Evaluation of the Research and Development Tax Relief for Small and Medium-sized Enterprises

HM Revenue and Customs Research Report 598

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Glossary

Annual Business Enquiry (ABI)	An Office for National Statistics (ONS) survey collecting economic and financial information for a sample of non-financial businesses in the UK. The financial information part of the survey was replaced by the Annual Business Survey (ABS) in 2009.
Annual Business Survey (ABS)	The main structural business survey conducted by the Office for National Statistics (ONS) collecting financial information on a sample of non-financial businesses in the UK.
Annual Respondents Database X (ARDx)	A research data set designed for users of the Secure Research Service (SRS). It is created using two ONS data sets (ABI and ABS) and covers years from 1998 onwards.
Arellano-Bond (A-B)	A generalised method of moments (GMM) estimator used to estimate dynamic panel data models.
Business Enterprise Research and Development (BERD)	An annual Office for National Statistics (ONS) survey collecting data on scientific and technological activities undertaken by UK businesses, for both civil and defence purposes.
Business Structure Database (BSD)	A database derived from the Inter-Departmental Business Register (IDBR) and provided in the Secure Research Service (SRS) for research purposes. It covers almost all businesses in the UK.
Computer Assisted Telephone Interviewing (CATI)	A telephone interviewing technique.
Corporation Tax (CT)	A direct tax applied to businesses' profits.
Financial Analysis Made Easy (FAME)	A Bureau van Dijk database containing detailed information on UK and Irish companies.
Fixed Effects (FE)	An econometric estimation technique used in panel data sets controlling for time-invariant unobserved individual characteristics.
Generalised Method of Moments (GMM)	A general estimation framework that is used to derive parameter estimates in statistical models.
Her Majesty's Revenue and Customs (HMRC)	A non-ministerial UK government department responsible for taxation, payments, and customs.
Herfindahl Hirschman Index (HHI)	A commonly used measure by competition regulators to assess the level of market concentration in a given industry.
Inter-Departmental Business Register (IDBR)	A comprehensive list of UK businesses providing the main sampling frame for surveys of businesses undertaken by the Office of National Statistics (ONS).
National Insurance (NI)	A tax on earnings that is used to fund some state benefits.
Ordinary Least Squares (OLS)	An econometric technique used to estimate the parameters of linear regression models. OLS parameter estimates minimise the sum of squared differences between predicted and observed outcomes.
Office of National Statistics (ONS)	The recognised national statistical institute of the UK.
Pay-As-You-Earn (PAYE)	Income Tax deducted from earnings.
Research and Development (R&D)	Systematic and creative activities undertaken to generate new knowledge and devise new applications of existing knowledge (OECD, 2015).

Research and Development Expenditure Credit (RDEC)	An R&D tax relief scheme that is available to large companies. It replaced the large company scheme in 2016.
Secure Research Service (SRS)	An ONS facility providing secure access to sensitive detailed data.
Small and Medium-sized Enterprises (SME)	The EU definition covers businesses with fewer than 250 employees, *and* annual turnover less than €50 million *or* a balance sheet less than €43 million. The definition under the scheme was expanded in 2008–09 to include businesses with fewer than 500 employees, *and* annual turnover less than €100 million *or* a balance sheet less than € 86 million.
Tax relief	Refers to tax relief offered under the Research and Development Tax Relief for Small and Medium-sized Enterprises scheme.
The scheme	Refers to the Research and Development Tax Relief for Small and Medium-sized Enterprises. Also referred to as the 'SME scheme' when compared to the RDEC scheme.
Value Added Tax (VAT)	An indirect tax applied on the consumption of goods and services.

Executive Summary

The research and development (R&D) tax relief for small and medium-sized enterprises (SMEs) is designed to encourage eligible businesses to invest in innovation by incentivising greater R&D expenditure. The scheme works by reducing a company's Corporation Tax liability (deduction claim), with the option of receiving a cash payment if the company is loss making (credit claim).

This report provides an independent evaluation of the scheme addressing the requirements of the evaluation plan set out in the European Commission (EC)'s decision letter[1] and the common methodology designed by the EC for state aid evaluations[2]. More specifically, the evaluation has three main objectives:

1) Assessing the direct impacts of the scheme, measured by the additionality effect on R&D expenditure (that is, the R&D expenditure that would not have been undertaken in the absence of the scheme).
2) Understanding the indirect impacts of the scheme in terms of firm productivity (proxied by turnover and innovation behaviour), and the extent to which the scheme may distort market competition.
3) Determining the 'proportionality' of the scheme (whether the same level of R&D expenditure can be achieved with lower relief rates), and the 'appropriateness' of the scheme (whether alternative forms of support would be better suited to incentivise R&D expenditure).

Direct impacts of the SME R&D tax relief

To investigate the impact of the scheme at the intensive margin of R&D expenditure and relief claimed (that is, whether businesses are conducting more R&D or claiming larger amounts as a result of the scheme's increasing generosity), an econometric analysis estimates how changes in tax relief can affect R&D expenditure. The 'additionality ratio' (the additional R&D expenditure that would be generated by an increase in the generosity of the scheme relative to the additional cost incurred by the Exchequer) for a deduction claim is estimated to range between 0.75 and 1.28 for a one percentage point (pp) increase in the additional deduction rate (from 130% to 131%). This indicates that every £1 foregone in tax revenue stimulates between £0.75 and £1.28 of R&D expenditure. In the case of a credit claim, the additionality ratio ranges from 0.60 to 1.00 (based on a one pp increase in the credit rate from 14.5% to 15.5%).[3] It is important to note that the additionality ratio is not a benefit-to-cost ratio as there are likely to be other knock-on (or 'spillover') benefits associated with the scheme that are not captured in this approach. For example, the analysis does not capture the impact of the scheme at the extensive margin of R&D expenditure (that is, whether new businesses are undertaking R&D as a result of the scheme's increasing generosity).

[1] The EC's decision letter to the then Secretary of State for Foreign and Commonwealth Affairs, The Rt Hon Philip Hammond, 30 September 2015. Published on 21 December 2015 and available at: http://ec.europa.eu/competition/state_aid/cases/258021/258021_1709375_48_6.pdf.

[2] Common methodology for State aid evaluation. Available at: http://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf.

[3] Estimates are relatively robust to changes in model specification, data sample, and underlying assumptions. Moreover, the estimates are consistent with results from previous evaluations of the scheme.

Indirect impacts of the SME R&D tax relief

For a business conducting R&D, the results suggest that a 1% increase in R&D expenditure is associated with a 0.021% increase in the business' turnover in the following year.[4] For a business conducting R&D, there is a negative sector-level spillover effect on turnover; that is, a business' R&D will have a negative knock-on effect on the turnover of other businesses that undertake R&D in the same sector. This may be due to a market competition effect among these businesses. In other words, an increase in the R&D expenditure of one business leads to a decrease in another business' turnover within the same sector due to market competition. Conversely, there is a positive regional spillover effect among businesses that undertake R&D.[5] This is supported by findings from existing studies that suggest that physical proximity facilitates knowledge diffusion. In contrast, businesses that do not undertake R&D benefit from both positive sector-level and regional spillover effects. In this case, these businesses may not be direct competitors to businesses that undertake R&D and may purchase existing innovations that are generated.

An analysis of quantitative survey data gathered during this evaluation suggests that 'claimants' (businesses claiming R&D tax relief under the scheme) are more likely to generate a larger share of their turnover from goods, services, or processes that are new-to-market in comparison to non-claimants who conduct R&D. Claimants show increases in innovative behaviour as more patent applications are filed in the year that they first claim under the scheme and the average number of patents filed per claimant increases in subsequent years. In terms of distorting market competition, there is no evidence to suggest that the relief favours businesses with market power, businesses in specific regions (in other words, location effects), or incumbents over new entrants.

Proportionality and appropriateness of the relief

The econometric analysis suggests a decreasing proportionality in more recent years. That is, R&D expenditure incentivised by recent increases in the relief rates is lower than expenditure incentivised by previous increases. This result was supported by the quantitative and qualitiative interview evidence gathered during this evaluation. In particular, 71% of claimants reported that a hypothetical increase in the deduction rate of 10 pp would not affect their level of R&D expenditure. In qualitative interviews, some businesses suggested that a change of 10 pp was too small and that it would take an increase in the deduction rate, ranging from 20% to 60% depending on the respondent, to encourage further R&D spending.

The evaluation also considers whether a tax relief is the most appropriate financial instrument to incentivise R&D expenditure. In quantitative interviews, 56% of claimants stated that they would not change their level of R&D expenditure if they received the amount of tax relief that they claimed in the form of a grant or subsidy at the start of the financial year before undertaking any R&D. However, 39% reported that they would increase their R&D expenditure under this hypothetical scenario. Findings from the qualitative interviews supported these results, suggesting that access to matched-funded grants is appealing to some businesses. However, many businesses in the qualitative interviews had little to no awareness of the types of grants available for R&D expenditure. Moreover, some businesses raised concerns about the administrative burden of grant or subsidy funding.

[4] This impact is statistically significant at the 1% level.

[5] This can be thought of as a 'cluster' or 'agglomeration' effect in the sense that physical proximity of businesses can generate benefits in the form of knowledge diffusion. It should be noted that knowledge spillovers are not the only type of agglomeration effect. For a detailed discussion of agglomeration effects, see Glaeser (2010).

1 Introduction

1.1 The UK R&D tax relief for SMEs

Economic theory and empirical evidence suggest that the social benefits of R&D exceed its private returns (for example, through knowledge spillovers).[6] Because of this, the level of private R&D expenditure is likely to be less than the level of R&D expenditure that is desirable for society as a whole (Nelson, 1959; Arrow, 1972). To address this market failure, tax relief can be used to subsidise R&D expenditure to narrow the gap between its private and social rates of return, thereby incentivising greater R&D expenditure.

In the UK, R&D tax relief for small and medium-sized enterprises (SMEs) was introduced in the financial year 2000–01, with the aim of encouraging R&D expenditure among eligible businesses. The scheme works by reducing a company's Corporation Tax (CT) liability, with the option of receiving a cash payment if the company is loss making. Eligible R&D activities include projects that aim to make an advance in science or technology.

Three examples of how the value of relief can be calculated under the scheme for the current rates are provided below (Table 1). In the first case, a profit-making firm can save on its CT liability by deducting its R&D expenditure from its profits, scaled by an 'additional deduction rate' of 130% on top of the typical 100% for most other eligible expenses. The sum of R&D expenditure and the additional deduction (in other words, 230% of R&D spend) is referred to as 'enhanced expenditure'. In the second case, a loss-making firm is able to receive a payable credit (worth 14.5% of the surrenderable loss) that is proportional to R&D enhanced expenditure. In the third case, a profit-making firm claims a deduction that exceeds its profits so, in addition to reducing its CT liability to zero, it will be able to claim a payable credit worth 14.5% of the difference between the deduction and its profits.

Table 1 Illustrative examples of R&D tax relief claims at current rates

Deduction claim	Credit claim	Combined claim
R&D expenditure = £100,000	R&D expenditure = £100,000	R&D expenditure = £100,000
Profit before R&D deduction = £500,000	Loss = –£500,000	Profit before R&D deduction = £50,000
R&D enhanced deduction = £130,000 (£100,000 x 130%). Note: 100% deductions already built into original profit.	R&D enhanced expenditure = £230,000 (£100,000 x 230%)	R&D enhanced deduction = £130,000 (£100,000 x 130%). Note: 100% deductions already built into original profit.
CT if no claim @ 19% = £95,000 (£500,000 x 19%) CT if claim @ 19% = £70,300: (£500,000–£130,000) x 19%	Not liable for CT but can claim payable tax credit Maximum loss to surrender to HMRC = = £230,000 (£100,000 x 230%)	CT if no claim @ 19% = £9,500 (£50,000 x 19%) CT if claim @ 19% = £0 as (£50,000–£130,000) <0. Maximum loss to surrender to HMRC = £80,000 (£130,000–£50,000)
CT saved = £24,700 (£95,000 – £70,300) **(25% saving)**. With the £19,000 in CT saved on the	**Max saving from payable credit= £33,350** (£230,000 x 14.5%) **(33% saving)**	1. CT saved = £9,500 (£9,500 – £0) (10% saving)

[6] See, for instance, Griliches (1998) as well as section 3.4.

Deduction claim	Credit claim	Combined claim
£100,000 spend (19% of £100,000), this gives a total benefit of £43,700 (44% saving).	Note: in addition, 100% deductions already built in	2. Max saving from payable credit= £11,600 (12% saving) (£80,000 x 14.5%) **Total saving = £21,100 (21%)**. With the £19,000 in CT saved on the £100,000 spend (19% of £100,000), this gives a total benefit of £40,100 (40% saving).

Note: Companies can also choose to carry forward all or some of their loss into future periods. The % savings in the last row are calculated as a proportion of R&D expenditure.
Source: London Economics

The eligibility conditions and generosity of R&D tax relief for SMEs have changed since the scheme was introduced in 2000–01. Notable changes include:

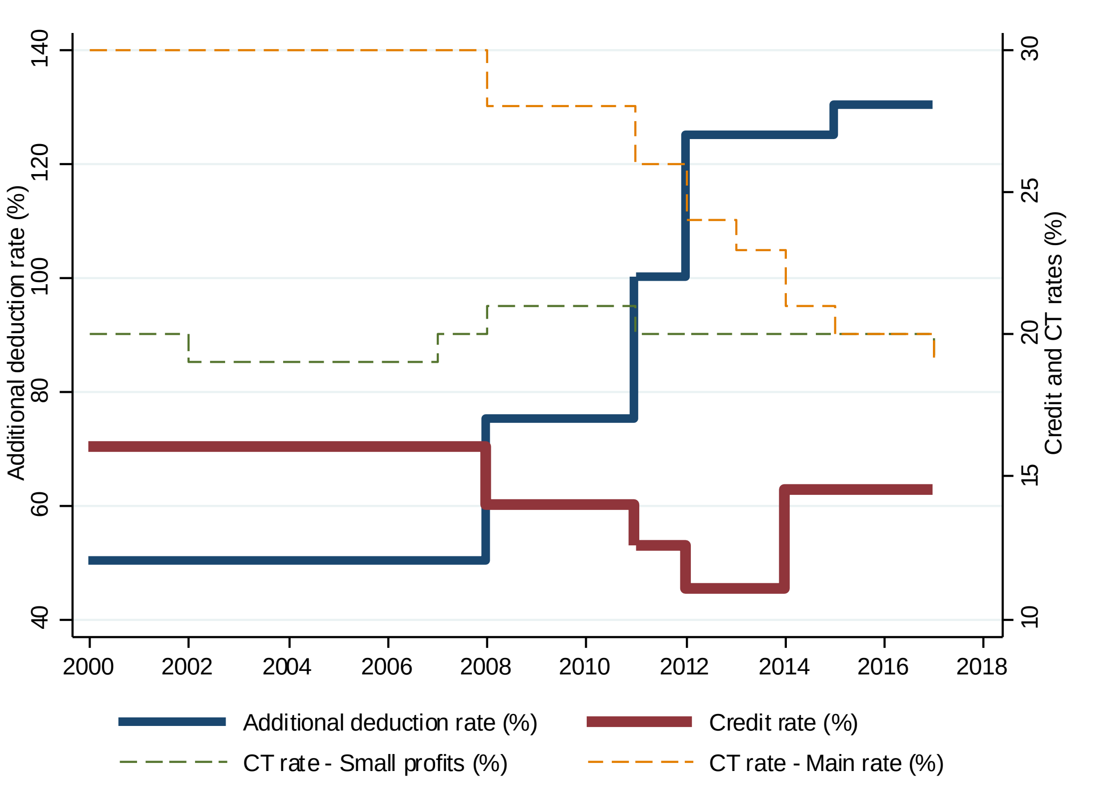
- In 2008–09, the definition of SMEs was broadened to include larger companies.[7]
- The additional deduction rate was increased in 2008–09 (from 50% to 75%), and again in 2011–12 (from 75% to 100%), 2012–13 (from 100% to 125%), and 2015–16 (from 125% to 130%). Since 2015–16, profit-making companies can make an additional deduction of 130% from their taxable income (on top of the usual 100%) on qualifying R&D expenditure.
- Companies that are loss-making can claim a cash credit of 14.5% of their R&D expenditure (hereafter, the 'credit rate'), up from 11% before 2014–15.
- In 2012–13, the requirement for a minimum R&D expenditure of £10,000 was removed as well as the Pay-As-You-Earn (PAYE) and National Insurance (NI) restriction, which limited the amount of payable tax credit that companies can claim.

The changes in the additional deduction and credit rates associated with the scheme since its introduction in 2000–01, as well as changes in the CT rates are shown in Figure 1.

Prior to this report, two evaluations of the R&D tax relief scheme for SMEs had been undertaken for Her Majesty's Revenue and Customs (HMRC), centring primarily on the direct impact on R&D expenditure of companies claiming under the SME scheme and the large company scheme. The main outcome measure in these two evaluations was the 'additionality ratio', which measures the amount of R&D that is incentivised for every £1 foregone by the Exchequer.

[7] Before 1 August 2008: The EU definition of a SME was used (that is, that company had fewer than 250 employees, *and* annual turnover less than €50 million *or* a balance sheet worth less than €43 million). From 1 August 2008, the eligibility threshold was raised to companies with fewer than 500 employees, *and* annual turnover less than €100 million *or* a balance sheet worth less €86 million.

Figure 1 Additional deduction, credit, and Corporation Tax rates (by year, 2000–17)



Note: The small profit CT rate was replaced with the main rate from 2015–16 onwards.
Source: HM Revenue and Customs (HMRC)

1.2 Purpose and objectives of this evaluation

According to Article 107 of the Treaty on the Functioning of the European Union (EU), the R&D tax relief scheme for SMEs constitutes State Aid; therefore, it requires approval by the European Commission. This was received in 2011, as well as in 2015, following amendments to the scheme. In the process of gaining approval in 2015, the UK government committed to provide, by September 2019, an independent evaluation of the scheme that meets the following requirements:

- the evaluation plan set out in the European Commission (EC)'s decision letter[8]; and
- the common methodology designed by the EC for state aid evaluations[9].

HMRC commissioned London Economics to undertake this evaluation with the objective to assess:

1) the direct impact of the scheme (in other words, the tax relief's additionality effect on R&D expenditure);
2) the indirect impacts of the scheme in terms of firm productivity (proxied by turnover and innovation behaviour), whether and to what extent the scheme distorts competition; and

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[8] The EC's decision letter to the then Secretary of State for Foreign and Commonwealth Affairs, The Rt Hon Philip Hammond, 30 September 2015. Published on 21 December 2015 and available at: http://ec.europa.eu/competition/state_aid/cases/258021/258021_1709375_48_6.pdf.

[9] Common methodology for State aid evaluation. Available at: http://ec.europa.eu/competition/state_aid/modernisation/state_aid_evaluation_methodology_en.pdf.

3) the 'proportionality' of the scheme (whether the same level of R&D expenditure can be achieved with lower tax relief rates), and the 'appropriateness' of the scheme (whether alternative forms of support would be better suited to incentivise R&D expenditure).

1.3 Methodology of this evaluation

A three-staged econometric approach was used to measure the direct impact of the scheme on the 'intensive margin' of R&D expenditure (that is, the same companies undertaking more R&D activities as a result of the scheme). The analysis was based on HMRC administrative data that was matched to the Financial Analysis Made Easy (FAME) and Inter-Departmental Business Register (IDBR) databases. Consistent with previous studies, the responsiveness of R&D expenditure to changes in the user cost of capital (that is, the cost of financing R&D activities) was estimated (known as the user cost elasticity) and used to calculate the additionality ratio.

The indirect impacts stemming from R&D expenditure that is incentivised by the scheme were measured by drawing on a range of databases to explore changes in business turnover and innovative behaviour, as well as the distortion of market competition.[10] In addition, the impact of R&D expenditure on turnover was quantified based on a matched data set combining the Annual Respondents Database X (ARDx) and Business Enterprise Research and Development (BERD) survey. This was done through econometric analysis that distinguishes between potential effects at the business, sectoral and regional levels.

Primary research was gathered to assess the proportionality and appropriateness of the scheme. This consisted of:

- Quantitative survey data collected using Computer Assisted Telephone Interviewing (CATI), which comprised:
  - 800 interviews with companies who have claimed R&D tax relief; and
  - 400 interviews with a control group of similar companies who have not claimed R&D tax relief; of which:
    - 91 had conducted R&D but not claimed under the scheme since 2015–16; and
    - 309 had not conducted R&D.
- Qualitative face-to-face interviews with 20 claimants who had taken part in the CATI survey (and agreed to be recontacted).

Please note that some figures in this report (particularly in sections 2.2 and 3.3) may not match the most recent National Statistics publication. Please see section A1.2 for more information.

[10] Specifically, the analysis is based on the HMRC administrative data, the Business Structure Database (BSD), the Intellectual Property Office's (IPO) patent application database, and quantitative survey evidence.

2 Direct Impact of R&D Tax Relief for SMEs

2.1 Overview

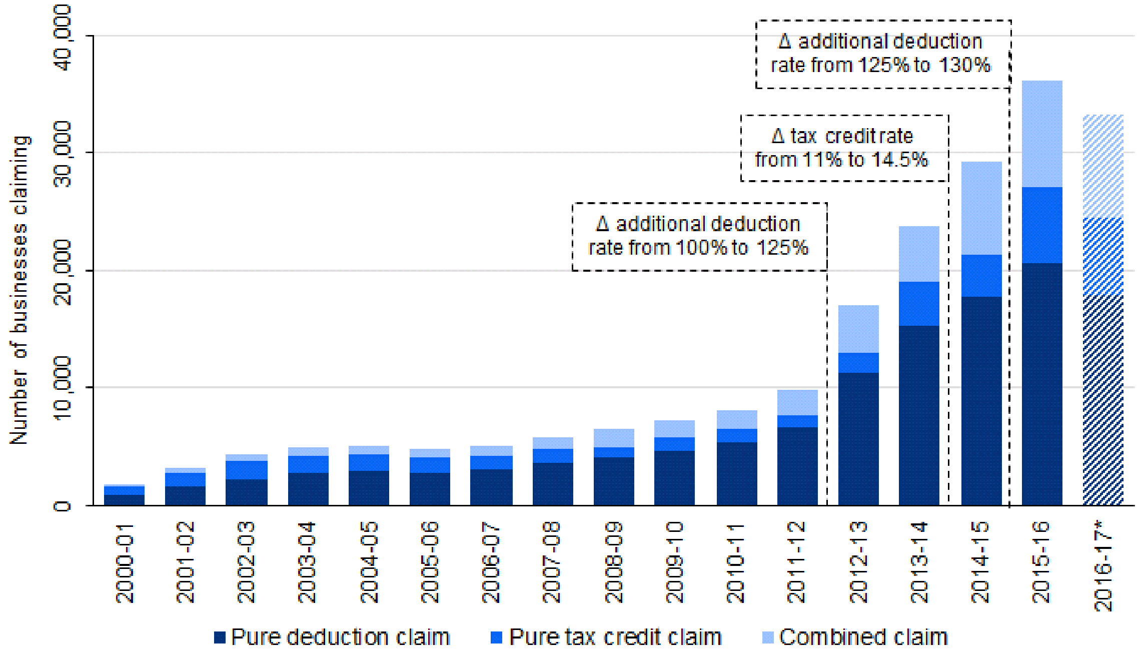
Since its introduction, the R&D tax relief scheme for SMEs has increased in generosity with numerous policy changes aimed at influencing the level of R&D expenditure by eligible businesses in the UK. This chapter begins by exploring important trends in the number of businesses claiming under the scheme, the amount of relief paid, and the associated R&D expenditure. The second part of the chapter estimates the direct impact of these policy changes on R&D expenditure via the 'user cost of capital' (the cost to finance R&D activities) using econometric methods.

2.2 Number of businesses claiming under the scheme, amount of relief, and associated R&D expenditure

2.2.1 Number of businesses claiming under the scheme

Since its introduction in 2000–01, 67,473 companies have claimed R&D relief under the scheme.[11] The annual number of 'claimants' has increased from 1,781 in 2000–01 to 36,165 in 2015–16 (Figure 2). Of these, 20,561 (57%) were pure deduction claims, 6,468 (18%) were credit claims, and 9,136 (25%) claimed both a deduction and payable credit.[12,13]

Figure 2 Number of businesses claiming under the scheme by claim type (by year, 2000–17)



Note: Total number of observations = 206,592. In cases where a business has multiple claims in the same financial year, the latest claim is included only. *Provisional estimates, based on partial data, are provided for 2016–17 as some claims had not yet been processed. Data prior to 2012–13 is incomplete; please see section A1.2 for more information.
Source: London Economics' analysis of HMRC, IDBR and FAME matched data set

[11] See section A1.2 for further details on the data used in this chapter.

[12] The approach used to identify the type of claim is provided in section A1.1 in Technical Annex 1.

[13] These figures may differ slightly to the most recent National Statistics publication and similar discrepancies exist in the remainder of section 2.2.1. Please see section A1.2 for more information. Note also that the figures presented above only include the latest claim for businesses that claimed several times within a given year.

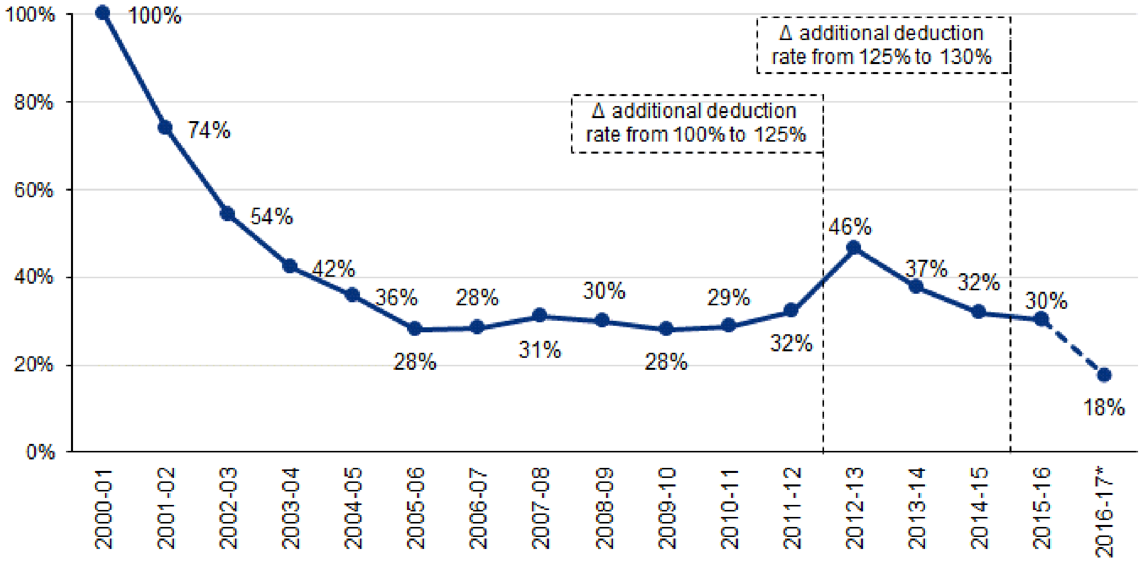
There was a pronounced increase (73%) in the number of claims from 2011–12 to 2012–13, which reflects a number of changes in R&D tax credit policy introduced in April 2012; namely:

- the additional deduction rate was increased from 100% to 125%;
- the PAYE and NI restriction was removed, which limited the amount of payable tax credit that companies can claim;
- the requirement for a minimum R&D expenditure of £10,000 to qualify for a claim was also removed; and
- there will also be some impact from the data in 2012–13 being more complete than in previous years; please see section A1.2 for more information.

The extent to which the R&D tax relief scheme for SMEs incentivises businesses to undertake R&D expenditure may be reflected in the number of 'new' businesses (that is, businesses claiming under the scheme for the first time) that claim under the scheme.

There was a considerable change in the proportion of new claimants in 2012–13, increasing from 32% in 2011–12 to 46% in 2012–13, which occurred at a time of notable policy changes (as discussed above) (Figure 3). The increase in new claimants may correspond to new businesses undertaking R&D activities, capturing increases in the 'extensive margin' of R&D expenditure (that is, new businesses undertaking R&D activities for the first time). After 2012–13, the proportion of new claimants reverted to pre-2012–13 levels. This number may also be partly due to the data being more complete than in previous years.

