for R&D expenditure above £100 million.

The pros and cons of the three options for the tax credit are set out in the consultative document. The main criteria against which each option is likely to be judged are

- cost-effectiveness;
- simplicity;
- certainty.

Cost-effectiveness can be measured as the ratio of additional R&D expenditure generated by the tax credit to its exchequer cost. For example, a cost-effectiveness ratio of one would imply that the tax credit generated an increase in R&D that was equal to the increase in exchequer cost. This is a useful yardstick, as it implies that the tax credit would generate the same amount of additional R&D expenditure as if the government conducted the R&D itself. But it is important to note that this measure of cost-effectiveness does not account for the cost of raising revenue (or of cutting public expenditure) to pay for the tax credit, nor does it account for compliance costs. In addition, the ultimate goal of subsidising R&D is to boost real value-added. An alternative measure of cost-effectiveness is the ratio of additional value-added to the cost of the policy.[10] This will additionally depend on the social rate of return to R&D and how it varies across projects.

[9] The research and development allowance allows firms to deduct 100% of capital expenditure on R&D from their taxable profits in the year it is incurred.

[10] See Griffith, Redding and Van Reenen (2001) for a detailed discussion of how this can be estimated.

There will often be a trade-off between the cost-effectiveness of the credit, in the narrow sense defined above, and its simplicity and certainty. This is because trying to target the tax credit to maximise its effect whilst minimising its cost tends to complicate the rules governing access to the credit. This trade-off needs to be taken into account when designing the credit.

3. Cost-effectiveness

The cost-effectiveness of a particular tax credit option will depend on how much additional R&D expenditure is generated and its exchequer cost. The factors that will influence the amount of additional R&D expenditure generated include the effect of the credit on the 'price' of R&D expenditure and the responsiveness of R&D expenditure to a change in the 'price' of R&D.

The effect of the credit on the price of R&D can be measured in a number of ways, depending on how we think decisions about R&D investment are made. We typically think of incentives to conduct additional R&D in terms of the marginal incentive to conduct an additional pound of R&D. This means the effect of an R&D tax credit on the price of R&D would be measured by the *marginal effective tax credit* or the user cost of R&D. We use this measure in our calculations. It is based on the idea that firms are already doing R&D up to the point at which the expected rate of return equals their cost of capital.

Alternatively, the decision to carry out R&D can involve a one-off or 'lumpy' investment. If a company is deciding where to carry out an individual R&D project – for example, in the UK or the USA – that is likely to more than cover its costs, then an additional factor that may influence the location is the total value of relief on offer – for example, as measured by an *average effective tax credit*.[11]

The cost-effectiveness will also depend on the exchequer cost of the policy option. The exchequer cost is made up of two components: the cost of giving the credit on R&D that would have taken place even in the absence of the credit (often called the deadweight cost) and the cost of rewarding additional R&D undertaken. These will depend on the credit rate, the responsiveness of R&D spending to a change in the price of R&D and the amount of R&D receiving the credit.

The next two subsections consider the effect of each of the three credit designs on the price of R&D and the amount of R&D receiving the credit. We then discuss the empirical evidence on the responsiveness of R&D spending to changes in the price, before comparing the cost-effectiveness of the three options.

Marginal effective tax credit

We measure the incentives an R&D tax credit provides for firms to do more R&D by the marginal effective tax credit (METC). The METC measures the impact of the credit on

[11] See Devereux and Griffith (1999) for a more detailed discussion of why average as well as marginal tax rates might influence investment decisions.

the price for the firm of increasing R&D expenditure at the margin – that is, increasing R&D by a pound. Because the R&D tax credit is implemented as a deduction against taxable profits, the METC will be affected by the statutory corporation tax rate (denoted *t*, and assumed to be 30% throughout).

Option 1

$METC = Credit\ rate \times t.$

For example, if the credit rate were 10% and the statutory corporation tax rate 30%, the value of the deduction to the firm would be to reduce the cost of an additional pound of R&D by 3 pence. Thus the METC would equal 3%.

Option 2

The METC faced by a firm will depend on the total R&D expenditure of the group.

For groups doing less than £100 million R&D per annum, $METC = Higher\ credit\ rate \times t.$
For groups doing £100 million or more R&D per annum, $METC = Lower\ credit\ rate \times t.$

Option 3

The METC for option 3 depends on whether and how the firm expects the base to be uprated in the future and the firm's discount rate.

