An Evaluation of Research and Development Tax Credits

This report summarises the findings of a suite of studies, undertaken or commissioned by HM Revenue & Customs (HMRC) to inform an evaluation of the research and development (R&D) tax credit schemes introduced since April 2000.

The report comprises three main components:

- A **literature review** summarising international evidence of the impact of tax policy on R&D spending and the methodological approaches used to measure this impact;
- An **econometric analysis** estimating the price elasticity of R&D spending in the UK using data for years after the introduction of R&D tax credits from companies making tax relief claims;
- A **qualitative survey** capturing businesses' views on the effectiveness of the schemes.

As the econometric analysis and the survey do not cover all companies making tax relief claims, these components are supplemented by:

- A **monitoring note** reporting on the value and volume of R&D tax credits broken down by year, geography, industry sector, etc.

Reports and detailed findings for each component are included in Appendices to the report.

Key findings

- There is a general consensus from studies of experience in different countries that additional tax relief for R&D expenditure results in higher levels of expenditure than would otherwise occur
- The studies show a wide range of estimates of the extent to which expenditure is increased as a result of tax relief (and therefore of the cost-effectiveness of the relief), given the variations between different systems of relief and estimation methods
- Analyses of UK claims also produce a wide range of cost-benefit estimates, but indicate that up to £3 of R&D expenditure might be stimulated by £1 of tax foregone
- UK companies surveyed believe that the overall amount of R&D is increased as a result of the R&D tax credit system
- The availability of R&D tax credits has little effect, however, on decisions to undertake specific R&D projects
- Between 2003 and 2007 R&D expenditure by UK business rose by 3% pa in real terms, but the number and value/tax cost of R&D tax relief claims grew faster
- Although regular claimants show healthy year-on-year increases in R&D investment, the increase in tax cost has been driven more by the increased number of (often new) claims
- Around 30% of claims each year are made by 'new' companies, ie those making R&D tax credit claims for the first time
- For SMEs, two thirds of claims and over 90% of the tax relief are for 'high tech' companies

UK schemes

Tax credits for companies investing in R&D were introduced for SMEs in 2000-01, extended to larger companies in 2002-03, and enhanced for vaccine research in 2003-04. Companies may claim relief for all their qualifying expenditure in a given accounting period (typically one year) in the form of an enhanced deduction when calculating their taxable profits. SMEs whose taxable profits are zero after making all relevant deductions may either carry forward their enhanced losses to a future accounting period, or surrender some or all of these enhanced losses in return for a payable credit. There were substantial alterations to all the schemes in 2008, in particular increasing the rates of enhanced deductions for the large company and SME schemes.

This relief applies to qualifying revenue expenditure: capital expenditure on R&D attracts a different form of tax relief. Further information about how the relief operates may be found at Research and Development (R&D) Relief for Corporation Tax

HMRC monitors the uptake of the relief in terms of the annual number and tax cost of claims, and publishes annual National Statistics, at Corporate Tax: Research and Development Tax Credits

Quite separately, the Office for National Statistics (ONS) reports annual figures for the total amount of R&D expenditure by businesses, as well as by universities, research councils, government departments, etc at UK gross domestic expenditure on research and development 2008

The ONS figures separate capital expenditure from revenue expenditure, so it is possible to relate the cost of the tax relief and the associated qualifying expenditure to the total amount of qualifying R&D expenditure by business.

Table 1: R&D expenditure 2003 to 2007 (£ billion)

	2003	2004	2005	2006	2007
Total revenue expenditure (BERD survey, cash terms*)	11.33	11.48	12.57	13.19	14.55
Expenditure used to claim tax credits	5.70	6.47	7.12	7.89	9.03
Percentage of total used to claim	50%	56%	57%	60%	62%

* Research and Development in UK Businesses, 2008 - Datasets

The table shows that while business expenditure on R&D increased in cash terms by 6% pa between 2003 and 2007 (and in real terms by 3%), an increasing proportion of this expenditure has attracted tax relief, so that the tax cost/value of the relief has increased by 12% pa over the same period. This may be due in part to increasing awareness of the relief, that is, more R&D investing companies are claiming, and part due to companies claiming for proportionately more of their R&D expenditure, as well as the overall real terms increase in R&D investment.

International context - literature review

Governments in many developed countries provide support for R&D undertaken by business, and several research studies of the effectiveness of that support have been published.

In 2006, HMRC commissioned a feasibility study, including a literature review, to examine how UK company data (including tax return data) might be used to evaluate the effectiveness of UK R&D tax credits. The report by Oxera, published on the HMRC website at HMRC Research Report 19, described a range of econometric models that had been used in previous studies based on either company-level or country-level data.

The report also concluded that suitable econometric models, together with tax, administrative and survey data on R&D by companies, could be used to evaluate the effectiveness of UK R&D tax credits. The feasibility study indicated that a R&D price elasticity estimation might lead to the most accurate estimates of the impact of any R&D credit scheme.

It also suggested the use of a control group as part of the process of measuring the counterfactual and minimising the risk of overestimating the potential impact of the policy. As part of this recommendation it was also suggested that a potential control group could be formed through the identification of firms that have similar characteristics but do not claim R&D tax credits. An alternative option for a control group could be the use of data from the same firms before the introduction of the policy. Both options were based on the assumption that data were available and could be properly matched.

In 2010, HMRC undertook an updated literature review (see Appendix A) which again focused on the range of econometric models employed, and importantly on the results obtained, by previous studies. The review describes and tabulates the various tax incentive schemes that have been used by over 20 developed countries, drawing attention to the differences between them which mean direct comparisons of effectiveness are not always appropriate.

Tax concessions for R&D activities are extensively used as a policy tool designed to stimulate business R&D indirectly. The exact form of tax incentive scheme varies greatly, but most allow companies either an enhanced deduction based on the amount of R&D spending in their corporation tax computation (such as in the UK); or a reduction of net tax payable, based again on the amount of R&D spending (a true tax credit). In either case, the relief may be based on the actual expenditure for the current year (for so-called volume or level-based reliefs as in the UK), or on the current increase in R&D expenditure over some reference level (incremental reliefs). The rate of relief is also substantially different across countries, and often smaller companies are favoured either directly with a separate higher rate (for example, the UK) or implicitly through a limit on the total relief available.

The review then concentrates on those studies that estimate the tax price responsiveness of R&D investment, and which form the majority of recent work. Different measures can be obtained, depending on the particular models chosen and the assumptions made when applying the models to particular data sets. Two such measures are:

- the benefit-cost ratio - the ratio of the R&D spending induced by the scheme to the tax revenue lost as a result of the incentive; and
- the price elasticity of R&D investment - the percentage change in R&D spending resulting from a 1 per cent change in the user cost of R&D.

(Note that since we expect R&D spending to rise as the user cost falls, we expect the elasticity to have a negative value.)

Table 2 in Appendix A comprehensively details the results of 20 different studies, including that undertaken by HMRC (see below, and Appendix D). The reported elasticities vary considerably, from −2.78 to −0.07. We may expect this variation for studies looking at different countries, over different time periods and with different base data. Even papers investigating the same country do not agree. The results from the UK econometric analysis fall in between the maximum and minimum values reported by other studies.

A similar picture emerges for the benefit-cost ratio. There is considerable variation between reported values, from 0.29 to 3.6 - again even studies examining the same country's scheme, but using different methodologies or making different assumptions, show large variations. The estimates for UK R&D tax credits again lie within the range established by other studies.

Apart from one study looking at industry sectors in Northern Ireland, the literature reviews and searches have not found any other studies of the UK R&D tax credit schemes using company-level data. The R&D Scoreboard published by the Department of Business, Innovation and Skills (BIS) at R&D Scoreboard is a useful reference for monitoring R&D investment by the largest companies, but makes no distinction between capital and revenue expenditure, or between UK and global expenditure, to identify qualifying expenditure for UK tax credit purposes.

Monitoring the uptake - who claims, how many, how often, how much?

HMRC has prepared a monitoring note on R&D tax relief (see Appendix B) which supplements the National Statistics, covering claims for all the years from 2000-01 to 2008-09.

Altogether, almost 20,000 companies have claimed the relief since it was introduced in 2000-01, with a total tax cost approaching £5 billion, based on R&D investment by companies totalling £52 billion over the 9 year period. From a relatively low base, the annual number and cost of claims have continued to rise strongly. So since 2004-05, on an annualised basis, the number of claims has increased by 7% pa, and the value of the claims by 14% pa, resulting in 8,800 claims for 2008-09, with a value/tax cost of £980 million, and for qualifying R&D expenditure of over £10 billion.

Table 2: Numbers and costs of claims for 2004-05 to 2008-09

Year	2004-05	2005-06	2006-07	2007-08	2008-09
SME claims	5,310	4,960	5,280	6,000	6,600
LC claims	1,310	1,480	1,670	2,030	2,190
SME costs (£m)	190	180	200	250	260
LC costs (£m)	400	450	490	560	720

Although the numbers of SME and large company claims are split 75:25, the costs are split 30:70. For 2008-09, the most recent year for which figures are complete, 6,600 SMEs made claims averaging £40k each, whereas 2,190 large companies made average claims of £328k.

Looking at average claim sizes over the last five years shows that the increase in tax cost has been driven more by the increased number of claims than by the increased investment in R&D by individual companies.

Table 3: Average claim sizes (£'000s) for 2004-05 to 2008-09

Year	2004-05	2005-06	2006-07	2007-08	2008-09
SME mean	35	37	39	41	40
SME median	9	9	9	10	11
LC mean	303	301	292	274	328
LC median	21	21	23	24	26

Some companies, particularly larger ones, undertake R&D as an essential part of their business, and claim every year. Other companies claim in some years but not others, depending on their business development strategies, and some only ever make a one-off investment and claim. The analysis of year-on-year claims shows that, in round figures, 60% of claims made in any one year are made by 'repeat' claimants, 10% by 'sporadic' claimants, and 30% by 'new' claimants.

Average claims by repeat claimants are significantly higher than those made by sporadic claimants. For example, the average for SMEs that have made just two claims is only £26k compared with £82k for those that have made six or more claims. Also, where companies claim in two or more successive years, the average year-on-year increase in investment is around 11% for SMEs and around 6% for large companies - noticeably higher than the yearly increases in average claim sizes.

Companies that have claimed every year are the subject of the econometric analysis (see below and Appendix D). It is less easy to model the behaviour of sporadic claimants, beyond the finding above that their average claims are much lower than regular claimants'.

Almost certainly, some of the 'new' claimants have undertaken R&D in previous years but have only now learnt about the relief, or chosen to submit a tax relief claim. Others will be genuinely new investors in R&D, whether as R&D professionals serving clients, inventive start-ups, or existing businesses developing a new product.

The OECD has defined high-tech industry sectors as those whose R&D expenditure exceeds 4% of their turnover. Clearly, within any such sector there will be some R&D intensive companies that meet this threshold, and others that fall below it. Likewise, in sectors that fall outside the high-tech definition, some companies may nevertheless be R&D intensive. Applying this R&D intensity threshold to individual companies is one way of defining a 'high-tech' company.

Using this definition, many of the SME claims are by high tech companies. Indeed, there are some companies whose R&D expenditure far exceeds their trading turnover, perhaps as they have yet to begin trading in their newly developed product. The numbers and costs of claims by R&D intensive companies are summarised in Table 4 below and show that, over the period 2004-05 to 2008-09, two thirds of SME claims have been by 'high tech' companies, and these claims have accounted for over 90% of the tax cost.

Table 4: Uptake of SME claims by 'high tech' companies

Year	2004-05	2005-06	2006-07	2007-08	2008-09
No of Hi-techs	3,260	2,980	3,140	3,610	4,010
Total SMES*	4,930	4,580	4,830	5,530	6,060
Hi-tech %	66	65	65	65	65
Cost of Hi-techs	150	150	166	206	208
Total cost*	163	164	181	224	228
Hi-tech %	92	92	92	92	91

* Total figures are less than those in Table 2 because in some cases turnover data were not available

The corresponding figures for large company 'high tech' claims are 42% and 74%.

Qualitative research

Qualitative research commissioned jointly by HMRC/BIS from Databuild investigated businesses' processes for making decisions about research and development (R&D), aiming to identify the effect on their behaviour of both R&D tax credits and government grants for R&D. The research report has been published at No. 101 - Qualitative research into businesses' R&D decision making processes (PDF 637K). For convenience, the report's summary is reproduced in Appendix C.

Interviews were conducted with managing directors, finance directors and the directors responsible for R&D in companies which undertake technology or science-based R&D. The companies varied in size from micro to multinational corporations. Of particular interest was how far it is possible to determine whether R&D tax credits and grants result in companies undertaking research that they would not otherwise have done.

In relation to R&D tax credits, the research found that in most respondent companies there was a belief that the overall amount of R&D increased as a result of the R&D tax credit system, though it was difficult to obtain quantitative evidence of this effect. The suggestion made was that in the long run, as R&D tax credit claims are made and received, confidence grew in the availability of this source of funding which could be invested in future R&D projects. For smaller companies, in particular, the cash flow was an important benefit which could allow the next R&D project to go ahead, possibly sooner than it might otherwise have done. Some respondents also said that R&D projects with a greater risk profile might be able to proceed because of the credits.

Although R&D tax credits were described by almost all the respondents as a bonus, the general opinion was that they had little if any effect on decisions to conduct individual pieces of R&D work. This disconnect appears to be caused by the timing of claims (after the expenditure has been incurred), and by the gap between R&D and the finance function.