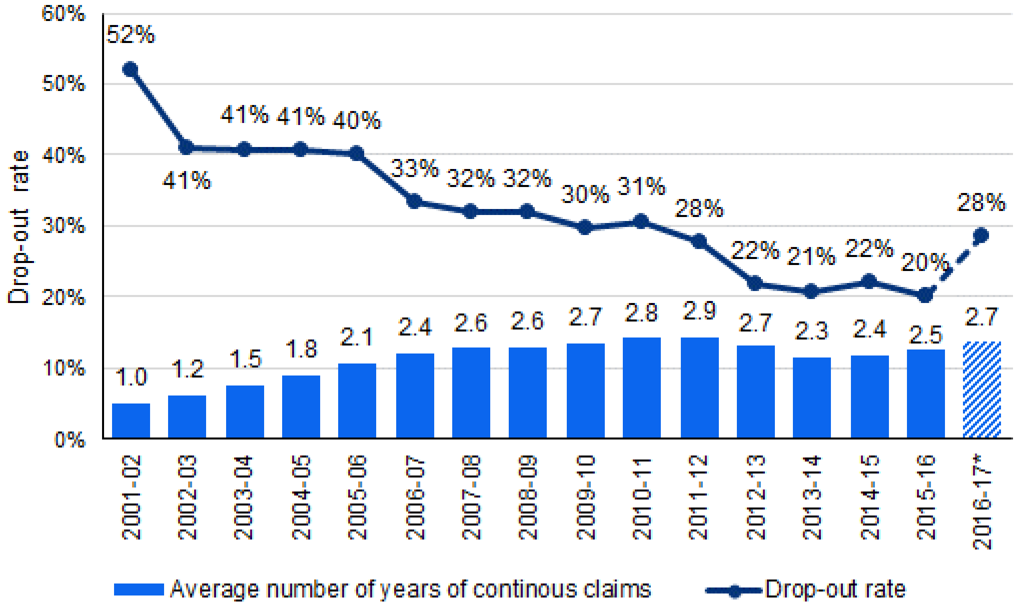
Figure 3 New claimants as a percentage of all claimants, under the scheme (by year, 2000–17)



Note: Total number of observations = 67,473 new claimants and 139,119 repeat claimants. *Provisional estimates, based on partial data, are provided for 2016–17. Data prior to 2012–13 is incomplete; please see section A1.2 for more information.
Source: London Economics' analysis of HMRC, IDBR and FAME matched data set

Businesses are more likely to repeatedly claim R&D tax relief after claiming for the first time, as the drop-out rate associated with the scheme has steadily declined over time from over 40% in 2002–03 to 20% in 2015–16 (Figure 4). Moreover, the average length in years of continuous claims increased from 1 in 2001–02 to approximately 3 in 2011–12. The subsequent decrease in the average length in years correspond to the considerable change in the number of new claimants (Figure 3).

Figure 4 Proportion of claimants that do not claim in subsequent year (drop-out rate) and average length in years of continuous claims under the scheme (by year, 2001–17)



Note: Number of observations = 173,315. *Provisional estimates, based on partial data, are provided for 2016–17. Data prior to 2012–13 is incomplete; please see section A1.2 for more information.
Source: London Economics' analysis of HMRC, IDBR and FAME matched data set

2.2.2 Amount of relief claimed

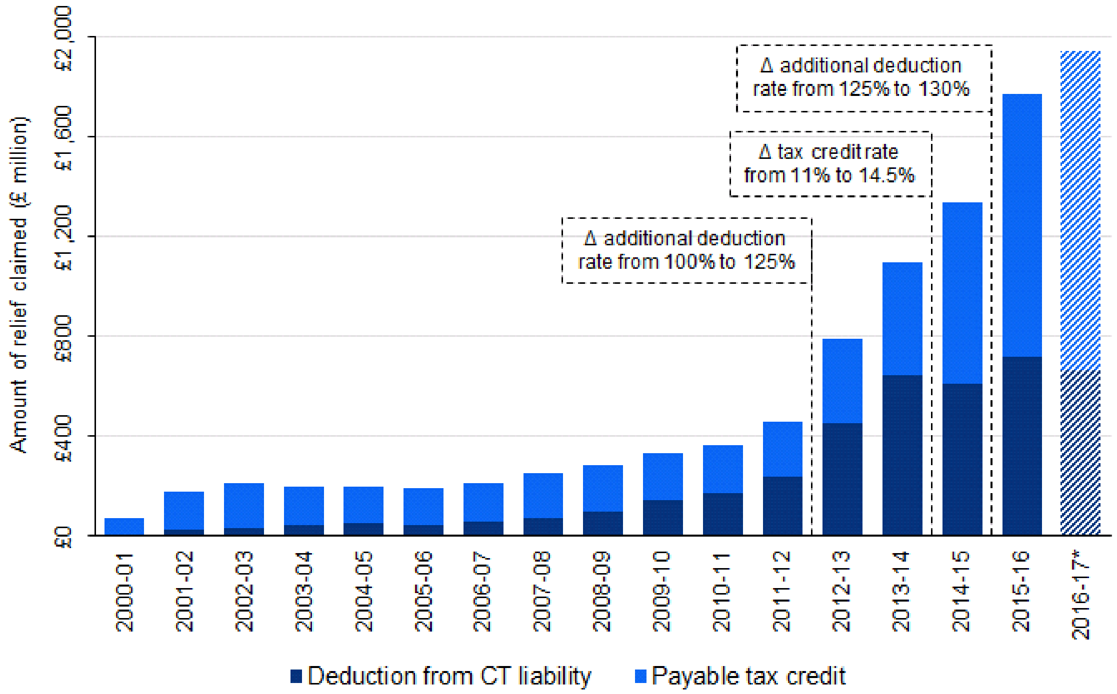
Since its introduction, the cost of support under the scheme has totalled £10 billion, with approximately £1.9 billion estimated for 2016–17 alone (Figure 5).[14] Each year, the majority of relief has been received in the form of a payable tax credit with exceptions observed between 2011–12 and 2013–14, which may be explained by the increased generosity of the deduction rate of the scheme in this period. In 2015–16, relief in the form of deductions amounted to £717 million (40%), while £1,054 million (60%) was paid out in the form of a payable credit.

As shown in Figure 6, from 2007–08 to 2015–16, the average amount of relief claimed under the scheme ranged from approximately £43,700 to £49,000, per claimant. However, this masks significant differences between the types of relief. The average amount of relief claimed in the form of a Corporation Tax (CT) deduction steadily increased from approximately £10,000 per claimant in 2005–06 to approximately £27,000 per claimant in 2013–14; whereas, average relief in the form of a tax credit decreased in the same period from approximately £30,100 to £19,000 per claimant. These changes coincided with progressive increases in the deduction rate and a declining credit rate (as shown in Figure 1).

These trends reversed following the first increase in the credit rate (from 11% to 14.5%) in April 2014, with the average deduction claim decreasing to £19,800 per claimant and the average credit claim increasing to £29,100 per claimant in 2015–16.

[14] These figures may differ slightly to the most recent National Statistics publication and similar discrepancies exist in the remainder of section 2.2.12. Please see section A1.2 for more information.

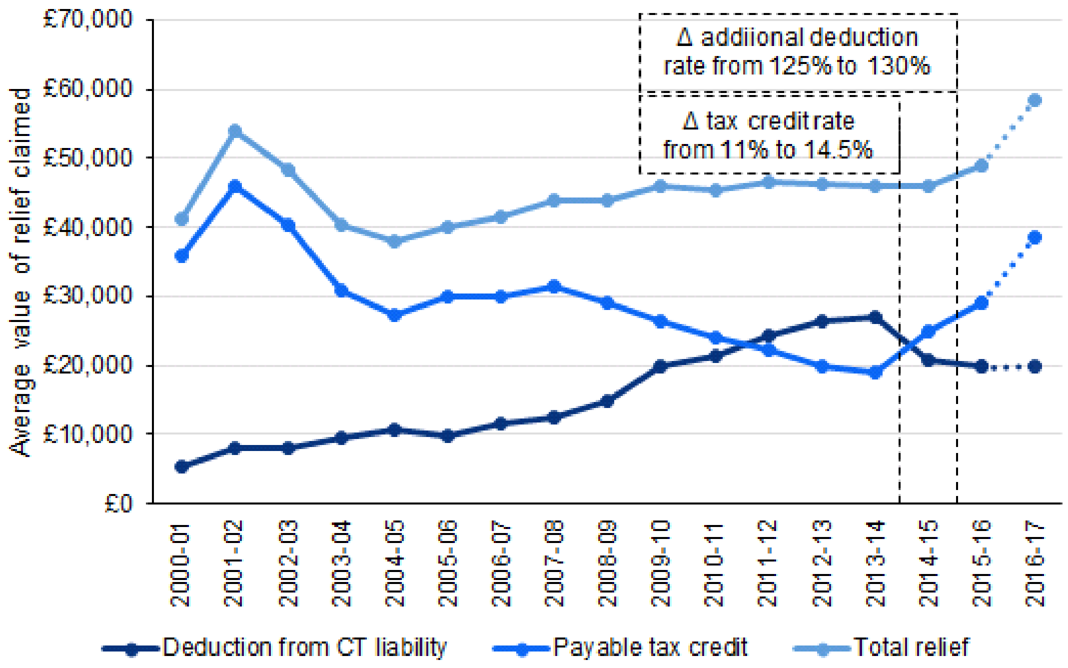
Figure 5 Amount of relief claimed under the scheme by relief type (by year, 2000–17)



Note: Total number of observations = 211,266. Multiple claims by some businesses in the same financial year are included. *Provisional estimates, based on partial data, are provided for 2016–17. Data prior to 2012–13 is incomplete; please see section A1.2 for more information.

Source: London Economics' analysis of HMRC, IDBR and FAME matched data set

Figure 6 Average amount of relief claimed under the scheme by relief type (by year, 2000–17)



Total number of observations = 206,592. Multiple claims by some businesses in the same financial year are included. *Provisional estimates, based on partial data, are provided for 2016–17. Data prior to 2012–13 is incomplete; please see section A1.2 for more information.

Source: London Economics' analysis of HMRC, IDBR and FAME matched data set

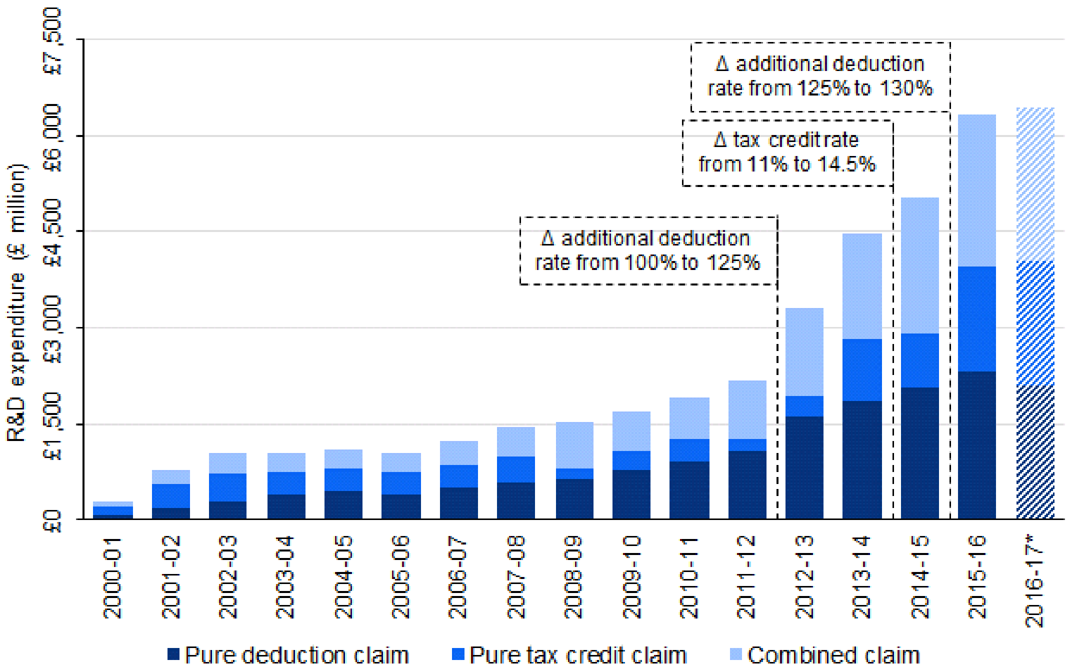
2.2.3 R&D expenditure associated with the scheme

The amount of R&D expenditure used to claim under the scheme from 2000–01 to 2016–17 has followed a similar pattern to the number of claims and amount of relief claimed (see Figure 7). In 2015–16 (most recent financial year for which all claims have been received), approximately £6.3 billion[15] R&D expenditure is directly associated with the scheme, of which, approximately £2.3 billion was related to pure deduction claims, £1.7 billion with pure credit claims, and £2.4 billion with a combination of both.

On average, businesses that have claimed previously have a higher R&D expenditure in comparison to businesses that claim for the first time (Figure 8). However, on average, the difference in R&D expenditure between the two groups has decreased over time, from approximately £250,000 in 2001–02 to less than £100,000 in 2015–16. The relative difference between both averages has also declined: from 123% to 93%.

Moreover, since the introduction of the scheme, the average amount of R&D expenditure has declined for both types of claimants, which suggests that increases in aggregate R&D expenditure may, in large part, be due to the number of businesses claiming as opposed to the same businesses spending more on R&D activities. Furthermore, the increasing number of claims and aggregate R&D expenditure, combined with the declining average R&D spend suggest that the scheme is increasingly being used by businesses with lower R&D expenditure.

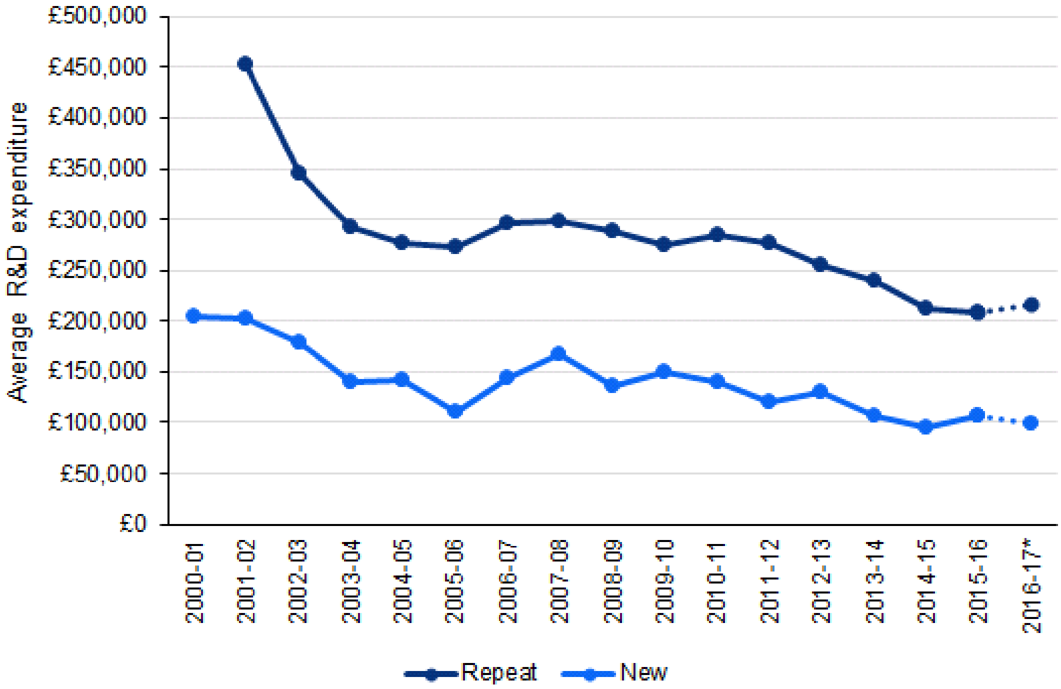
Figure 7 R&D expenditure associated with scheme by claim type (by year, 2000–17)



Note: Number of observations = 205,925. 5,341 cases are excluded as R&D enhanced expenditure is not reported. *Provisional estimates, based on partial data, are provided for 2016–17. Data prior to 2012–13 is incomplete; please see section A1.2 for more information.
Source: London Economics' analysis of HMRC, IDBR and FAME matched data

[15] These figures may differ slightly to the most recent National Statistics publication and similar discrepancies exist in the remainder of section 2.2.13. Please see section A1.2 for more information.

Figure 8 Average R&D expenditure associated with the scheme per claiming business, for new and repeat claimants (by year, 2000–17)



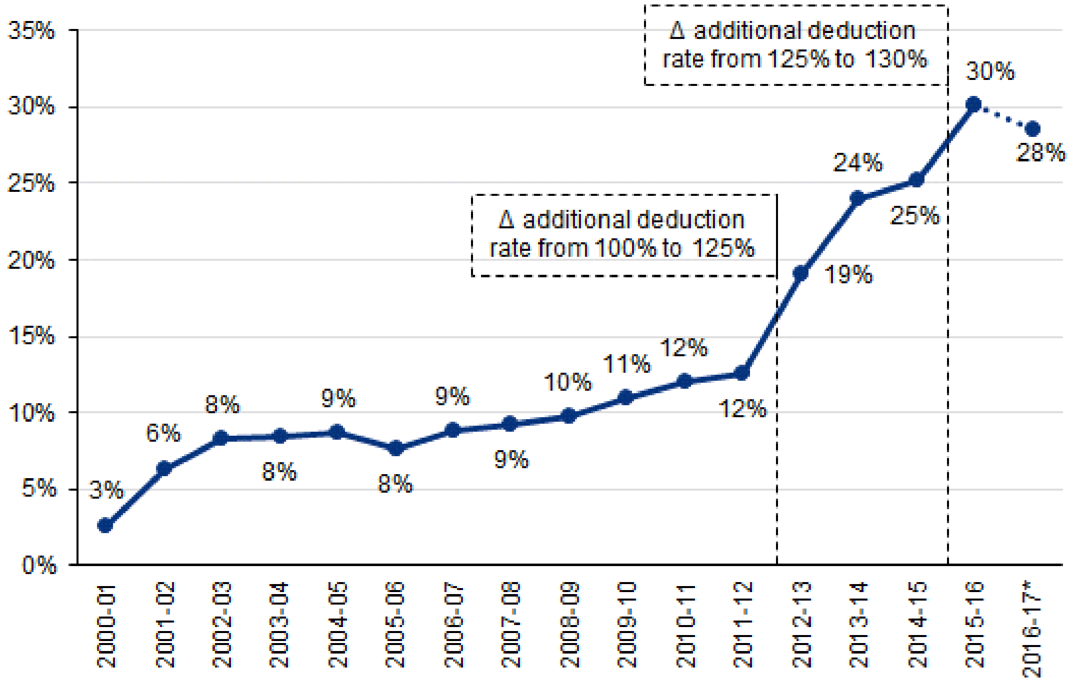
Note: Number of observations = 201,443. R&D expenditure is aggregated across multiple claims by the same business in the same year. *Provisional estimates, based on partial data, are provided for 2016–17. Data prior to 2012–13 is incomplete; please see section A1.2 for more information.

Source: London Economics' analysis of HMRC, IDBR and FAME matched data

Figure 9 shows R&D expenditure used to claim R&D tax relief under the scheme as a share of total business R&D expenditure in the UK[16] between 2000–01 and 2016–17. Reflecting the changes in R&D tax relief in 2012–13 (discussed in the subsection 2.2.1), R&D expenditure associated with the scheme accounted for a larger share of total estimated R&D expenditure in the UK, increasing from 12% in 2011–12 to 30% by 2015–16. However, comparisons should be treated with caution as there are differences in the way R&D expenditure is measured between HMRC and ONS. For example, overseas expenditure is not counted in the ONS' BERD survey but may qualify for R&D tax relief under the scheme.

[16] The ONS conducts the Business Enterprise Research and Development (BERD) survey, which provides annual estimates of the annual spending and employment related to R&D in the UK.

Figure 9 R&D expenditure associated with the scheme as a percentage share of total UK R&D expenditure (by year, 2000–17)



Note: BERD data is reported on a calendar basis whereas HMRC data is reported by financial year. For comparison purposes, the calendar year (for example, 2016) is aligned to the first year in the financial year (for example, 2016 in 2016–17). There are differences in the way that HMRC and BERD measure R&D expenditure. For example, overseas expenditure is not counted in BERD but may qualify for R&D tax relief under the scheme; hence, comparisons should be treated with caution.

Source: London Economics' analysis of HMRC, IDBR and FAME matched data and BERD data

2.3 Quantifying the direct impact of changes in R&D tax relief on R&D expenditure

The direct effect of the scheme on a company's decision to conduct R&D, is evaluated by estimating the impact of changes in R&D tax relief on R&D expenditure. This impact is expected to arise because tax relief affects the cost to finance R&D activities or the 'user cost of capital for R&D expenditure'[17] (hereafter, referred to as the 'user cost') via reductions in CT liability or payable credits. To quantify this impact, it is therefore necessary to estimate how sensitive or 'elastic' R&D expenditure is to changes in the user cost that may result from amendments to the scheme.

2.3.1 Econometric methodology

Following existing studies examining the effectiveness of tax relief schemes[18], this chapter uses an R&D demand framework[19] to estimate the 'user cost elasticity' (that is, the responsiveness of a company's R&D expenditure to changes in its user cost[20]), while controlling for various other factors that may affect a company's decision to conduct R&D.

[17] This is also sometimes referred to as the 'price' of R&D (see Fowkes, Sousa, and Duncan, 2015).

[18] See, for example, Bloom and others (2002), HMRC (2010), Fowkes, Sousa, and Duncan (2015), and Dechezleprêtre and others (2019).

[19] In other words, the econometric models estimate how businesses' demand for R&D is affected by its price (that is, the user cost).

[20] Formally, the user cost elasticity measures the percentage change in company's R&D expenditure following a percentage change in the user cost.

Using econometric techniques to estimate the user cost elasticity requires an identification strategy that considers a number of important trade-offs, such as the choice of variables to include in the model, their functional form, and the estimation method. Following Fowkes, Sousa, and Duncan (2015), a three-staged approach is used to estimate the user cost elasticity via an R&D demand equation. The three stages relate to three different estimation techniques; namely, Ordinary Least Squares (OLS), Fixed Effects (FE), and Arellano-Bond (A-B) estimation[21].

It is important to note that the approach only measures the impact of the scheme at the intensive margin of R&D expenditure (that is, the same companies undertaking more R&D activities) as information on financial years in which businesses do not do any R&D activities is not observed. Furthermore, it should be noted that the user cost elasticity is estimated based on a subset of businesses for which all variables are populated. In particular, lags of the dependent and independent variables are required in A-B estimation, which implies that new claimants, for which no lags are available, are not included in the analysis.[22] Further details on the identification strategy used to estimate the direct impact in a robust manner, the variables and sample data are provided in sections A1.4 to A1.6 of Technical Annex 1.

2.3.2 Baseline results

User cost elasticity

Table 2 presents the lower and upper bound elasticity estimates (computed at the mean value of the user cost for the estimation samples) obtained in the various model specifications based on the three different estimation techniques.[23,24] In line with economic theory, the user cost elasticities are negative in all models, which means that an increase (decrease) in the user cost leads to a decrease (increase) in the level of R&D expenditure. This suggests that R&D tax relief policy that lowers the user cost has the potential to incentivise greater R&D expenditure.

The A-B estimates of the user cost elasticity are more elastic than the FE estimates but less elastic than the OLS estimates. As OLS and FE techniques do not address the issues of reverse causality and omitted variables,[25] these estimates are likely to be biased and thus fail to capture the true effect of the user cost.

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[21] The Arellano-Bond estimator uses Generalised Methods of Moments (GMM) estimation to fit a transformed model to accurately identify the parameter of interest (here, the user cost elasticity). Further details are provided in section A1.4.

[22] On average, new claimants represent approximately 30% of all claimants since 2005-06 (Figure 3).

[23] User cost elasticities are also calculated using the median value of the user cost of the businesses in the estimation sample. These are provided in Table 23 and Table 25 in section A1.7 of Technical Annex 1. It should be noted that the user cost elasticities calculated at the mean value are larger than those calculated at the median value because the distribution of the user cost in all estimation samples is positively skewed.

[24] The different 'model specifications' are each based on different sets of variables. These build upon a parsimonious model that is progressively augmented with additional predictors. On the rationale for including different predictors, see section A1.5.

[25] Reverse causality or 'simultaneity' may arise if the dependent variable (here, R&D expenditure) determines the explanatory variable of interest (here, the user cost). Estimation techniques that do not take this into account may conflate the effect of the dependent variable on the independent variable with the true impact of interest (here, the impact of the user cost on R&D expenditure), thereby producing misleading results. Similarly, if an 'omitted variable' affecting both the user cost and R&D expenditure is not taken into account, parameter estimates may be incorrect. The inclusion of control variables in the OLS and FE models partially addresses the latter issue.

Table 2 User cost elasticities for different model specifications, by estimation technique

User cost at mean value	Ordinary Least Squares (OLS)	Fixed Effects (FE)	Arellano-Bond (A-B)
Lower bound[26]	–1.03***	–0.11*	–0.50
Upper bound	–1.64***	–0.16***	–1.04**

Note: Full OLS and FE estimation results are provided in Table 22. Full Arellano-Bond estimation results are provided in Table 24. Asterisks indicate statistical significance where p-values are: *** p<0.01, ** p<0.05, * p<0.1.
Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Based on the mean value of the A-B estimation sample, a 1% increase (decrease) in the user cost is associated with a 0.50% to 1.04% decrease (increase) in R&D expenditure.[27]

Similar studies that have assessed the effectiveness of R&D tax incentives to stimulate R&D expenditure show estimates of user cost elasticities ranging from –4.0 to –0.1.[28] The estimated elasticities in this analysis are well within this range. However, in most cases, the estimates from the literature are based on different R&D tax relief schemes (in different countries), as well as different methodological approaches used to measure the response in a company's R&D expenditure to changes in the user cost of capital. Comparisons should therefore be treated with caution.

The HMRC (2010) evaluation of the R&D tax relief schemes (both the SME and large company schemes) in the UK is the only existing report that can be directly compared to the analysis presented in this chapter.[29] Using AB estimations, the user cost elasticity estimates associated with the SME scheme are relatively more elastic in the 2010 evaluation, ranging from –2.6 to –1.6.[30] This suggests that companies claiming under the SME scheme may have become less responsive to changes in their user cost over time.

Additionality ratio

A common approach to assess the 'incentive effect' of an R&D tax relief scheme is to calculate the additional R&D expenditure generated by an increase in the generosity of the scheme, relative to the additional cost incurred by the Exchequer. This measure is called the additionality ratio (also referred to as the 'incrementality ratio' or 'bang-for-the-buck' measure).

It is important to note that the additionality ratio is not a benefit-to-cost ratio, as it does not capture all positive externalities that may be associated with R&D expenditure. A more complete cost-benefit analysis would follow HM Treasury's Green Book guidelines and consider the opportunity

[26] With respect to magnitude.

[27] The statistical significance of the A-B results vary with the lower bound estimate of –0.50 being statistically insignificant and upper bound estimate of –1.04 being statistically significant at the 5% level. In other words, this means that there is at least a 10% chance (for the lower bound) or less than a 5% chance (for the upper bound) that businesses are not responding to the scheme through increased R&D. Overall, the model properties of all A-B estimations are relatively good. The null hypothesis that second-order autocorrelation in the error term is absent cannot be rejected, and the Hansen test for over-identifying restrictions is comfortably passed as well (that is, the null hypothesis that the instruments are jointly valid is not rejected).

[28] A summary of the literature review of studies estimating the elasticity of user cost of capital for R&D expenditure is provided in section A1.10 of Technical Annex 1.

[29] The 2015 HMRC evaluation (Fowkes, Sousa and Duncan, 2015) was based on a sample combining claimants from both the large company and SME tax relief schemes and is therefore not directly comparable with the analysis in this report.

[30] Based on estimation periods of 2000-07 and 2003-07, respectively.

cost of the scheme. Hence, on its own, the additionality ratio is likely to underestimate the benefits to society of additional R&D expenditure stimulated by the scheme.

Table 3 shows the additionality ratios calculated for a pure deduction and pure credit claim based on the user cost elasticities obtained from the A-B estimations (see Table 2). A formal derivation of the additionality ratio is provided in section A1.9.1. The additionality ratio for a deduction claim ranges from 0.75 to 1.28 following a one pp increase in the additional deduction rate from 130% to 131%. This indicates that every £1 foregone in tax revenue stimulates between £0.75 and £1.28 of R&D expenditure for deduction claims.[31] In the case of a credit claim, the additionality ratio ranges from 0.60 to 1.00, based on a one percentage point increase in the credit rate from 14.5% to 15.5%. This indicates that every £1 spent on payable credits stimulates between £0.60 and £1.00 of R&D expenditure for credit claims.