For example, if the firm believes that the base will never be uprated, then

$METC = Credit\ rate \times t.$

This would also be the METC if the firm believes that the base will be uprated by an index unrelated to its own R&D and that is less than the rate of growth of its R&D (for example, by the retail price index).

If the firm believes with certainty that the credit will be uprated every year, and the base is defined as half of the previous year's expenditure, then

$$METC = Credit\ rate \times t\left[1 - 0.5\frac{1}{1+r}\right],$$

where *r* is the firm's real discount rate.

If a firm is unsure about when the credit will be uprated, the METC will also depend on its assessment of the probability, *p*, that the base will be uprated to half of this year's level of R&D in *n* years:

$$METC = Credit\ rate \times t\left[1 - p0.5\frac{1}{(1+r)^n}\right].$$

For example, if the firm believes that the base will be uprated every year, and if the credit rate is 10%, the statutory corporation tax rate is 30% and the firm's real discount rate is 10%, then the METC will be 1.6% – only half as great as if the firm believed the base would never be uprated. If instead the firm believes that there is a 1 in 2 chance that the base will be uprated in five years' time, the METC will be 2.5%. In practice, the likelihood that the government will uprate the base in any given time period and the precise form of uprating may be uncertain. It is important to bear in mind that any uncertainty means that the additional R&D generated and therefore the cost-effectiveness of option 3 may be overstated compared with the other two options.

Eligible R&D expenditure

The consultation document discusses which categories of R&D expenditure will qualify for the credit. It suggests that qualifying R&D expenditure is likely to be defined as current expenditure conducted by the firm in the UK. This excludes capital expenditure, R&D conducted overseas and extramural R&D – that is, R&D paid for by the firm but conducted outside the firm. An exception to the latter may be made for some collaborative research carried out outside the firm – for example, in conjunction with universities. R&D conducted by small and medium-sized enterprises (SMEs) that are claiming the SME credit will also be ineligible. It is also possible that, as under the SME credit, R&D that is directly or indirectly funded by government would be excluded (although this is not made clear).

We estimate the amount of R&D eligible for the credit using the enterprise-level data that underlies the 1999 Survey of Business Enterprise Research and Development (BERD). Table 1 describes the estimated breakdown of UK intramural R&D between SMEs and non-SMEs by product group.[12] The first column shows the total amount of intramural R&D carried out in respect of each product group. Around 80% of R&D is carried out in the manufacturing sector, and the largest individual product group is pharmaceuticals, which accounts for more than 20% of R&D. The second column of the table shows our estimate of the number of enterprises in the sampled BERD data that are owned by large firms (non-SMEs) and the third column the number owned by SMEs. Across all product groups, the majority of R&D expenditure is carried out by large firms.[13]

Under the government's proposals,[14] firms eligible for both the SME credit and the new credit will only be able to receive one of them. Since the R&D tax credit for large firms is likely to be less generous than that for SMEs, we have assumed that SMEs will opt for the SME tax credit whenever possible. We therefore exclude R&D carried out by SMEs when calculating the amount of R&D eligible for the new tax credit. We also exclude capital expenditure, as this is ineligible for the new credit. Table 2 shows that roughly 90% of total intramural R&D expenditure carried out by non-SMEs is current expenditure.

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[12] See the Data Annex for a description of the survey data used and for a definition of product groups.

[13] We do not directly observe which firms are SMEs. This is estimated as described in the Data Annex.

[14] HM Treasury and Inland Revenue, 2001a.

Table 1: Total intramural R&D, 1999

Product group	Intramural R&D (£ million)	Number of non-SMEs	Number of SMEs	Percentage of expenditure done by non-SMEs
Pharmaceuticals	2,500	66	15	96%
Chemicals	671	124	78	97%
Mechanical engineering	734	252	163	94%
Electrical machinery	1,233	172	110	96%
Transport equipment	1,218	92	24	99%
Aerospace	1,230	32	7	100%
Other manufacturing	1,024	348	211	88%
Services	1,677	163	512	85%
Other	330	62	15	98%
Total	**10,616**	**1,311**	**1,135**	**94%**

Source: Enterprise-level Survey of Business Enterprise Research and Development, 1999.