It was clear that accountants and other professionals did not always provide accurate information about government support for R&D. This led to uncertainty amongst those making claims for R&D tax credits about what they may claim for and when. It was not uncommon for companies to learn about R&D tax credits only when they appointed new accountants.

The existence of both the SME scheme and the large company scheme appeared to puzzle some respondents, both those in the finance function and those conducting R&D. Very few respondents could quote the R&D tax credit percentage rates for either scheme and although a few were aware of differing rates of credit available under the two schemes, most said that they did not know about this and their accountant would deal with it. Several SME respondents whose claims were being made under the large company scheme could not understand why this should be so – it appears that either there is a degree of misunderstanding amongst professional advisors, or they are not explaining to those concerned the reason for claiming under the scheme they have chosen.

Quantitative research

Research undertaken in the UK and elsewhere has found that providing tax relief increases the amount of R&D expenditure undertaken by business (see Appendix A). Estimates of the extent of such increases have varied from insignificant to substantial: benefit-cost ratios up to 3.6 have been reported, that is, £1 of tax relief cost has resulted in an extra £3.60 of R&D expenditure, implying the relief is cost effective. Conversely, ratio estimates below 1 have also been found, implying that the relief is not cost effective and it would be cheaper to fund R&D projects directly.

In order to estimate this benefit-cost ratio for the UK tax relief, we applied established econometric models to HMRC data on R&D tax credit claims supplemented by company accounts data. In line with the recommendations from the feasibility study, we used similar models to those used in previously published studies of the effect of R&D tax relief, involving the estimation of the R&D price elasticity. The analysis does not involve the use of a control group since it was difficult to find matching data from similar companies that have not claimed R&D tax credits or indeed matching data from the same companies before the introduction of the policy. Given the lack of a control group the counterfactual (and the benefit-cost ratio) is approximated by calculating the marginal cost and benefit of a 1 percentage point change in the rate of the R&D tax credit enhanced relief using the estimated elasticity.

The results of the analysis gave estimates for the benefit-cost ratio of between 0.41 and 3.37 (see Appendix D for further details and explanations of these results).

The particular models used to analyse the data required observations in the form of 'panel data', that is, complete observations for several companies over several years. So companies that claimed in some years but not others could not be included in the panels. Even so, we were able to assemble the relevant data for 215 companies claiming under the large company scheme between 2003 and 2007, and for 236 SMEs making claims over the same period. These numbers represent 13% of large companies and 4% of SMEs claiming in 2007. Both the large company and SME datasets encompass periods before the rates of the enhanced R&D deductions were increased (in 2008). Currently, it is too early to measure any effects that this change in rate may have caused on company R&D activities.

The econometric model relates a company's R&D expenditure in year t to several 'explanatory' variables, including the company's size, industry sector, and user cost of R&D investment. The general model is expressed in the equation below:

$$\log R_{it} = \alpha_0 - \sigma C_{it} + \gamma \log X_{it} + \log U_{it}$$

where R is the R&D investment, α_0 is a constant, C_{it} is the user cost of R&D, X_{it} stands for various control variables and U_{it} is a stochastic error term.

This formulation is then modified to introduce dynamics into the relationship between R&D and its user cost. The lag of the dependent variable, that is, the logarithm of the R&D investment in year t -1, is introduced on the right hand side.

The statistical analysis, using a standard application, calculates estimates of the various coefficients, and tests their statistical significance using normal methods. Most of the variables were found to have little individual effect on the level of expenditure; but the user cost of R&D expenditure was found to be highly significant. Importantly, it is this user cost that is directly affected by the rate of tax relief. A straightforward calculation converts a change in the tax cost to a change in the user cost, and the coefficient of the user cost converts this into a change in R&D expenditure.

Relevant results from the econometric analysis are presented in Table 3 of Appendix D.

In summary, the user cost of R&D is a statistically significant determinant of R&D investment for companies. In other words, the amount a company invests in R&D is responsive to changes in the user cost of R&D and by implication changes in the generosity of R&D tax credit policy. Estimates of the return on foregone tax revenues resulting from the introduction of R&D tax credits vary considerably. Depending on the techniques employed, £1 of foregone tax revenue stimulates between £0.41 and £3.37 of R&D investment.

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Appendix A: UK Research and Development Tax Credits Evaluation Literature Review

This review provides an international context for the evaluation of UK Research & Development (R&D) tax credits. First, we compare both the format and generosity of the R&D tax incentives offered by other countries to those in the UK. Second, we look at previous econometric work, particularly evaluations of the tax price responsiveness of R&D expenditure. We extract two measures of the responsiveness from a wide variety of sources: the price elasticity of R&D and the benefit-cost ratio. These two parameters are also estimated for the UK large company and Small and Medium-sized Enterprise (SME) schemes in the accompanying econometric analysis component of this evaluation (see Appendix D). Few studies have previously looked at the UK R&D tax credit programme, so we necessarily focus on schemes internationally.

1. International tax incentives for R&D

Governments often look towards increasing national R&D activity as a means to boost productivity, long-term economic growth and competitiveness. For example, European Union member countries set a goal of increasing R&D investment intensity to 3 per cent of GDP by 2010 in the Lisbon Agenda of 2000. Such targets are not limited to Europe or the OECD[1] with China recently committing to a R&D intensity target of 2.5 per cent of GDP by 2020. Without government support, firms tend to under invest in R&D relative to the social optimum, for example, Jones & Williams (1998) suggest that this optimum level of investment is two-four times higher than actual investment in the United States. Tax concessions for R&D activities are extensively used as a policy tool designed to stimulate business R&D indirectly. Across the OECD such measures are becoming increasingly popular: the latest figures for 2008 list 21 schemes, an increase from previous totals of 12 in 1999 and 18 in 2004 (Warda 2001, 2009).

The exact form of tax incentive scheme varies greatly, but mostly they allow companies, in their corporation tax computation, either an enhanced deduction from income (such as in the UK) or a reduction of the net tax payable, based in either case on the company's R&D expenditure (a true tax credit, such as in France and Canada). The relief is generally based on either the actual expenditure for the current year (so-called volume or level-based reliefs as in the UK) or the increase in R&D expenditure over some reference level (incremental reliefs, for example, the US). Elsewhere (for example, Australia and Spain) the tax incentive combines both of these computation methods. The rate of relief is also substantially different across countries and often small companies are favoured either directly with a separate higher rate (for example, the UK) or implicitly through a limit on the total relief available.

Although reductions in corporation tax based on R&D expenditure are the most popular methods of support, they are not the only type of tax incentive on offer. The Netherlands has a unique incentive that allows companies to reduce the amount of income tax and social security contributions they pay on behalf of employees engaging in R&D. New Zealand recently withdrew its R&D tax credit system altogether and replaced it with a system of cash grants and vouchers that

[1] The Organisation for Economic Co-operation and Development.

must be approved before the R&D is undertaken. There are numerous other variations between schemes including: the rules about what constitutes R&D activity, the types of expenditure allowable, where that expenditure must take place to qualify and whether a company requires prior approval for the R&D to be allowable. Table 1 provides summary information for 10 R&D tax incentive schemes internationally, including the UK.

The relative tax treatment of R&D in the UK internationally (particularly its generosity, which is compared in Section 1.1) is not only of passing academic interest. There is growing evidence that R&D tax relief affects where companies choose to perform their R&D. A study of the state tax credit in California found that it not only induced Californian firms to spend more on R&D but also caused firms to relocate there (Paff 2005). Similarly, Wilson (2007) found US state tax credits stimulated a relocation of R&D. In other words, he found that the positive increase of R&D expenditure caused by the state tax credit was almost entirely drawn away from neighbouring states. Similar effects are also observed internationally. For example, Bloom & Griffith (2001) found that R&D in one country responds to the change in price of another 'competitor' country.

1.1. The generosity of different international R&D tax subsidies

A quantitative international comparison of the generosity of R&D tax incentives is not a straightforward undertaking, given the variation in corporation tax rates and degree or type of tax subsidy. In addition, various components of tax incentives, such as severe restrictions on the allowable R&D activity or a limit on the credit claimable, are difficult to incorporate and typically omitted. Most studies, notably those by the OECD (for example, Warda, 2001), compare the B-index (McFetridge & Warda 1983). The B-index is defined as the present value of before-tax income required to cover the initial cost of R&D investment and to pay corporate tax. Algebraically it is written

$$B = \frac{(1-A)}{(1-\tau)}, \qquad \textbf{(1)}$$

where A is the net discounted value of the R&D depreciation allowances, tax credits and any other special allowances for R&D assets, whilst τ is the statutory corporate tax rate. If a country allows the full write-off of R&D expenditure with no tax incentive (as was the case in the UK prior to the introduction of R&D tax credits), then B=1. The more generous a country's R&D tax incentives, the smaller the value of B. To estimate the subsidy rate per monetary unit (1 USD say) we can compute $1-B$. In Figure 1, we compare the generosity of R&D tax incentives for SMEs and large companies, enumerated through $1-B$, using 2008 data for 37 countries from the OECD (Warda 2009). $1-B$ for UK R&D tax credits is 0.105 and 0.179 for the large company and SME schemes respectively. The most generous countries (for both SMEs and large companies) are France and Spain, with R&D tax subsidies for large companies that are 4.0 and 3.3 times more generous respectively than those of the UK. Overall, the UK is ranked 19th and 11th in subsidy order (out of 37) for the large company and SME schemes respectively. UK subsidies are more generous than those for some major economies, for example, Germany, Russia and the US, but are behind others such as China, India and Japan, plus of course France and Spain[2]. We should also remember that the B-index only provides a rough guide to each scheme's

[2] Due to the differential rate of UK R&D tax credits for SMEs and large companies, we have a more generous SME subsidy than China and Japan.

Table 1: An international comparison of selected R&D tax incentives in 2010. Some schemes have been simplified for clarity and ease of comparison. Sources: KPMG (2010), Scitax (2010).

Country	Year initiated	Type of benefit†	Benefit rates	Comments and status
Australia	1985	Enhanced deduction LEVEL and INCREMENTAL	125% deduction of R&D expenditures. No benefit on first $20,000 175% deduction on current expenditure in excess of average of past 3 yr	This system was due to be replaced with a tax credit system in July 2010 although new legislation failed to pass through the Senate at the first attempt. It is back on the legislative agenda for Autumn 2010.
Canada	1986	Cash refund and/or tax credit LEVEL	Various rates depending on nature of company. 20% tax credit for Canadian corporations on current and capital expenditures (no refund)	In addition, R&D tax incentives are also offered by most provinces.
China	2008	Enhanced deduction LEVEL	150% deduction of various R&D expenditures	R&D spending must have increased by 10% over previous yr
France	1983	Tax credit and/or cash refund after 3 yr if no tax is owed LEVEL	30% for first €100m of expenditure (50 and 40% for 1st and 2nd yr claiming for R&D tax credits) 5% for expenditure over €100m	
India	1997	Enhanced deduction LEVEL	150% deduction of R&D expenditure	Scheme expires in March 2012.
The Netherlands	1994	Tax credit and/or cash refund LEVEL	50% of first €220,000 of wage costs, then 18% for any wage costs remaining. Start-up companies can claim 64% of the first €220,000.	Innovative scheme that reduces the income tax and national insurance contributions paid by companies for their R&D employees. The wages costs are computed from an average hourly rate, either the rate from 2008 or if the company did not claim in 2008, 29 €/hr. The exact percentages and amounts are sometimes adjusted year-to-year.
New Zealand	2008	Pre-approved cash grant and vouchers	Large companies with income over $3m for past three yr can claim up to 20% of R&D expenditures up to $2.4m Small companies can be awarded $100,000-200,000 technology transfer vouchers, which can only be spent at public research institutions.	NZ withdrew its tax credit system in 2010 and replaced it with this system of cash grants for commercially focussed R&D, which has to demonstrate a direct overall benefit to NZ.
Spain	1995	Tax credit LEVEL and INCREMENTAL	25% of R&D expenditure +42% of increase in R&D expenditure over average of the previous 2 years +8% of R&D related investments	Gross tax charge (GTC) must be positive to claim deduction. The limit is 35% of GTC or 50% of the GTC if tax credits exceed the GTC. Any remaining R&D credits can be claimed over the next 15 yr.
UK	2000 (SMEs) 2002 (LCs)	Enhanced deduction and/or cash refund (SMEs only) LEVEL	175% deduction of R&D expenditure (SMEs) 130% deduction of R&D expenditure (LCs)	If the SME is making a loss or the enhanced R&D deduction causes a loss, then the SME can chose to take a cash refund equivalent to 14% of the surrenderable loss.
United States	1983	Tax credit INCREMENTAL	Two basic methods to compute the tax credit: 1. 20% of increase in current R&D expenditure over a base amount (complicated way to compute this) 2. 14% of increase in current R&D expenditure over 50% of the average amount spent on R&D over the past 3 yr.	Status of tax credit always uncertain as temporary legislation which has lapsed 13 times. Moves by President Obama to enhance the system and make it permanent. Many US states also offer their own tax incentives for R&D.

† Benefits are either enhanced deductions (deduction of more than 100% of the expenditure), tax credits (net tax payable is reduced by some % of expenditure) or cash refunds. The value of the incentive is computed either based on the increase in R&D over some base level (incremental) or as some % of the actual R&D expenditure in that year (level).

generosity. For example, restrictions on the definition of R&D applied, any caps on the amounts that can be claimed, and the level of administrative burden imposed, are not captured in this measure and can impact severely on the attractiveness of the scheme and the benefits provided.