Table 3 Additionality ratio range for deduction and credit claims

	A-B user cost elasticity estimates Lower bound –0.50	A-B user cost elasticity estimates Upper bound –1.04
Deduction claim	0.75	1.28
Credit claim	0.60	1.00

Note: The deduction claim considers a one pp change from 130% to 131% and the credit claim considers a one pp change from 14.5% to 15.5%. The relevant rates (deduction, credit and CT) used in the calculations are based on those applicable in 2016–17. Additionality ratios for OLS and FE estimations are provided in Table 23.
Source: London Economics' analysis

In 2015–16, the total R&D expenditure associated with the scheme was approximately £6.3 billion; the additionality ratios suggest that, of this, between £1.2 billion and £2.1 billion may have been stimulated by the scheme.[32] In other words, in the absence of the scheme, R&D expenditure would have been in the range of £4.2 billion and £5.1 billion in 2015–16.

Given that a one pp increase in the credit rate is larger (in proportion to the baseline rate) than an equivalent one pp increase in the additional deduction rate[33], an alternative method to calculate the additionality ratio would be to consider a one per cent increase in both rates. In this case, the additionality ratios are within the same range shown in Table 3 above.[34]

HMRC (2010) estimated an additionality ratio ranging between 2.33 and 3.37 for the SME scheme; whereas, Fowkes, Sousa, and Duncan (2015) generated a range between 1.53 and 1.88. In the latter case, the estimated elasticity underlying the calculations was based on an estimation combining both the large and SME tax relief schemes. A more direct comparison between the elasticities is

[31] The main reason the additionality ratio is higher for a deduction claim is that the increase in the Exchequer cost (following a one percentage point increase in the additional deduction rate) is relatively lower than the increase following an equivalent change in tax credit rate.

[32] This is calculated by multiplying the total amounts of payable credits and CT deductions claimed by the corresponding additionality ratio estimates. These figures are calculated based on the assumptions that all claims were either pure deduction or pure credit claims, and that the estimated additionality ratios apply to all businesses, including those that were not in the estimation sample (for example, new claimants).

[33] Taking the 2016-17 rates, a one percentage point increase in the credit rate is equal to 6.9% ((15.5%-14.5%)/14.5%) and a one percentage point increase in the additional deduction rate is equal to 0.77% ((131%-130%)/130%).

[34] Underlying calculations are provided in Table 33 and Table 34 in section A1.9.2 of Technical Annex 1.

provided in section 2.3.3 which follows this section, in which the preferred A-B model is re-estimated over time periods similar to those used in the two previous evaluations.

Taken together, the results are intuitive as the increasing generosity of the scheme would result in a smaller impact on R&D expenditure as the incremental impact of a change in the deduction or credit rate would diminish as the rate(s) increase(s). For example the 25 pp increase in the additional deduction rate observed in 2012–13 (from 100% to 125%) represented a 25% increase, while a 25 pp increase in the current additional deduction rate of 130% would represent a 19% increase only. Despite its diminishing impact, the scheme still represents positive marginal benefits (in the form of additional R&D expenditure that is incentivised) when compared to the counterfactual of having no scheme.

Moreover, the methodological approach used in this analysis does not capture the potential impact of R&D expenditure at the extensive margin.[35] However, any incentive effect of the scheme generated from encouraging businesses to undertake any R&D for the first time could not be measured as the data set only observes the years in which businesses claim under the scheme. Hence, the full impact of the scheme is likely to be underestimated. In addition, as mentioned above, the Arellano-Bond estimator uses lagged claims (that is, from previous years) and hence requires businesses to be 'year-on-year' claimants, which may not be entirely representative of the population of claimants. On average, businesses claim less than three consecutive years and 'repeat claimants' represent approximately 70% of all claimants in the sample (Figure 4).

Overall, these findings add to those from section 2.2 which suggested that the scheme attracted new claimants (which may or may not have conducted R&D in the absence of the scheme) rather than incentivised additional R&D expenditure by existing claimants. The econometric analysis suggests that the scheme does in fact stimulate additional expenditure by businesses that do conduct R&D (in other words, affects the intensive margin of R&D expenditure) in addition to attracting new claimants.

2.3.3 Robustness checks

Overall, the preferred model[36] is robust to changes in its specification, sample data and underlying assumptions. Details on these robustness checks are provided in section A1.8 of Technical Annex 1. Fowkes, Sousa, and Duncan (2015) estimate a user cost elasticity of –1.96 which combines companies claiming under both the large company and SME schemes in the period from 2003–04 to 2012–13. Re-estimating the preferred model over a similar period (2002-03 to 2012-13) period for companies claiming under the SME scheme only results in a higher elasticity of –3.16 (and hence, larger additionality ratios).[37] This is consistent with findings suggesting that, for a given scheme, SMEs are more responsive to R&D tax incentives than larger companies, as they are more likely to be financially constrained (Dechezleprêtre and others, 2019).

Moreover, the model estimation over the pre-financial crisis period (2002–03 to 2007–08) provides a statistically insignificant user cost elasticity estimate, which is also consistent with results obtained by Fowkes, Sousa, and Duncan (2015). This may be expected as the deduction and credit rates did

[35] For instance, new claimants (that is, businesses that had never claimed before) make up approximately 30% (on average) of the total population of claimants in each year from 2005-06 (Figure 3).

[36] The preferred A-B estimation is provided in penultimate column in Table 24, which controls for the user cost, lagged user cost, lagged real R&D expenditure, real turnover, number of employees, growth in industry-level GVA and time dummies. The estimated user cost elasticity in this case is –0.89 with additionality ratios of 1.15 for a deduction claim and 0.91 for a tax credit claim.

[37] See column RC11 in 0 in section A1.7 of Technical Annex 1.

not change in this period and hence, there is no statistical evidence of an incremental impact on R&D expenditure. Estimation in the recent financial years of 2013–14 to 2016–17 also provides a statistically insignificant user cost elasticity when compared to the preferred model estimate. This may be due to a lack change in the deduction rate over this period.

3 Indirect Impacts of R&D Tax Relief for SMEs

3.1 Overview

The additional R&D expenditure that is incentivised by the R&D tax relief scheme is likely to have indirect impacts (or wider economic impacts) on business performance. In line with the requirements of the evaluation plan set out by the EC in its decision letter[38], this chapter examines the indirect effects of the scheme by considering:

- changes in business innovative behaviour;
- changes in business turnover; and
- distortion of market competition using indicators such as firm age, firm size, sector, region and market concentration.

Moreover, econometric models are estimated to quantify the impact of R&D expenditure on turnover for both businesses that undertake R&D and those that do not, distinguishing between potential effects at the business, sector and regional levels.

3.2 Changes in innovative behaviour and turnover

3.2.1 Changes in innovative behaviour

Innovative behaviour is measured by examining the number of UK patent applications filed by claimants in the years prior to and after their first claim, as well as comparing the types of intellectual property (IP) protections used by claimants to those by non-claimants.

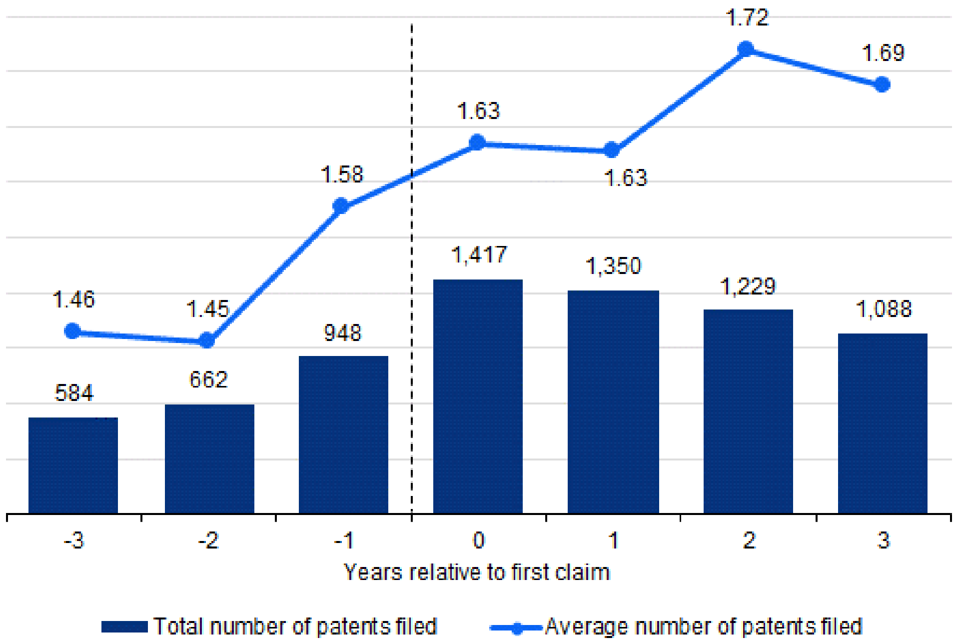
In total, the number of UK patent applications filed peaked in the year in which the business first claimed under the scheme (Figure 10). In comparison to years before claiming, the average number of applications filed per business per year increases after their first claim, suggesting that businesses are more innovative after having claimed under the scheme.

Following businesses' first claim, the decreasing total number of patents filed, and the increasing average number of patents filed per business, suggests that there is a select group of claimants that are more innovative than others. However, results are likely to underestimate the number of UK patent applications among claiming businesses as only exact matches based on the company name and region are used.[39]

[38] The EC's decision letter to the then Secretary of State for Foreign and Commonwealth Affairs, The Rt Hon Philip Hammond, 30 September 2015. Published on 21 December 2015 and available at: http://ec.europa.eu/competition/state_aid/cases/258021/258021_1709375_48_6.pdf.

[39] See section A2.1.1 for further details.

Figure 10 Total number and average number of UK patent applications filed by claimants, relative to year of first claim (Year 0)



Note: Sample restricted to claimants with reported value in each reference year (34,827). Average number of UK patents filed calculated for those that filed a patent applications and not total number of claimants. Figures do not represent total patent activity for all claimants given data matching process.
Source: London Economics' analysis of HMRC-IPO matched data

Based on the quantitative survey data, for both claimants and non-claimants that undertake R&D activities, R&D expenditure is associated with the use of similar IP protections, except in the case of trade secrets, which are more likely to be used by claimants (Table 4).[40]

Table 4 Use of intellectual property protections following R&D expenditure, between claimants and non-claimants who undertake R&D

IP protections	Claimants	Non-claimants that undertake R&D
Patents	15%	15%
Trademarks	17%	11%
Design registrations	10%	9%
Copyrights	21%	25%
Confidentiality agreements	58%	52%
Trade secrets	34%	23%
Overseas protection	11%	12%
Other	3%	2%

Note: Number of claimant (weighted) responses range between 760 and 778. Responses include the use of IP protections used for R&D expenditure that was not associated with claiming tax relief under the scheme. Number of non-claimant (weighted) responses range between 86 and 88. Non-claimants in this case are businesses that undertake R&D activities but do not claim under the scheme. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

[40] In this case the difference between claimants and non-claimants is statistically significant at the 5% level. There is no statistically significant difference in the use of any other IP protections between claimants and non-claimants that undertake R&D.

3.2.2 Changes in turnover

Businesses that have claimed under the scheme have an average turnover that is approximately ten times larger than the average for all other businesses in the private sector (Table 5). Average turnover for claimants increased between 2010 and 2013, before decreasing marginally between 2014 and 2016. When businesses with zero or one employee are excluded, differences between average turnovers reduce to a factor of approximately three. These results should not be interpreted as a 'causal impact' of the scheme on turnover. Instead, they most likely reflect differences in underlying characteristics across the two groups, combined with the potential causal effect of R&D on turnover among claimants (the impact of R&D on turnover is explored in further detail in section 3.4).

Table 5 Average turnover for claimants and all other businesses (by year, 2010–16)

(£ million)	2010	2011	2012	2013	2014	2015	2016
Claimants	3.60	3.79	4.04	4.21	4.18	4.22	4.11
All other businesses	0.40	0.36	0.35	0.35	0.34	0.36	0.38
Claimants (excluding businesses with 0 to 1 employees)	4.25	4.42	4.64	4.83	4.79	4.86	4.80
All other businesses (excluding businesses with 0 to 1 employees)	1.57	1.46	1.42	1.49	1.45	1.58	1.67

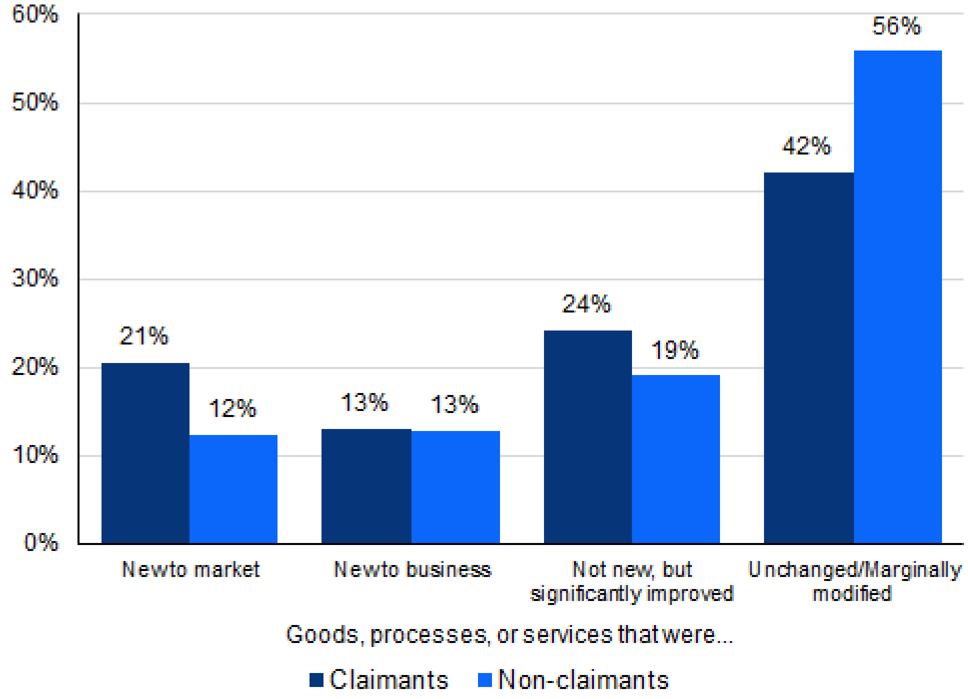
Note: Turnover for claimants includes turnover of claimants who may have claimed in previous years (and not necessarily in the reported year, that is, have claimed at least once before). Claimant enterprises with over 500 employees in the matched HMRC-BSD data were excluded. All other businesses include the population of UK private sector enterprises that have not claimed under the scheme and have up to 499 employees.
Source: London Economics' analysis of HMRC-BSD and ONS Business Population Estimates data

The composition of turnover reported in the quantitative survey by claimants, and non-claimants who conducted R&D but did not claim under the scheme, shows that, on average, 21% of claimants' turnover came from goods, processes, or services that were new-to-market, compared to only 12% for non-claimants (Figure 11).[41] Contrastingly, non-claimants made a higher proportion of their turnover from goods, processes, or services that were unchanged or marginally modified (56% on average) compared to claimants (42% on average).[42]

[41] This 8 pp difference is statistically significant at the 5% significance level.

[42] This 14 pp difference is statistically significant at the 1% significance level.

Figure 11 Composition of turnover for claimants and non-claimants who undertake R&D (last reported financial year)



Note: Number of claimants (weighted) = 648, Number of non-claimants (weighted) = 71. Non-claimants in this case are businesses that undertake R&D activities but do not claim under the scheme. For 152 claimants and 18 non-claimants, the sum of the shares of turnover was less than 100% (this is because they answered 'don't know' for some categories). These businesses were excluded. Note that businesses that answered 'don't know' for some categories but for which the remaining categories added up to 100% were included in the analysis (in those cases, the 'don't know' categories were coded as zeros).
Source: London Economics' analysis of quantitative survey data

3.3 Distortion of market competition

3.3.1 Sectoral distribution

The number of claims and total relief claimed are concentrated in the 'information and communication', 'manufacturing' and 'professional, scientific and technical' sectors, which accounted for 74% of the relief claimed in 2015–16 (Table 6).[43] [44] However, this information is subject to a number of caveats. For example, the primary sector of a business may change over time; or, R&D activities may be conducted in other sectors (different to the primary sector); or, companies may file a claim under the holding company whose primary activity may be in a sector that is different to its subsidiary. Therefore, these results should be treated with caution.

Table 6 Amount of relief claimed under the scheme by sector (2015–16)

Sector	Number of claims	Amount of relief claimed (£ million)
Information and communication	9,249 (27%)	487 (27%)

[43] A more detailed breakdown at the two-digit SIC 2007 level is provided in Table 20 in section A1.2 of Technical Annex 1.

[44] These figures may differ slightly to the most recent National Statistics publication and similar discrepancies exist in the remainder of section 2.2.1. Please see section A1.2 for more information.

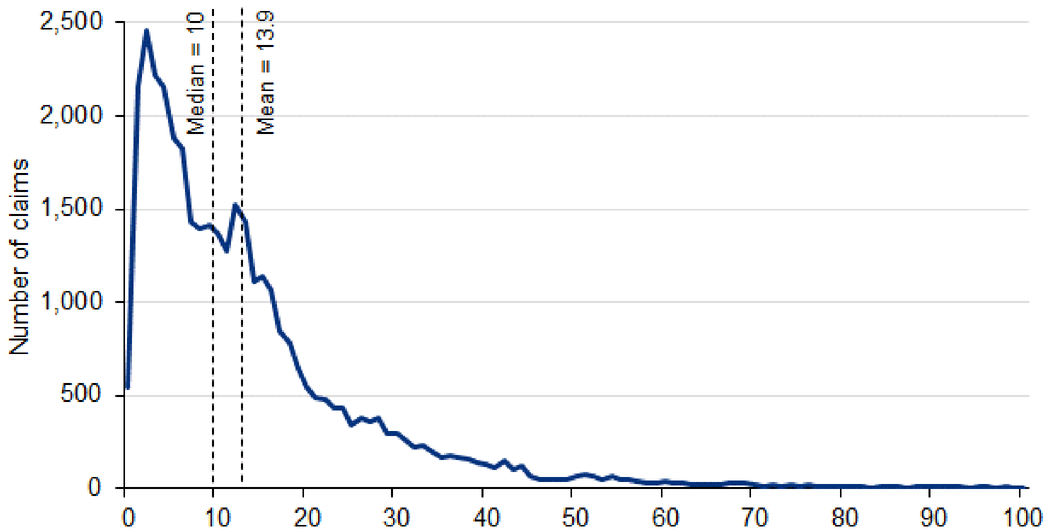
Sector	Number of claims	Amount of relief claimed (£ million)
Manufacturing	9,611 (24%)	413 (23%)
Professional, scientific and technical activities	6,978 (19%)	408 (23%)
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	4,173 (11%)	123 (7%)
Administrative and Support Service Activities	2,041 (6%)	85 (5%)
Other sectors	4,725 (13%)	255 (14%)
Total	**36,777**	**1,770**

Note: Number of observations = 36,777. One claim in 2015–16 was not assigned a UK Standard Industrial Classification code and is excluded. 'Other sectors' includes all other sectors that are not reported.
Source: London Economics' analysis of HMRC, IDBR and FAME matched data set

3.3.2 Firm age

Over a quarter (26%) of claims were made by businesses that were incorporated in the five years prior to 2015–16 (Figure 12). These businesses also claim most (22%) of the relief paid (Table 7), suggesting that the scheme provides support to new entrants as well as incumbents.[45] The average age of claiming businesses was 14 years, which is higher than the average age of 8.5 years for all UK registered companies.[46] This may be due to a small number of claiming businesses aged above 40, which increases the average age. On average, businesses aged 60 to 69 in 2015–16 claimed the most tax relief, equal to approximately £76,300, whereas businesses less than five years old claimed the lowest amount equal to approximately £42,000 per business (Table 7).

Figure 12 Distribution of claims under the scheme by firm age (2015–16)



Note: Total number of observations = 36,745. 33 cases with no reported date of incorporation or a negative age were excluded.
Source: London Economics' analysis of HMRC, IDBR and FAME matched data set

[45] These figures may differ slightly to the most recent National Statistics publication and similar discrepancies exist in the remainder of section 2.2.12. Please see section A1.2 for more information.

[46] ONS (2019a). 'Companies register activities: statistical release 2017 to 2018'. Published 28 June 2018. Available here: https://www.gov.uk/government/publications/companies-register-activities-statistical-release-2017-to-2018/companies-register-activities-2017-to-2018#other-statistics-in-this-release

Table 7 Distribution of business claiming, amount of relief claimed, and average relief per business, by age band (2015–16)

Age band	Number of businesses claiming	Total amount of relief claimed (£ million)	Average relief per business (£)
Less than 5	9,166	385	41,953
5–9	7,864	364	46,266
10–14	6,649	316	47,458
15–19	4,425	234	52,904
20–29	4,086	246	60,217
30–39	1,991	104	52,064
40–49	854	45	52,809
50–59	492	25	51,179
60–69	249	19	76,287
70–79	127	7	57,532
80–89	84	4	51,756
90–99	64	3	51,231
100+	81	5	64,717
Total	36,132	1,757	48,632

Note: Total number of observations = 36,132. 33 cases with no reported date of incorporation or a negative age were excluded.
Source: London Economics' analysis of HMRC, IDBR and FAME matched data set

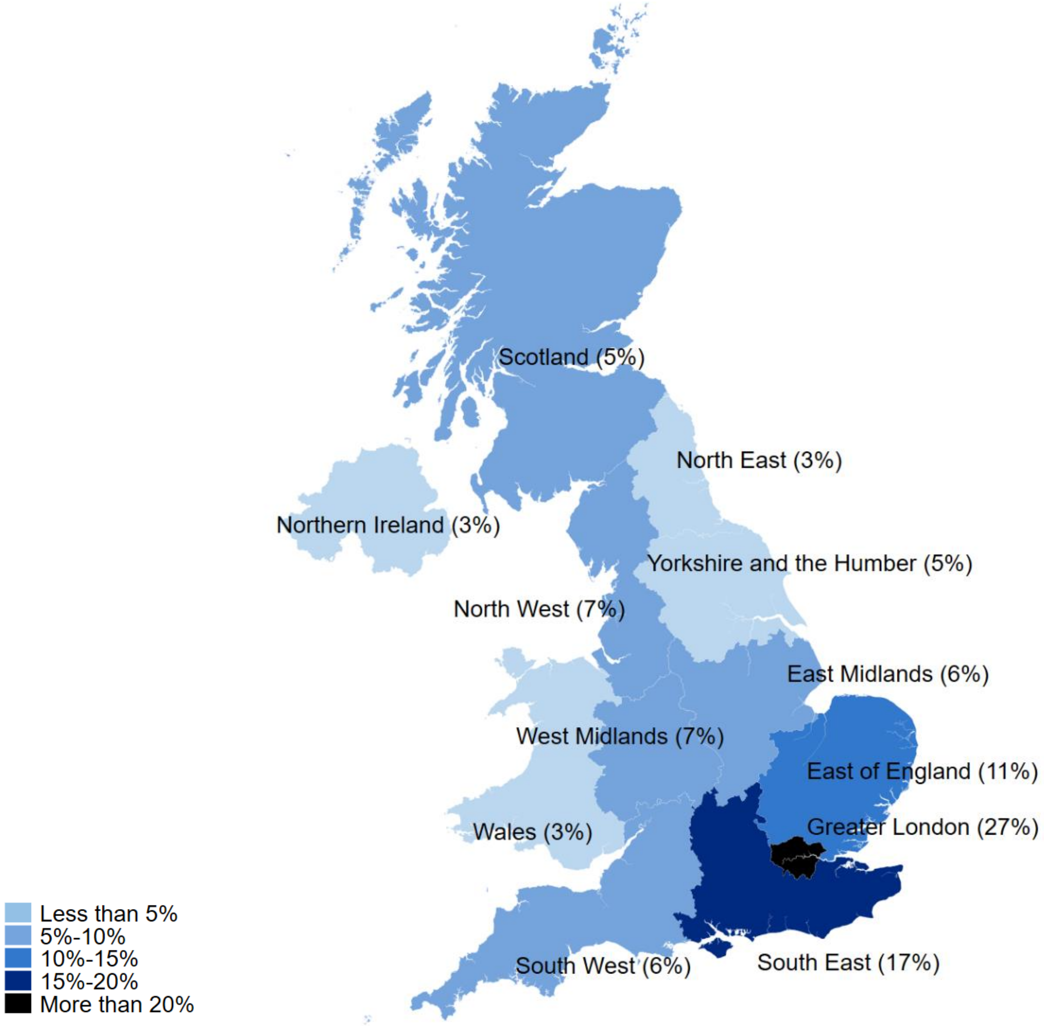
3.3.3 Regional distribution

Overall, companies with registered offices in London (27%), the South East of England (17%) and the East of England (11%) accounted for more than half of the relief that was claimed under the scheme in 2015–16 (Figure 13).[47] This distribution is relatively consistent with the distribution of private sector businesses in general, as 44% of the UK business population is concentrated in London, the South East of England and the East of England.[48] This suggests that there is no concentration of beneficiaries (from the scheme) in one location. However, these figures should also be treated with caution as businesses may undertake their R&D activities at locations other than their registered address.

[47] These figures may differ slightly to the most recent National Statistics publication and similar discrepancies exist in the remainder of section 2.2.13. Please see section A1.2 for more information.

[48] See, for example, 'Business population estimates for the UK and regions 2015'. ONS statistical release. Published 14 October 2015. Available here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/467443/bpe_2015_statistical_release.pdf.

Figure 13 Regional distribution of the amount of relief claimed under the scheme (2015–16)



Note: Number of observations = 36,757. 21 claims did not have a reported region and are excluded.
Source: London Economics' analysis of HMRC, IDBR and FAME matched data and BERD data

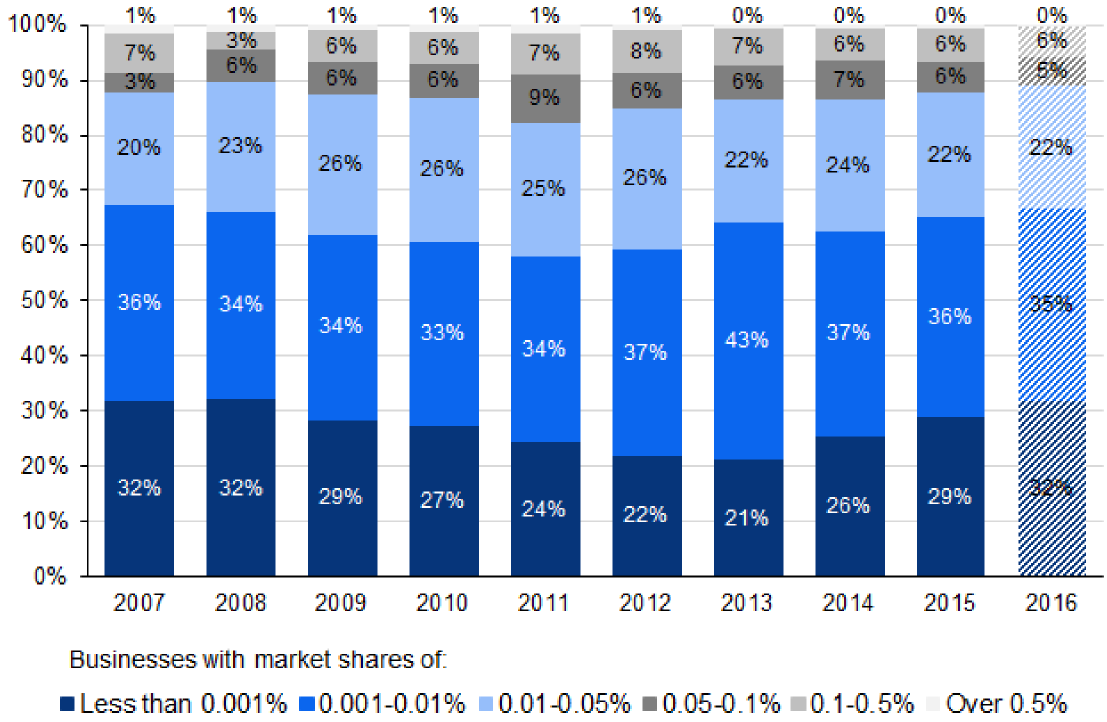
3.3.4 Market competition and concentration

Two measures are considered to assess whether the amount of tax relief claimed under the scheme is more likely to support businesses with more market power.[49] These measures are addressed by Figure 13 and Table 7 respectively. Overall, businesses with a market share of 0.05% or smaller claimed over 80% of the relief. In contrast, on average, businesses with a market share over 0.5% only claimed less than 1% of the relief. This suggests that the scheme does not especially benefit businesses with more market power. However, the analysis presented is undertaken at the two-digit SIC 2007 level; the businesses' market shares within more specific markets may be different. Given the confidentiality of such data, it was not possible to explore this in further detail for the purposes of this report.[50]

[49] Market power is the relative ability of a business (or a set of businesses) to raise the prices of goods and services sold over their marginal cost.