It is not clear how government-subsidised R&D will be treated for the purposes of the new credit. The R&D allowance and R&D tax credit for SMEs are not available on R&D that is directly funded by grants, contributions or subsidies from the government or other public bodies. In addition, if part or all of the costs of a particular R&D project are met by a 'notified State Aid', such as Smart or LINK awards, this is considered to be indirectly funded and none of the R&D expenditure incurred on that project is eligible for the SME credit.

Table 2: Total intramural R&D by non-SMEs, 1999

Product group	Intramural R&D by non-SMEs (£ million)	Percentage current expenditure	Percentage not publicly funded	Percentage done by firms receiving no public funding
Pharmaceuticals	2,390	80%	100%	85%
Chemicals	652	91%	100%	52%
Mechanical engineering	691	96%	69%	33%
Electrical machinery	1,185	90%	85%	48%
Transport equipment	1,205	91%	91%	77%
Aerospace	1,226	91%	75%	1%
Other manufacturing	899	89%	83%	40%
Services	1,434	94%	90%	33%
Other	323	91%	84%	15%
Total	**10,005**	**89%**	**89%**	**50%**

Note: The total figure in column 1 differs from that implied by the final column of Table 1 due to rounding.

Source: Enterprise-level Survey of Business Enterprise Research and Development, 1999.

Table 2 shows the proportion of intramural expenditure in each product group that is not subsidised, under two alternative definitions. Under the narrow definition, we assume that only R&D expenditure that is directly funded by the government or the European Union is excluded from eligible expenditure. Under the broad definition, we would like to exclude only those *projects* that receive public funding, to see the effect if the same rules were adopted as for the SME credit. But the BERD survey does not collect R&D data at the level of individual projects. Instead, we exclude all expenditure by enterprises that receive any public funding. In practice, this is almost certainly a lower bound to the amount that would be eligible, but it serves to illustrate the large impact that this policy option has. Only 11% of R&D carried out by non-SMEs is publicly funded, but 50% is carried out by firms receiving at least some public funding for R&D.

There are some large differences across product groups in the amount of R&D that is publicly funded. Broadly speaking, those industries with a relatively high proportion of defence spending, such as mechanical engineering and aerospace, receive the most government funding for R&D.

In our cost-effectiveness estimates, we assume that all current intramural R&D expenditure carried out by large firms – around £8.9 billion in 1999 prices – would be eligible for the credit.

Table 3 shows our estimate of the amount of R&D on which the credit would be payable under each of the three options. In the bottom row, it also shows the amount of R&D carried out by firms that are receiving each rate of credit on their marginal pound of R&D expenditure. Under option 1, the credit is payable on all eligible R&D expenditure carried out by the firm, and each firm receives the same credit rate on its marginal pound of R&D expenditure. Similarly under option 3, as long as firms are above the baseline level, each will receive the same credit rate on its marginal pound of R&D expenditure. But under option 3, the credit is only payable on expenditure above the baseline – in this illustration, assumed to be half the current year's level.[15]

Table 3: R&D on which credit payable and R&D carried out by firms receiving each credit rate on their marginal pound of R&D expenditure (£ million, 1999)

	Option 1	Option 2		Option 3
		Expenditure tranche		
		<£100m (higher rate)	£100m+ (lower rate)	
R&D expenditure on which:				
Credit payable	8,887	6,015	2,872	4,443
Credit rate operates at margin	8,887	4,315	4,572	8,887

Source: Enterprise-level Survey of Business Enterprise Research and Development, 1999.

Under option 2, the higher rate of credit would be payable on approximately 70% of qualifying R&D expenditure. But around 50% of qualifying R&D is carried out by firms that are part of groups spending more than £100 million on R&D. These firms receive the lower credit rate on their marginal pound of R&D expenditure, and therefore face a lower incentive to increase their R&D expenditure. This will be reflected in the cost-effectiveness of option 2.

Concentration of R&D

Table 4 shows that within most product groups, the majority of the R&D tax credit would be received by 10 firms or fewer. Within each product group, the largest 10 firms,

[15] Strictly, this assumes perfect indexation – i.e. uprating of the base by the actual average growth rate of R&D. If the base were indexed by less than the actual R&D growth rate, more than half of the current year's R&D would receive the credit.

ranked by the amount of R&D they carry out, would receive between 50% and 100% of the credit. In the economy as a whole, the 10 firms doing the most R&D would receive around 40% of the credit under options 1 and 3, and around 25% under option 2. This reflects the higher credit rate given to firms' first £100 million of expenditure under option 2.