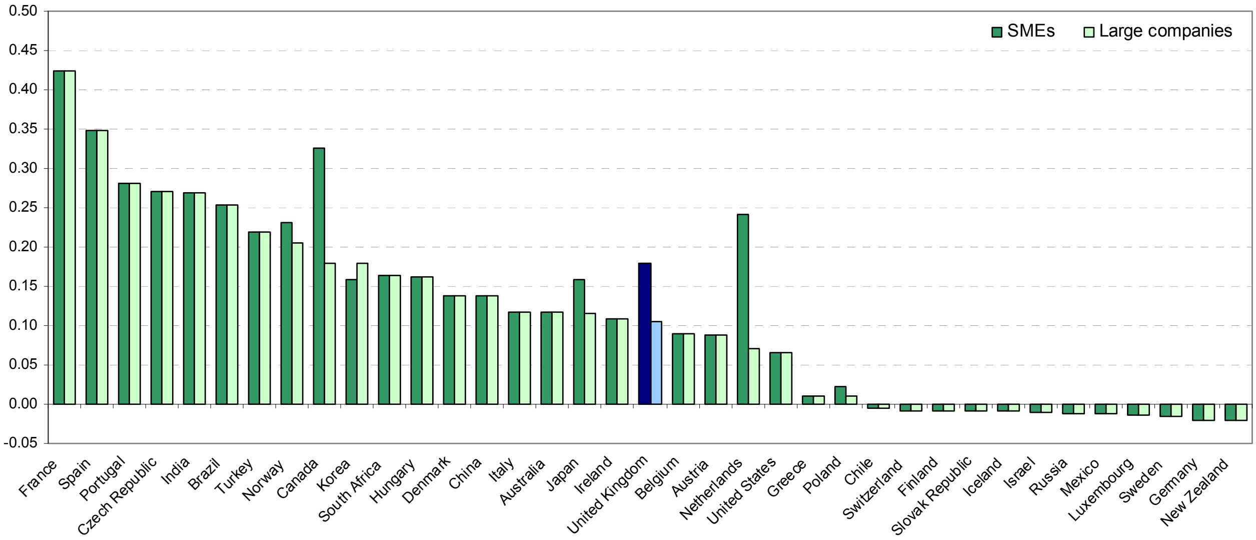

Figure 1: Comparison of the SME and Large Company 2008 tax subsidy rates for $1 of R&D across the OECD countries (except Slovenia) and a number of other major economies (Brazil, China, India, the Russian Federation and South Africa). The subsidy is computed as 1-*B*, where *B* is the B-index (see text). The UK schemes are highlighted in blue. The data are from Warda (2009).

2. Quantifying the effectiveness of R&D tax incentives

There are numerous econometric studies whose aim is to evaluate the effectiveness of tax incentives designed to increase R&D investment. Early studies focused on the US tax credit system (see the survey by Hall and Van Reenen 2000), although increasingly other international schemes are being examined in detail. A comprehensive review of the methods and parameters deployed is beyond the scope of this evaluation. Instead, we summarize typical empirical approaches and the values of two key parameters for comparison with our econometric evaluation: the benefit-cost ratio and the price elasticity of R&D. However, any such comparisons must be made with caution given the variation in macro-economic conditions and the implementation of R&D tax incentives between countries. Furthermore, very few studies to date have investigated UK R&D tax credits with reliable firm-level data. Greater detail regarding different econometric approaches used in the literature can be found in the review commissioned by HMRC as part of this evaluation's feasibility study (Oxera 2006).

2.1. Empirical approaches

Most econometric studies and evaluations of R&D tax credits attempt to explain company R&D investment using a set of variables, such as firm size, profitability and others relating to the tax incentive. The non-tax variables control for structural characteristics of the firm that affect its level of R&D investment. Such a model of R&D investment is then typically evaluated using company data, although some analyses have been performed using macro, country-level data (for example, Bloom et al. 2002; Guellec and van Pottelsberghe 2003).

We concentrate here on studies that estimate the tax price responsiveness and which form the majority of recent work. The effect of the tax incentive is incorporated into the model via an R&D price variable, which is also the approach taken in the UK HMRC evaluation. Numerous other approaches have been used (see for example, Hall and Van Reenen 2000 or Oxera 2006 for reviews), for example models where the effect of the tax incentive is incorporated as a shift parameter in the R&D demand equation (for example, Berger 1993; McCutchen 1993; Thomas et al. 2003).

2.2. Determining the tax price responsiveness

In this approach, the responsiveness of R&D expenditure to changes in the price of R&D is measured. An R&D demand equation is constructed, which controls for the non-tax determinants of R&D and depends on an R&D price variable, usually the user cost of R&D. The user cost captures the marginal cost of R&D and normally depends explicitly on the level of tax subsidy provided. The exact form of the model employed and the regressions carried out to estimate the model parameters vary a great deal. Often authors take great care regarding the type of regression used, owing to issues of simultaneity, which may cause variables to be endogenous. Of particular interest in the context of this evaluation are two measures of an R&D tax policy's effects: the benefit-cost ratio and the price elasticity of R&D. The next two sections present brief descriptions of what these parameters are and various issues associated with their calculation, before we look at the values listed in recent work. Various estimates of these determinants, computed from HMRC's econometric analysis, are presented in Appendix D.

2.2.1. The benefit-cost ratio

Most evaluations of the cost effectiveness of R&D tax incentives compute the ratio of the R&D spending induced by the scheme to the tax revenue lost as a result of the incentive. This is often called the benefit-cost ratio, incrementality ratio, tax sensitivity ratio or 'bang for the buck' (see Parsons & Phillips 2007). If the ratio is greater than one, the incentive has stimulated more R&D spending than it has cost so might be considered to be cost-effective. By comparison, ratios less one imply less R&D spending has been generated than the revenue sacrificed by the Exchequer, so the credit scheme is not cost effective and it would be cheaper to fund R&D projects directly.

However, simply dividing R&D tax incentive schemes into those that are cost effective and those that are not on the basis of whether the computed benefit-cost ratio is greater than or less than one respectively, may not encompass the true costs and yields associated with particular R&D subsidies (see for example, Mohnen & Lokshin 2009). If the ratio is greater than one, then the policy may in reality be ineffective due to a high transfer cost (or deadweight loss) as it subsidises R&D that would have been carried out anyway (it is difficult to measure purely the R&D generated by the policy) or large implementation costs. Equally, if the ratio is small it may only demonstrate that the total R&D expenditure generated does not fully reflect the total benefits from the tax policy, which could also include for example, returns from the R&D investment and spillover effects (see also Parsons & Phillips 2007).

Furthermore, comparisons of cost-benefit ratios are not always straightforward between countries and studies. This is because estimation methods vary and the country's scheme and economic conditions can be very different. In general, incremental schemes are found to be more cost effective, as they naturally reward increases in a company's R&D spending. Surprisingly, few countries opt for incremental programmes, perhaps because they are costly and difficult to administer (costs which in general are not included in the benefit-cost ratio) and they encourage market distortions with companies having cyclical R&D spending (Lemaire 1996).

2.2.2. The price elasticity of R&D

Other evaluations of R&D tax incentives look at the responsiveness of R&D investment to the government subsidy, commonly evaluated through econometric modelling. Often, the price elasticity of R&D and its significance are calculated. This typically occurs by fitting the R&D investment model to company data using some sort of regression method. From the fitted model coefficients, the price elasticity of R&D can be formed. This relates the percentage change in R&D spending from a 1 per cent change in the user cost of R&D.

2.2.3. Results from and approaches of individual studies

Table 2 is a summary of benefit-cost and price elasticity estimates found in the econometric studies in the literature. Each study typically looked at a single country or state within a country. The reported elasticities vary considerably from −2.78 (France: Mairesse & Mulkay 2004) to −0.07 (short-run estimate for Canadian companies: Dagenais et al. 1997)[1]. We may expect this for studies looking at different countries, over different time periods and with different base data. Even papers investigating the same country do not agree (look at the results from the US for example in Table 2). The results from the UK econometric evaluation fall in between the maximum and minimum values reported by other studies. A similar picture emerges for the benefit-cost ratio. There is considerable variation between reported values from 0.29 to 3.6, again even studies examining the same country's scheme show large variations. This evaluation's estimates for UK R&D tax credits again lie interspersing the other values. Providing technical details for all of the studies listed in Table 2 is beyond the scope of this review. Instead we contrast the approach and results of three papers: Hall (1993), Bloom et al. (2002) and Mairesse & Mulkay (2004). Each of these influential and oft cited studies adopts a slightly different approach to the problem and examines a different country's (or countries') R&D tax incentive system.

[1] Excluding the large -10.0 value reported by Hall and Van Reenen (2000) from McCutchen (1993).

Table 2: R&D price elasticity and benefit-cost ratio estimates in the literature after 1990.

Study	Countries	Data	Dates	Elasticity Short- (SR) or Long-run (LR) where available	Benefit-cost	Notes
HMRC (2010), this analysis	UK	HMRC data & FAME database	2003-07	−2.41 to −0.91 (SR) [1] −5.16 to −1.11 (LR) [1] −2.59 to −1.60 (SR) −2.41 to −1.66 (SR)	0.41 to 3.37 [2]	Used in the HMRC UK R&D evaluation.
Lokshin & Mohnen (2010)	Netherlands	Firm-level unbalanced data from surveys and government datasets.	1996-04	−0.5 to −0.2 (SR) −0.8 to −0.4 (LR)	0.42 to 3.24	Benefit-cost ratio computed for different types of company as function of time. For all firms after 1 year 1,05 then declines to 0.54 after 15 yrs. Also differences small and large companies.
Baghana & Mohnen (2009)	Quebec	Firm level data, survey data and province administrative data of the actual amount of incentive received.	1997-03	−0.14 (SR) −0.19 (LR)	1 to ~3 Depending on tax incentive and size of firm	Elasticities are for small companies.
Hægeland & Møen (2007)	Norway	Various methods, using data from surveys and government databases	1993-05		1.5 to 3.0	
Lokshin & Mohnen (2007)	Netherlands	Firm-level unbalanced data from surveys and government datasets	1996-04	−0.5 to −0.3 (SR) −0.7 to −0.3 (LR)	0.4 to ~3.5	Cost-benefit ratio computed for different types of company as function of time. Greatest return on medium then small companies with large companies having the smallest return of all. Declines from a peak after 1 year.
Wilson (2007)	US	NSF R&D by state	1981-04	−1.2 (SR) −2.2 (LR)	.	Between state comparison.
Harris et al. (2005)	Northern Ireland	Follows Bloom et al. (2002). Firm-level data for 11 manufacturing industries. From BERD/ARD surveys	1998-03	−1.36 (LR)		
McKenzie & Sershun (2005)	G7 + Australia & Spain			−0.3 to −0.2 (SR) −0.9 to −0.7 (LR)		
Klassen et al. (2004)	Canada & US	Matched sample of 58 Canadian and 110 US firms from Compustat	1991-97		1.30 (Canada) 2.96 (US)	Comparison between two types of R&D incentive to see which is most effective
Mairesse & Mulkay (2004)	France	765 manufacturing firms.	1983-97	−2.78 to −2.68	2.0 to 3.6	
Bloom et al. (2002)	G7 + Australia & Spain	OECD BERD survey	1979-97	−0.14 (SR) −1.09 (LR)	.	
Parisi & Sembellini (2001)	Italy	Balanced panel 726 firms	1992-97	−1.77 to −1.50		
van den Hove et al. (1998)	Netherlands		1994-96		0.7 to 1.7 [3]	
Dagenais et al.	Canada	Unbalanced	1975-	−0.07 (SR)	0.98	

(1997)		panel of 437 firms, Compustat	92	−1.08 (LR)		
Mamuneas & Nadiri (1996)	US	Data for 15 Industries from NSF and US Bureau of Labor Statistics	1956-88	−1.0 to −0.84	0.95 [4]	
Shah (1994)	Canada	18 Industries	1963-83	-0.16 (SR)	1.80	
Berger (1993)	US	263 firms, balanced panel data from Compustat	1982-85	−1.5 to −1.0 [5]	1.74	
Hall (1993)	US	800+ firms unbalanced Compustat	1981-91	−1.5 to −0.8 (SR) −2.7 to −2.0 (LR)	2	
Hines (1993)	US	116 multinationals from Compustat	1984-89	−1.6 to −1.2	1.3 to 2.0 [5]	
McCutchen (1993)	US	20 large pharmaceutical companies, from IMS.	1982-85	−10.0 to −0.28 [5]	0.29 to 0.35	

[1] Semi-elasticity estimates, so not comparable directly to the other estimates in the table. The difference is explained in Appendix D.
[2] Calculated from long-run elasticities and semi-elasticities (again see Appendix D).
[3] Quoted by Cornet (2001).
[4] Quoted by Parsons & Phillips (2007).
[5] From Hall and Van Reenen (2000).