[50] The analysis undertaken in the SRS cannot be shared because the number of businesses in more specific markets is very small, therefore it may be possible to identify individual businesses.

Figure 14 Distribution of amount of relief claimed under the scheme by market share (by year, 2007–2017)



Note: Number of observations: 165,793. *Provisional estimates for 2016–17 as HMRC data is not complete for this financial year. Market shares calculated at the two-digit SIC 2007 level.
Source: London Economics' analysis of HMRC and BSD matched data

The Herfindahl-Hirschman Index (HHI) is a commonly used measure by competition market regulators to assess the level of concentration in a given industry. A higher HHI suggests that one or a few businesses have a higher market share; thus, the market is more concentrated and less competitive. Industries were grouped based on their HHI and the amount of relief claimed by the industry was aggregated by HHI bands. In 2015–16, the amount of relief claimed under the scheme was predominately claimed by businesses in competitive industries (Table 8); this distribution is consistent across the reference period.

Table 8 Proportion of relief claimed under the scheme by HHI (2015–16)

Market concentration	Amount of relief claimed (£ million)	Proportion of total
Competitive (HHI under 1,500)	1,785	99.7%
Moderately concentrated (HHI between 1,500 and 2,500)	3	0.2%
Highly concentrated (HHI greater than 2,500)	2	0.1%

Note: Number of observations: 31,011. HHI is calculated by taking the sum of squared market shares for all firms in a given industry. Totals and market shares are calculated at the two-digit SIC level. Analysis at more granular SIC codes cannot be shared because the number of businesses in more specific markets is very small, therefore it may be possible to identify individual businesses.
Source: London Economics' analysis of HMRC and BSD matched data

The quantitative survey data is used to compare the perceived impact of R&D expenditure on (own) market share for claimants and non-claimants who undertake R&D (Table 9). Overall, 84% of claimants reported that their business' market share increased or was expected to increase as a result of their R&D expenditure compared to 68% of non-claimants.[51]

Table 9 Perceived impact of R&D on businesses' market share between claimants and non-claimants who undertake R&D

Increase or expected increase in market share as a result of R&D expenditure	Claimants	Non-claimants who undertake R&D	Difference statistically significant at 95% confidence level?
Yes	84%	68%	Yes
No	16%	32%	Yes

Note: Number of claimant respondents (weighted) = 772. 28 claimants answered 'Don't know' and are excluded. Number of non-claimant respondents (weighted) = 85. 3 non-claimants answered 'Don't know' and are excluded. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

3.3.5 Firm size

Businesses with fewer than 250 employees filed most of the claims under the scheme compared to those with employees between 250 and 499, and hence account for most of the relief claimed (95%) (Table 10). However, as expected, the average amount of relief is markedly larger for businesses with 250 to 499 employees: approximately £238,900, compared to approximately £46,500 for businesses with fewer than 250 employees.

Table 10 Distribution of businesses claiming, amount of relief claimed, and average relief per business by firm size (2015–16)

Number of employees	Number of businesses claiming	Total amount of relief claimed (£ million)	Average relief per business (£)
Fewer than 250	34,764 (99%)	1,617 (95%)	46,527
Between 250 and 499	345 (1%)	82 (5%)	238,854
Total	**35,109**	**1,699**	**48,416**

Note: 1,056 businesses have missing employee data in 2015–16 and are excluded from the analysis.
Source: London Economics' analysis of HMRC, IDBR and FAME matched data set

3.4 R&D spillover effects on turnover

3.4.1 Understanding spillover effects of R&D Expenditure

A large body of literature on R&D shows that there are economically significant impacts of one business' R&D on its own performance as well as the performance of other businesses.[52] In other words, if a business conducts more R&D, this may have a knock-on effect on its own turnover but also on that of other businesses through knowledge diffusion. The latter effect is referred to as a 'spillover effect'. The remainder of this chapter investigates these wider impacts (or indirect impacts) of R&D by testing whether business-, sector- and region-level R&D is associated with businesses' turnover in the UK.

[51] This difference between the two groups is statistically significant at the 5% significance level.

[52] See for instance Hall and Mairesse (1995), Jaffe and others (1993), Bloom and others (2013), Jaffe (1986), Bernstein and Nadiri (1989).

The impact of R&D and its potential spillover effects on turnover are estimated through a 'production function' approach. This involves exploring the relationship between turnover (a proxy for business output) and inputs (for example, labour and materials) as well business-, sector- and region-level R&D expenditure.[53] Estimating this model through a single equation would give the average impact of each explanatory variable across all businesses in the sample, regardless of whether they conduct R&D. However, companies that conduct R&D are presumably different to businesses that do not (for example, they may have fundamentally different business models). These differences may influence how each type of business is affected by R&D spillovers. To account for these differences, the model is estimated separately for businesses that conduct R&D and businesses that do not. The models are fit using fixed effects estimation with lagged values of R&D expenditure and factor inputs as explanatory variables. Sectoral and regional gross value added (GVA) are used to control for macroeconomic effects. The identification strategy, variables and sample data are described in further detail in Technical Annex 2. The main results are discussed in the following section.

3.4.2 The effect of business-, sector-, and region-level R&D expenditure on turnover

Table 11 provides the estimation results, which suggest that among businesses that undertake R&D, increasing R&D expenditure can have a positive impact on turnover. This is in line with findings from the existing literature[54], which find a positive impact of R&D on firm performance. The elasticity of turnover with respect to R&D expenditure is equal to 0.021. In other words, a 1% increase in R&D expenditure is associated with a 0.021% increase in turnover in the following year. It should be noted that this is likely to underestimate the full impact of R&D as its results may materialise over longer horizons (for example, an R&D project may take several years before it translates into a commercialised product[55]).[56] .

Table 11 Indirect and spillover impacts of R&D expenditure on real turnover

Type of business	Indirect impact	Regional spillovers	Sectoral spillovers
R&D undertaken	0.021***	0.052***	–0.011*
R&D not undertaken	N/A	0.042***	0.006***

Note: Full estimation results are presented in column 2 of Table 37 in Technical Annex 2. Asterisks indicate statistical significance where p-values are: *** p<0.01, ** p<0.05, * p<0.1.
Source: London Economics analysis of ARDx-BERD matched data set

The coefficients on regional R&D are positive and statistically significant for both businesses that conduct R&D and those that do not. Positive regional spillovers are consistent with the idea that physical proximity is conducive to knowledge dissemination. As documented in the literature, the diffusion of knowledge between neighbouring businesses can occur through a number of mechanisms such as the movement of specialised workers across firms (people who change jobs bring the experience and skills that they acquired in their previous role), but also through the exchange of ideas between employees from neighbouring businesses (for example, through social ties) (Döring and Schnellenbach, 2006). Geographic proximity can be particularly important in the

[53] See Haskel (2007) for a similar approach applied to the impact of inward FDI.

[54] See for instance Hall and Mairesse (1995).

[55] On the length of the 'innovation cycle', see Hanna and others (2015).

[56] The addition of further lags in the model would lead to the loss of observations and would make the results less representative of the population.

exchange of tacit knowledge (for example, 'know-how'), which is more likely to require direct contact than the diffusion of codified knowledge (for example, publications) (Döring and Schnellenbach, 2006).[57]

The estimated impacts on real turnover with respect to sector-level R&D differ markedly across both types of businesses. For a business that does not conduct R&D, a 1% increase in the R&D expenditure of its sector is associated with a 0.006% increase in real turnover of that business. This is consistent with the existence of sectoral knowledge spillovers. Knowledge may flow across businesses within the same sector through a variety of mechanisms such as trade fairs, publications, competitor analysis (for example, reverse engineering), or R&D alliances (see Haskel and others, 2007; Goyal and Moraga-González, 2001).[58]

In contrast, the impact on real turnover with respect to sector-level R&D expenditure is estimated at –0.011 among businesses that conduct R&D. In other words, in the case of businesses that operate within the same sector, higher R&D expenditure may have a negative effect on other businesses that also conduct R&D (that is, a negative spillover impact). This does not mean that sectoral knowledge spillovers are absent among these types of businesses. Rather, the market competition effect may dampen the direct positive effect of R&D expenditure. This market competition effect is as follows. Businesses that conduct R&D are more likely to unlock innovations that allow them to produce more or at a lower price, which may undermine the sales of other businesses that operate in the same market (Bloom and others, 2013; Jaffe, 1986). If businesses that engage in R&D have a higher tendency to compete with each other (within two-digit SIC 2007 sectors) rather than with businesses that do not conduct R&D, then the market rivalry effect could plausibly outweigh the knowledge spillover effects among businesses that conduct R&D, thereby leading to a negative coefficient on sector-level R&D expenditure. This effect is likely to be more pronounced in 'winner takes all' industries, which are usually R&D intensive.

On the other hand, businesses that do not conduct R&D may be insulated from the market rivalry effect if they tend to not directly compete with business that undertake R&D, but still benefit from knowledge spillovers. It should be noted that this effect is less likely to be reflected in region-level R&D, which includes R&D conducted by businesses in different sectors which are less likely to directly compete with one another.

Another factor that may explain the difference between the sectoral spillover effects of those who conduct R&D and those who do not is that many businesses tend to subcontract R&D. Hence, their R&D activities are not included within intramural R&D, but these companies would still benefit from R&D commissioned to other firms, possibly within the same sector.

It should be noted that, although the negative sectoral spillover effect among businesses conducting R&D is higher in magnitude than its positive counterpart among those not undertaking R&D, the latter affects considerably more businesses. For instance, in the estimation sample, there are more

[57] For a survey of the literature on geographical knowledge spillovers, see for instance, Döring and Schnellenbach (2006). See also Jaffe and others (1993).

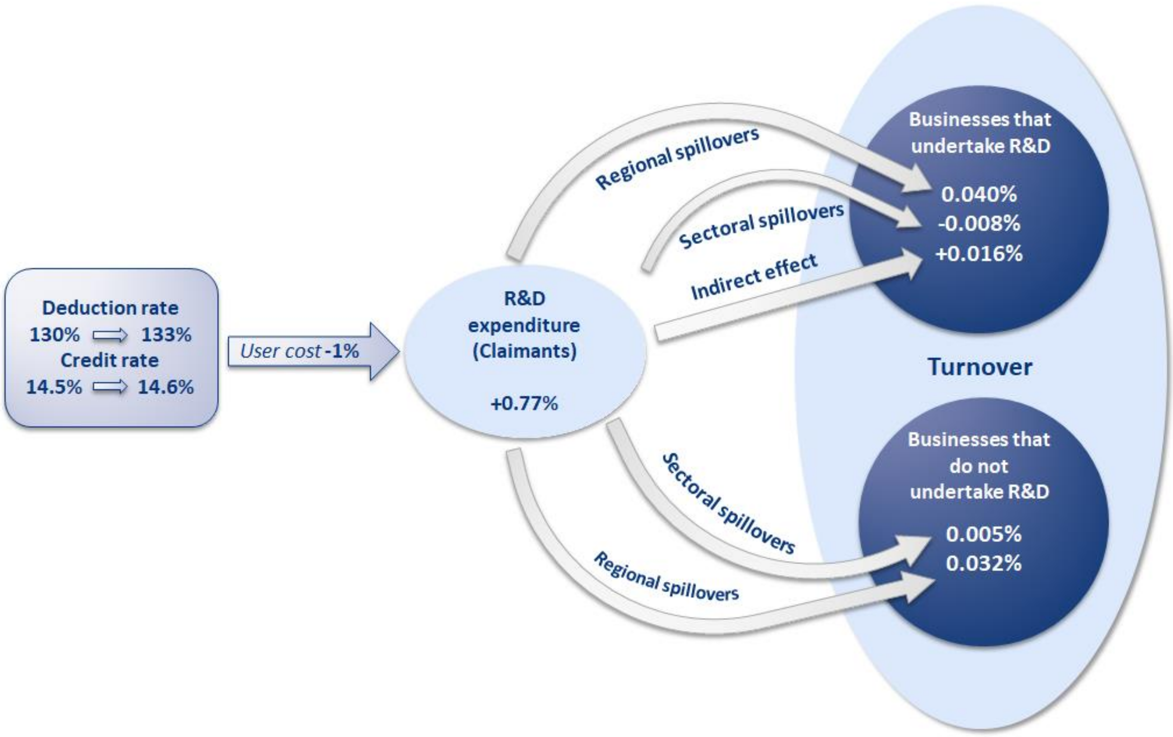
[58] On sectoral R&D spillovers, see also Bernstein and Nadiri (1989).

than five times as many businesses not conducting R&D as there are conducting R&D (this compares to a ratio of less than two in the magnitude of the spillover effects[59]).[60]

3.4.3 The combined direct and indirect effects of R&D expenditure on turnover

A combination of the results from this section with those presented on the direct impacts of the relief in Chapter 2 yields an estimate of the potential impact of a one per cent decrease in the user cost on real turnover for claimants and non-claimants. An increase in the deduction or credit rates is estimated to incentivise additional R&D expenditure, which would in turn have a positive impact on the real turnover of claimants in future periods. In addition, the growth in aggregate R&D expenditure will generate positive externalities that will translate into higher turnover for all businesses. Figure 15 illustrates this process. Model robustness checks are discussed in detail in section A2.6 of Technical Annex 2.

Figure 15 The direct, indirect, and spillover effects on turnover, following a change in relief rate, among businesses that do and do not undertake R&D



Note: This assumes that the R&D expenditure in all regions and sectors increases by the same percentage as that of businesses that claim under the R&D tax relief scheme for SMEs subsequent to a change in R&D tax relief policy. This is equivalent to assuming that all businesses conducting R&D have the same user cost elasticity of R&D expenditure. This also assumes that all businesses file either pure deduction or pure credit claims.
Source: London Economics analysis

[59] The ratio of elasticities across the two models is approximately 1.8 ($\frac{0.011}{0.006} \approx 1.8$).

[60] It should also be noted that, even if the sectoral spillover effect was negative for both sets of businesses, this could be a result of new innovative businesses entering certain markets, which may put downward pressure on average turnover, but increase aggregate sales: this could potentially increase consumer (and possibly producer) surplus and therefore lead to a positive welfare effect.

4 Proportionality and Appropriateness of R&D Tax Relief for SMEs

4.1 Overview

The evaluation plan described in the EC's decision letter[61] included an assessment of the 'proportionality' of the R&D tax relief scheme for SMEs (that is, whether the same level of R&D expenditure can be achieved with lower relief rates), and 'appropriateness' of the scheme (whether alternative forms of support would be better suited to incentivise R&D expenditure).

Quantitative surveys of claimants and non-claimants were used to gather evidence that examines the proportionality and appropriateness of the scheme. Two types of non-claimants were surveyed: those who had not conducted R&D since 2015–16, and those who had but had not claimed under the scheme. The latter group form the true counterfactual in the analysis and allow for direct comparisons with claimants. Qualitative interviews with claimants were also undertaken to provide context and a deeper understanding of findings from the quantitative interviews. Further details on the methodology are provided in section A3.1 of Technical Annex 3. Analysis of other survey questions and topics explored in the qualitative interviews are provided in sections A3.2 and A3.3 (respectively) of Technical Annex 3.

4.2 Comparison between claimants and non-claimants who undertake R&D

For claimants and non-claimants who undertake R&D, R&D activities were mainly conducted to provide (or with an aim to provide) an advance in a technological problem (Figure 16). This was the case for over two thirds (68%) of claimants and 57% of non-claimants. Overall, a quarter (25%) of non-claimants reported to undertake R&D for purposes other than scientific research or a technological problem[62] compared to only 8% of claimants.[63] This result suggests that non-claimants may not apply for R&D tax relief because their R&D activities do not qualify.

In terms of the commercial success of the R&D project undertaken (Figure 17), a larger share (80%) of projects undertaken by claimants were reported to be commercially successful compared to those undertaken by non-claimants (59%).[64] Moreover, non-claimants (12%) were more likely to perform R&D activities that were not relevant in terms of commercial success compared to claimants (3%).[65]

[61] The EC's decision letter to the then Secretary of State for Foreign and Commonwealth Affairs, The Rt Hon Philip Hammond, 30 September 2015. Published on 21 December 2015 and available at: http://ec.europa.eu/competition/state_aid/cases/258021/258021_1709375_48_6.pdf

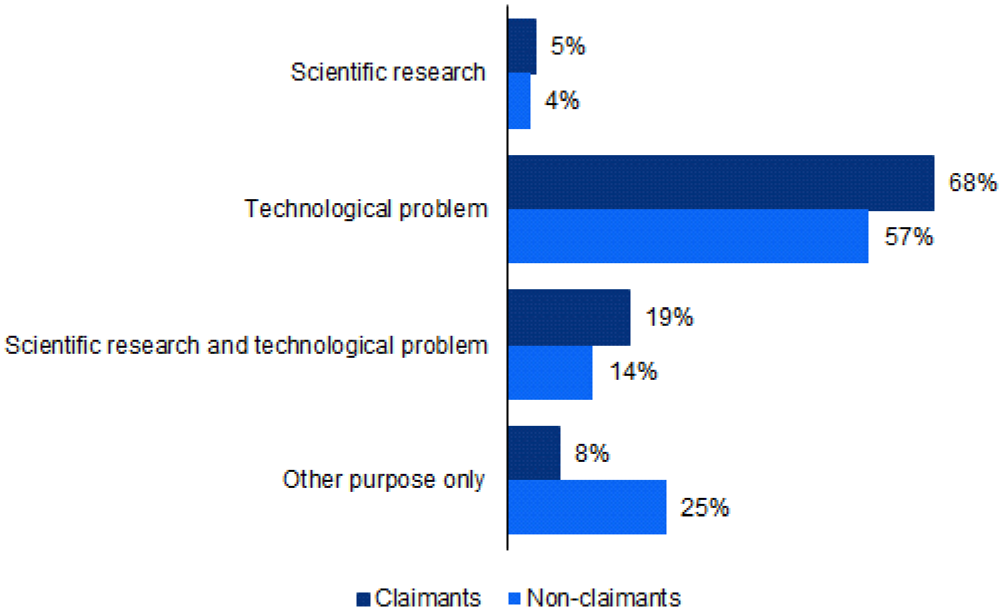
[62] Examples include improving customer service, extending a product range, website development.

[63] The difference between these two groups is statistically significant at the 1% level.

[64] The difference between the two groups is statistically significant at the 1% level. If businesses that reported commercially successful (unsuccessful) projects are pooled with businesses for which the project is likely (unlikely) to be successful, the difference is also statistically significant at the 1% level, with the proportion of commercially successful projects standing at 93% among claimants and 78% among non-claimants.

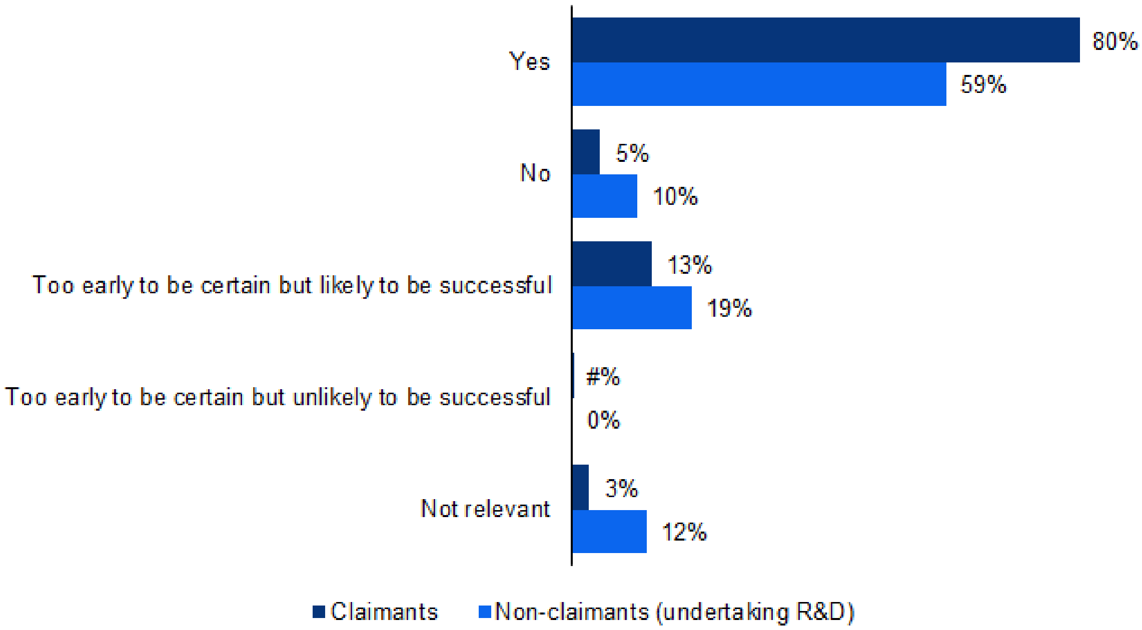
[65] The difference between the two groups is statistically significant at the 5% level.

Figure 16 Claimants' and non-claimants' purpose(s) of R&D activities



Note: Total claimant respondents (weighted) = 794. 6 claimants answered 'Don't know' and are excluded. Total non-claimant respondents (that undertake R&D) (weighted) = 86. 3 non-claimants answered 'Don't know' and are excluded. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

Figure 17 Claimants' and non-claimants' answer to whether their R&D project was commercially successful



Note: Total claimant respondents (weighted) = 786. 14 claimants answered 'Don't know' and are excluded. Total non-claimant respondents (weighted) = 89. Results refer to the most recent financial year in which qualifying R&D was undertaken. #% refers to percentages between 0% and 1%.
Source: London Economics' analysis of quantitative survey data

Overall, 81% of claimants incurred all their R&D expenditure in the UK compared to 71% of non-claimants who undertake R&D.

On average, for both claimants and non-claimants who undertake R&D, most of the R&D expenditure is incurred in the UK (Table 12). Across all regions, the differences between the two groups are not statistically significant.

Table 12 Proportion of R&D expenditure incurred in the UK, the EEA (excluding the UK), and outside the EEA, among claimants and non-claimants

	R&D expenditure incurred in the UK	R&D expenditure incurred in the EEA (excluding the UK)	R&D expenditure incurred outside the EEA
Claimants	94%	3%	3%
Non-claimants	88%	5%	7%

Note: Total claimant respondents (weighted) = 788. 12 claimants answered 'Don't know' and are excluded. Total non-claimant respondents (weighted) = 84. 5 non-claimants answered 'Don't know' and are excluded. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

4.3 Proportionality of the scheme

Three main groups of claimants emerge when assessing the responsiveness of R&D to a hypothetical change in the additional deduction rate (Table 13):

- A large group (71%) of claimants that would not change their R&D expenditure following a hypothetical 10 pp change in the additional deduction rate;
- A small group (11%) of claimants that would change their R&D expenditure following either an increase or decrease of 10 pp in the additional deduction rate; and
- A small group (13%) of claimants that would increase their R&D expenditure following a hypothetical increase of 10 pp in the additional deduction rate but would not decrease their R&D expenditure if the additional deduction rate was reduced by 10 percentage points.

Overall, at the current additional deduction rate, almost three-quarters (71%) of claimants would not increase (or decrease) their R&D expenditure if the rate was increased (or decreased) by 10 pp. This is supported by the empirical results of the analysis measuring the direct impact of the scheme (presented in section 2.3.2), which showed a diminishing impact of changes in R&D tax policy (captured through the user cost of capital) on the level of R&D expenditure in the recent period from 2013–14 to 2016–17.

Table 13 Responsiveness of claimants to a hypothetical 10 pp increase and 10 pp decrease in the additional deduction rate

	Increase from 130% to 140%: Spend the same on R&D	**Increase from 130% to 140%:** Increase R&D expenditure	**Total**
Decrease from 130% to 120%: Spend the same on R&D	71%	13%	**85%**
Decrease from 130% to 120%: Decrease R&D expenditure	4%	11%	**15%**
Total	**76%**	**24%**	**100%**

Note: Number of respondents (weighted) = 746 (93%). 22 respondents (3%) answered 'Don't know' in one of the two questions and are excluded and 32 responses (4%) are excluded where respondents suggested they would increase (decrease) spending if the additional deduction rate was decreased (increased). Figures may not add up to the total due to rounding. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

Findings from the qualitative interviews also support the above results. A 10 pp change in the additional deduction rate was considered to be too marginal to influence the level of R&D expenditure. The increase in the additional deduction rate perceived to be needed to influence the level of R&D expenditure varied across the businesses interviewed, ranging from 20% to 60%.

"It [change in the deduction rate] would have to be moderate to significant for us to re-evaluate and really up-scale something [that] we were doing…anything that is an extra 50% or 60% would be welcomed"

Business in wholesale and retail sector, 5–19 employees, South East of England.

The majority of claimants that were interviewed reported a need for agility in financial spending. As such, they often approached their R&D activity and spending in an ad hoc manner, with decisions made on a project-by-project basis about whether to allocate time or money to particular projects.

"We started looking around and seeing what wasn't available [products not currently in the market that the business could look to develop] …It was just if the money is in the bank, and it is not going to hurt the company by doing it."

Business in manufacturing sector, 5–19 employees, North West of England.

As such, determining the direct impact of tax relief on R&D expenditure is not always easy to do, nor very precise or detailed, which suggests that the relief rate may not be a 'game changer'.

"I don't know what it [the value of relief claimed] will look like this year. We are not banking on a penny of R&D relief in our planning."

Business in manufacturing sector, 20–49 employees, West Midlands.

"We adjust the overall financial model as a result of tax credit, but the amount is not directly affecting the level of spending."

Business in financial and insurance sector, 100–249 employees, London.

"Our R&D isn't fuelled by what we can get off our tax bill."

Business in manufacturing sector, 5–19 employees, North West of England.

Some businesses did report an impact of the relief on the level of R&D expenditure undertaken. The reduction in CT contributes to overall financial health and cashflow. As such, the relief will contribute to the decision of whether to conduct R&D or not; however, with other factors also playing a role, sometimes it was difficult to quantify the exact impact of the relief.

"[If no tax credit funds were available] the projects would be on a smaller scale and take longer to filter into the business... you might do a trial of X size with the R&D in place, but only Y size without it in place…it would be slower to market."

Business in agriculture, forestry and fishing sector, 100–249 employees, West Midlands.

"Two years ago, we had no knowledge of the relief at all, so we had no budget for R&D, no planning for R&D…no record-keeping for R&D…We are more willing to put a lot more money into R&D now."

Business in wholesale and retail sector, 5–19 employees, South East of England.

"We have done projects where we have thought it might be a break-even product, but if we can get the R&D [tax relief] on it, we might make some margin towards the overheads."

Business in manufacturing sector, 50–99 employees, East of England.

Most claimants (85%) that would increase their expenditure in response to a rise in the additional deduction rate suggested that they would do so by up to 20%. Similarly, approximately nine in ten claimants that would decrease their expenditure if the rate dropped by 10pp would do so by up to 20% (Table 14). This suggests that among claimants that would respond to a change in the additional deduction rate, their R&D is only moderately elastic to changes in the rate.