Table 4: Total current R&D expenditure by non-SMEs and concentration of R&D

Product group	Total current R&D expenditure (£ million, 1999)	Proportion of credit received by 10 firms doing largest amount of R&D		
		Option 1	Option 2	Option 3
Pharmaceuticals	1,917	79%	69%	79%
Chemicals	593	71%	68%	71%
Mechanical engineering	663	63%	61%	63%
Electrical machinery	1,066	69%	62%	69%
Transport equipment	1,091	79%	75%	79%
Aerospace	1,115	98%	96%	98%
Other manufacturing	800	53%	48%	53%
Services	1,350	68%	62%	68%
Other	292	85%	83%	85%
Total	**8,887**	**41%**	**26%**	**41%**

Source: Enterprise-level Survey of Business Enterprise Research and Development, 1999.

Responsiveness of R&D to price

Estimates of the amount of new R&D undertaken in response to the tax credit will depend on how responsive we think firms are to a change in the price of R&D. Hall and Van Reenen (1999) survey the empirical evidence on how R&D expenditure responds to changes in its tax price using cross-country data at the industry level. Bloom, Griffith and Van Reenen (2000) provide estimates that suggest that the own-price impact, or short-run, elasticity is around 0.12 and the long-run elasticity is around 0.86. This means that a 10% decrease in the price of R&D will lead to an immediate increase of 1.2% in R&D expenditure and an 8.6% increase in the long run. In the calculations below, we assume an immediate impact of 0.1 (that is, for a 10% decrease in the price of R&D, the amount of R&D will increase by 1%) and a long-run effect of 1.0.

In order to estimate the amount of new R&D that is conducted in response to a change in the tax price, we assume that the change in the user cost of capital gives a good approximation of the change in the price faced by firms. The user cost of capital is given by

$$\frac{1-A^d-A^c}{1-t}(\rho+\delta)$$

where A^d is the net present value of standard depreciation allowances (assumed to be equal to 0.287),[16] A^c is the net present value of standard depreciation allowances as

[16] See Griffith, Redding and Van Reenen (2001).

measured by the METC given above, t is the statutory corporation tax rate, ρ is the firm's real discount rate and δ is the economic depreciation rate. We are interested in the proportional change in the user cost due to the R&D tax credit; this is equal to

$$\ln\left[\frac{1-A^d}{1-t}(\rho+\delta)\right]-\ln\left[\frac{1-A^d-A^c}{1-t}(\rho+\delta)\right]=\ln\left[\frac{1-A^d}{1-A^d-A^c}\right].$$

Estimates of cost-effectiveness

Having estimated the amount of R&D expenditure that would be eligible for the credit, and derived expressions for the effect of the credit on the price of R&D, we can estimate the amount of additional R&D expenditure generated by the credit, the cost of the credit and its cost-effectiveness under each option. Table 5 shows the immediate and long-run annual increases in R&D that we would expect for each option, using credit rates that are estimated to lead to a £300 million exchequer cost for each option in the long run, and using the assumed price elasticities stated earlier. The table also shows the cost-effectiveness of each option, calculated as the amount of additional R&D generated per pound of exchequer cost.

Table 5: Additional R&D generated and cost-effectiveness (£ million, 1999) at £300 million exchequer cost

	Option 1	Option 2	Option 3 Perfect indexation	Option 3[a] Annual uprating
Additional R&D (£ million, 1999)[b]				
Short-run	41	34	75	43
Long-run	409	344	749	428
Cost-effectiveness (£ additional R&D / £ exchequer cost)				
Short-run	0.14	0.12	0.29	0.16
Long-run	1.37	1.15	2.50	1.43

[a] The METC under option 3 with annual uprating is calculated assuming a 10% real discount rate.

[b] Figures for additional R&D are in 1999 prices and reflect 1999 R&D volumes.

Notes: Calculations based on the enterprise-level BERD survey, 1999. Option 1 is the simple volume scheme, option 2 the two-tiered volume scheme and option 3 the baseline volume scheme.

The table shows that very little additional R&D is generated in the short run under any option, suggesting that the impact of the policy is likely to take some time to build up. As a result, the short-run cost-effectiveness of all three options is low, as the exchequer must still bear the cost of giving the credit on existing R&D even though little new R&D has been generated. However, in the long run, the cost-effectiveness of all three options is greater than one, given our assumptions about the price-responsiveness of R&D.