One of the earliest evaluations of the tax responsiveness of R&D expenditure was made by Hall (1993) in her analysis of US R&D tax policy during the eighties. She constructs a model of R&D investment derived from an Euler equation representation for the optimal R&D investment and Cobb-Douglas production function. This model depends on the tax price of R&D and incorporates the high adjustment costs for R&D activity. The model coefficients are then calculated using an instrumental variable estimation method from an unbalanced panel of US company data. The data from Compustat span 1980-91 and consist of around 1000 US manufacturing firms per year. She finds the tax price response of R&D is significant with estimated elasticities of between −1.5 and −0.8 in the short run and −2.7 and −2.0 in the long run. Furthermore, she estimates that the tax policy stimulates about $2 billion per year of R&D spending, whilst about $1 billion is foregone in tax revenue, implying a benefit-cost ratio of 2.

Bloom et al. (2002) make one of the few inter-country comparisons, using a balanced panel of nine OECD countries (the G7 plus Australia and Spain) over 19 years (1979-97). They specify a simple model of R&D investment, common to many similar studies, where the logarithm of the R&D investment is inversely proportional to the log of the user cost of R&D. Bloom et al. comment that this can be considered as the form of the demand equation for R&D derived from a constant elasticity of substitution production function. To introduce dynamics into the relationship between R&D investment and its user cost (for example, due to adjustment costs), they simply make the current R&D investment dependent on its lag, rather than say estimating an Euler equation which they say tends to lack robustness. In other words the level of

R&D investment in the current year depends on the level of R&D investment in the year before. Owing to concerns about whether the user cost of R&D is endogenous, they use an instrumental variable procedure to fit the model to their empirical data. The data themselves are aggregate, country-level figures from the OECD business enterprise R&D (BERD) database. They find a significant elasticity in the short-run of −0.16, although this is one of the smallest reported figures (see Table 2). The longer term trend is higher with an elasticity of between −1.5 and −1.0. Interestingly, they also suggest that changes in the user cost of R&D can stimulate companies to relocate their R&D activities between countries.

Similarly, Mairesse & Mulkay (2004) investigate the French R&D tax credit system, deriving a model relating the optimal stock of R&D capital to the user cost of R&D from a production function with again a constant elasticity of substitution. A further transformation produces an error correction specification of an autoregressive distributed lag model, which preserves the long-run equilibrium relationship between R&D capital stock and user cost. They apply this formulation to a panel of 765 manufacturing firms in France over the years 1983-97 and find a significant, large long-run elasticity (around −2.7) in addition to some of the largest benefit-cost ratios reported at between 2.0 and 3.6. These large ratios compared to other studies may be partly because incremental tax credit systems, such as in France, are usually seen as more cost-effective with less deadweight loss.

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Appendix B: Monitoring Note on Research and Development (R&D) tax credits

1. Introduction

This note expands on the National Statistics published in October 2010, and relates to claims for R&D tax credits made in Company Tax returns received for accounting periods ending in financial years up to 2008-09.

The statistical tables are published in the National Statistics section of the HMRC website: Corporate Tax: Research and Development Tax Credits

2. Summary of key points

In the first nine years of R&D tax credit schemes, more than 52,000 claims have been made in total and over £4.8 billion of relief has been claimed.

In 2008-09, the latest year for which information is broadly complete:

- *The claims made for R&D tax credits in 2008-09 were 8,540:* 6,600 claims under the SME scheme, 2,190 claims under the large company scheme and 10 claims under the vaccine research relief scheme[1] [2]

- *£980m of support has been claimed through R&D tax credits in 2008-09*; £260m under the SME scheme and £720m under the large company scheme. This is an accounting period based figure, reflecting the end-date of the accounting period covered by the claim.

- *Almost £10.8 billion of R&D expenditure in 2008-09 has been used to claim R&D tax credits*; nearly £1.7 billion under the SME scheme and £9.0 billion under the large company scheme.

- *Over 17,100 different companies* have made claims under the SME scheme since it began, and over 4,200 under the large company scheme.

- *R&D tax credit claims are from two main industry sectors*; Business services accounts for 36 per cent and Manufacturing accounts for 31 per cent of all R&D tax credit claims in 2008-09.

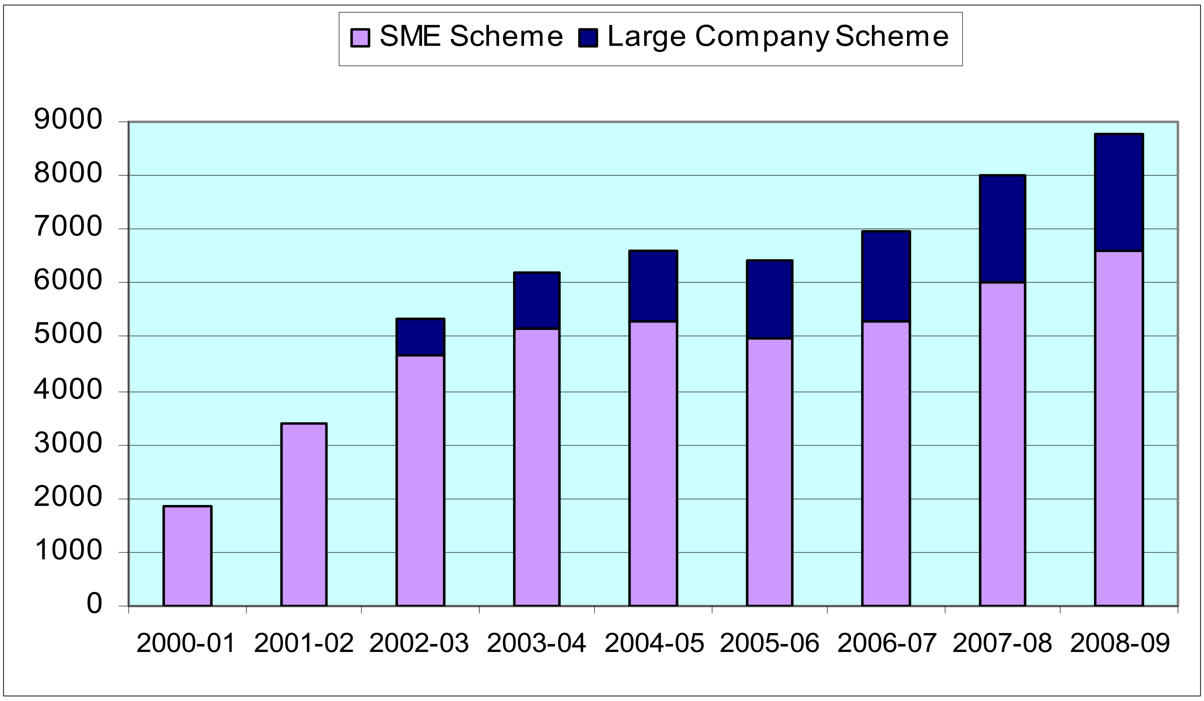
- *21 per cent of all R&D tax credits claims are from Company Tax returns of companies registered in the South East*. London (17 per cent) and the East of England (11 per cent) are regions with the next highest proportion of claims.

[1] A company is a SME if it has fewer than 250 employees, and either an annual turnover not exceeding €50m or an annual balance sheet total not exceeding €43m, and is not part of a larger enterprise that would fail these tests.

[2] Totals for all R&D schemes do not sum to totals of individual schemes as some SME subcontractor and vaccine research relief claims are included with existing SME or large company claims. These claims have been removed from the total to avoid double counting.

3. Take-up of R&D tax credits [3] [4]

Figure 1: Total number of claims received for R&D tax credits by scheme



The number of claims received for 2008-09, the latest year for which claims data should be broadly complete, was 8,540 (see footnote 2 on p. 2). This is a rise of 730 (9%) from the 7,810 claims received for 2007-08.

Table 1: Numbers of claims received for R&D tax credits by scheme

Financial year	SME R&D scheme			Large company R&D scheme		Vaccine research relief	All R&D Schemes
	Deductions from CT liability	**Payable credits**	**Combination**	**Large companies**	**SME Subcontractor**		
2000-01	990	630	240				1,860
2001-02	1,650	1,130	630				3,420
2002-03	2,370	1,380	880	630	60		5,300
2003-04	2,940	1,290	940	920	120	10	6,130
2004-05	3,120	1,280	920	1,090	220	10	6,490
2005-06	2,960	1,100	900	1,190	290	10	6,290
2006-07	3,230	1,060	1,000	1,320	350	10	6,770
2007-08	3,760	1,100	1,140	1,640	390	10	7,810
2008-09	4,140	570	1,890	1,750	440	10	8,540
Total	25,150	9,540	8,520	8,530	1,880	70	52,620

[3] Estimates of the numbers of claims are rounded to the nearest ten. Totals may not sum due to rounding
[4] The number of claims is based on the date that the accounting period covered by the claim ends.

There were 6,600 claims under the SME scheme in 2008-09, up from 6,000 in 2007-08:

- Deductions from CT liability were the most common way to claim R&D tax credits, with 4,140 such claims in 2008-09;

- There were 570 claims for a payable credit in 2008-09. This is a sharp decline from the 2007-08 figure, with simultaneous increases in those making combination and deduction claims. This is due to the changes to the R&D tax credit schemes which came into effect during 2008-09.

- The number of payable credit claims has declined from a peak of 1,380 in 2002-03.

- The number of claims for a combination of both deductions and a payable credit increased sharply from 1,140 claims in 2007-08 to 1,890 in 2008-09. The size of the increase was due to the changes in the R&D tax credit schemes which came into effect during 2008-09. There was a simultaneous decline in those making claims for a payable credit.

In total there were 2,190 claims under the large company scheme in 2008-09, up from 690 claims in 2002-03, which was the first year of the scheme, and 2,030 claims in 2007-08:

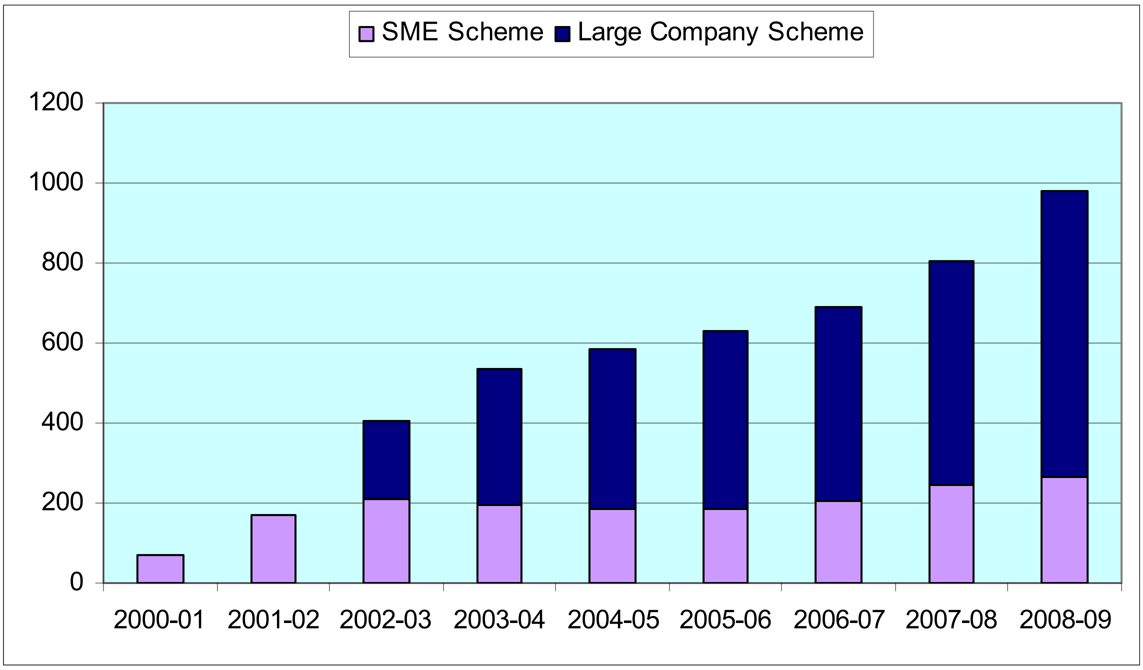
- There were 1,750 claims by large companies themselves in 2008-09, up from 620 claims in 2002-03;

- Claims by SME subcontractors under the large company scheme are fewer, but have risen steadily from 60 in 2002-03 to 440 in 2008-09.

The number of claims for the vaccine research relief has remained around 10 a year since the VRR scheme was introduced in 2003-04.

4. Support claimed through R&D tax credits [5] [6]

Figure 2: Total support claimed through R&D tax credits by scheme (£m, accounting period basis)



The cost of support claimed over time has continued to increase each year. The total cost of support claimed was £980m in 2008-09, an increase of £170m (21%) from £810m in 2007-08. This year-on-year increase may be explained in part by the increased number of claims (9%) and in part by the enhancements to the relief introduced from 1 April 2008. For example, raising the large company enhanced deduction from 25% to 30% would increase those costs by 20% in a full year. Similarly for SMEs, the increased enhancement from 50% to 75% would increase the pure deduction costs by 50%.

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[5] Estimates of the cost of support claimed are rounded to the nearest £10m. Totals may not sum due to rounding.
[6] Table 2 apportions costs to financial years based on the accounting period end-date of the R&D tax claim.

Table 2: Cost of support claimed for the R&D tax credit by scheme and financial year (£m, accounting period basis), 2000-01 to 2008-09.