Table 14 Claimants' changes in R&D expenditure following a 10 pp increase and 10 pp decrease in the additional deduction rate

	Increase by 1–20%	Increase by 21% or more
Change in R&D expenditure given a hypothetical increase in the additional deduction rate from 130% to 140%	89%	11%
	Decrease by 1–20%	**Decrease by 21% or more**
Change in R&D expenditure given a hypothetical decrease in the additional deduction rate from 130% to 120%	85%	15%

Note: Number of respondents (weighted) = 105 (bottom row), 170 (top row). 17 respondents answered 'Don't know' to at least one question and are excluded. 22 respondents answered 'Don't know' to whether they would increase or decrease their R&D expenditure in response to an increase or decrease in the additional deduction rate and are excluded. 32 responses are excluded where respondents suggested they would increase (decrease) spending if the additional deduction rate was decreased (increased). Note, businesses that reported that their spending would not change in the event of an increase (decrease) in the additional deduction rate were included in the analysis of the alternative scenario. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

4.4 Appropriateness of the scheme

Only 7% of claimants received funding in the form of a grant or subsidy for R&D activities that were undertaken in 2015–16 or 2016–17 alongside tax relief under the scheme (Table 15). Over a third of these claimants received grant funding from Innovate UK.[66] Interestingly, non-claimants who undertook R&D activities but did not claim under the scheme also had a similar profile with 7% receiving some form of grant of subsidy funding and 93% not receiving any. This result is consistent with findings from the qualitative interviews described below, which point to a lack of awareness and administrative burden.

While the majority of claimants (56%) said they would not change their R&D spend if they received the amount of tax relief that they claimed in the form of an up-front grant or subsidy, 39% reported that they would increase their R&D expenditure. Moreover, claimants who currently received grant or subsidy funding were more likely (46% compared to 39% who did not receive grant or subsidy

[66] This percentage is calculated relative to a base which excludes businesses who did not know whether they received a grant or subsidy for R&D activities.

funding) to report that they would spend more if the tax relief was received at the start of the financial year.

Table 15 Change in R&D expenditure in response to receiving a grant or subsidy funding of the same value as the R&D tax relief, between claimants who had used grants or subsidies and those who had not

Actual use of grants or subsidies	Spend the same	Spend more	Spend less
No	57%	39%	5%
Yes	52%	46%	2%
Total	**56%**	**39%**	**5%**

Note: Number of respondents (weighted) = 751; of which 697 (93%) did not use grant or subsidy funding for R&D and 55 (7%) reported the use of grant or subsidy funding. 49 respondents answered 'Don't know' to at least one of the two questions and are excluded. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

These results were in line with findings from the qualitative interviews. A small proportion of innovation-led businesses reported receiving grants and subsidies, and were therefore 'plugged into' the funding landscape. They actively searched for funding opportunities, and in some cases, their overall strategic planning was underpinned by the grants they accessed.

"If we manage to get a grant, that will be the big factor determining whether we do something or not in many cases."

Business in information and communication sector, 20–49 employees, London.

However, most businesses in the qualitative interviews had little or no awareness of grants for R&D expenditure, and often did not have time to consider or explore these opportunities. Furthermore, many were quite sceptical about the likely administrative burden associated with accessing such funding, and about the chances of being successful when applying for it.

"I have not got the free time to research any of this [availability of government grants] for what would probably come back as a negative anyway."

Business in manufacturing sector, 20–49 employees, North West of England.

"With anything to do with government stuff it's never quite straightforward…you have to weigh up the opportunity cost of you spending three months going through an application process versus three months doing the actual work."

Business in information and communication sector, 5–19 employees, London.

This suggests that there is a high opportunity cost associated with searching and applying for grant funding (for example, in terms of time spent). In contrast, the opportunity cost may be lower when preparing a claim for R&D tax relief as these are generally handled by third-party specialists that have a comparative advantage in preparing claims. In addition, repeating the application process for R&D tax relief was often described as easier (once a process and templates has been established), which businesses felt may not be the case with grants.

Nevertheless, in principle, the idea of accessing matched-funded grants was appealing to some because it would improve cashflow and therefore help overcome the uncertainty regarding the outcome of the tax relief application. This higher level of certainty could encourage greater overall business investment and a willingness to consider higher risk or innovative areas.

"It [Receiving up-front grant funding] might encourage more investment…be more forward looking."

Business in financial and insurance sector, 100–249 employees, London.

Under the scenario of a 10 pp increase in the additional deduction rate, approximately one in four (24%) claimants suggested that they would increase their R&D expenditure (see Table 13), with 89% suggesting that they would increase their spending by up to 20% and 11% by 21% or more.[67] In contrast, 39% suggested that they would increase their R&D expenditure if they received relief in the form of a grant or subsidy (see Table 15) and this is likely to stimulate more R&D expenditure with 38% of these increasing their R&D spend by 21% or more (Table 16).[68]

These results are supported by the qualitative interview findings that suggested that access to matched funded grants was appealing to some businesses. In addition, it should be noted that although the grant application process was often considered burdensome in the qualitative interviews, the question in the quantitative interview does not explicitly refer to the process of applying and places greater emphasis on the 'upfront' nature of the hypothesised grant.[69] In that sense, while the qualitative interviews may have been better suited to capture businesses' experience with the grant application process, the quantitative survey may have captured their concerns over cash flows.

Table 16 Changes in R&D expenditure in response to a 10 pp increase in the additional deduction rate and receiving a grant or subsidy, among claimants who would increase their R&D expenditure

	Increase R&D expenditure by 1–20%	Increase R&D expenditure by 21% or more
Hypothetical increase in the additional deduction rate from 130% to 140%	89%	11%
Grant or subsidy funding (equal to amount received in tax relief)	62%	38%

Note: Number of respondents (weighted) = 153 respondents answered that they would increase their R&D expenditure if the additional deduction rate increased from 130% to 140% (and either increase their spending or spend the same if they received a grant or subsidy instead of tax relief, in other words, the 'alternative scenario'); and 265 respondents answered that they would increase their R&D expenditure if they received a grant or subsidy (equal to the tax relief) (and either increase their spending or spend the same if the deduction rate increased, in other words, the 'alternative scenario'). 28 respondents answered 'Don't know' in at least one of the two questions and are excluded. Note, businesses that reported that their spending would not change in the event of an increase of the additional deduction rate (if they received a grant or subsidy instead of tax relief) were included in the analysis of the alternative scenario. Figures may not add up to the total due to rounding. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

[67] Note that the base samples of the two figures are not exactly identical, as described in the note of each table.

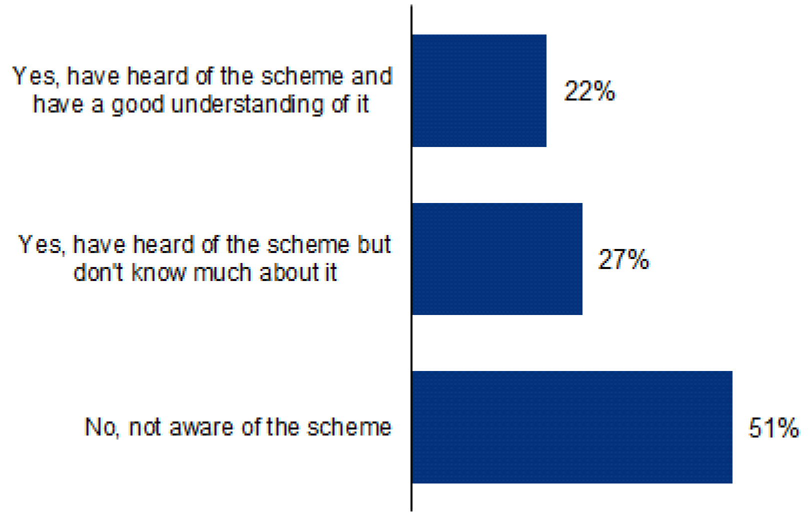
[68] Note that the base samples of the two figures are not exactly identical, as described in the note of each table.

[69] The question in the claimant survey was phrased as follows: 'if your business was instead offered a grant or subsidy at the start of the financial year…'.

4.5 Awareness of the scheme

The fieldwork was also used to gain a better understanding of the awareness of the scheme among non-claimants. Of the non-claimants surveyed, 89 (22%) of them had undertaken R&D during or after financial year 2015–16 with only 5 (1%) claiming relief under the scheme prior to 2015–16. Approximately half of the non-claimants (49%) were aware of the scheme and 22% had a good understanding of how it works (Figure 18).

Figure 18 Non-claimants' awareness of the scheme



Note: Number of respondents (weighted) = 400.
Source: London Economics' analysis of quantitative survey data

Half (51%) of the non-claimants surveyed did not know about the R&D tax relief scheme for SMEs. However, this group of non-claimants was also unaware of other public R&D support schemes (Table 17).[70]

Table 17 Non-claimants' awareness of other public R&D support schemes

Awareness of other public R&D support schemes	Non-claimants who are Aware of scheme	Non-claimants who are Not aware of scheme
Innovate UK innovation loans	25%	9%
Horizon 2020 R&D funding	17%	7%
Industrial Strategy Challenge Fund (ISCF)	11%	1%
Global Challenges Research Fund (GCRF)	8%	1%
Newton Fund	6%	1%
Small Business Research Initiative (SBRI)	22%	8%
EUREKA Eurostars funding	8%	6%

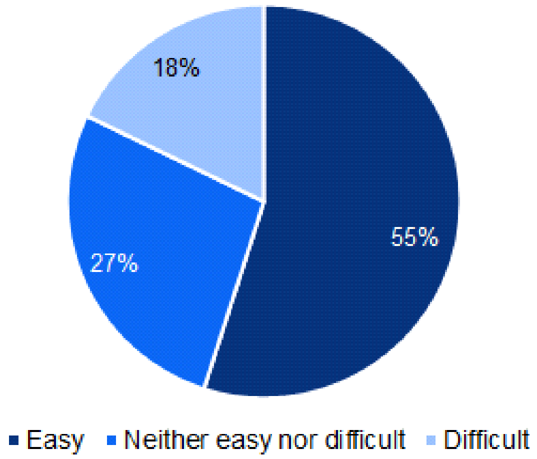
Note: Number of respondents (weighted) = 400.
Source: London Economics' analysis of quantitative survey data

[70] All proportions are statistically significantly different at the 95% confidence level, except for awareness of EUREKA Eurostars funding.

4.6 Functioning of the scheme

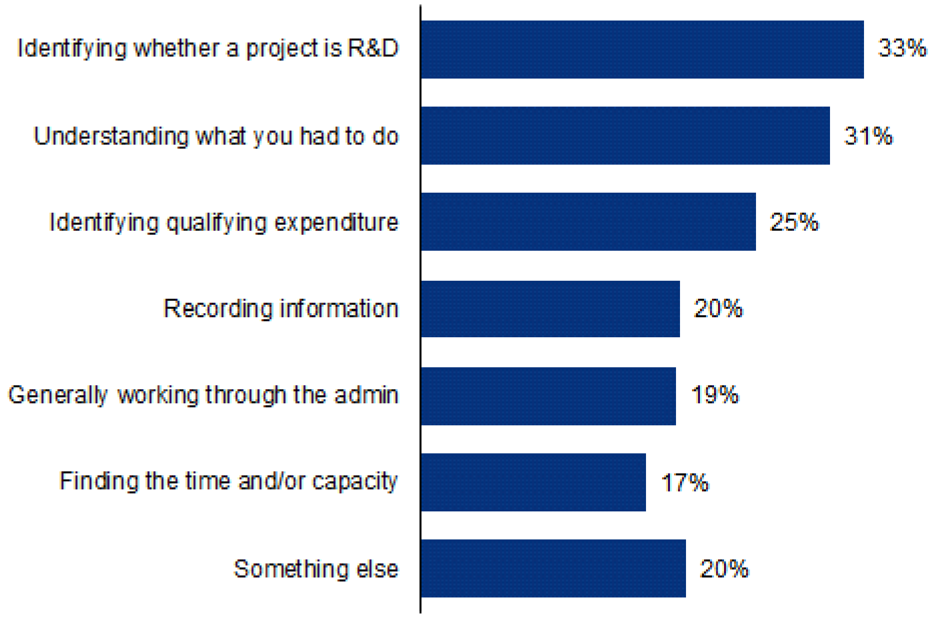
Over half (55%) of claimant respondents reported that the application process was 'easy' and close to a fifth (18%) assessed it to be 'difficult' (Figure 19). The three main reasons why this latter group of claimants found the application process to be 'difficult' were: identifying whether the project is R&D when applying (33%), understanding what to do when applying for relief (31%), and identifying the qualifying expenditure (25%). Other factors that made the application process 'difficult' are provided in Figure 20 below.

Figure 19 Claimants' ease of applying for the scheme



Note: Total number of respondents (weighted) = 764 (96%). 36 respondents answered 'Don't know' and are excluded. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

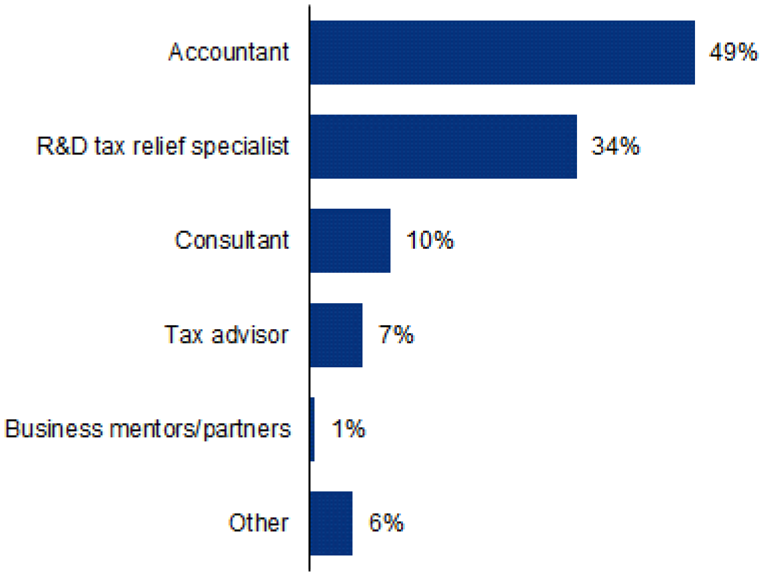
Figure 20 Claimants' reasons for finding the scheme application process 'difficult'



Number of respondents (weighted) = 136 (18%). 'Something else' included reasons such as the difficulty of finding appropriate third-party support and a lack of guidance or support from HMRC. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

Approximately 84% of claimants used external support to complete the application process for the R&D tax relief. Of those that used external support 49% used an accountant and 34% used an R&D tax relief specialist (Figure 21).

Figure 21 Type of external support used to complete the application process



Note: Total respondents (weighted) = 670. 121 did not use any external support and 9 answered 'Don't know'. Respondents may have provided multiple answers. Other types of support included auditors and accountancy firms. Results refer to the most recent financial year in which qualifying R&D was undertaken.
Source: London Economics' analysis of quantitative survey data

These findings were also corroborated by the qualitative interviews that suggest that using third party support generally made the process of collating the necessary information for the application quite easy. Moreover, accountants provided a 'sense-check' to businesses with regards to whether their claims met the qualification criteria.

"He [the accountant] did it for us…I maybe signed a form. That part was a very simple part…We would go through our accounts; the money in, money out, and highlight the expenditure that we would deem fit to be applicable."

Business in information and communication sector, 0–4 employees, London.

Businesses completing the application themselves for the first time often described it to be challenging as the data requirements were viewed to be complex and the guidance lacked clear examples on how information should be presented or submitted.

"The first time it was like 'oh dear!' I was on the verge of 'I might not bother'…I would say easily [it took] a couple of weeks of my time."

Business in information and communication sector, 5–19 employees, London.

The main difficulty businesses highlighted with the application process in the qualitative interviews was the ambiguity of what was within the scope of R&D expenditure.

"The main thing is, when you look at the guide..., you have to think 'the bit I am doing now, is that in, or is that out?"

Business in information and communication sector, 5–19 employees, South East of England.

"The biggest issue is considering 'is this unique? Are you really breaking scientific ground?'"

Business in information and communication sector, 0–4 employees, London.

This leads to two different responses:

- Some businesses report including expenditure that they are unsure they will meet the criteria for, thus relying on their accountants to maximise their chance of success or filter out some of the expenditure before submission.
- Others report a more cautious approach, excluding any expenditure that they are not certain will qualify. These businesses suggest that they may be 'missing out' on some relief as a result.

Applying for R&D tax relief has prompted a more organised approach to R&D record-keeping among some businesses. This enables them to provide an audit trail and makes preparing applications less arduous. It also has a knock-on benefit of helping them plan and understand their R&D expenditure better, driving greater efficiency in some cases.

4.7 R&D barriers and incentives

The quantitative survey of non-claimants was also used to gain a better understanding of the underlying reasons why non-claimant businesses did not carry out any R&D activities since 2015–16. The three main reasons were R&D being irrelevant to the business, utilising existing R&D undertaken by other businesses and a lack of funds to finance R&D expenditure (Table 18). The category 'Other' included reasons such as the head office, parent company, or R&D element of the business being based overseas.

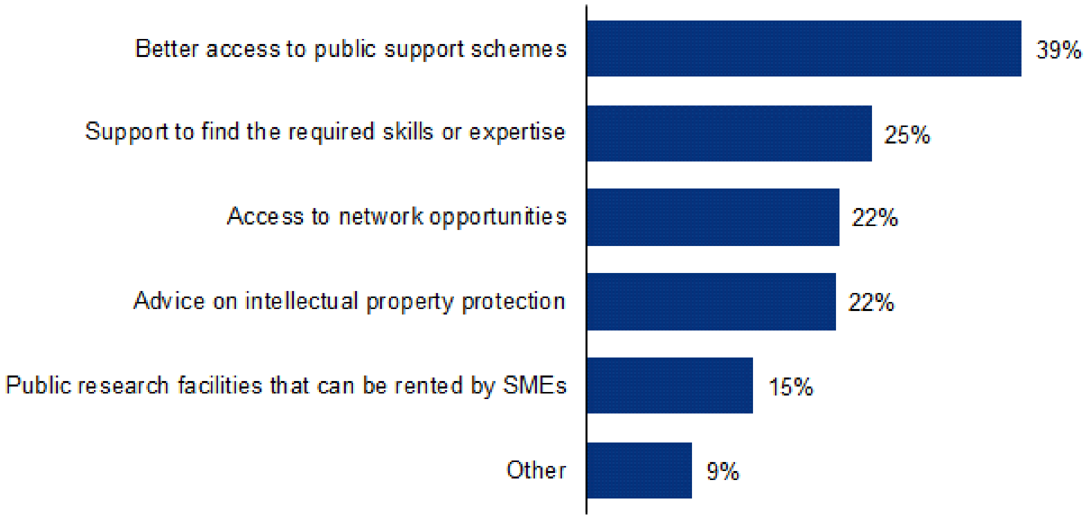
Table 18 Non-claimants' reasons for not undertaking R&D activities

Reason for not undertaking R&D	Percentage of non-claimants who did not undertake R&D
R&D is not relevant to business activities	60%
It made more business sense to utilise existing R&D undertaken by other businesses	11%
Lack of funds to finance R&D expenditure	8%
No need to conduct R&D due to previous R&D activities undertaken prior to 2015–16	4%
Lack of specialised staff, know-how or facilities	2%
Uncertain market demand for potential innovation	2%
Legal or administrative burden	1%
No need to conduct R&D due to very little competition in the market	1%
Difficulties in obtaining government grants or subsidies	1%
Other	10%

Note: Total respondents (weighted) = 298. Businesses that had not done any R&D activities since 2015–16 only. 13 respondents answered 'No' or 'Don't know' to all options and are excluded. The table provides the main reason reported by non-claimants for not undertaking R&D.
Source: London Economics' analysis of quantitative survey data

Non-claimants that did not undertake R&D were then prompted on the types of support or improvements that may incentivise them to carry out R&D (Figure 22). Overall, the most common support or improvement requested by non-claimants (39%) was better access to public support schemes[71]. The next top three areas that non-claimants suggested would incentivise R&D activities were: support to find the required skills or expertise, access to network opportunities, and advice on IP protection. In addition to these points, 9% specified other areas that would incentivise R&D activities, this included, support from universities, changes in the legal environment, or information on funding opportunities, among others.

Figure 22 Types of support that would encourage R&D activities, among non-claimants who did not undertake any R&D



Note: Total respondents (weighted) = 311. Businesses that have not done any R&D activities since 2015–16 only. Multiple responses were possible.

Source: London Economics' analysis of quantitative survey data

[71] The interpretation of 'better access' was left to respondents. As such, this could refer to information availability, ease of the application process, scope (for example, eligibility criteria), and so on.

5 Conclusion

This report provides an independent evaluation of the UK R&D tax relief scheme for SMEs, considering not only its direct impact on R&D expenditure, but also its wider economic effects, and its proportionality and appropriateness.

The analysis of the scheme's direct impact considered historical trends in its uptake and the impact at the intensive margin of R&D expenditure. There has been a surge in the number of businesses claiming and amount of relief paid since 2012–13. This is most likely due to the increasing generosity of the scheme. However, R&D expenditure per business has declined, suggesting a growing popularity of the scheme among businesses with low R&D expenditure. The scheme has an incentive effect at the intensive margin of R&D; in other words, it encourages claimants to increase their R&D expenditure. A range of additionality ratios were calculated, most of which are above one, suggesting R&D expenditure induced by the scheme exceeds the scheme's cost to the Exchequer. Results are mostly robust to changes in model specification and estimation sample, although applying the model to more recent years yields lower additionality ratios, suggesting the scheme may be subject to decreasing returns.

Limiting the analysis of the scheme to these direct effects would capture only a portion of the economic benefits induced by the relief. Hence, its indirect effects were investigated by comparing the performance of claiming businesses to that of non-claimants. The results indicate that claimants show a stronger performance than non-claimants on a number of indicators. This may reflect both differences in demographics and a potential impact of the scheme on business performance. For example, claimants have larger revenues than other businesses and tend to generate a higher proportion of their turnover on innovative products or processes than businesses that do not claim under the scheme. Furthermore, the number of patents filed by claimants is highest in the year in which they first claimed. There is no evidence that the scheme distorts competition as there are no unexplained location effects, the scheme supports both incumbents and new entrants and the relief is hardly claimed among businesses with market power or in highly concentrated industries.

Econometric results suggest that businesses' turnover can grow in response to increases in their own R&D expenditure (in other words, an indirect impact of the scheme) but also regional R&D expenditure (that is, regional spillover effects of the scheme). Sector-level R&D is estimated to have a positive impact on the turnover of businesses that do not engage in R&D and a negative impact on the turnover of businesses that conduct R&D (this is referred to as the sectoral spillover effects of the scheme). The latter may be a result of increased competition, which may outweigh a potentially positive impact of knowledge spillovers.

During quantitative and qualitative fieldwork, 72% businesses reported that they would not be responsive to a 10 percentage point increase or decrease in the additional deduction rate, which tended to be perceived as too small a change in the qualitative interviews. The scheme was compared to alternative incentive mechanisms (namely, grants and subsidies). During quantitative fieldwork, more businesses reported that they would be responsive to the hypothetical receipt of a grant or subsidy at the start of the year than an increase in the additional deduction rate. This echoes findings from the qualitative interviews, reflecting concerns over cash flows. On the other hand, findings from the qualitative interviews also suggest that applying for grants can be perceived to be a daunting process involving high search costs.

Finally, the main reasons why businesses do not undertake R&D included R&D being irrelevant to the business, more beneficial to use existing R&D from other businesses and the availability of funding. Further investigation into these concerns may provide additional evidence on the potential of the scheme to influence the extensive margin of R&D.

With regards to claimants, one avenue for improvement may be in facilitating the application process. Indeed, although most claimants (73%) did not find the scheme's application process difficult, many businesses (84%) received support in applying, and those that did not often found the process more challenging. In the qualitative interviews, some businesses noted that the application process encouraged better R&D record-keeping and planning, which in some cases unlocked efficiency gains.

Taken together, the findings from this evaluation suggest that the scheme generates direct, indirect, and spillover effects benefiting not only businesses that claim under the R&D tax relief scheme for SMEs but the economy as a whole. As such, the scheme can be seen as satisfying its general and specific objectives. In addition, there is no evidence that the scheme distorts competition. Although recent evidence suggests that businesses may not be as responsive to tax incentives as in previous years, the scheme still continues to incentivise R&D that would not have taken place otherwise.

References

Angrist JD and Pischke JS (2008). ‘Mostly harmless econometrics: An empiricist's companion’ Princeton University Press

Arellano M and Bond S (1991). ‘Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations’ The Review of Economic Studies: volume 58, issue 2, pages 277–297

Arrow KJ (1972) ‘Economic welfare and the allocation of resources for invention’ Readings in Industrial Economics: pages 219–236, London: Palgrave

Baltagi B (2008) ‘Econometric analysis of panel data’: volume 1, John Wiley and Sons

Berger P (1993) ‘Explicit and implicit tax effects of the R&D tax credit’ Journal of Accounting Research: volume 31, issue 2, pages 131–171

Bernstein J and Nadiri M (1989) ‘Research and development and intra-industry spillovers: An empirical application of dynamic duality’ The Review of Economic Studies: volume 56, issue 2, pages 249–267

Bloom N, Griffith R, and Van Reenen J (2002) ‘Do R&D tax credits work? Evidence from a panel of countries 1979–1997’ Journal of Public Economics: volume 85, issue 1, pages 1–31

Bloom N, Schankerman M, and Van Reenen J (2013) ‘Identifying technology spillovers and product market rivalry’ Econometrica: volume 81, issue 4, pages 1347–1393

Bozio A, Irac D, and Py L (2014) ‘Impact du crédit impôt recherche sur la R&D et l’innovation: l’expérience française’ Document de Travail: n° 532, Banque de France, décembre

Carboni OA (2011) ‘R&D subsidies and private R&D expenditures: evidence from Italian manufacturing data’ International Review of Applied Economics: volume 25, issue 4, pages 419–439

Glaeser E (2010) ‘Agglomeration economics’ University of Chicago Press

Czarnitzki D (2006) ‘Research and development in small and medium-sized enterprises: The role of financial constraints and public funding’ Scottish Journal of Political Economy: volume 53, issue 3, pages 335–357

Dagenais M, Mohnen P, and Therrien P (1997) ‘Do Canadian firms respond to fiscal incentives to research and development?’ CIRANO Working Papers: 97s-34, CIRANO

Dechezleprêtre A, Einiö E, Martin R, Nguyen K, and Van Reenen J (2019) ‘Do tax incentives for research increase firm innovation? An RD design for R&D’ CEP Discussion Paper: 1413

Döring T and Schnellenbach J (2006) ‘What do we know about geographical knowledge spillovers and regional growth?: A survey of the literature’ Regional Studies: volume 40, issue 3, pages 375–395

Dummont M and Meeusen W (2000) ‘Knowledge spillovers through R&D cooperation’

European Commission (2014) ‘A study on R&D tax incentive: Final report’ Taxation Papers: working paper 52

Falk M (2006) ‘What drives business Research and Development (R&D) intensity across Organisation for Economic Co-operation and Development (OECD) countries?’ Applied Economics: volume 38, issue 5, pages 533–547

Fowkes R, Sousa J, and Duncan N (2015) ‘Evaluation of Research and Development Tax Credit’ HMRC Working Paper 17

Goyal S and Moraga-González J (2001) ‘R&D Networks’ The RAND Journal of Economics: volume 32, issue 4, pages 686–707

Hægeland T and Møen J (2007) ‘The relationship between the Norwegian R&D tax credit scheme and other innovation policy instruments’ Reports 2007/45

Hall B (1993) ‘R&D tax policy during the Eighties: success or failure?’ Tax Policy and the Economy: volume 7, pages 1–36

Hall BH and Mairesse J (1995) ‘Exploring the relationship between R&D and productivity in French manufacturing firms’ Journal of econometrics: volume 65, issue 1, pages 263–293

Hall B and Van Reenen J (2000) ‘How effective are fiscal incentives for R&D? A review of the evidence’ Research Policy: volume 29, issues 4–5, pages 449–469

Hall R and Jorgenson D (1967) ‘Tax policy and investment behavior’ The American Economic Review: volume 57, issue 3, pages 391–414

Hanna R, Gross R, Speirs J, Heptonstall P, and Gambhir A (2015) ‘Innovation timelines from invention to maturity’ UK Energy Research Centre Working Paper

Hansen LP (1982) ‘Large sample properties of generalized method of moments estimators’ Econometrica: volume 50, issue 4, pages 1029–1054

Harris R, Li Q, and Trainor M (2009) ‘Is a higher rate of R&D tax credit a panacea for low levels of R&D in disadvantaged regions?’ Research Policy: volume 38, issue 1, pages 192–205

Haskel JE, Pereira SC, and Slaughter MJ (2007) ‘Does inward foreign direct investment boost the productivity of domestic firms?’ The Review of Economics and Statistics: volume 89, issue 3, pages 482–496