Option 2 is the least cost-effective of the three options. As shown above, under option 2, around half of qualifying R&D is carried out by firms receiving the lower credit rate on their marginal pound of R&D expenditure. This means they face a lower incentive to increase R&D expenditure, but they still receive a large payment from the higher rate applied to the first £100 million of their expenditure. Option 2 is less cost-effective than option 1 because this higher deadweight cost more than outweighs the effect on additional R&D generated by the higher marginal effective tax credit for firms doing less than £100 million of R&D.

The cost-effectiveness of option 3 will vary depending on how the government chooses to uprate the baseline level of R&D. Two versions of option 3 are considered: perfect indexation – that is, uprating of the base by the annual average growth rate of R&D – and annual uprating of the base with respect to a firm's own R&D expenditure. The two versions considered are extreme cases, and in practice it is likely that the government would opt for something between the two if it chose option 3 (for example, it could uprate by the growth rate of GDP).

The third column of Table 5 shows the amount of additional R&D generated and the cost-effectiveness of the credit if the base is uprated in line with annual average R&D growth. This is the most cost-effective option, but it should be noted that if the uprating were less than the annual average growth rate of R&D, the long-run cost-effectiveness figure given in the third column would be an overstatement, as exchequer costs would rise over time as the base declined relative to the level of R&D expenditure. In an extreme case, if the base is not indexed or ever uprated, the cost-effectiveness of option 3 would tend towards that of option 1, i.e. a volume-based scheme.

The last column of Table 5 shows the amount of additional R&D generated and the cost-effectiveness of the credit under option 3 if the base is uprated annually using the firm's own R&D expenditure. This is equivalent to an incremental credit with a one-year moving-average base, but with the base set to half the level of R&D expenditure in the previous year. The cost-effectiveness of this version of option 3 is much lower. This is because firms will take into account that increasing their R&D expenditure this year will also increase their base next year. This will significantly reduce the incentive effect of the credit. If, in addition, the rules for uprating the baseline level of R&D are not set out in advance, this will make the future price of R&D very uncertain. It is possible that this uncertainty would be so great as to reduce still further the effectiveness of this option at encouraging more R&D.

4. Simplicity and certainty

The measure of exchequer cost used in the cost-effectiveness estimates shown in Table 5 excludes compliance and administrative costs. As well as cost-effectiveness, simplicity of design and implementation is desirable. A simple design will tend to have lower compliance costs (the cost to firms of claiming the credit) and administrative costs (the cost to the government of administering and policing the credit). In addition, a simple design that is not subject to change usually means that it will be easier for firms to calculate how much credit they should receive under different circumstances, and when. This increases the degree of certainty that companies have over the amount of tax credit that they will receive on a given R&D project.

The simplicity and certainty of the credit will depend on the clarity of the rules surrounding the credit, and the extent of Inland Revenue discretion over how much R&D is deemed to qualify for the credit. Option 1 is the simplest option because the credit is payable on all qualifying R&D expenditure by a given company. It can therefore be calculated at the group or subsidiary level, and requires no reference to past R&D expenditure.

Because both options 2 and 3 target the tax credit at expenditure above or below a certain threshold, they would require more complex rules than option 1 to ensure that groups of companies could not manipulate R&D expenditure in order to maximise the value of the deduction to the group without necessarily conducting any more R&D. Option 3 is the most complex scheme, since, as well as requiring the group rules of option 2, the baseline level of R&D would need to be uprated on a pre-announced or ad hoc basis. Furthermore, as option 3 requires reference to past R&D expenditure, it raises issues about how to deal with new firms and firms that restructure. For these reasons, option 3 would probably involve the highest compliance and administrative costs and provide the least predictable tax credit for companies.

There is clear evidence that uncertainty over tax treatment can have a negative impact on investment, especially for investments in R&D which are often planned a long time in advance, have a long payback period and are subject to high adjustment costs once started. The responsiveness of firms' R&D expenditure to the tax credit is likely to be affected by the permanence of the policy. In the USA, where the R&D credit was initially introduced as a temporary measure, this was found to be an important factor (see, *inter alia*, Hall (1995)). This is likely to be due to high adjustment costs in R&D – it is expensive to hire scientists and, once hired, the firm is unlikely to want to fire them quickly. The degree of certainty will also depend on how explicit the government is about its future intentions for the credit, which is likely to be particularly important for option 3.