Financial year	SME R&D scheme		Large company R&D scheme		Vaccine research relief	All R&D schemes
	Deductions from CT liability	Payable credits	Large companies	SME subcontractors		
2000-01	10	60				70
2001-02	20	150				170
2002-03	30	180	200	*		400
2003-04	40	150	340	*	*	540
2004-05	50	140	390	*	*	590
2005-06	40	140	440	10	*	630
2006-07	50	150	480	10	*	700
2007-08	60	180	550	10	*	810
2008-09	80	190	710	10	*	980
Total	380	1,340	3,100	40	10	4,880

* Negligible amount (less than £5m)

The continuing growth in total costs is being driven mainly by the large company scheme, where the cost of support claimed has more than tripled from £190m in 2002-03 to £720m in 2007-08. The cost of support claimed under the SME scheme was stable at around £200m a year, but rose in 2007-08 to £240m and in 2008-09 to £270m.

Payable credits continue to account for most of the support claimed under the SME scheme. Although the cost of payable credits claims fell slightly from £180m in 2002-03 to around £150m in subsequent years, it has risen to £190m in 2008-09.

Support claimed in deductions from CT liability has increased steadily each year since the SME scheme was introduced, to reach £80m in 2008-09.

Large companies themselves account for almost all of the support claimed under the large company scheme. SME subcontractors claimed less than £5m in support each year until 2005-06, when the figure rose to £10m of support claimed and has remained the same since.

The vaccine research relief contributes only a very small amount to the costs, with support claimed of around £1m each year (not shown in Figure 2, due to size).

5. Actual R&D expenditure supported by R&D tax credits[7]

R&D expenditure used to claim tax credits has increased every year reaching £10,750m in 2008-09.

[7] Estimates of R&D expenditure are rounded to the nearest £10m. Totals may not sum due to rounding.

Figure 3: Total R&D expenditure used to claim R&D tax credits by scheme (£m, accounting period basis)

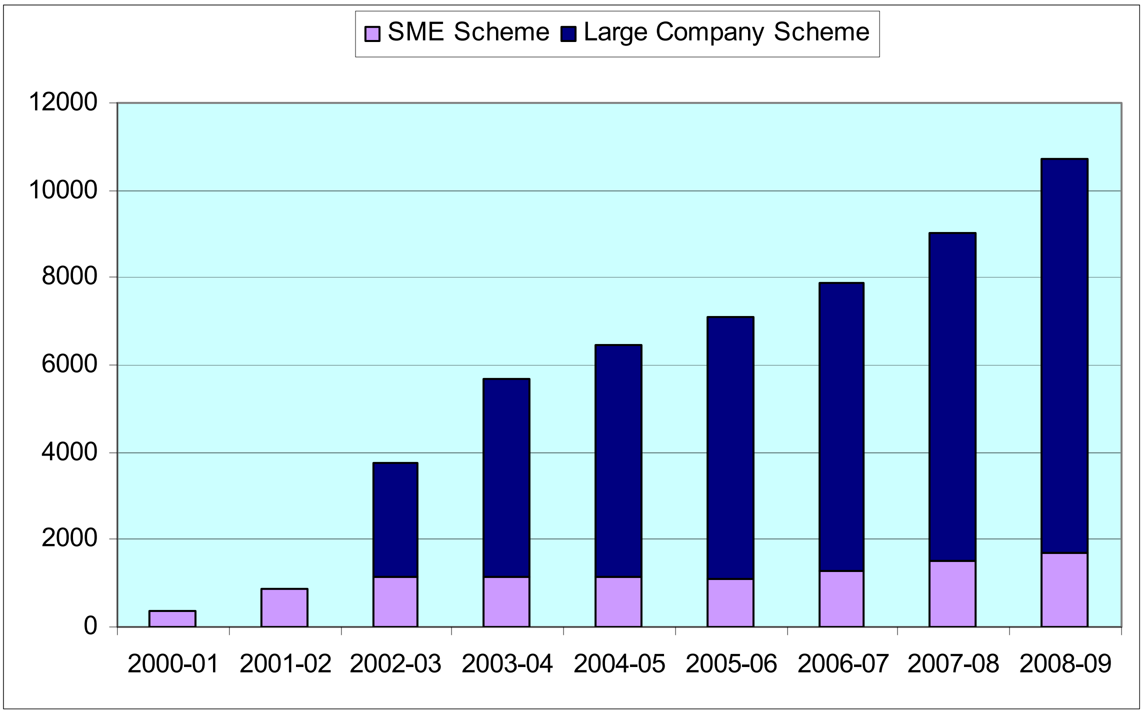


Table 3: Actual R&D Expenditure by scheme and financial year (£m, accounting period basis)

Financial year	Actual expenditure SME				Actual expenditure LC			VRR spend	All Total
	All credits	All losses	Mixed credits	Total	Large companies	Sub contractor	Total		
2000-01	170	80	110	360					360
2001-02	420	190	270	890					890
2002-03	450	310	370	1,140	2,600	30	2,630		3,770
2003-04	370	400	360	1,130	4,520	40	4,560	10	5,700
2004-05	350	450	350	1,150	5,250	60	5,300	20	6,470
2005-06	330	410	360	1,090	5,840	170	6,010	20	7,120
2006-07	330	500	460	1,290	6,390	180	6,570	30	7,890
2007-08	410	590	530	1,530	7,320	150	7,480	20	9,030
2008-09	140	670	870	1,690	8,870	170	9,040	20	10,750
Total	2,990	3,600	3,690	10,280	40,800	800	41,600	100	51,980

R&D spending used to claim tax credits is driven mainly by the large company scheme. In 2008-09, 84 per cent of total R&D expenditure used in R&D tax credit claims was for support under the large company scheme.

Almost all of the £9.0bn of R&D expenditure used to claim support under the large company scheme in 2008-09 has been in claims from large companies themselves, with SME subcontractors accounting for £0.17bn of R&D expenditure, about 2% of the total.

R&D expenditure by companies claiming under the SME scheme in 2008-09 was almost £1.7bn, a rise of some 10% from 2007-08.

£670m of R&D expenditure in the SME scheme was used to claim pure deductions from CT liability, £140m for payable credits and £870m for combination claims in 2008-09. Figures for 2007-08 were £590m, £410m and £530m respectively. The pronounced shift in favour of combination claims arises from changes to the R&D tax credit schemes which came into effect during 2008-09. The VRR scheme expenditures have risen from £10m in 2003-04, when the scheme was introduced, to £20m in 2008-09.

The Office for National Statistics (ONS) conducts the annual Business Enterprise Research and Development (BERD) survey of 400 of the largest R&D spenders and a sample of 4,400 other companies. Together these companies account for 84 per cent of the total R&D expenditure by businesses, not including government, higher education and research council expenditure.

The following table shows the BERD survey estimates of R&D revenue expenditure by businesses and the expenditure used to claim tax credits. The BERD figure for 2008 of £14.99 billion compares with our claims-related expenditure figure of £10.75 billion for 2008-09. This indicates that 72% of all R&D revenue expenditure by business was used to claim R&D tax credits. Note that the BERD figures for calendar years 2007 and 2008 most closely correspond with our AP figures for Financial Years 2007–08 and 2008–09.

Table 4: R&D expenditure 2003 to 2008 (£ billion)

	2003	**2004**	**2005**	**2006**	**2007**	**2008**
Total revenue expenditure (BERD survey, cash terms)	**11.33**	**11.48**	**12.57**	**13.19**	**14.56**	**14.99**
Expenditure used to claim tax credits	**5.70**	**6.47**	**7.12**	**7.89**	**9.03**	**10.75**
Percentage of total used to claim	**50%**	**56%**	**57%**	**60%**	**62%**	**72%**

Comparing our data with the BERD data, both follow an upward trend. Also, the percentage of total R&D expenditure used to claim tax credits has increased steadily from 50% in 2003 to 72% in 2008. Again, this may be explained partly by the increased number of claims, but partly also by a small number of large claimants having underestimated their expenditure in earlier years.

The BERD figures also show that, alongside R&D revenue expenditure, R&D capital expenditure totalled £1,079m in 2007 and £911m in 2008, ie around 6% of total R&D expenditure of c. £15 billion a year. R&D capital expenditure attracts separate tax relief.

6. Industry sector analysis for R&D tax credits

In order to capture industry sectors, the administrative tax data, comprising all R&D tax credit claims received for financial years up to 2008-09, was matched to FAME data which provides standard industrial classification (SIC) codes.

The industry information available only reflects the main economic activity of the business, which may not be the same activity as the actual R&D. For example, a company in the service sector may undertake R&D for a manufacturing company. This R&D should be classified as manufacturing. Similarly, manufacturing companies could be involved in R&D that should be classified in the service sector. Therefore, these figures should be seen as indicative and not necessarily taken to represent the industry sector of R&D activity supported by R&D tax credits.

In 2008-09, where industry information is available, most claims for R&D tax credits fall into two main categories: Real estate, renting & business activities; and Manufacturing. Figures 4, 5 and 6 show the main industries with more than one per cent of total claims.

The Real estate, renting & business activities sector accounted for 36 per cent of all claims in 2007-08, while Manufacturing accounted for 31 per cent of all R&D tax credit claims. In terms of the cost of support this represents £385m claimed by companies in Real estate, renting & business activities and £390m claimed by Manufacturing companies.

Figure 4: Percentage of R&D claims and cost of support by main industry sector 2008-09

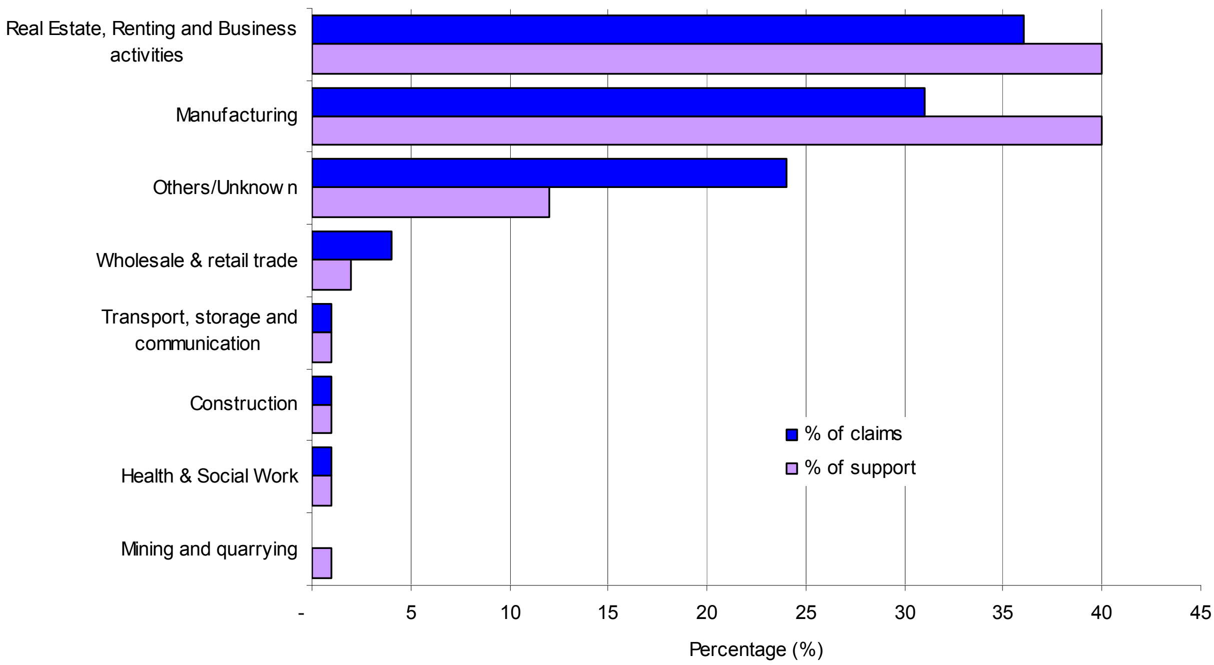


Figure 5: Percentages of number of claims by Top Sectors for the financial year 2008-09

Figure 6: Percentages of support claimed by Top Sectors for the financial year 2008-09

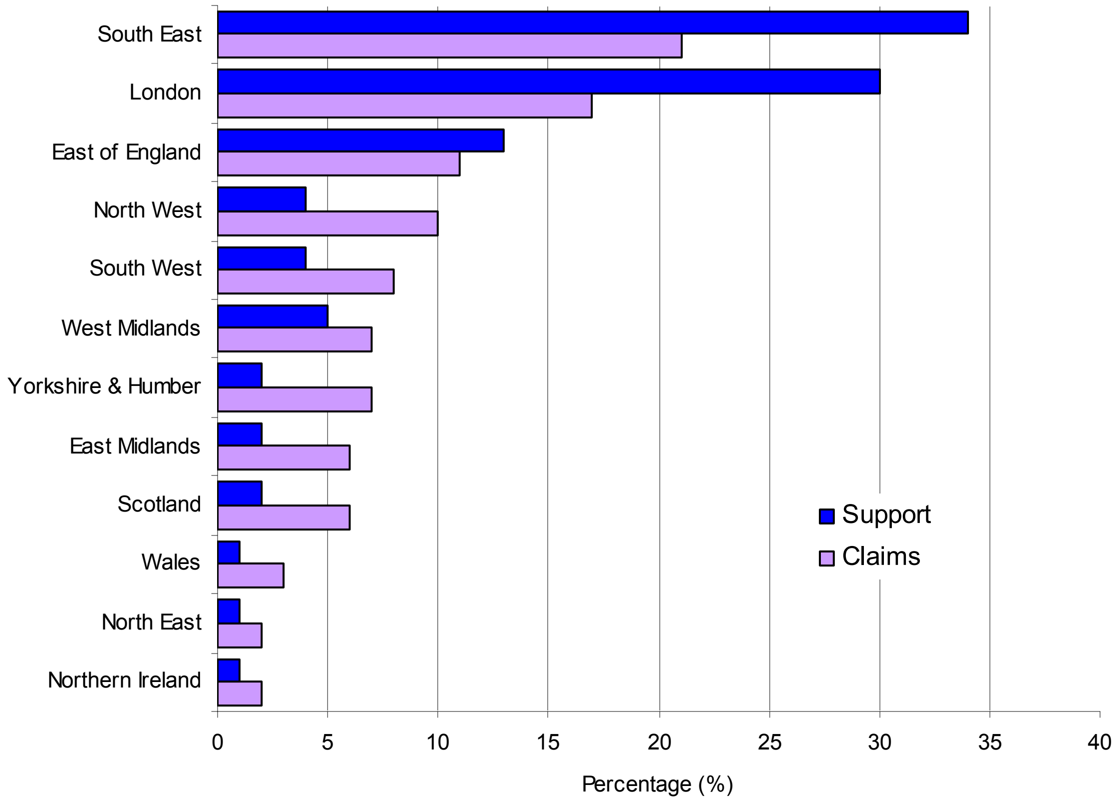
7. Geographical analysis for R&D tax credits

This section provides an indication of the geographic distribution of claims and cost of support under the R&D tax credit scheme.