Hines J (1993) ‘On the sensitivity of R&D to delicate tax changes: the behaviour of US multinationals in the 1980s’ in Giovannini A, Hubbard G, and Slemrod J (1993) Studies in International Taxation: pages 149–194, University of Chicago Press

HMRC (2010) ‘An Evaluation of Research and Development Tax Credits’

HMRC (2018) ‘Research and Development Tax Credits Statistics: September 2018’

Jaffe A (1986) ‘Technological opportunity and spillovers of R&D: Evidence from firms' patents, profits, and market value’ The American Economic Review: volume 76, issue 5, pages 984–1001

Lokshin B and Mohnen P (2007) 'Measuring the effectiveness of R&D tax credits in the Netherlands' MERIT Working Papers 025, United Nations University – Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT)

Lopez J and Mairesse J (2018) 'Impacts du CIR sur les principaux indicateurs d'innovation des enquêtes CIS et la productivité des entreprises, rapport final pour France Stratégie, décembre'

Malerba F, Mancusi M, and Montobbio F (2013) 'Innovation, international R&D spillovers and the sectoral heterogeneity of knowledge flows' Review of World Economics: volume 149, issue 4, pages 697–722

Mamuneas T and Nadiri M (1996) 'Public R&D policies and cost behavior of the US manufacturing industries' Journal of Public Economics: volume 63, issue 1, pages 57–81

Marshall A (1920) 'Principles of economics', Macmillan

McCutchen W (1993) 'Estimating the impact of the R&D tax credit on strategic groups in the pharmaceutical industry' Research Policy: volume 22, issue 4, pages 337–351

Mulkay B and Mairesse J (2018) 'Nouveaux résultats sur l'impact du crédit d'impôt recherche, étude pour le ministère de l'enseignement supérieur, de la recherche et de l'innovation, septembre'

Nelson RR (1959) 'The simple economics of basic scientific research' Journal of Political Economy: volume 67, issue 3, pages 297–306

Nickell S (1981) 'Biases in dynamic models with fixed effects' Econometrica: volume 46, issue 6, pages 1417–1426

OECD (2015) 'Frascati manual 2015: Guidelines for collecting and reporting data on research and experimental development, the measurement of scientific, technological and innovation activities' OECD Publishing

Olley G and Pakes A (1996) 'The dynamics of productivity in the telecommunications equipment industry' Econometrica: volume 64, issue 6, pages 1263–1297

ONS (2006) 'Business structure database user guide, UK data archive study number 6697 – business structure database: secure access'

ONS (2016) 'Business enterprise research and development (BERD) microdata metadata, UK data archive study number 6690 – business expenditure on research and development: secure access'

ONS (2018) 'Nominal and real regional gross value added (balanced) by industry' (viewed on 13 August 2019)

ONS (2019a) 'Companies register activities: statistical release 2017 to 2018' (viewed on 13 August 2019)

ONS (2019b) 'GDP deflators at market prices and money GDP' (viewed on 13 August 2019)

ONS (ND) 'ARDx capital stock user guide, UK data archive study number 7989 – annual respondents database X: secure access'

Parisi M and Sembenelli A (2003) 'Is private R&D spending sensitive to its price? Empirical evidence on panel data for Italy' Empirica: volume 30, issue 4, pages 357–377

Roodman D (2009a) 'How to do xtabond2: An introduction to difference and system GMM in Stata' The STATA Journal: volume 9, issue 1, pages 86–136

Roodman D (2009b) 'A note on the theme of too many instruments' Oxford Bulletin of Economics and Statistics: volume 71, issue 1, pages 135–158

Shah A (1994) 'The economics of research and development: how research and development affects production and markets and is affected by tax incentives' Policy Research Working Paper 1325, World Bank Policy Research Institute

University of the West of England, Bristol (ND) 'ARDx draft guide, UK data archive study number 7989 – annual respondents database X: Secure access'

Wooldridge JM (2001) 'Applications of generalized method of moments estimation' Journal of Economic Perspectives: volume 15, issue 4, pages 87–100

ANNEXES

A1 Technical Annex 1: Direct Impact

A1.1 Identification of the type of claim

The type of claim and the associated tax relief amount are determined following a similar approach to that used by HMRC in compiling the annual statistical publication on R&D tax credits. The company tax return form (also known as the CT600) records the amount of:

- Enhanced R&D expenditure (denoted as '*rdee*')
- Payable tax credit (denoted as '*rdtc*', or '*rdrp*' if '*rdtc*' is zero or missing)

The table below outlines how these variables are used to identify the type of claim and the amount of relief claimed using examples based on the additional deduction and credit rate in 2016–17.

Table 19 Identification of the type of claim and calculation of the relief

Type of claim	Case 1: Corporation Tax (CT) deduction	Case 2: Combination	Case 3: Payable tax credit
Overview	The whole of the enhanced expenditure amount is used to claim a CT deduction.	Part of the enhanced expenditure amount is used to claim a payable credit, and part is used to claim a deduction.	The whole of the enhanced expenditure amount is used to claim a payable credit.
Identification of claim type	*rdee* > 0 AND *rdtc* and *rdrp* are both zero or missing	*rdee* > 0 AND *rdtc* > 0 AND *rdtc* < *rdee* multiplied by the credit rate	*rdee* > 0 AND *rdtc* > 0 AND *rdtc* ≥ *rdee* multiplied by the credit rate
Calculation of relief	Relief = CT forgone by HMRC Relief = (*rdee* – R&D expenditure) x CT rate	Relief = CT forgone by HMRC + payable tax credit The cost of the payable tax credit is obtained in the same way as in Case 3. To calculate the cost of the deduction (CT forgone), the amount of enhanced R&D expenditure used for the deduction needs to be established. Enhanced R&D expenditure used for deduction = *rdee* – (*rdtc*/credit rate) – R&D expenditure	Relief = Payable tax credit Relief = *rdtc*

Type of claim	Case 1: Corporation Tax (CT) deduction	Case 2: Combination	Case 3: Payable tax credit
Example	Actual R&D expenditure = £1,000 SME additional deduction rate = 130% Enhanced R&D expenditure = *rdee* = £1,000 + £1,300 = £2,300 *rdtc* and *rdrp* are both zero or missing CT rate = 20% CT forgone by HMRC (deduction from company's CT liability) = £1,000 x 20% = £200 Relief = (£2,300 – £1,000) x 20% = £260	Actual R&D expenditure = £1,000 SME additional deduction rate = 130% Enhanced R&D expenditure = *rdee* = £1,000 + £1,300 = £2,300 Company uses £800 of the *rdee* to claim a payable tax credit and the remaining *rdee* to reduce its CT liability Payable credit rate = 14.5% Payable tax credit claimed = *rdtc* = £800 x 14.5% = £116 Enhanced R&D expenditure used for deduction = £2,300 – (£116/14.5%) – £1,000 = £500 Cost of deduction = *rdee* used for deduction x CT rate = £500 x 20% = £100 Relief = Cost of payable tax credit + Cost of deduction = £116 + £100 = £216	Actual R&D expenditure = £1,000 SME additional deduction rate = 130% Enhanced R&D expenditure = *rdee* = £1,000 + £1,300 = £2,300 Payable credit rate = 14.5% Payable tax credit claimed = *rdtc* = £2,300 x 14.5% = £333.50 Relief = *rdtc* = £333.50

Note: In cases where *rdtc* is missing or equal to zero, *rdrp* is used in the calculation.

A1.2 Data

The analysis presented in Chapters 2 and 3 uses information submitted by businesses on their CT600 form.[72] The CT600 form identifies businesses that are claiming under the R&D tax relief scheme for SMEs (hereafter referred to as the scheme or SME scheme), and shows the enhanced level of R&D expenditure and the amount of any R&D payable tax credit that can be claimed.

Similar data was used to produce HMRC's most recent National Statistics publication. There are some differences between the number of claims in this report and that publication due to:

- figures in the most recent National Statistics publication were rounded to the nearest 10 or £10 million up to 2012–13 and to the nearest 5 or £5 million from 2013–14 onwards, while figures in the present report were not rounded;
- in the interests of being an independent evaluation, the present report used a slightly different methodology to categorise claims between schemes; and
- data for the years 2012–13 and 2013–14 contain additional cases as, at the time of producing the 2018 National Statistics, HMRC made a change to their methodology, incorporating some additional management information to correct for data that had been missing in earlier years. The 2012–13 and 2013–14 data in this report pick up additional management information cases that were not incorporated into the 2018 National Statistics since at the time HMRC decided not to revise earlier years. The management information for these years will itself be partial; so while the data is more complete it is still not a full data set. Earlier years have not been corrected at all and so will be missing cases consistent with HMRC's 2018 National Statistics.

HMRC continue to keep the methodology used in the National Statistics under review. This will mean that there may be revisions to these time series in later HMRC publications that could cause further divergences to this report. This data set was the best available for the evaluation at the time.

The data set used by the present report contains 211,266 claims made by 67,473 businesses from the financial years 2000–01 to 2016–17.[73] Provisional data are used for the financial year 2016–17 as not all claims in the accounting period had been processed when the analysis was undertaken. The data set is enriched through matching with firm-level data from the ONS' Inter-Departmental Business Register (IDBR), and Bureau van Dijk's Financial Analysis Made Easy (FAME) database. This provides additional economic and financial information such as employment, value of current assets and liabilities, and the main economic activity of the claiming business based on its UK Standard Industrial Classification (SIC) 2007 code. The data set is also matched to macroeconomic variables from the ONS, including Gross Domestic Product (GDP) deflator, which is a measure of general inflation in the UK economy, and industry-level Gross Value-Added (GVA) growth.[74]

[72] This is reconciled with management information collected by HMRC in the administration of the scheme.

[73] Businesses are identified in the data set by their company registration number (CRN). The CRN is provided for 67,395 businesses (and 211,128 claims) and the remaining 78 businesses (and 138 claims) are identified using the company name and assigned a pseudo CRN.

[74] See ONS (2019b) 'GDP Deflators at Market Prices and money GDP'. Available at: https://www.gov.uk/government/statistics/gdp-deflators-at-market-prices-and-money-gdp-march-2019-quarterly-national-accounts and ONS (2018) 'Nominal and real regional gross value added (balanced) by industry'. Available at: https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalandrealregionalgrossvalueaddedbalancedbyindustry

A1.3 Additional descriptive statistics

Table 20 Number of claims, amount of relief, and R&D expenditure by sector division level (2015–16)

Code	Division description	Number of claims	Amount of relief (£m)	R&D expenditure (£m)
01	Crop and animal production, hunting and related service activities	241	10.1	38.1
02	Forestry and logging	*	*	*
03	Fishing and aquaculture	12	2.3	2.4
05	Mining of coal and lignite	*	*	*
06	Extraction of crude petroleum and natural gas	*	*	*
08	Other mining and quarrying	19	1.7	5.7
09	Mining support service activities	10	0.8	3.0
10	Manufacture of food products	532	24.5	101.9
11	Manufacture of beverages	129	2.4	7.2
12	Manufacture of tobacco products	*	*	*
13	Manufacture of textiles	187	5.3	18.7
14	Manufacture of wearing apparel	63	1.2	4.8
15	Manufacture of leather and related products	31	0.9	3.6
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	174	4.4	17.1
17	Manufacture of paper and paper products	165	5.2	19.6
18	Printing and reproduction of recorded media	334	10.2	38.5
19	Manufacture of coke and refined petroleum products	23	1.0	3.1
20	Manufacture of chemicals and chemical products	497	21.8	76.1
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	116	10.7	35.9
22	Manufacture of rubber and plastic products	689	26.0	100.0
23	Manufacture of other non-metallic mineral products	206	6.8	25.7
24	Manufacture of basic metals	177	8.7	34.5
25	Manufacture of fabricated metal products, except machinery and equipment	1,762	62.7	249.6
26	Manufacture of computer, electronic and optical products	1,072	66.9	239.3
27	Manufacture of electrical equipment	591	27.1	98.1
28	Manufacture of machinery and equipment NEC	1,158	50.4	189.3
29	Manufacture of motor vehicles, trailers and semi-trailers	299	18.2	70.6
30	Manufacture of other transport equipment	179	11.5	42.1
31	Manufacture of furniture	270	8.0	31.1
32	Other manufacturing	679	26.2	91.7

Code	Division description	Number of claims	Amount of relief (£m)	R&D expenditure (£m)
33	Repair and installation of machinery and equipment	277	12.6	49.4
35	Electricity, gas, steam and air conditioning supply	66	10.3	31.4
36	Water collection, treatment and supply	*	*	*
37	Sewerage	16	0.3	1.2
38	Waste collection, treatment and disposal activities; materials recovery	165	7.5	26.8
39	Remediation activities and other waste management services.	22	1.0	3.5
41	Construction of buildings	206	11.5	46.6
42	Civil engineering	176	16.0	63.8
43	Specialised construction activities	955	40.0	164.5
45	Wholesale and retail trade and repair of motor vehicles and motorcycles	406	11.0	43.9
46	Wholesale trade, except of motor vehicles and motorcycles	2,677	85.0	318.1
47	Retail trade, except of motor vehicles and motorcycles	1,090	26.5	95.6
49	Land transport and transport via pipelines	115	3.1	11.9
50	Water transport	*	*	*
51	Air transport	*	*	*
52	Warehousing and support activities for transportation	132	5.9	20.9
53	Postal and courier activities	47	1.8	6.0
55	Accommodation	34	0.8	2.7
56	Food and beverage service activities	113	2.6	9.4
58	Publishing activities	624	25.9	92.3
59	Motion picture, video and television programme production, sound recording and music publishing activities	232	9.1	30.3
60	Programming and broadcasting activities	27	1.0	3.5
61	Telecommunications	446	25.1	87.5
62	Computer programming, consultancy and related activities	7,280	395.1	1,431.0
63	Information service activities	640	30.3	101.0
64	Financial service activities, except insurance and pension funding	172	13.8	46.2
65	Insurance, reinsurance and pension funding, except compulsory social security	19	1.0	3.6
66	Activities auxiliary to financial services and insurance activities	326	22.5	81.2
68	Real estate activities	129	4.4	16.1
69	Legal and accounting activities	166	4.5	17.1
70	Activities of head offices; management consultancy activities	1,579	50.4	187.9

Code	Division description	Number of claims	Amount of relief (£m)	R&D expenditure (£m)
71	Architectural and engineering activities; technical testing and analysis	2,161	100.6	358.6
72	Scientific research and development	997	183.7	533.1
73	Advertising and market research	836	30.2	112.1
74	Other professional, scientific and technical activities	1,203	37.9	137.2
75	Veterinary activities	36	1.0	4.0
77	Rental and leasing activities	212	10.4	37.5
78	Employment activities	266	11.7	41.2
79	Travel agency, tour operator and other reservation service and related activities	158	5.7	20.9
80	Security and investigation activities	144	5.7	20.8
81	Services to buildings and landscape activities	120	2.8	10.9
82	Office administrative, office support and other business support activities	1,141	48.9	167.5
84	Public administration and defence; compulsory social security	*	*	*
85	Education	370	11.1	40.2
86	Human health activities	241	11.2	41.1
87	Residential care activities	20	0.3	1.1
88	Social work activities without accommodation	37	0.5	1.6
90	Creative, arts and entertainment activities	173	4.4	17.0
91	Libraries, archives, museums and other cultural activities	11	0.3	1.1
92	Gambling and betting activities	28	2.1	7.2
93	Sports activities and amusement and recreation activities	151	29.2	113.0
94	Activities of membership organisations	60	2.7	8.9
95	Repair of computers and personal and household goods	107	3.3	13.2
96	Other personal service activities	468	16.4	56.4
97	Activities of households as employers of domestic personnel	*	*	*
98	Undifferentiated goods- and services-producing activities of private households for own use	*	*	*
99	Missing, dormant	53	14.9	42.2

Note: * Cell sizes less than 10 are suppressed.

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

A1.4 Identification strategy

Following Fowkes, Sousa, and Duncan (2015), a three-staged approach is used to estimate the user cost elasticity via an R&D demand equation. The three stages relate to three different estimation techniques; namely, Ordinary Least Squares (OLS), Fixed Effects (FE) and Arellano-Bond (A-B) estimation. The advantages and shortcomings of each estimation technique are examined in turn hereafter.

Ordinary Least Squares (OLS) estimation

In its simplest form, the model can be estimated assuming there is a linear and static relationship between R&D expenditure and the user cost of capital (as well as the other set of controls). This is achieved by OLS estimation. The general form of a demand equation in this setting can be expressed as follows:

$$y_{it} = \beta_0 + \beta_1 C_{it} + \theta' X_{it} + \varepsilon_{it} \quad (1)$$

- y_{it} is the dependent variable (in this case, log R&D expenditure) for company *i* at time *t*;
- C_{it} is the user cost of capital for company *i* at time *t*;
- X_{it} is a set of other determinants of R&D expenditure including company characteristics and macroeconomic factors;
- ε_{it} is the error term; and
- β_0, β_1, and θ are parameters which are to be estimated.

The parameter β_1 denotes the percentage change in R&D expenditure associated with a 0.01 increase in the user cost of capital.[75] Therefore, it can be taken as a measure of the effectiveness of the scheme in encouraging R&D expenditure via the user cost of capital. By pooling observations across companies, OLS estimation does not require several continuous years of observed data for each firm. However, the estimate of the coefficient attached to the user cost is likely to be inconsistent (that is, it does not converge to its true value) if there are unobserved firm-specific characteristics (such as managerial ability and entrepreneurial culture) that influence the level of R&D expenditure and are also correlated with the user cost.[76] The effects of these characteristics on R&D expenditure would be captured by the coefficient estimate on the user cost.

Fixed Effects (FE) estimation

Measuring the direct effects of the scheme on R&D expenditure through a model estimating the determinants of R&D expenditure at the firm-level is subject to unobserved firm-level heterogeneity (see μ_i in the first equation below), which could bias the results (see previous paragraph).[77] If unobserved firm-specific effects are constant across time, their impact on R&D expenditure can be eliminated by estimating the demand model using FE estimation. This is equivalent to fitting a model

[75] This is referred to as the 'semi-elasticity' of R&D expenditure with respect to the user cost of capital. If R&D expenditure were in linear form, β_1 would represent the absolute change in R&D expenditure associated with a unit increase in the user cost of capital.

[76] In equation (1), ε_{it} may embody the unobserved firm-specific effects, such that it can be expressed as $\varepsilon_{it} = f_i + u_{it}$, where f_i are unobserved firm-specific effects and u_{it} is an idiosyncratic error term.

[77] For example, differences in unobserved innovative ability may affect how responsive companies' R&D expenditures are to changes in the generosity of the R&D tax relief scheme for SMEs. More innovative firms may expect greater returns to R&D expenditure at the margin and therefore expand R&D spending more than others in response to an increase in R&D tax relief. The estimated user cost elasticity of R&D expenditure will therefore reflect the mix of companies' innovative traits as much as the scheme's effects.

in which all variables have been transformed through subtraction of their average across time (this is commonly referred to as the 'within-transformation') – see the second equation below. This means that any variables which are time-invariant, such as unobserved firm-specific effects (μ_i), are eliminated, as they are equal to their mean across time – see the third equation below.

$$y_{it} = \beta_0 + \beta_1 C_{it} + \theta' X_{it} + \mu_i + \varepsilon_{it}$$

$$y_{it} - \overline{y_\iota} = \beta_0 - \overline{\beta_0} + \beta_1(C_{it} - \overline{C_\iota}) + \theta'(X_{it} - \overline{X_\iota}) + (\mu_i - \overline{\mu_\iota}) + \varepsilon_{it} - \overline{\varepsilon_\iota}$$

$$y_{it} - \overline{y_\iota} = \beta_1(C_{it} - \overline{C_\iota}) + \theta'(X_{it} - \overline{X_\iota}) + \varepsilon_{it} - \overline{\varepsilon_\iota}$$

Where the overlines denote averages across time (for example, $\overline{X_\iota} = \frac{1}{T}\sum_t^T X_{it}$). The model that is estimated is therefore:

$$y^*{}_{it} = \beta_1 C^*{}_{it} + \theta' X^*{}_{it} + \varepsilon^*{}_{it} \quad \text{.........(2)}$$

where:

- $y^*{}_{it} = y_{it} - \overline{y_\iota}$
- $C^*{}_{it} = C_{it} - \overline{C_\iota}$
- $X^*{}_{it} = X_{it} - \overline{X_\iota}$

R&D expenditure may be persistent over time; that is, R&D expenditure today may be determined by its past values. These dynamic effects can be accounted for by including lagged R&D expenditure in the demand model. However, the combined presence of unobserved firm-specific effects and the lagged dependent variable as a control presents problems in a dynamic model when estimated by OLS and FE.

Firstly, past values of R&D expenditure are a function of the unobserved firm-specific effects that are time-invariant; therefore, OLS estimation yields biased and inconsistent estimates – this is commonly referred to as 'dynamic panel bias' (Nickell, 1981). As such, the model estimated by OLS in this analysis does not control for the lagged R&D expenditure term. Secondly, while FE estimation removes the unobserved firm-specific effects by demeaning the variables in the model, the estimates remain biased and inconsistent, as lags of the dependent variable are correlated with the average value of the error term (Baltagi, 2005). As such, the FE model is also estimated without a lagged R&D expenditure term and therefore does not control for the dynamic effects of R&D expenditure.

Another identification issue that may not be addressed when estimating the demand model by OLS and FE is the issue of simultaneity (or reverse causality). This form of endogeneity arises when the dependent variable influences the independent variable of interest. In the present context, the user cost of capital can be influenced by R&D expenditure as the type of claim (and hence the associated user cost of capital) may depend on the relative magnitudes of R&D expenditure and profits. If not accounted for, simultaneity can lead an estimator to be inconsistent because the effect of the dependent variable on an independent variable is conflated with the true impact of interest (namely the impact of the latter on the former).

Arellano-Bond (A-B) estimation

A more robust dynamic panel data estimation technique, Generalised Methods of Moments (GMM), uses lagged values of variables as instrumental variables to address the endogeneity issues discussed above.[78] One type of GMM estimation proposed by Arellano and Bond (1991) combines the first-difference transformation (to remove unobserved firm-level heterogeneity) and the use of instrumental variables (to address dynamic panel bias and simultaneity). More formally, the model equation can be represented as follows:

$$\Delta y_{it} = \gamma_1 \Delta y_{i,t-1} + \beta_1 \Delta C_{it} + \theta' \Delta x_{it} + \Delta u_{it} \qquad (3)$$

- y_{it} is the dependent variable (in this case, log R&D expenditure) for company *i* at time *t*;
- $y_{i,t-1}$ is log R&D expenditure for company *i* at time *t–1* capturing the dynamic effect;
- C_{it} is the user cost of capital for company *i* at time *t*;
- x_{it} is a set of other controls including company characteristics and macroeconomic factors;
- u_{it} is the idiosyncratic error term;
- Δ is the first-difference operator; and
- γ_1, β_1 and θ are parameters which are to be estimated.

In this case, the Arellano-Bond estimation provides a more robust estimate of the responsiveness of a company's R&D expenditure to changes in its user cost of capital (measured by β_1) and is the preferred estimation approach.

The validity of using lagged values of endogenous variables as instruments in the A-B estimation can be examined using two misspecification tests:

- The consistency of the A-B estimates requires the instruments to be valid. Joint instrument validity can be tested directly through the Hansen test of overidentifying restrictions, provided that the number of instruments exceeds the number of endogenous variables (Hansen, 1982).
- Arellano and Bond (1991) also propose a test for an important assumption underlying the validity of lags as instruments, namely the absence of autocorrelation in the disturbance term (this test is often referred to as the 'Arellano-Bond test').[79] If the idiosyncratic error term influences its future values, then lags of endogenous variables, which by definition are related to the error term in the same period, may also be correlated with the contemporaneous error term.

However, the A-B estimation also has a few notable drawbacks that must be considered. Firstly, the use of the first-difference transformation restricts the estimation sample to pairs of consecutive observations, which can reduce the number of observations and provide estimates that are not necessarily representative of businesses that claim under the scheme intermittently (the introduction of the lagged dependent variable means that at least three consecutive observations are required). Secondly, the use of too many instruments relative to the sample size can affect the validity of the instruments and undermine the method's ability to eliminate endogeneity, which biases the parameter estimates (Roodman, 2009b). Therefore, using the three-staged approach ensures that the preferred parameter estimates capture the true extent to which changes in the scheme incentivise additional R&D expenditure.

[78] Instrumental variables are correlated with the variable treated as being endogenous but are uncorrelated with the error term.

[79] Strictly speaking, certain lags of the endogenous variables may be valid instruments in the presence of autocorrelation, provided that they are of a sufficiently high lag order.

Finally, as mentioned in 2.3.2, it is important to note that all three approaches (OLS, FE and A-B) will only measure the impact of the scheme at the intensive margin of R&D expenditure (that is, the same companies undertaking more R&D activities) as the data set does not provide information on financial years in which businesses do not do any R&D activities. In other words, the methodology does not capture the extensive margin of R&D expenditure (that is, new companies undertaking R&D activities for the first time).

A1.5 Variables

The variables considered in the econometric model are described below alongside the rationale for their inclusion. Controlling for other factors that influence a company's R&D expenditure decisions will ensure that the effect of the user cost on R&D expenditure is isolated and estimated consistently.

Real R&D expenditure

The primary dependent variable is the natural logarithm of R&D expenditure in real prices. Enhanced R&D expenditure (that is, R&D expenditure multiplied by 100% plus the additional deduction rate) associated with a company's tax relief claim is reported on their CT600 form. Actual R&D expenditure can be derived by dividing the enhanced expenditure by the relevant deduction rate in the year in which the company files its claim (for example, 230% in 2016–17). This is then converted into real prices using the GDP deflator at market prices with the base period equal to the financial year of 2017–18.

In the case of the Arellano-Bond estimation, the lagged term of real R&D expenditure is also included as a control to capture the dynamic effects related a company's R&D expenditure decisions. It is treated as an endogenous variable with a maximum of two lags used as instruments, starting from the second lag.[80]

User cost of capital for R&D expenditure

The analysis focuses on the coefficient estimate associated with the user cost of capital for R&D expenditure (that is, the cost of financing R&D activities). The user cost elasticity is used to measure the impact of R&D tax policy changes associated with the scheme on the level of R&D expenditure made by companies.

The user cost of capital for R&D expenditure is computed based on the formula developed by Hall and Jorgenson (1967). In general, the user cost (C) is a function of the real interest rate (r), which captures the general financial cost of capital to a company and the depreciation rate of capital (δ). Three cases are distinguished based on the type of claim made by the company, in which the user cost is determined by the additional deduction rate (e), credit rate (s), or the effective Corporation Tax (CT) rate (τ).

[80] Often, endogenous variables can be instrumented using their second and further lags. A first model was run in which endogenous variables were instrumented with their second and third lags, but the Arellano-Bond test rejected the null hypothesis that there was no second-order auto-correlation in the transformed (first-differenced) disturbance term, which suggests that the non-transformed error term is serially correlated of order 1. Consequently, the instrument structure was altered such that endogenous variables are instrumented using the third and fourth lags.

1) For a pure deduction claim:

$$C_{it} = \frac{(1-(1+e_t)\tau_{it})}{1-\tau_{it}}(r_{it}+\delta)$$

- τ_{it} denotes the relevant CT rate, which may vary across companies *i* (depending on their profits) and time *t*.
- e_t denotes the additional deduction rate, which varies across time but is the same for all companies claiming under the scheme.
- r_{it} is the real interest rate and δ is the depreciation rate of capital. Following Harris and others (2009) and Fowkes, Sousa, and Duncan (2015), r_{it} is assumed to be equal to 10% and δ is assumed to equal 15%.

$(1+e_t)\tau_{it}$ is the effective tax relief rate. It captures the rate at which each pound of R&D expenditure translates into CT savings. This occurs through two mechanisms. First, in the absence of any tax incentives, a company's expenses on R&D reduce profits and therefore CT liability. Second, given that each pound spent on R&D is enhanced at the given rate e_t, an additional $e_t\tau_{it}$ pounds are deducted from a company's CT liability. These savings, in the form of lower CT liability, reduce the effective cost of financing R&D (that is, the user cost).

2) For a pure tax credit claim:

$$C_{it} = (1-(1+e_t)s_t)(r_{it}+\delta)$$

- s_t denotes the credit rate, which varies across time but is the same for all companies claiming under the scheme.

For firms that are loss-making and decide to surrender all of their losses, the user cost is calculated in a similar manner to a pure deduction claim, but without drawing on the CT rate, as it is not relevant in the case of a surrender. Rather, the rate at which R&D expenditure translates into tax relief is determined by the credit rate s_t and additional deduction rate e_t.