5. Conclusion

Option 2 – the two-tiered scheme – is the least cost-effective design. Option 1 is the simplest volume-based credit and will very likely have the lowest compliance and administrative costs. Option 3 is the most cost-effective design, but the cost-effectiveness of this option will vary considerably with how the base is increased over time and with firms' expectations about how it will be increased. Therefore the judgement between options 1 and 3 depends crucially on whether the cost of the greater complexity and uncertainty of option 3 outweighs its additional cost-effectiveness.

Data annex

We estimate the amount of R&D eligible for the tax credit using data for 1999 from the Survey of Business Enterprise Research and Development (BERD). The BERD survey covers all business R&D expenditure *undertaken* in the UK. The sample of firms covered includes both UK and foreign-owned firms. It differs from accounting data[17] in that it does not include R&D done by overseas subsidiaries of UK firms but does include R&D done by UK subsidiaries of foreign firms. The companies covered by the survey correspond closely to the companies that will be eligible for the R&D tax credit. The survey gives information on the breakdown of R&D by source of funding and between capital and current expenditure.

Total intramural R&D expenditure in 1999 is calculated by aggregating the BERD data across reporting units. A reporting unit may report on its own R&D or on the R&D done by itself and related plants owned by the same firm. It may be either a stand-alone firm or a subsidiary of a larger firm. Total intramural R&D in the sampled population is £10,616 million. This is around 6% lower than the published total,[18] because we have not grossed up the figures (enterprises doing less than £2.5 million of R&D are only sampled). All of the numbers are reported for the sample, not the population. This is not likely to affect estimates of expenditure eligible for the large-firm credit significantly, since the firms doing the vast majority of expenditure should be included in the sample.

Small and medium-sized enterprises

The EU definition of a small or medium-sized enterprise (SME) is a business with fewer than 250 employees and *either* turnover less than 40 million euro *or* net assets less than 27 million euro. We identify firms as SMEs using information from the Inter-Departmental Business Register (IDBR). Firms reported as having fewer than 250 employees or less than £25 million turnover in IDBR are classed as SMEs. Reporting units that are foreign-owned are assumed not to be SMEs, as they will typically be part of larger groups. But there will still be some inaccuracy in this estimate, as the employment measure may be understated for some reporting units engaged in R&D that are subsidiaries of domestic groups.

Definitions of product groups

The BERD survey data include the industry of the reporting unit and product group in respect of which the R&D is undertaken. The two are not necessarily the same. For instance, many BERD reporting units are classified as R&D services (two-digit industry code 73 (sic92)), whereas they mainly undertake R&D in the area of manufacturing (particularly pharmaceuticals). All of the breakdowns are given in terms of product groups, rather than industry (sic) codes. The definitions of the product groups are given below.

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[17] As used, for example, in Bloom, Griffith and Van Reenen (2000).

[18] Office for National Statistics, 2001.

Product group	Description	Industry code (sic92)
Pharmaceuticals	pharmaceuticals, medical chemicals and botanical products	24.4
Chemicals	chemicals, chemical products and man-made fibres	24 (excluding 24.4)
Mechanical engineering	non-metallic minerals, basic iron & steel and ferro-alloys, fabricated metal products and machinery and equipment (n.e.s.)	26, 27.1, 27.2, 27.3, 27.51, 27.52, 28, 29
Electrical machinery	office machinery, computers, electrical machinery, radio, TV and communications equipment	30, 31, 32
Transport equipment	motor vehicles, motor parts and engines, railway locomotives and rolling stock, ships and boats and transport equipment (n.e.s.)	34, 35.2, 35.4, 35.5
Aerospace	aircraft and spacecraft	35.3
Other manufacturing	food, beverages, tobacco, textiles, clothes, leather, footwear, wood and wood products, pulp, paper, publishing, printing, recorded media, refined petroleum products, nuclear fuel, rubber and plastics, precious and non-ferrous metals, medical and precision instruments, furniture, jewellery, musical instruments, sports goods, games and toys and other manufacturing (n.e.s.)	15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 27.4, 27.53, 27.54, 33, 36
Services	wholesale, retail, transport, storage, post, financial, real estate, computing, R&D services, public administration	50, 51, 52, 55, 60, 61, 62, 63, 64, 65, 66, 67, 70, 71, 72, 73, 74, 75–99
Other	agriculture, extraction, electricity, gas, water, construction	01, 02, 05, 10, 11, 12, 13, 14, 40, 41, 45

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