Figure 7 is derived from the company registration postcode data. The geographical analysis may not represent the location of either the company making the claim or where the R&D was carried out, as the postcode could refer to the company headquarters or the registered office and sometimes the address of the accountant who deals with the tax return.

The largest numbers of R&D tax credits claims have been filed by companies in Southern England, with 21 per cent of all claims filed in the South East, 17 per cent in London and 11 per cent in East of England. The cost of support in these three regions amounts to £755m, which is 77% of the total cost of support.

Figure 7: Percentage of R&D claims and cost of support by Government Office Region 2008-09.



8. Companies claiming R&D tax credits from year to year

In this section the figures and trends show in detail which companies claim R&D tax credits from year to year, which ones return to claim after a break, and which are newcomers to the scheme.

Table 5 shows the incidence of companies claiming R&D tax credits under the SME scheme from year to year. Those claiming in any particular year are either (a) continuing companies who claimed the previous year, (b) returning companies who have claimed before but not in the previous year, or (c) new companies that are making a SME claim for the first time.

Table 5: Companies claiming under the SME scheme from year to year

Finance Year	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Previous year's companies	0	1780	3270	4460	5010	5160	4820	5130	5830
Of which not claimed this year	0	930	1340	1820	2030	2070	1610	1650	1910
Of which have claimed again this year (a)	**0**	**860**	**1930**	**2640**	**2970**	**3090**	**3210**	**3480**	**3920**
as percentage of previous year's claimants		*48%*	*59%*	*59%*	*59%*	*60%*	*67%*	*68%*	*67%*
Returning companies who claimed before last year (b)	**0**	**0**	**120**	**260**	**350**	**390**	**460**	**530**	**600**
as percentage of dormant pool			*5%*	*6%*	*6%*	*5%*	*5%*	*5%*	*5%*
Companies who have not claimed before (c)	**1780**	**2410**	**2410**	**2110**	**1840**	**1350**	**1460**	**1810**	**1930**
Companies claiming this year (a+b+c)	**1780**	**3270**	**4460**	**5010**	**5160**	**4820**	**5130**	**5830**	**6450**
Cumulative number who have ever claimed SME credits	*1780*	*4200*	*6610*	*8720*	*10550*	*11900*	*13360*	*15170*	*17110*

The number of companies continuing to claim from one year to the next increased each year, both in absolute numbers and as a proportion of the previous year's claimants, until 2008-09 when, although absolute numbers continued to increase, there was a very slight reduction of the proportion. The numbers of returning claimants have also increased, being consistently around 5% of the (expanding) pool of 'dormant' claimants. In contrast, new companies were falling sharply in number until 2006-07, when they increased by 5%, by another 12% in 2007-08 and by another 7% in 2008-09. These trends are shown in **Figure 8** below.

Figure 8: Number of companies claiming under the SME scheme

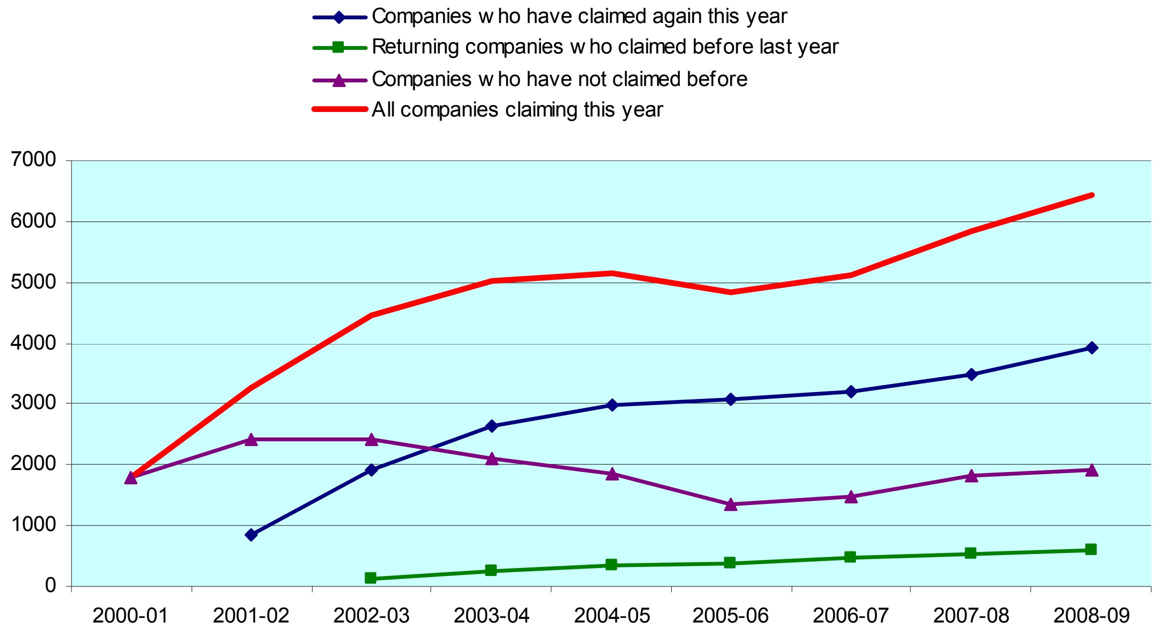


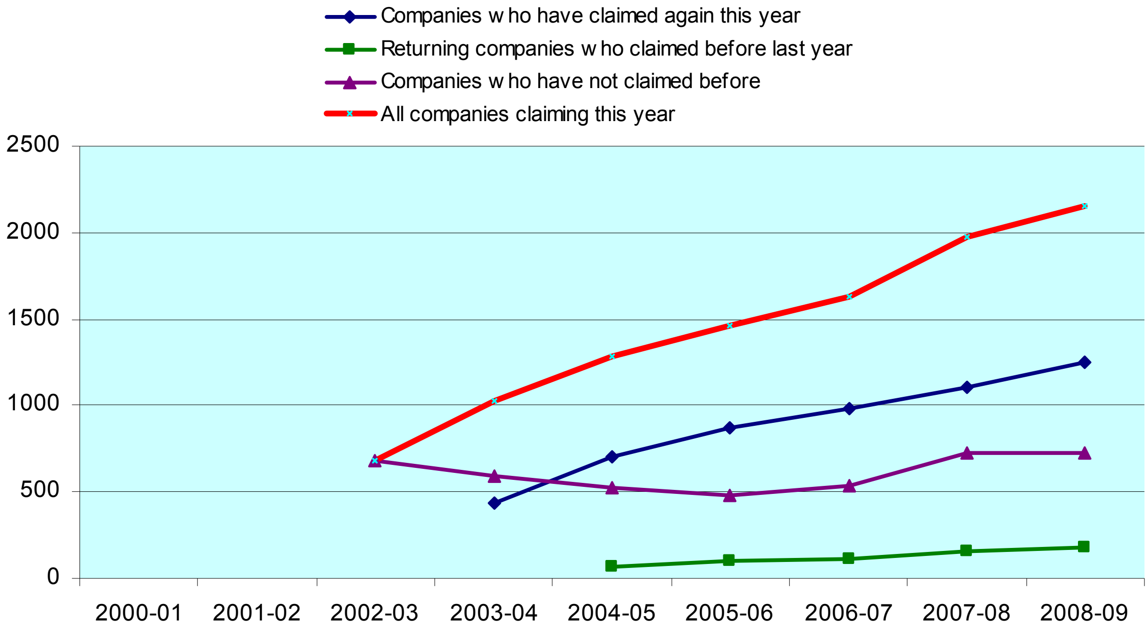
Table 6 shows the incidence of companies claiming R&D tax credits under the Large Company scheme, including SMEs claiming as subcontractors to a large company. The number of companies continuing to claim from one year to the next has risen each year in absolute numbers: some two-thirds of companies claiming in one year have also claimed in the next. They have been supplemented by a small but increasing number of returning companies - around 9% of the dormant pool - and by companies claiming for the first time under the LC scheme - around 700 a year.

Table 6: Companies claiming under the LC scheme from year to year

Finance Year	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**
Previous year's companies	0	0	0	680	1030	1280	1460	1630	1980
Of which not claimed this year	0	0	0	240	330	410	470	530	730
Of which have claimed again this year	**0**	**0**	**0**	**440**	**700**	**870**	**980**	**1100**	**1250**
as percentage of previous year's claimants				*65%*	*68%*	*68%*	*67%*	*67%*	*63%*
Returning companies who claimed before last year	**0**	**0**	**0**	**0**	**70**	**100**	**110**	**160**	**180**
as percentage of dormant pool					*11%*	*11%*	*8%*	*9%*	*8%*
Companies who have not claimed before	**0**	**0**	**680**	**590**	**520**	**480**	**540**	**720**	**730**
Companies claiming this year	**0**	**0**	**680**	**1030**	**1280**	**1460**	**1630**	**1980**	**2150**
Cumulative number who have ever claimed LC credits	*0*	*0*	*680*	*1270*	*1790*	*2270*	*2810*	*3540*	*4260*

These trends are shown in Figure 9 below.

Figure 9: Number of companies claiming under the LC scheme



Comparing the two schemes, the patterns of continuing and returning claimants are broadly similar, but with slightly higher rates for the large company scheme, and a more stable flow of newcomers.

Appendix C: Summary section of the Databuild report

The full report may be found at [No. 101 - Qualitative research into businesses' R&D decision making processes (PDF 637K)]

Background

HM Revenue & Customs, (HMRC) in conjunction with the Department for Business, Innovation and & Skills, (BIS) commissioned qualitative research to investigate businesses' processes for making decisions about research and development (R&D) and to identify the effects of two state sponsored research incentives: R&D tax credits and grants for R&D, on their behaviour. Of particular interest was how far it is possible to determine whether R&D tax credits and grants result in companies undertaking research that they would not otherwise have done.

Interviews were conducted with managing directors, finance directors and the directors responsible for R&D in companies which undertake technology or science-based R&D. The companies varied in size from micro to multinational corporations. They were operating at varying stages of their development and covered a wide range of sectors. Their characteristics can be broadly described by five typologies which the study identified:

- One person, one product
- Small, research-based business
- Established SME, suite of products
- High-tech, high ambition
- Large company, separate R&D department

These typologies are by no means exhaustive or rigid, and some companies have elements of more than one typology. But the typologies serve to set the context in which the decisions on R&D are being made.

Findings

For most companies interviewed, R&D is so deeply embedded in the company that the decision whether to conduct R&D is scarcely a consideration. What needs to be decided is the priority for individual projects when resources are under pressure.

Generally, companies have an overall idea of where the R&D is heading. Decision-making processes within this are informal and flexible, with minimal documentation. Any form of financial evaluation other than an estimation of potential sales is rare. Project lengths vary greatly and the start and end of individual pieces of work are not always defined.

Applying for R&D tax credits is seen as a matter of accounting routine and there appears to be a disconnect between the R&D and finance functions in many companies. Very often, those engaged in R&D are not personally involved in making the claim since it is handled by others, frequently outside the company. The provision of the required information can be challenging at the start but soon becomes part of a routine. At the end of year, external accountants play a major part in giving advice and processing the claim but do not always provide accurate information.

Third parties are also very important in guiding companies towards the grants and in providing assistance with applications. This includes both HMRC specialist R&D units and accounting professionals. In general, the advice and support provided is helpful and effective.

Many companies find the procedure surrounding grant applications time consuming and onerous. In particular, ongoing reporting during the period of the grant is often described as tedious. The requirement for match-funding causes difficulty for some companies and may be off-putting. Some companies acknowledge that they may 'tailor' a project to suit grant criteria and may divert from the company's overall goal in order to secure the funding.

R&D tax credits are described by almost all the sample as a bonus. The general opinion was, though, that they have little if any effect on decisions to conduct individual pieces of R&D work. This disconnect appears to be caused by the timing of claims and the gap between R&D and the finance function.

In most companies, however, there is a belief that the overall amount of R&D is increased as a result of the R&D tax credit system, though it is difficult to obtain quantitative evidence of this effect. The suggestion made is that in the long run, as R&D tax credit claims are made and received, confidence grows in the availability of this source of funding which can be invested in future R&D projects. For smaller companies, in particular, the cash flow is an important benefit which may allow the next R&D project to go ahead, possibly sooner than it may otherwise have done. Some respondents also say that R&D projects with a greater risk profile may be able to proceed because of the credits.