3) For combined claims, the user cost of capital depends on how much enhanced R&D expenditure was used to reduce the CT liability and surrendered to claim a payable tax credit. In this case, the user cost is computed as a weighted average between the user cost for a pure deduction claim and for a tax credit claim, where the weights are the shares of enhanced R&D expenditure used to claim each type of relief. More formally, this can be represented as follows:

$$C_{it} = \left[\alpha_{it}\frac{(1-(1+e_t)\tau_{it})}{1-\tau_{it}} + (1-\alpha_{it})(1-(1+e_t)s_t)\right](r_{it}+\delta)$$

- $\alpha_{it} = \frac{R_{it}^p}{R_{it}}$ is the share of enhanced R&D expenditure that was not surrendered.
- R_{it} is total enhanced R&D expenditure.
- R_{it}^p is enhanced R&D expenditure that is not surrendered (that is, 'used' to save in CT liability).

The payable CT rate was determined using the profits chargeable to CT variable. In the case that a company is loss-making after deductions, it was assumed to be subject to the small profits rate[81]. This is in line with Fowkes, Sousa, and Duncan (2015). Figure 1 provides the historical additional deduction, credit, and CT rates for the period of analysis.

Contemporaneous user cost is modelled as an endogenous variable in the Arellano-Bond estimation with a maximum of two lags used as instruments. When lagged user cost is included in the model, it is treated as pre-determined (in other words, related to the error term in previous periods only). As the user cost is not log-transformed, it is assumed to have a log-linear relationship with the dependent variable (that is, real R&D expenditure) in the estimations. More specifically, if the dependent variable is in natural logarithm and the independent variable(s) in levels, the estimation of β_1 in equation (2) provides a semi-elasticity, which measures the percentage change in R&D expenditure associated with a 0.01 change in the user cost of capital. More formally, this can be represented as:

$$\beta_1 = \frac{\partial y_{it}}{\partial C_{it}} \frac{1}{y_{it}}$$

- y_{it} is R&D expenditure and
- C_{it} is the user cost of capital for company *i* at time *t*.

One advantage of estimating semi-elasticities rather than elasticities is that it does not restrict elasticities to be constant and therefore allows one to evaluate it at different values of the user cost, for example, the mean (denoted $\bar{C}$). In this case, the user cost elasticity (denoted η) is computed as:

$$\eta = \frac{\partial y_{it}}{\partial C_{it}} \frac{\bar{C}}{y_{it}}$$

Annexes A2.5 and A2.6 provide the estimates of the user cost elasticity evaluated at both the mean and median value of user cost for the companies in the estimation sample.

Other company-specific control variables

A company's ability to invest in R&D activities is likely to be influenced by the revenue that it generates from its business activities. Trading turnover reported in a company's CT600 form is used to control for the impact of turnover on the level of R&D expenditure. It is converted into real prices using the GDP deflator at market prices and expressed in natural logarithm form.

The size of a company may affect its ability to undertake R&D activities. The number of employees reported in the IDBR data set is used as a measure of company size and expressed in natural logarithm form.

The liquidity ratio is the ratio of current assets to current liabilities.[82] It measures a company's ability to pay off its short-term debt obligations; and therefore, its ability to finance R&D activities in the short-term. It is constructed using data from the FAME database.

[81] The CT rate applicable to businesses with profits under £300,000 (in place until 2014).

[82] Current assets refer to assets that can be exchanged or used within a financial year (for example, accounts receivable and inventories), and current liabilities denote liabilities that need to be settled within the financial year (for example, interest payments and pensions).

All three variables are treated as endogenous variables in the Arellano-Bond estimation with a maximum of two lags used as instruments.

The type of claim made by a company is dependent on its profits before taxation and deductions, which affect its ability to invest in R&D. However, profits before taxation and deductions are not consistently reported in the HMRC administrative data set[83] and gross profits reported in the FAME data set are only reported in 22% of cases. Therefore, to avoid including a variable that may be inaccurately specified, the econometric model does not control for the type of claim.

Macroeconomic control variables

Growth in industry-level gross value added (GVA) accounts for the dynamism of the sector in which companies that claim under the scheme operate. Businesses operating within fast-growing sectors have an incentive to innovate to remain competitive. Therefore, industry-specific GVA growth may influence a company's level of R&D expenditure. To control for universal time-related shocks, time dummies are used in all estimations.[84] These macroeconomic controls are assumed to be strictly exogenous in the Arellano-Bond estimations.

A1.6 Sample data

In line with Fowkes, Sousa, and Duncan (2015), two major changes are made to the matched data set described in section A1.2 to obtain the estimation sample. Namely:

- There are 4,674 instances in which a company has filed more than one claim in a given financial year. In these cases, only the last claim (determined by the latest accounting period end or start date) is included in the analysis. Hence, the estimation sample contains 206,592 claims made by 67,473 businesses between the financial years 2000–01 and 2016–17.
- Missing observations for the control variables are linearly interpolated if there are reported values in the years immediately preceding and following the missing cases. As a robustness check, the preferred estimation is also run with non-interpolated data[85].

Table 21 summarises the available sample size (in terms of companies in each financial year) for each estimation approach (discussed in section A1.4) when all variables are included. As expected, the Arellano-Bond estimation sample is much lower than the OLS and FE samples and will exclude one-time or occasional claimants who do not claim in consecutive years. Given the trade-offs across the different approaches, a range of estimation results are examined in the next section.

[83] See A1.1 which outlines the approach used to identify the type of claims in the HMRC administrative data set.

[84] In the case of the Arellano-Bond estimation (discussed in section A1.4), Roodman (2009a) advocates the use of time dummies to ensure that the assumption of no correlation across the idiosyncratic error terms and robust estimation of coefficient standard errors are satisfied.

[85] This leads to the loss of 1300 observations.

Table 21 Sample size for data set including all variables by estimation approach

Financial year	Ordinary Least Squares (OLS)	Fixed Effects (FE)	Arellano-Bond (A-B)
2000–01	1,175	1,175	0
2001–02	2,369	2,369	0
2002–03	3,430	3,430	369
2003–04	3,985	3,985	933
2004–05	4,120	4,120	1,409
2005–06	3,984	3,984	1,684
2006–07	4,313	4,313	1,913
2007–08	4,959	4,959	2,032
2008–09	5,664	5,664	2,303
2009–10	6,461	6,461	2,748
2010–11	7,263	7,263	3,134
2011–12	8,823	8,823	3,508
2012–13	11,667	11,667	4,364
2013–14	13,876	13,876	5,778
2014–15	15,822	15,822	9,841
2015–16	19,072	19,072	13,725
2016–17	21,862	21,862	15,175
Total	**138,845**	**138,845**	**68,916**

Note: The Arellano-Bond estimation first-differences the data and includes the lagged dependent variable as a control, which removes observations in the financial years of 2000–01 and 2001–02.

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

A1.7 Estimation results

A1.7.1 Ordinary Least Squares (OLS) and Fixed Effects (FE) estimations

Table 22 OLS and FE model estimations

Model	OLS 1	OLS 2	OLS 3	OLS 4	FE 1	FE 2	FE 3	FE 4
User cost of capital (t)	–9.127*** (0.395)	–8.816*** (0.397)	–5.701*** (0.380)	–7.718*** (0.408)	–0.901** (0.353)	–0.915** (0.355)	–0.590* (0.344)	–0.795** (0.368)
Turnover (t)	0.276*** (0.002)	0.282*** (0.002)	0.057*** (0.003)	0.034*** (0.003)	0.232*** (0.006)	0.232*** (0.006)	0.165*** (0.006)	0.147*** (0.006)
Sector-level GVA growth		1.366*** (0.057)	1.713*** (0.055)	1.855*** (0.064)		0.028 (0.043)	0.061 (0.043)	0.050 (0.050)
Number of employees			0.417*** (0.004)	0.466*** (0.005)			0.314*** (0.009)	0.333*** (0.010)
Liquidity ratio				0.005*** (0.001)				0.000 (0.001)
Constant	8.874*** (0.106)	8.673*** (0.107)	10.205*** (0.103)	11.428*** (0.097)	8.443*** (0.102)	8.433*** (0.102)	8.465*** (0.095)	8.722*** (0.103)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	187,074	185,920	182,566	138,845	187,074	185,920	182,566	138,845
Adjusted R^2	0.156	0.159	0.215	0.219	0.764	0.764	0.770	0.776
Coefficient on user cost	–9.127	–8.816	–5.701	–7.718	–0.901	–0.915	–0.590	–0.795
Coefficient on user cost (p-value)	0.000	0.000	0.000	0.000	0.011	0.010	0.087	0.031

Note: Asterisks indicate statistical significance where p-values are: *** p<0.01, ** p<0.05, * p<0.1. Values in parentheses are standard errors.
Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 23 OLS and FE model: additionality ratios

Table 23.a User cost mean and median

Model	OLS 1	OLS 2	OLS 3	OLS 4	FE 1	FE 2	FE 3	FE 4
User cost mean (based on estimation sample)	0.180	0.180	0.180	0.183	0.180	0.180	0.180	0.183
User cost median (based on estimation sample)	0.172	0.172	0.172	0.173	0.172	0.172	0.172	0.173

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 23.b Short-run user cost elasticity

Model	OLS 1	OLS 2	OLS 3	OLS 4	FE 1	FE 2	FE 3	FE 4
At mean	–1.643	–1.586	–1.026	–1.410	–0.162	–0.165	–0.106	–0.145
At median	–1.569	–1.515	–0.980	–1.337	–0.155	–0.157	–0.101	–0.138
User cost elasticity (p-value)	0.000	0.000	0.000	0.000	0.011	0.010	0.087	0.031

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 23.c Additionality ratios

Model	OLS 1	OLS 2	OLS 3	OLS 4	FE 1	FE 2	FE 3	FE 4
Deduction claim (*At mean value of user cost)*	1.693	1.660	1.268	1.551	0.278	0.282	0.187	0.251
Payable credit claim (*At mean value of user cost)*	1.312	1.288	0.994	1.206	0.224	0.227	0.151	0.202
Deduction claim (*At median value of user cost)*	1.649	1.617	1.230	1.502	0.267	0.271	0.179	0.239
Payable credit claim (*At median value of user cost)*	1.280	1.256	0.965	1.170	0.215	0.218	0.144	0.193

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

A1.7.2 Arellano-Bond (A-B) estimations

Table 24 A-B model estimations

Model	A-B 1	A-B 2	A-B 3	A-B 4	A-B 5
User cost of capital (t)	–2.819 (2.366)	–3.858 (2.768)	–3.770 (2.774)	–2.580 (2.579)	–0.798 (2.705)
User cost of capital (t–1)		–1.954 (2.122)	–2.057 (2.128)	–2.411 (2.045)	–2.430 (2.109)
Turnover (t)	–0.136*** (0.039)	–0.155*** (0.039)	–0.155*** (0.039)	–0.123*** (0.039)	–0.092** (0.039)
R&D expenditure (t–1)	0.308*** (0.036)	0.324*** (0.035)	0.323*** (0.035)	0.324*** (0.037)	0.294*** (0.040)
Sector-level GVA growth			0.015 (0.054)	0.018 (0.054)	0.018 (0.058)
Number of employees				–0.100 (0.062)	–0.085 (0.062)
Liquidity ratio					0.003 (0.005)
Year dummies	Yes	Yes	Yes	Yes	Yes
Number of observations	69,868	69,868	69,595	68,916	58,307
Joint coefficient on user cost	–2.819	–5.812	–5.827	–4.991	–3.228
Joint coefficient on user cost (p-value)	0.233	0.010	0.010	0.022	0.136
Number of instruments	94	119	120	147	174
Hansen test: degrees of freedom	χ(76)	χ(100)	χ(100)	χ(126)	χ(152)
Hansen test: test statistic	86	112	111	127	158
Hansen test (p-value)	0.21 (satisfied)	0.20 (satisfied)	0.21 (satisfied)	0.46 (satisfied)	0.35 (satisfied)
Arellano-Bond test – AR(3) (p-value)	0.41 (satisfied)	0.39 (satisfied)	0.41 (satisfied)	0.29 (satisfied)	0.23 (satisfied)

Note: Asterisks indicate statistical significance where p-values are: *** p<0.01, ** p<0.05, * p<0.1. Values in parentheses are standard errors.
Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 25 A-B model: Additionality ratios

Table 25.a User cost mean and median

Model	A-B 1	A-B 2	A-B 3	A-B 4	A-B 5
User cost mean (based on estimation sample)	0.178	0.178	0.178	0.178	0.180
User cost median (based on estimation sample)	0.172	0.172	0.172	0.172	0.172

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 25.b Short-run user cost elasticity

Model	A-B 1	A-B 2	A-B 3	A-B 4	A-B 5
At mean	–0.503	–1.037	–1.040	–0.890	–0.581
At median	–0.484	–0.999	–1.001	–0.858	–0.555
User cost elasticity (p-value)	0.233	0.010	0.010	0.022	0.136

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 25.c Additionality ratios

Model	A-B 1	A-B 2	A-B 3	A-B 4	A-B 5
Deduction claim (*At mean value of user cost)*	0.749	1.278	1.280	1.151	0.839
Payable credit claim (*At mean value of user cost)*	0.595	1.001	1.002	0.905	0.665
Deduction claim (*At median value of use cost)*	0.726	1.246	1.248	1.122	0.810
Payable credit claim (*At median value of use cost)*	0.577	0.977	0.978	0.882	0.642

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

A1.7.3 Robustness checks estimations

The robustness of the results obtained using the preferred Arellano-Bond model specification[86] is tested in a number of ways:

- Changes to the model specification:
  - A second additional lagged term of the user cost is included in the model (RC 1); and
  - The full set of instruments available for the user cost are used instead of limiting the maximum to two lags (RC 2).
- Changes to the data sample:
  - The 1st and 99th percentiles of real R&D expenditure are trimmed from the estimation sample (RC 3);
  - The 99th percentile of real R&D expenditure is trimmed from the estimation sample (RC 4);
  - The estimation is rerun using non-interpolated data (RC 5); and
  - The estimation is rerun excluding combined claims (RC 6).
- Changes to underlying assumptions:
  - The combined value of the general-purpose financial cost of capital and the depreciation rate of capital used in the calculation of the user cost[87] is varied from 15%, 20%, 30%, and 35% (compared to the baseline value of 25%) (RC 7 to 10).
- Changes to the estimation period:
  - In line with Fowkes, Sousa, and Duncan (2015), the model is re-estimated from 2002–03 to 2012–13 (RC 11);
  - The model is also re-estimated in the recent financial years of 2013–14 to 2016–17 (not included in Fowkes, Sousa, and Duncan (2015)) (RC 12);
  - In line with HMRC (2010), the model is re-estimated from 2002–03 to 2007–08 (RC 13); and
  - The model is also re-estimated in the financial years of 2008–09 to 2016–17 (RC 14).

[86] The preferred A-B estimation is provided in the penultimate column in Table 24. Explanatory variables are the user cost, lagged user cost, lagged real R&D expenditure, real turnover, number of employees, growth in industry-level GVA and time dummies (liquidity ratio is not included in the preferred model because this would lead to the loss of over 10,000 observations, as illustrated by the difference in sample sizes between models A-B 4 and A-B 5). The estimated user cost elasticity in this case is –0.89 with additionality ratios of 1.15 for a deduction claim and 0.90 for a tax credit claim.

[87] See section A1.5 for further details.

Table 26 Robustness checks (RC 1 to RC 7) estimations

Model	RC 1	RC 2	RC 3	RC 4	RC 5	RC 6	RC 7
User cost of capital (t)	–1.308 (2.363)	–2.430 (2.376)	–2.973 (2.724)	–2.969 (2.761)	–2.429 (2.747)	–2.117 (4.055)	–4.300 (4.298)
User cost of capital (t–1)	–1.857 (2.283)	–1.829 (1.855)	–3.354 (2.160)	–2.173 (2.197)	–2.478 (2.154)	–0.823 (3.187)	–4.018 (3.408)
User cost of capital (t–2)	1.114 (0.922)						
Turnover (t)	–0.082** (0.036)	–0.087** (0.036)	–0.151*** (0.043)	–0.150*** (0.043)	–0.123*** (0.043)	–0.064 (0.063)	–0.123*** (0.039)
R&D expenditure (t–1)	0.346*** (0.065)	0.255*** (0.036)	0.368*** (0.038)	0.349*** (0.039)	0.307*** (0.038)	0.223*** (0.060)	0.324*** (0.037)
Sector-level GVA growth	0.042 (0.064)	0.023 (0.052)	0.023 (0.054)	0.014 (0.055)	0.020 (0.054)	–0.003 (0.067)	0.018 (0.054)
Number of employees	–0.064 (0.063)	–0.011 (0.057)	0.053 (0.063)	–0.066 (0.064)	–0.080 (0.063)	–0.209** (0.084)	–0.100 (0.062)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	43,851	68,916	67,550	68,233	67,616	40,804	68,916
Joint coefficient on user cost	–2.051	–4.259	–6.327	–5.142	–4.907	–2.940	–8.318
Joint coefficient on user cost (p-value)	0.224	0.040	0.005	0.022	0.028	0.399	0.022
Number of instruments	156	291	147	147	147	147	147
Hansen test: degrees of freedom	χ(135)	χ(270)	χ(126)	χ(126)	χ(126)	χ(126)	χ(126)
Hansen test: test statistic	135	299	155	135	129	128	127
Hansen test (p-value)	0.47 (satisfied)	0.11 (satisfied)	0.04 (not satisfied)	0.27 (satisfied)	0.40 (satisfied)	0.43 (satisfied)	0.46 (satisfied)
Arellano-Bond test – AR(3) (p-value)	0.46 (satisfied)	0.53 (satisfied)	0.41 (satisfied)	0.24 (satisfied)	0.23 (satisfied)	0.62 (satisfied)	0.29 (satisfied)

Note: Asterisks indicate statistical significance where p-values are: *** p<0.01, ** p<0.05, * p<0.1. Values in parentheses are standard errors.

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 27 Robustness checks (RC 1 to RC 7): Additionality ratios

Table 27.a User cost mean and median

Model	RC 1	RC 2	RC 3	RC 4	RC 5	RC 6	RC 7
User cost mean (based on estimation sample)	0.179	0.178	0.178	0.178	0.178	0.179	0.107
User cost median (based on estimation sample)	0.172	0.172	0.172	0.172	0.172	0.172	0.103

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 27.b Short-run user cost elasticity

Model	RC 1	RC 2	RC 3	RC 4	RC 5	RC 6	RC 7
At mean	–0.366	–0.760	–1.129	–0.917	–0.876	–0.525	–0.890
At median	–0.352	–0.732	–1.087	–0.884	–0.843	–0.505	–0.858
User cost elasticity (p-value)	0.224	0.040	0.005	0.022	0.028	0.399	0.022

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 27.c Additionality ratios

Model	RC 1	RC 2	RC 3	RC 4	RC 5	RC 6	RC 7
Deduction claim *(At mean value of user cost)*	0.576	1.028	1.351	1.176	1.138	0.775	1.151
Payable credit claim *(At mean value of user cost)*	0.459	0.811	1.056	0.923	0.895	0.615	0.905
Deduction claim *(At median value of use cost)*	0.557	1.000	1.318	1.145	1.108	0.752	1.122
Payable credit claim *(At median value of use cost)*	0.444	0.789	1.032	0.900	0.872	0.597	0.882

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 28 Robustness checks (RC 8 to RC 14) estimations

Model	RC 8	RC 9	RC 10	RC 11	RC 12	RC 13	RC 14
User cost of capital (t)	–3.225 (3.223)	–2.150 (2.149)	–1.843 (1.842)	–8.365* (4.976)	2.532 (3.472)	5.688 (11.756)	–3.526 (2.718)
User cost of capital (t–1)	–3.014 (2.556)	–2.009 (1.704)	–1.722 (1.461)	–7.894 (5.420)	–1.771 (2.145)	–13.051 (11.180)	–1.721 (2.118)
User cost of capital (t–2)							
Turnover (t)	–0.123*** (0.039)	–0.123*** (0.039)	–0.123*** (0.039)	–0.073 (0.059)	–0.081 (0.081)	–0.140 (0.101)	–0.110** (0.044)
R&D expenditure (t–1)	0.324*** (0.037)	0.324*** (0.037)	0.324*** (0.037)	0.162** (0.068)	0.292*** (0.056)	0.220** (0.107)	0.346*** (0.041)
Sector-level GVA growth	0.018 (0.054)	0.018 (0.054)	0.018 (0.054)	–0.008 (0.074)	0.042 (0.068)	–0.386** (0.184)	0.065 (0.057)
Number of employees	–0.100 (0.062)	–0.100 (0.062)	–0.100 (0.062)	–0.091 (0.076)	0.149 (0.148)	0.017 (0.133)	–0.160** (0.074)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	68,916	68,916	68,916	24,397	44,519	8,340	60,576
Joint coefficient on user cost	–6.239	–4.159	–3.565	–16.259	0.761	–7.363	–5.247
Joint coefficient on user cost (p-value)	0.022	0.022	0.022	0.002	0.824	0.649	0.020
Number of instruments	147	147	147	103	45	48	100
Hansen test: degrees of freedom	χ(126)	χ(126)	χ(126)	χ(86)	χ(35)	χ(36)	χ(85)
Hansen test: test statistic	127	127	127	80	44	25	96
Hansen test (p-value)	0.46 (satisfied)	0.46 (satisfied)	0.46 (satisfied)	0.67 (satisfied)	0.13 (satisfied)	0.92 (satisfied)	0.19 (satisfied)
Arellano-Bond test – AR(3) (p-value)	0.29 (satisfied)	0.29 (satisfied)	0.29 (satisfied)	0.93 (satisfied)	0.57 (satisfied)	0.24 (satisfied)	0.15 (satisfied)

Note: Asterisks indicate statistical significance where p-values are: *** p<0.01, ** p<0.05, * p<0.1. Values in parentheses are standard errors.

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 29 Robustness checks (RC 8 to RC 14): Additionality ratios

Table 29.a User cost mean and median

Model	RC 8	RC 9	RC 10	RC 11	RC 12	RC 13	RC 14
User cost mean (based on estimation sample)	0.143	0.214	0.250	0.194	0.170	0.207	0.174
User cost median (based on estimation sample)	0.138	0.206	0.241	0.191	0.169	0.210	0.170

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 29.b Short-run user cost elasticity

Model	RC 8	RC 9	RC 10	RC 11	RC 12	RC 13	RC 14
At mean	–0.890	–0.890	–0.890	–3.162	0.129	–1.523	–0.915
At median	–0.858	–0.858	–0.858	–3.113	0.128	–1.543	–0.889
User cost elasticity (p-value)	0.022	0.022	0.022	0.002	0.824	0.649	0.020

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

Table 29.c Additionality ratios

Model	RC 8	RC 9	RC 10	RC 11	RC 12	RC 13	RC 14
Deduction claim *(At mean value of user cost)*	1.151	1.151	1.151	2.311	–0.255	1.622	1.174
Payable credit claim *(At mean value of user cost)*	0.905	0.905	0.905	1.763	–0.208	1.259	0.922
Deduction claim *(At median value of use cost)*	1.122	1.122	1.122	2.296	–0.254	1.634	1.151
Payable credit claim *(At median value of use cost)*	0.882	0.882	0.882	1.753	–0.207	1.268	0.904

A1.8 Robustness checks

Table 30 provides a summary of the user cost elasticity estimate and associated additionality ratio (by type of claim) for each of the robustness checks described above.

To check whether results are robust to an alternative specification, a second lag of the user cost was included in the model. The estimate from this specification is less elastic than that from the preferred model and no longer statistically significant. It should be noted, however, that the addition of the second lag of user cost leads to the loss of over 25,000 observations (which are unlikely to be randomly distributed with respect to variables of interest), so it is possible that the lower elasticity is at least in part due to the change in estimation sample.

As noted in A1.4, the baseline A-B models limit the number of instruments to avoid instrument proliferation. If, instead, all available instruments are used, the estimated elasticity and additionality ratios are still within the range of those obtained from the baseline specifications and close to the estimate from the preferred model.

Trimming the data sample yields more elastic (in other words, more negative) estimates of the user cost compared to the chosen model specification, which may be expected as outliers are excluded when the data sample is trimmed. Dropping combined claims leads to a lower elasticity (in terms of magnitude). Given the sizeable proportion of combination claimants and the fact that these applicants are likely to have particular characteristics,[88] their exclusion is expected to impact results. It should be noted, however, that the preferred model joint coefficient (that is, the estimate of the semi-elasticity) lies within the 95% confidence interval of all three model estimates, suggesting that the model is relatively stable.

There is little to no change in the user cost elasticity when the model is estimated using non-interpolated data or when underlying assumptions used to calculate the user cost are changed.

As shown in the last rows of Table 30, R&D expenditure is estimated to be less elastic to changes in the user cost in more recent years compared to earlier years. Sub-section 2.3.3 provides a more detailed discussion.

[88] For instance, profitable businesses with enhanced R&D expenditure in excess of profits (these are a subset of combined claimants), may have a successful business model (they are profitable), as well as a strong reliance on innovation (because of high R&D expenditure relative to profits).

Table 30 Robustness checks based on preferred A-B model specification

Robustness check	Estimated user cost elasticity[1]	Additionality ratio[2] Deduction claim	Additionality ratio[2] Tax credit claim
Introducing a second lag of user cost	–0.37	0.58	0.46
Using the full set of instruments for endogenous variables	–0.76**	1.03	0.81
Trimming the 1st and 99th percentiles (based on R&D expenditure)	–1.13***	1.35	1.06
Trimming the 99th percentiles (based on R&D expenditure)	–0.92**	1.18	0.92
Using non-interpolated data variables	–0.88**	1.14	0.90
Dropping combined claims	–0.53	0.78	0.62
Changes to the general-purpose financial cost of capital and the depreciation rate used to calculate the user cost	–0.89***	1.15	0.91
Estimation period: 2002–03–2012–13	–3.16***	2.31	1.76
Estimation period: 2013–14–2016–17	0.13	–0.26	-0.21
Estimation period: 2002–03–2007–08	–1.52	1.62	1.26
Estimation period: 2008–09–2016–17	–0.92***	1.17	0.92

Note: (1) Full Arellano-Bond estimation results are provided in Table 26 and 0. Estimated user cost elasticities are based on mean value of user cost in the estimation sample. Elasticities at the median value are also provided in the Table 27 and Table 29. (2) Examples of the calculation of the additionality ratio are provided in Table 31 for a deduction claim and Table 32 for a tax credit claim. Asterisks indicate statistical significance where p-values are: *** p<0.01, ** p<0.05, * p<0.1.

Source: London Economics' analysis of HMRC-IDBR-FAME matched data

A1.9 Calculating the additionality ratio

A1.9.1 Assuming a one percentage point increase in the additional deduction or credit rate

Table 31 and Table 32 show the stepwise calculation of the additionality ratio for a deduction and credit claim (respectively), assuming a one percentage point increase in the relevant rate in 2016–17.