Grants are crucial to many start-up companies and vital in the early stages of the life of research-based SMEs. There are also significant indirect benefits arising from the award of a grant.

The business disciplines imposed by the grant application process can be helpful to the management of the company. The award of a grant may exert a leveraging effect on other funding and is beneficial in terms of recognition and kudos for the company. Staff recruitment and retention is often improved as a result. R&D rarely goes to waste and may be usable on future projects. Networking, which often arises through the third parties involved in the grant process, can open up opportunities for further work.

It is clear that accountants and other professionals do not always provide accurate information about government support for R&D. This leads to uncertainty amongst those applying for grants and making claims for R&D tax credits about what and when they may claim for. It is not uncommon for companies to discover R&D tax credits, for example, only when they appoint new accountants.

Guidance for the reader

The reader should bear in mind that the sample for the study is small (69 organisations) and was not constructed to achieve a statistically representative sample. The results of the study are reported in general terms throughout this report (some, most, all) rather than using percentages as it is not appropriate to infer conclusions about the precise number of organisations in the market who would share the same attitudes or behaviours. In turn it is not possible to provide detailed recommendations for future policy or delivery.

The full report may be found at No. 101 - Qualitative research into businesses' R&D decision making processes (PDF 637K)

Appendix D: Research and Development Tax Credits: Technical Summary of the Econometric Analysis

Overview

This document provides a technical summary of the econometric analysis of UK Research and Development (R&D) tax credits. In this evaluation, an econometric model of R&D investment is presented, whose coefficients are estimated from company level data. The econometric R&D model was developed and applied to the UK large company scheme by Peter Knizat in his MSc dissertation (Knizat 2010). Subsequently, HMRC extended this analysis, in particular to include the small and medium-sized enterprise (SME) scheme. 215 companies claiming under the large companies' scheme every year between 2003 and 2007 are investigated, as well as 236 SMEs over a similar period. A measure of the responsiveness of R&D investment to changes in the user cost of R&D is constructed. A benefit-cost ratio for the UK R&D tax credit schemes is formed on the basis of the responsiveness measure, which in turn is used to assess the cost effectiveness of the R&D tax credit policy. Both of these indicate that UK R&D tax credit policy has an effect on the level of R&D investment. However, the magnitude of this effect varies depending on the assumptions and method of estimation. One pound foregone in UK corporation tax revenues is estimated to stimulate between 0.41 and 3.37 of R&D investment in the long run.

This research forms part of the wider evaluation of R&D tax credits undertaken by HMRC in November 2010. Overall, the summary is intended to provide a moderate amount of detail to explain the basis of the econometric results presented in the main evaluation document.

1. UK R&D tax credits 2003-07[1]

Tax credits for R&D were introduced for SMEs in April 2000. They allow an SME to deduct an enhanced amount of R&D expenditure (150%) from their taxable profits in their corporation tax calculation. If an SME makes a loss after this enhanced deduction, then they also can opt for a cash payment of up to 16% of this loss (a payable credit) instead of carrying the loss forward to future financial years. The tax credit scheme was extended to include large companies from April 2002. Large companies can deduct 125% of their actual investment in their tax computation and they are not eligible for payable credits. From April 2003, a third scheme (Vaccine Research Relief) was added for vaccine and drug research into certain nominated diseases. This allows an extra deduction equalling 50% of the actual R&D expenditure, in addition to any other enhancements already claimed under the SME or large company schemes.

[1] There were significant reforms to R&D tax credits in 2008, in particular altering the rates of relief for all three schemes thereafter. The econometric evaluation of R&D tax credits summarized in this document only covers the period 2000-2007, so we do not discuss these changes here.

2. General theoretical framework

The basic empirical approach follows Bloom et al. (2002), except HMRC applies it to company-level data. Similar formulations are used widely in the econometric study of R&D (see for example, Hall & Van Reenen 2000). An R&D demand equation is constructed with various determinants of R&D investment, including a price variable, the user cost of R&D, that incorporates the effects of the UK's tax incentives. The non-tax variables control for structural characteristics of the company or industry that might affect R&D expenditure, such as the number of employees or profits. The general form of the econometric model for a company *i* at time *t* is

$$\log R_{it} = \alpha_0 - \sigma C_{it} + \gamma \log X_{it} + \log U_{it}, \qquad \textbf{(1)}$$

where R is the R&D investment, α_0 is a constant, C_{it} is the user cost of R&D, X_{it} stands for various control variables and U_{it} is a stochastic error term. This formulation is modified further following Bloom et al. (2002) to introduce dynamics into the relationship between R&D and its user cost. The lag of the dependent variable, that is, the logarithm of the R&D investment in year $t-1$, is introduced on to the right hand side.

The focus of the analysis is to estimate the coefficients in front of the variables, that is, σ, γ in Equation (1). From these coefficients two measures of the responsiveness of R&D spending to changes in the tax credit scheme are estimated: the R&D price elasticity and the benefit-cost ratio. The price elasticity quantifies the percentage change in R&D expenditure resulting from a one per cent change in the user cost of R&D, keeping all other variables the same. The sign of the elasticity is also important, indicating if a change in the user cost will cause an increase or decrease in the R&D expenditure. For example, an elasticity of +5 means that a one per cent increase in the user cost (for example, from 0.2 to 0.202) will result in a 5 per cent increase in the level of R&D expenditure. Likewise, an elasticity of −5 means that a one per cent increase in the user cost will result in a 5 per cent *decrease* in R&D expenditure. In the general form of econometric model, detailed in Equation (1), the logarithm of the user cost is not taken. Therefore, the *semi*-elasticity of R&D expenditure with respect to the user cost of R&D is actually measured. This quantifies the percentage change in R&D expenditure from a one percentage point change in the user cost of R&D, that is, the user cost increasing from say 0.50 to 0.51. In general, a semi-elasticity should *not* be directly compared to an elasticity, the latter of which is more usually calculated in the literature. This evaluation mainly estimates semi-elasticities. However, given that most estimates in the literature are actual elasticities, HMRC also calculates comparable elasticity estimates. The elasticity estimates presented here are for effects over different time periods (either in the short- or long-run) and are derived from the model coefficients following Bloom et al. (2002). Companies may take time to adjust their R&D investment in response to a change in the user cost (that is, there is a lag), which would explain differences between the immediate effects (quantified via the short-run estimates) and those over a longer timescale (the long-run estimates).

The benefit-cost ratio measures the amount of R&D investment (in £) induced by £1 of foregone tax revenues. We do not directly measure the benefit-cost ratio, but instead infer its value. The user-cost incorporates the effect of UK R&D tax credits, so all else being equal we can determine the change in the user cost caused by a change in the enhancement rate of the R&D tax credit (and we know the associated cost of this). From this change in the user cost, we also know the difference in R&D spending from the price elasticity. More detailed examples of these calculations are given in Section 8 at the end of this appendix.

2.1. The user cost of R&D

This analysis defines the user cost of R&D, which captures the marginal cost of R&D, in a similar way to the standard Hall-Jorgenson formula for the user cost of capital:

$$C_{it} = \frac{1-A}{1-\tau}(P_{it} + \delta), \qquad \textbf{(2)}$$

where τ is the corporation tax rate, A is the tax credit rate, P_{it} is the company's financial cost of capital and δ is the depreciation rate of the capital (taken to be 15%, in line with previous studies). A represents the reduction in corporation tax liability for each pound of R&D investment [$(1+\rho)\tau$, where ρ is the UK enhancement rate, 25 or 50% for large companies and SMEs respectively in 2003-07]. The fraction in Equation (2) is commonly referred to as the B-index [McFetridge & Warda 1983; $B=(1-A)/(1-\tau)$], which encompasses the effects of R&D tax credit policy. B is often used to compare the generosity of different R&D tax subsidies internationally (for example, Warda 2001; see also the accompanying Literature Review in Appendix A). Its value for UK R&D tax credits in 2003-07, was 0.88 and 0.89 for the large company and SME schemes respectively. Increasing the R&D tax credit enhancement rate, reduces B and correspondingly the user cost of R&D. HMRC's evaluation follows Thomson (2009) and approximates the financial cost of capital as a simple return on assets (ROA) measure, which can easily be calculated from company financial data[2]. The ROA is defined as

$$\text{ROA}_{it} = \frac{\text{profits}_{it} + \text{interest}_{it}}{\text{assets}_{it}} \qquad \textbf{(3)}$$

where the profits are recorded before tax and the assets are the total quoted company assets. Since R&D is not capitalised in company financial statements, the denominator in Equation (3) will be underestimated for companies investing heavily in R&D, implying overestimated returns. To overcome this difficulty, annual R&D expenditure is added to the numerator and an imputed R&D stock to the denominator. In general, such a modification should not change the ROA significantly as typically R&D only contributes a small amount to a company's overall assets.

2.2. Non-tax determinants of R&D

In addition to the user cost of R&D, we include the following explanatory variables to control for various structural characteristics of each company:

[2] Thomson (2009) also considered a more complicated measure of financial capital, computed using the capital asset pricing model. However, this did not give significantly different results to his more simple return on assets approach which HMRC adopted.

1. Lagged R&D – R&D investment is influenced by expenditures in previous years.
2. Sales – assumed to be a pre-determined variable as investment in R&D may influence only future sales.
3. Growth rate in sales – controls for the growth in demand.
4. Profits – again assumed to be pre-determined like sales.
5. Number of employees – controls for company size.
6. Liquidity ratio – determines a firm's ability to pay off its short-term debt obligations. It is calculated as current assets divided by current liabilities.
7. Real interest rate – the nominal interest rate minus inflation.
8. GDP growth rate – on an industry level [identified through the UK standard industry classification (SIC) code].

3. Data and analysis

3.1. Large company scheme

This evaluation analyses a strongly balanced panel of data from 215 firms, which claimed under the large company scheme in every year between 2003 and 2007 (the panel comprises 5 years of data). This sample of firms is around 15 per cent of all the companies claiming under the large company scheme in that period, but includes a majority of the total enhanced R&D expenditure (55 per cent). The data in the panel for these companies were taken from company corporation tax returns and accounts[3]. If values for the parameters of interest were missing from the accounts data for two or more consecutive years then the firm was excluded from the analysis (this reduced the initial sample size by approximately 40 per cent to a total of 215). Otherwise missing values were replaced with an average of the two adjacent years.

After construction of the panel, the econometric model [whose general form was given in Equation (1)] was estimated using two dynamic panel data estimators, one introduced by Arellano & Bond (1991) and the other by Blundell & Bond (1998). Moreover, since the user cost depends on various characteristics of the firm, its level of R&D investment and user cost may be simultaneously chosen. Given this potential simultaneity issue HMRC treats the user cost in two different ways, assuming it is either exogenous or endogenous to the model[4].

3.1.1. Arellano-Bond Estimator

First, the model is differenced (that is, the model at time $t-1$ is subtracted). Then, the differences for any endogenous variables (profit, sales, lag of the R&D expenditure and sometimes the user cost) are replaced with their own difference lags which are used as instrumental variables. For example, if x_{it} represents the log of an endogenous variable, then Δx_{it} would be replaced with $\Delta x_{i,t-1}$ and similarly $\Delta x_{i,t-1}$ with $\Delta x_{i,t-2}$. The coefficients are then estimated following various assumptions, using either the generalized method of

[3] These data are mainly based on the filings supplied to Companies House.
[4] Exogenous variables are independent variables that can affect an economic model but are not affected by it. Endogenous variables by contrast are formed inside models.

moments (GMM) or the robust variance matrix approach. In practice, both techniques yielded the same values for the coefficients, only their standard errors differed.

3.1.2. Blundell-Bond Estimator

The Blundell-Bond estimator is similar to Arellano-Bond, with further constraints and a slightly different way to form the instruments. The instruments replacing the endogenous variables are now combinations of lagged differences in the first-differenced model equation (as for Arellano-Bond) and lagged levels in the model (that is, x_{it} is replaced by $x_{i,t-1}$ etc.). The estimation technique can again use either the GMM or robust approaches as for the Arellano-Bond estimator.

A full description of the Arellano-Bond and Blundell-Bond estimators, their associated assumptions and the specifics of their application to this model is beyond the scope of this summary but full details are provided by Knizat (2010).

3.2 SME scheme

A balanced panel of SME data was constructed for every SME that claimed R&D tax credits in every year from 2000 to 2007 (8 years of data), similar to the large company panel. The resulting dataset encompassed 236 companies, approximately 2 per cent of SMEs claiming R&D tax credits in this period. A second panel was also constructed using a sub-set of these data over the period 2003-2007. This second panel is more closely comparable to large company data as it spans the same time period. We calculated the coefficients in the R&D model using the Arellano-Bond estimator only, assuming the user cost is exogenous. In addition, the model was also evaluated using the logarithm of the user cost, so that an elasticity could be estimated in addition to the semi-elasticity estimates (see Section 2).

4. Results

4.1. Elasticity

Estimates of the short- and long-run semi-elasticity of R&D expenditure with respect to the user cost of R&D obtained for the large company scheme are summarized in Table 1 and similar estimates for the SME scheme Table 2 (including associated elasticity estimates).

Table 1: Summary of the short- and long-run semi-elasticity of R&D investment with respect to the user cost of R&D estimated for the large company scheme using various regression techniques. Only values derived from coefficients estimated to be significant at the 5 per cent level have been listed. The estimator type has been further subdivided into whether the R&D user cost is treated as an exogenous or endogenous.

Estimator		Short-run semi-elasticity		Long-run semi-elasticity	
		Exogenous	Endogenous	Exogenous	Endogenous
Arellano-Bond	GMM	−2.41	.	−3.65	.
	Robust	−2.41	.	−3.65	.
Blundell-Bond	GMM	−2.27	−0.91	−5.16	−2.60
	Robust	−2.27	−0.91	−5.16	−2.60

Table 2: Summary of the short- and long-run elasticity and semi-elasticity of R&D investment with respect to the user cost of R&D estimated using a balanced panel of companies claiming under the SME scheme. All parameters are estimated to be significant at the 5 per cent level and have been computed using the Arellano-Bond estimator, assuming the user cost is exogenous. For comparison the results found by for the large company scheme using the same estimation method are also listed.

Panel data	Years	Number of companies	Semi-elasticity		Elasticity	
			Short-run	Long-run	Short-run	Long-run
SME	2000-07	236	−1.06	−1.11	−1.60	−1.66
SME	2003-07	236	−2.05	−1.90	−2.59	−2.41
Large Company	2003-07	215	−2.41	−3.65	.	.

4.2. Benefit-cost ratio

Most econometric studies of R&D tax incentive programmes determine their effectiveness by evaluating the ratio of R&D expenditure induced by the scheme to its tax cost. This ratio is called either the benefit-cost ratio, incrementality ratio, tax sensitivity ratio or the 'bang for the buck'. If the ratio is greater than one, more industrial R&D expenditure is stimulated by the tax incentive than it costs to the taxpayer and the scheme can be considered cost effective. In reality, this ratio does not take into account all of the costs (such as administration) and benefits (for example, the social returns on the R&D investment) of the R&D subsidies, so simply determining if the scheme is cost effective based on this ratio may be misleading (see for example, Mohnen & Lokshin 2009) .

In the econometric model used in this evaluation, we can indirectly estimate the benefit-cost ratio. Increasing the R&D credit rate, increases the tax cost and decreases the user cost of R&D, correspondingly increasing the R&D investment (quantified via the elasticity or semi-elasticity). Using the detailed relationships, we can compute how much R&D investment is stimulated by £1 of foregone tax revenue (two example computations are laid out in Section 8). The semi-elasticities derived by for the large company scheme imply a benefit-cost ratio of between 0.93 and 1.85 in the long-run. In other words, over time £1 of cost to the taxpayer returns between £0.93 and £1.85 of R&D investment. The estimates for the SME scheme are somewhat smaller if they are based on semi-elasticities (0.41 or 0.71), but much larger if they are derived from the elasticity estimates (2.33 and 3.37). Table 3 provides a full list of the benefit-cost ratios derived.

Table 3: Benefit-cost ratios derived from econometric analysis carried out by for the large company (LC) or SME schemes. The ratios are derived from long-run elasticities and semi-elasticities as stated. The type of estimator is either Arellano-Bond (A-B) or Blundell-Bond (B-B) and the user cost of R&D is either assumed to be exogenous (exo) or endogenous (end).

Scheme	Estimator	Years	Elasticity (E) or Semi-elasticity (SE)	Benefit-cost ratio
LC	A-B, exo	2003-07	SE	1.31
LC	B-B, exo	2003-07	SE	1.85
LC	B-B, end	2003-07	SE	0.93
SME	A-B, exo	2003-07	SE	0.41
SME	A-B, exo	2003-07	E	2.33
SME	A-B, exo	2000-07	SE	0.71
SME	A-B, exo	2000-07	E	3.37

5. Discussion

The principal finding of this econometric analysis is that the user cost of R&D is a significant determinant of R&D investment for companies claiming under both the large company and SME schemes. Equally, the amount of R&D investment by a company is responsive to the user cost of R&D, with the responsiveness quantified via the price elasticity. The elasticities computed are all negative implying that a *decrease* in the user cost brings about an *increase* in the amount spent on R&D.

For the large company scheme, assuming the user cost of R&D is exogenous, we find similar short-run semi-elasticity estimates from the Arellano-Bond and Blundell-Bond techniques (−2.41 and −2.27 respectively). This implies that a large company will respond immediately to a 1 percentage point decrease in the user cost of R&D through raising its R&D expenditure by over 2 per cent. If the user cost is treated as an endogenous variable then the semi-elasticity decreases in magnitude to under 1 for the Blundell-Bond estimator. With Arellano-Bond the user cost becomes insignificant. There are greater differences between the two techniques for the long-run estimates because of changes in the coefficient of the lagged dependent variable. The long-run semi-elasticities are greater in magnitude than the short-run estimates. This indicates that there is a lag in the effect of changing the user cost of R&D, that is, it takes large companies a few years to adjust their R&D spending to changes in the user cost. These large differences ultimately make only a small difference to the inferred benefit-cost ratios. Both of the estimates are greater than one (1.31 for Arellano-Bond and 1.85 for Blundell-Bond), implying that for every pound of lost tax revenue for the large company scheme, over one pound is returned in company R&D investment. Given that the ratios are both over unity, this implies it is more efficient to fund R&D through the tax credit system rather than directly. If there was for example, a system of direct grants to companies, we might expect £1 of Exchequer cost to return only £1 of company R&D expenditure.

The semi-elasticity estimates derived for the large company scheme are typically not directly comparable to the values reported in the literature (see the literature review in Appendix A). This is because studies usually only report and estimate *elasticities*. In addition, there are very few studies that analyse UK tax incentives for R&D econometrically using detailed firm-level data. International comparisons are more difficult to interpret given the different methods of estimation, format of the scheme and economic conditions. There are no similar confusions to the semi-elasticity/elasticity difficulty for benefit-cost ratios, only multiple approaches to computing them. The ratios for the large company scheme are in the middle of the estimates in the literature.

The resultant semi-elasticities for the SME scheme are smaller in magnitude than for the large companies. Over the entire duration of the scheme (2000-07) our short-run estimate is −1.06, but for only the same period as analysed for the large company scheme (2003-07) this falls to −2.05 (lower magnitude than the comparable large company estimate of −2.41). This implies that R&D expenditure by SMEs is less responsive to changes in the user cost of R&D than for large companies. The increase in magnitude of the estimate for the later period over that for the entire duration, perhaps suggests that SMEs have become more responsive to changes in the user cost as the scheme progressed. Looking over the long-run the estimates do not change a great deal. For the SME scheme HMRC has also estimated the price elasticity (which will be directly comparable with other work). The estimates reflect similar changes over the duration of the scheme, being −1.06 for 2000-07 and −2.41 for 2003-07 (both short-run figures). A price elasticity of around unity is often found in studies (see the summary in Appendix A). The higher magnitude estimate is more unusual but comparable to the elasticity found for French manufacturing firms by Mairesse & Mulkay (2003).

The benefit-cost ratios for SMEs show considerable variation depending on whether semi-elasticity or elasticity estimates are used to calculate them. Over both periods they are less than one (0.41, 2000-07; 0.71, 2003-07) if the computation is carried out from the semi-elasticity. However, they are much greater than one (2.33, 2000-07; 3.37, 2003-07) if the elasticity estimates are used instead. These ratios would lead to very different conclusions if looked at in isolation: either a highly cost-effective scheme (for the large ratios) or a very ineffective one (the low ratios). High ratios are not unprecedented. Mairesse & Mulkay (2003), who also found the comparable elasticity estimates in France, note benefit-cost ratios of between 2.0 and 3.6. Furthermore, Lokshin & Mohnen (2007, 2010) find a wide variation in the ratio from about 0.4 to 3.5 in the Netherlands. They also show that the ratio varies depending on the timescale over which changes are examined. For all companies the scheme has its largest impact initially (that is, the ratio is largest over a short-timescale), which then falls off over time (in the long-run). This fall off is most pronounced for small companies (<50 employees), where the scheme is also most cost effective. Although the Dutch R&D tax credit scheme has an unusual format, we can find similarities in some UK elasticity estimates. For example, both the semi-elasticity and elasticity estimates for SMEs between 2003 and 2007 are smaller in magnitude for the long-run compared to the short-run estimates. This perhaps would be expected if the scheme has the greatest impact on small companies initially and thereafter the level of R&D investment is not so affected by reductions in the user cost.

However, the same pattern is not seen in the 2000-07 data or for large companies.

5.1. The limitations of this analysis

HMRC's econometric analysis only examined a portion of companies claiming R&D tax credits between 2003 and 2007. The measurable effects of R&D tax credit policy may be different in the companies not included, leading to wider range of effectiveness measures.

HMRC's analysis is based on the R&D expenditure a company declares in its corporation tax return to claim R&D tax credits. This may not be the same as other measures of company R&D expenditure. Suppose a company performs the same amount of R&D year-on-year. In HMRC's data this company might appear to be increasing its R&D expenditure, if they merely claim tax relief for an increasing proportion of this expenditure. In this econometric analysis, the same elasticity might be found when in reality the company does not increase its R&D expenditure at all as a result of the tax credit policy. To investigate this possible bias in the measured elasticity, we compared the changes in R&D spending for the sample of large companies and SMEs from company tax returns to the variations in total UK business R&D spending, taken from the Office for National Statistics' (ONS) BERD (Business Enterprise R&D) survey. We found that the total R&D spending apparent in the large companies' and SME samples increased from 2003 to 2007 by an average of 4.7 and 4.0% per annum respectively. The BERD survey reports that UK R&D spending increased by an average of 5.7% pa in cash terms over the same period. Given that the increases for the two samples are very similar to and slightly smaller than the overall changes reported by the ONS, it does not suggest that the increase in claim size for an individual company is dominated by them claiming an increasing proportion of their R&D expenditure. Perhaps it suggests that the sample selected will *under*-estimate the elasticity and effects of the tax credit policy.

Furthermore, the elasticities reported here were derived using data only in the period after the introduction of R&D tax credits and not beforehand. In addition, a reliable comparison group could not be constructed. Therefore, we were not able to assess the impact that the introduction of the tax credit had on companies who undertook R&D and claimed the credit and those that undertook R&D but did not. This absence was partly overcome by using an estimate of the benefit-cost ratio as the basis for the effectiveness of the policy, which is the measure that is most widely used in existing studies of the effectiveness of R&D tax credits (see for example, Hall & Van Reenen 2000).

6. Conclusion

HMRC analysed the impact of R&D tax credit policy in the UK. A simple model of R&D investment was formulated with the user cost of R&D a key determinant of a company's R&D expenditure, computed using a return on assets measure multiplied by an index that incorporates the tax incentive. A balanced panel of data was constructed for 215 companies claiming under the large companies R&D tax credit scheme and 236 companies in the SME scheme from HMRC corporation tax returns, supplemented with company accounts data. From these panels the model coefficients were calculated using various techniques, particularly the Arellano-Bond estimator.

The user cost of R&D is a statistically significant determinant of R&D investment for companies. In other words, the amount a company invests in R&D is responsive to changes in user cost of R&D and by implication changes in the generosity of R&D tax credit policy. Estimates of the return on foregone tax revenues resulting from the introduction of R&D tax credits vary considerably. Depending on the techniques employed £1 of foregone tax revenue stimulates between £0.41 and £3.37 of R&D investment.

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8. Example benefit-cost calculations

8.1. Large company scheme, semi-elasticity

For the large company scheme, using the robust Arellano-Bond estimator and assuming the user cost of R&D is an exogenous variable, the semi-elasticity is −3.65 in the long run. The average user cost of R&D between 2003 and 2007 for the 215 large companies in the panel data is 0.224. Suppose the tax credit rate changed by 1 percentage point, from 25 to 26 per cent. This would decrease the B-index (and the user cost of R&D) by 0.4 per cent, from 0.893 to 0.889[5]. Such a decrease would *increase* the R&D expenditure by 0.004 × 0.22 × 3.65 = 0.39 per cent. If a company invests £100 in R&D and claims the R&D tax credit, the credits cost £25 × 0.30 = £7.50, that is, the loss in tax on the 25% enhancement[6]. If the rate is increased to 26% this has cost an extra £0.30 in tax and has induced £0.39 of increased R&D expenditure. Therefore the cost benefit ratio is 1.31. £1 of tax cost has stimulated £1.31 of R&D expenditure.

8.2. SME scheme, elasticity

For the SME scheme over the same period (2003-07), using the robust Arellano-Bond estimator and assuming the user cost of R&D is an exogenous variable, the elasticity is estimated to be −2.41. Again, suppose the SME tax credit rate changed by 1 percentage point, from 50 to 51 per cent. This would decrease the B-index (and the user cost of R&D) by 0.27 per cent, from 0.883 to 0.880. Such a decrease would *increase* the R&D expenditure by 0.27 × 2.41 = 0.64 per cent. If a company invests £100 in R&D and claims the R&D tax credit, the credits cost £50 × 0.19 = £9.50, that is, the loss in tax on the 50% enhancement[7]. If the rate is increased to 51% this has cost an extra £0.19 in tax and has induced £0.64 of increased R&D expenditure. Therefore the cost benefit ratio is 3.37. £1 of tax cost has raised £3.37 of R&D expenditure.

[5] The user cost of R&D would decrease from 0.224 to 0.223.
[6] Assuming a corporation tax rate of 0.3 for large companies.
[7] Assuming a corporation tax rate of 0.19 for SMEs between 2003 and 07.