Table 31 Calculation of the additionality ratio assuming a 1pp increase in the additional deduction rate

Table 31.a User cost elasticity estimate (η): Lower bound: –0.50

	Formulas and notations	Before (b)	After (a)
Additional deduction rate	ρ_1	130%	131%
CT rate	τ	20%	20%
User cost of capital	$C = \frac{1-(1+\rho_1)*\tau}{1-\tau}*(r+\delta)$	0.169	0.168
R&D expenditure	$R_a = R_b*(1+\eta*\frac{C_a-C_b}{C_b})$	100.00	100.19
Exchequer cost	$E = \tau * R * \rho_1$	26.00	26.25
Additionality ratio	$A = \frac{R_a-R_b}{E_a-E_b}$	**0.75**	**0.75**

Note: r is the general-purpose financial cost of capital to the firm (assumed to be 10%) and δ is the depreciation rate of capital (assumed to be 15%).
Source: London Economics' analysis

Table 31.b User cost elasticity estimate (η): Upper bound: –1.04

	Formulas and notations	Before (b)	After (a)
Additional deduction rate	ρ_1	130%	131%
CT rate	τ	20%	20%
User cost of capital	$C = \frac{1-(1+\rho_1)*\tau}{1-\tau}*(r+\delta)$	0.169	0.168
R&D expenditure	$R_a = R_b*(1+\eta*\frac{C_a-C_b}{C_b})$	100.00	100.39
Exchequer cost	$E = \tau * R * \rho_1$	26.00	26.30
Additionality ratio	$A = \frac{R_a-R_b}{E_a-E_b}$	**1.28**	**1.28**

Note: r is the general-purpose financial cost of capital to the firm (assumed to be 10%) and δ is the depreciation rate of capital (assumed to be 15%).
Source: London Economics' analysis

Table 32 Calculation of the additionality ratio assuming a 1pp increase in the credit rate

Table 32.a User cost elasticity estimate (η): Lower bound: –0.50

	Formulas and notations	Before (b)	After (a)
Additional deduction rate	ρ_1	130%	130%
Credit rate	ρ_2	14.5%	15.5%
User cost of capital	$C = (1 - (1 + \rho_1) * \rho_2) * (r + \delta)$	0.167	0.161
R&D expenditure	$R_a = R_b * (1 + \eta * \frac{C_a - C_b}{C_b})$	100.00	101.70
Exchequer cost	$E = \rho_2 * R * (1 + \rho_1)$	33.35	36.27
Additionality ratio	$A = \frac{R_a - R_b}{E_a - E_b}$	**0.60**	**0.60**

Note: r is the general-purpose financial cost of capital to the firm (assumed to be 10%) and δ is the depreciation rate of capital (assumed to be 15%).
Source: London Economics' analysis

Table 32.b User cost elasticity estimate (η): Upper bound: –1.04

	Formulas and notations	Before (b)	After (a)
Additional deduction rate	ρ_1	130%	130%
Credit rate	ρ_2	14.5%	15.5%
User cost of capital	$C = (1 - (1 + \rho_1) * \rho_2) * (r + \delta)$	0.167	0.161
R&D expenditure	$R_a = R_b * (1 + \eta * \frac{C_a - C_b}{C_b})$	100.00	103.59
Exchequer cost	$E = \rho_2 * R * (1 + \rho_1)$	33.35	36.93
Additionality ratio	$A = \frac{R_a - R_b}{E_a - E_b}$	**1.00**	**1.00**

Note: r is the general-purpose financial cost of capital to the firm (assumed to be 10%) and δ is the depreciation rate of capital (assumed to be 15%).
Source: London Economics' analysis

A1.9.2 Assuming a one per cent increase in the additional deduction and credit rates

Table 33 and Table 34 show the stepwise calculation of the additionality ratio for a deduction and credit claim (respectively), assuming a one per cent increase in the relevant rate in 2016–17.

Table 33 Calculation of the additionality ratio assuming a 1% increase in the additional deduction rate

Table 33.a User cost elasticity estimate (η): Lower bound: –0.50

	Formulas and notations	Before (b)	After (a)
Additional deduction rate	ρ_1	130%	131.3%
CT rate	τ	20%	20%
User cost of capital	$C = \frac{1-(1+\rho_1)*\tau}{1-\tau}*(r+\delta)$	0.169	0.168
R&D expenditure	$R_a = R_b*(1+\eta*\frac{C_a-C_b}{C_b})$	100.00	100.24
Exchequer cost	$E = \tau * R * \rho_1$	26.00	26.32
Additionality ratio	$A = \frac{R_a-R_b}{E_a-E_b}$	**0.75**	**0.75**

Note: r is the general-purpose financial cost of capital to the firm (assumed to be 10%) and δ is the depreciation rate of capital (assumed to be 15%).
Source: London Economics' analysis

Table 33.b User cost elasticity estimate (η): Upper bound: –1.04

	Formulas and notations	Before (b)	After (a)
Additional deduction rate	ρ_1	130%	131.3%
CT rate	τ	20%	20%
User cost of capital	$C = \frac{1-(1+\rho_1)*\tau}{1-\tau}*(r+\delta)$	0.169	0.168
R&D expenditure	$R_a = R_b*(1+\eta*\frac{C_a-C_b}{C_b})$	100.00	100.50
Exchequer cost	$E = \tau * R * \rho_1$	26.00	26.39
Additionality ratio	$A = \frac{R_a-R_b}{E_a-E_b}$	**1.28**	**1.28**

Note: r is the general-purpose financial cost of capital to the firm (assumed to be 10%) and δ is the depreciation rate of capital (assumed to be 15%).
Source: London Economics' analysis

Table 34 Calculation of the additionality ratio assuming a 1% increase in the credit rate

Table 34.a User cost elasticity estimate (η): Lower bound: –0.50

	Formulas and notations	Before (b)	After (a)
Additional deduction rate	ρ_1	130%	130%
Credit rate	ρ_2	14.5%	14.6%
User cost of capital	$C = (1 - (1 + \rho_1) * \rho_2) * (r + \delta)$	0.167	0.166
R&D expenditure	$R_a = R_b * (1 + \eta * \frac{C_a - C_b}{C_b})$	100.00	100.25
Exchequer cost	$E = \rho_2 * R * (1 + \rho_1)$	33.35	33.77
Additionality ratio	$A = \frac{R_a - R_b}{E_a - E_b}$	**0.60**	**0.60**

Note: r is the general-purpose financial cost of capital to the firm (assumed to be 10%) and δ is the depreciation rate of capital (assumed to be 15%).
Source: London Economics' analysis

Table 34.b User cost elasticity estimate (η): Upper bound: –1.04

	Formulas and notations	Before (b)	After (a)
Additional deduction rate	ρ_1	130%	130%
Credit rate	ρ_2	14.5%	14.6%
User cost of capital	$C = (1 - (1 + \rho_1) * \rho_2) * (r + \delta)$	0.167	0.166
R&D expenditure	$R_a = R_b * (1 + \eta * \frac{C_a - C_b}{C_b})$	100.00	100.52
Exchequer cost	$E = \rho_2 * R * (1 + \rho_1)$	33.35	33.86
Additionality ratio	$A = \frac{R_a - R_b}{E_a - E_b}$	**1.02**	**1.02**

Note: r is the general-purpose financial cost of capital to the firm (assumed to be 10%) and δ is the depreciation rate of capital (assumed to be 15%).
Source: London Economics' analysis

A1.10 Literature review and comparisons of user cost elasticity and additionality ratio

Table 35 Summary of empirical studies of user cost elasticity and additionality ratios

Study	Data	Geography	Period	Method	Elasticity	Additionality
Berger (1993)	Panel of 263 firms	United States	1975–1989	FE	–1.5 to –1.0	1.74
Hall (1993)	Panel of 800 firms	United States	1981–1991	GMM	–1.5 to –0.8	2
Hines (1993)	Panel of 116 firms	United States	1984–1989	OLS, IV	–1.6 to –1.2	1.3 to 2
Shah (1994)	Panel of 18 industries	Canada	1963–1983	System of simultaneous equations	–0.16	1.8
Mamuneas and Nadiri (1996)	15 industries	United states	1956–1988	MLE	–1 to –0.84	0.95
Dagenais and others (1997)	Panel of 437 firms	Canada	1975–1992	Generalised Tobit (FE)	–0.07	0.98
Bloom and others (2002)	Panel of 155 to 165 observations	Nine OECD Member States[89]	1979–1997	IV	–0.14	–
Parisi and Sembenelli (2003)	Panel of 726 firms	Italy	1992–1997	Tobit (RE)	–1.77 to –1.5	–
Harris and others (2009)	Panel of 563 firms	United Kingdom (Northern Ireland)	1998–2003	GMM	–1.36 (LR)	–
HMRC (2010)	Panel of 236 firms	United Kingdom	2003–2007	GMM (A-B)	–2.59 to –1.6	0.41 to 3.37
Lokshin and Mohnen (2012)	Panel of 1,185 observations	The Netherlands	1996–2004	ECM (IV, FE),	–0.5 to –0.2	0.42 to 3.24
Fowkes and others (2015)	Panel of 4,685 firms	United Kingdom	2003–2012	OLS, FE, GMM (A-B)	–1.96	1.53 (credit), 1.88 (deduction)
Bozio and others (2017)	Panel of up to 16,853 firms	France	2004–2010	DD with FE	–	1.1 to 1.5

[89] Australia, Canada, France, Germany, Italy, Japan, Spain, the United Kingdom and the United States.

Study	Data	Geography	Period	Method	Elasticity	Additionality
Lopez et Mairesse (2018)	Panel of 3,324 observations	France	2002-2012	System of simultaneous equations	–1.9 to –1.1 (LR)	1.2 (LR)
Mulkay et Mairesse (2018)	Panel of up to 4,037 firms	France	2008–2013	GMM (A-B)	–0.5 (LR)	0.9 (LR)
Dechezleprêtre and others (2019)	Panel of 5,888 firms	United Kingdom	2006–2011	RDD	–3.99 (median estimate)	SME scheme: 2.92 (credit), 3.87 (deduction)

Note: OLS=Ordinary Least Squares; FE=Fixed Effects estimation; GMM=Generalised Methods of Moments; A-B=Arellano-Bond estimation; IV=Instrumental Variable; MLE=Maximum Likelihood Estimation; RE=Random Effects; DD=Difference in Differences; ECM=Error Correction Model; RDD= Regression Discontinuity Design; LR=Long-run.

Source: London Economics, Fowkes and others (2015) and European Commission (2014)

A2 Technical Annex 2: Indirect Impacts

A2.1 Data

Multiple data sources are used to assess the wider economic effects of the R&D tax relief scheme for SMEs (hereafter referred to as the scheme or SME scheme). As identified in the evaluation plan set out in the EC's decision letter[90], the result indicators of interest are:

- Business turnover;
- Business innovative behaviour (for example, patent applications); and
- Distortion of market competition (based on the distribution of claims or relief claimed by firm age, sector, region and market concentration).

Where possible, comparisons with non-claimants are made. Elements of the analysis presented in this chapter were undertaken at the UK's Secure Research Service (SRS) facility in London to access restricted firm microdata from ONS surveys and other confidential data sets. These are described in turn below.

A2.1.1 Data used for descriptive statistics

Along with the HMRC data (described in section A1.2), a number of ONS data sets were used for the descriptive statistics presented in this chapter.

The Business Structure Database (BSD) provides financial and economic information (such as turnover, employment, and sector) for almost all businesses in the UK. It is primarily derived from the Inter-Departmental Business Register (IDBR), which records data from HMRC and complementary ONS data sets.

To investigate changes in turnover for businesses that claim under the scheme (both in years that they claim and do not claim), the HMRC administrative data set was matched to the BSD in the SRS using the company registration numbers (CRNs). For confidentiality reasons, the CRNs were matched to unique enterprise reference numbers, which can be used to match across other ONS data sets. The SRS team matched 65,956 unique CRNs (out of 67,395 in the HMRC data set from 2000–01 to 2016–17 to enterprise reference numbers.[91] In total, there were 65,833 unique enterprise reference numbers, with some businesses matching to the same enterprise reference number.

The matched HMRC-BSD data set is also used to assess the distribution of the amount of relief by the market share of claiming businesses and by market concentration based on the Herfindahl-Hirschman Index (HHI). The HHI is a measure of market concentration of a sector, where a higher value suggests that a set of firms have a higher market share (in other words, are concentrated). It is calculated by taking the sum of squared market shares for all firms in a given industry. The analysis is undertaken at the two-digit SIC 2007 code, which identifies the industry in which the business operates.

[90] Ibid.

[91] A match rate of 98%.

Data on UK patent applications filed with the Intellectual Property Office (IPO) is also matched with the HMRC administrative data using company name and region (no postcode data is provided in the HMRC data). Given the possibility of incorrect matches based on company name and region, only exact matches by these variables are used in the analysis. Therefore, figures presented may underestimate the number of patent applications filed by claimants. The report does not use data provided in the UK Innovation Survey (UKIS) (part of the wider Community Innovation Survey (CIS) covering European countries) to examine patent activity as relevant questions are inconsistent across years.

To provide context on the wider economic effects of the scheme, aspects of the quantitative survey (discussed in further detail in section A3.1.1) are also analysed in relation to the result indicators. This allows for comparisons with the counterfactual group (that is, businesses that undertake R&D activities but did not claim under the scheme).

A2.1.2 Data used for Econometric analysis

To empirically quantify the wider economic effect of the scheme, an econometric model is estimated, which assesses the potential indirect and spillover impacts (at the sector and region levels) of the scheme on business turnover. This is done by separately estimating the impact of business-, region- and sector-level R&D expenditure on the turnover of businesses that conduct R&D as well as other businesses. The analysis undertaken at the SRS facility matches two data sets; namely, the Annual Respondents Database X (ARDx) and the Business Enterprise Research and Development (BERD) survey data set.

The ARDx respondent files contain harmonised financial variables based on three surveys: the Annual Business Enquiry (ABI) for years 1998–2008, and the Annual Business Survey (ABS) combined with the Business Register and Employment Survey (BRES) for years 2009 to 2014. The data set provides information on 43,000–58,000 businesses per reference year and covers all sectors, except the financial sector.[92]

The BERD survey covers approximately 5,400 of the 31,400 businesses conducting R&D in the UK, as of 2015. This includes the 400 companies with highest R&D expenditure, as well as a sample of the other firms. R&D expenditure of non-responding businesses within the sample frame are imputed.[93]

[92] Two-digit SIC 2007 codes 64 to 66.

[93] For further details, see ONS, 2016.

A2.2 Identification strategy

A firm's production function is the mechanism through which its inputs are translated into outputs. A common way to express this is given by the following formula[94]:

$$y_{it} = \alpha + \gamma_1 k_{i,t} + \gamma_2 l_{i,t} + \gamma_3 m_{i,t} + \beta_1 R\&D_{i,t-1} + \beta_2 R\&D_{S,t-1} + \beta_3 R\&D_{R,t-1} + \boldsymbol{\varphi X_{i,t}} + e_{it},$$

where y_{it} denotes log real turnover (the proxy for output)[95] and $k_{i,t}$, $l_{i,t}$ and $m_{i,t}$ denote log capital, log labour and log intermediate inputs (respectively).

The variables of interest are $R\&D_{it-1}$, $R\&D_{S,t-1}$, and $R\&D_{R,t-1}$ refer to business-, sector- and region-level R&D expenditure.

β_1 captures the 'indirect' effect of the scheme on business turnover and β_2 and β_3 capture the spillover effects of increased R&D expenditure (which may be incentivised by changes in the generosity of the scheme). R&D expenditure is lagged to account for the fact that R&D is likely to pay off in later periods.[96] $X_{i,S,R,t}$ includes other observable determinants of turnover (see below).

As both dependent and independent variables are in log form, the coefficients of interest are interpreted as elasticities (that is, a percentage change in one of the explanatory variables is associated with a given percentage change in real turnover).

The model is estimated controlling for firm fixed effects. A number of identification challenges must be addressed when estimating the model described above. These are discussed in turn below.

Omitted variables bias

There is a risk that the estimates of β_1, β_2 and β_3 may absorb the effect of 'omitted' unobserved determinants of both real turnover and R&D expenditure if these are not controlled for. Of particular concern is the role of time invariant firm-specific effects that may be correlated with R&D expenditure (for example, a business' entrepreneurial culture).[97] These time invariant factors can be eliminated through the fixed effects estimation. In addition, sector and region GVA are included to control for sectoral and regional shocks that may affect both real R&D expenditure and turnover. Given these considerations, the model specification can be rewritten as follows:

$$y_{it} = \alpha + \gamma_1 k_{i,t} + \gamma_2 l_{i,t} + \gamma_3 m_{i,t} + \beta_1 R\&D_{i,t-1} + \beta_2 R\&D_{S,t-1} + \beta_3 R\&D_{R,t-1} + \theta_1 GVA_{S,t-1} + \theta_2 GVA_{R,t-1} + \mu_i + u_{it},$$

where μ_i denotes company-specific effects and $GVA_{S,t-1}$ and $GVA_{R,t-1}$ denote sector- and region-level GVA (respectively).

[94] This assumes that the production function follows a Cobb-Douglas form.

[95] Turnover is not a perfect proxy for output for several reasons. First, it does not include output that was not sold. Second, in some cases, changes in turnover may be due to changes in market power (that is, businesses' ability to influence prices). The use of industry-level deflators – see section A2.3 – only partially adjusts for the latter phenomenon, as certain markets may be defined at a more granular level than that of the deflators. Note also that total output at basic prices, which is used as an alternative proxy for output, is also subject to the second caveat.

[96] Further lags are not used as this would reduce the sample size (The ARDx data used for the analysis is an unbalanced panel, so there are few observations that will have multiple lags available).

[97] Formally, the disturbance term may take the following form: $e_{it} = \mu_i + u_{it}$ with $E(\mu_i | R\&D_{i,t-1}, R\&D_{S,t-1}, R\&D_{R,t-1}) \neq 0$

Selection bias

Related to the issue of omitted variable bias, there is also a risk that results may be biased due to the potential 'selection' of R&D expenditure into highly productive businesses. This is because R&D expenditure is not exogenous and is likely to be the outcome of a choice (for example, businesses' profit maximising behaviour). Businesses may decide on the optimal level of R&D expenditure based on a number of factors, such as productivity, which are not fully observable to the econometrician.

Indeed, returns to R&D are potentially larger in highly productive firms, as new ideas and inventions may smoothly translate into profit. This form of selection bias would lead to an overestimate of the impact of R&D on turnover. To overcome this risk, R&D variables are lagged so that the estimates do not reflect the selection of R&D into firms that have experienced a positive productivity shock.

Simultaneity

As explained in section A1.5, larger turnover is likely to increase the funding available to businesses for expenditure on R&D activities. The use of lagged R&D expenditure variables, as described above, is intended to insulate the R&D parameter estimates from this feedback effect.

A2.3 Variables

The econometric analysis is based on a matched data set that combines the Annual Respondents Database X (ARDx) files with data from the BERD survey at the reporting unit level[98], as explained in section A2.1.2. The following variables were used in the estimation of the model described above.

Real turnover

Turnover is the preferred proxy for output as it is more populated than total output. This variable is contained in the ARDx files and sourced from the IDBR. It refers to the annual turnover at the time that the sample was sourced, it is mainly derived from the VAT trader system. Turnover is deflated using experimental industry-level deflators (ONS, 2017).

Total Output

Total output is also used as the dependent variable to check the robustness of the results. Total output is taken from the ARDx files at basic prices. This means that it is net of taxes on the output and includes subsidies. In contrast to turnover, total output also includes increases in inventories and unfinished products. Output is deflated using experimental industry-level deflators (ONS, 2017).

Factor inputs

Labour, capital and intermediate inputs are respectively captured by the ARDx's capital stock, IDBR employment and the ARDx's purchases of goods and services.

The ABI and ABS do not directly ask respondents to report the value of their capital stock. However, an ancillary 'capstock' data set was imputed by Prof. Richard Harris based on a perpetual inventory model (PIM) (ONS, ND). Capital stock was drawn from that data set.

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[98] A reporting unit is the business unit that responds to the questionnaire. Answers may refer to the enterprise or to local units. In the majority of cases, the reporting unit level is the same as the enterprise level (ONS, 2018).

Employment is contained in the ARDx files and sourced from the IDBR. This variable includes employees as well as working proprietors at the time that the sample was sourced (ONS, 2006).

Intermediate inputs are proxied through purchases of goods and materials. These are included within the ARDx files and are deflated using experimental industry-level deflators (ONS, 2017).

Intramural R&D expenditure

Total in-house capital and non-capital R&D expenditure is sourced from the BERD survey. R&D expenditure is deflated using the GDP deflator.

Sector and region-level intramural R&D expenditure

Sector-level R&D is based on both matched and unmatched firms. It is mostly aggregated at the SIC 2007 two-digit level, although some sectors are grouped, for consistency with the industry breakdown of the sector-level GVA macro series (see below). Regional R&D expenditure was aggregated within the seven English regions, Wales, Scotland and Northern Ireland.

Sector- and region-level GVA

Sectoral and regional GVA in chained volume measures (adjusted for inflation) are taken from the ONS (2018). Aggregation is consistent with sector- and region-level R&D.

A2.4 Sample data

The ARDx files contain a total of 854,732 observations across 1998–2014 and the BERD a total of 280,413 observations. 225,025 observations from the BERD were not matched to the ARDx. Therefore, after matching, the final data set contained 55,388 observations of businesses that conducted R&D, out of a total of 854,732 observations.

To ensure that the results are not due to outliers, the first and 99th percentiles based on turnover were trimmed.

The estimation sample, for which all necessary variables were available, is made up of 148,947 observations from firms that did not conduct R&D and 26,396 observations from firms that conducted R&D. These numbers are broken down by year in Table 36.

Table 36 Estimation sample by year

Year	Businesses that have not undertaken R&D	Businesses that undertook R&D
1999	10,644	1,514
2000	11,039	1,317
2001	10,885	1,483
2002	12,266	1,353
2003	11,205	1,712
2004	11,689	1,470
2005	10,773	1,655
2006	9,213	1,524
2007	7,951	1,820

Year	Businesses that have not undertaken R&D	Businesses that undertook R&D
2008	7,488	1,676
2009	8,601	1,602
2010	7,752	1,938
2011	6,923	1,690
2012	7,750	1,804
2013	7,525	1,966
2014	7,243	1,872
Total	**148,947**	**26,396**

Source: London Economics analysis of ARDx-BERD matched data set

A2.5 Estimation results

Table 37 Fixed effects estimation

Table 37.a Fixed effects estimation: businesses that undertake R&D

Dependent variable (in log)	All businesses (Turnover)	Baseline (Turnover)	Lagged factor inputs (Turnover)	Sector and region dummies included (Turnover)	Employment under 500 (Turnover)	Total output as dependent variable
Log(R&D expenditure) t–1	0.003*** (0.000)	0.021*** (0.004)	0.014*** (0.004)	0.019*** (0.004)	0.016*** (0.004)	0.016*** (0.004)
Log(sector R&D expenditure) t–1	0.006*** (0.001)	–0.011* (0.006)	–0.012** (0.006)	–0.006 (0.006)	–0.006 (0.007)	–0.008 (0.007)
Log(region R&D expenditure) t–1	0.041*** (0.008)	0.052** (0.021)	0.057*** (0.020)	0.024 (0.015)	0.035 (0.022)	0.015 (0.020)
Log(Capital stock)t	0.008*** (0.001)	0.010*** (0.003)		0.004 (0.002)	0.008** (0.003)	0.019*** (0.005)
Log(Capital stock)t–1			0.008*** (0.003)			
Log(Employment) t	0.559*** (0.011)	0.510*** (0.024)		0.535*** (0.022)	0.556*** (0.029)	0.455*** (0.022)
Log(Employment) t–1			0.483*** (0.022)			
Log(Materials) t	0.033*** (0.002)	0.039*** (0.006)		0.046*** (0.006)	0.035*** (0.006)	0.169*** (0.010)
Log(Materials) t–1			0.072*** (0.007)			
Sector GVA	0.043*** (0.004)	0.041*** (0.008)	0.045*** (0.007)	–0.039 (0.032)	0.041*** (0.008)	0.029*** (0.006)
Region GVA	0.160*** (0.015)	0.211*** (0.042)	0.186*** (0.042)	0.826*** (0.075)	0.224*** (0.052)	0.207*** (0.040)
Constant	2.166*** (0.293)	1.766** (0.889)	2.036** (0.839)	–7.996*** (1.567)	1.380 (1.015)	1.639** (0.747)

Dependent variable (in log)	All businesses (Turnover)	Baseline (Turnover)	Lagged factor inputs (Turnover)	Sector and region dummies included (Turnover)	Employment under 500 (Turnover)	Total output as dependent variable
Sector and region dummies	No	No	No	Yes	No	No
Number of observations	180,734	26,396	26,393	26,396	21,079	23,322
Adjusted R^2	0.188	0.165	0.175	0.206	0.158	0.199
Root Mean Squared Error	0.321	0.284	0.281	0.277	0.262	0.221

Note: Asterisks indicate statistical significance where p-values are: *** p<0.01, ** p<0.05, * p<0.1. Values in parentheses are standard errors.
Source: London Economics' analysis of ARDx-BERD matched data

Table 37.b Fixed effects estimation: businesses that do not undertake R&D

Dependent variable (in log)	All businesses (Turnover)	Baseline (Turnover)	Lagged factor inputs (Turnover)	Sector and region dummies included (Turnover)	Employment under 500 (Turnover)	Total output as dependent variable
Log(R&D expenditure) t–1	0.003*** (0.000)					
Log(sector R&D expenditure) t–1	0.006*** (0.001)	0.006*** (0.001)	0.006*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.001 (0.001)
Log(region R&D expenditure) t–1	0.041*** (0.008)	0.042*** (0.009)	0.047*** (0.008)	0.023*** (0.008)	0.040*** (0.011)	0.028** (0.011)
Log(Capital stock)t	0.008*** (0.001)	0.008*** (0.001)		0.006*** (0.001)	0.006*** (0.001)	0.005*** (0.001)
Log(Capital stock)t–1			0.004*** (0.001)			
Log(Employment) t	0.559*** (0.011)	0.540*** (0.011)		0.523*** (0.011)	0.533*** (0.012)	0.420*** (0.014)
Log(Employment) t–1			0.467*** (0.010)			
Log(Materials) t	0.033*** (0.002)	0.032*** (0.002)		0.035*** (0.002)	0.028*** (0.002)	0.153*** (0.007)
Log(Materials) t–1			0.053*** (0.003)			

Dependent variable (in log)	All businesses (Turnover)	Baseline (Turnover)	Lagged factor inputs (Turnover)	Sector and region dummies included (Turnover)	Employment under 500 (Turnover)	Total output as dependent variable
Sector GVA	0.043*** (0.004)	0.052*** (0.006)	0.055*** (0.006)	0.148*** (0.022)	0.041*** (0.006)	0.008 (0.006)
Region GVA	0.160*** (0.015)	0.161*** (0.017)	0.139*** (0.016)	0.665*** 0.035)	0.197*** (0.024)	0.117** (0.021)
Constant	2.166*** (0.293)	1.892*** (0.320)	2.397*** (0.309)	–8.252	1.381*** (0.443)	3.286*** (0.432)
Sector and region dummies	No	No	No	Yes	No	No
Number of observations	180,734	148,947	148,205	148,947	124,168	81,314
Adjusted R^2	0.188	0.183	0.185	0.194	0.140	0.199
Root Mean Squared Error	0.321	0.296	0.290	0.294	0.269	0.249

Note: Asterisks indicate statistical significance where p-values are: *** p<0.01, ** p<0.05, * p<0.1. Values in parentheses are standard errors.

Source: London Economics' analysis of ARDx-BERD matched data

A2.6 Robustness checks

It is possible that unobservable time-invariant industry- and geographical-level factors are correlated with both R&D expenditure and real turnover.[99] For instance, R&D expenditure may be more important in certain sectors such as the pharmaceutical industry, in which revenue generation usually depends on the invention of new drugs. The stability of estimated parameters is investigated through the addition of sector and region indicators. The elasticity of turnover with respect to firm-level R&D expenditure remains robust to this change. The spillover effects, however, are sensitive to the inclusion of sector and region dummies as their magnitude is approximately halved (and in the case of businesses that do conduct R&D, they are no longer statistically significant).

Input choices may be the outcome of R&D expenditure in the previous period. For instance, a company may decide to open a new factory to scale up the production of a new innovative product (factor inputs can help exploit technological breakthroughs). In that sense, part of the effect of R&D expenditure on real turnover may be subsumed in the coefficients on factor inputs (see Angrist and Pischke, 2008). This effect is likely to be limited in a model that controls for lagged rather than contemporaneous factor inputs. Estimates on the indirect and spillover effects of R&D expenditure are fairly robust to the use of lagged employment, capital stock and materials.

The main difference is a markedly lower indirect effect among R&D investors (albeit of the same order of magnitude). This may indicate that the impact of R&D expenditure on turnover operating through inputs is negative, in other words, higher R&D is associated with lower factor inputs in following periods. This is consistent with the idea that process innovations can allow firms to produce a given amount by using less resources.[100]

A further variation of the model uses total output at basic prices rather than turnover as the dependent variable. Although the indirect effects among R&D investors are reasonably robust to this change, the spillover estimates are quite sensitive. Indeed, the regional spillover effects decrease in magnitude for both groups of businesses and lose statistical significance among those that undertake R&D. Coefficients measuring the sectoral spillovers lose statistical significance across both groups of businesses. Given that total output is much more sparsely populated than turnover in the data set, it is unclear whether the difference in results is due to the choice of dependent variable or sample size.[101]

Finally, the model is run on the subsample of businesses that have fewer than 500 employees. This is intended to approximate eligibility to the scheme in its current form, as businesses that are eligible may have different turnover elasticities of R&D to businesses that are not eligible. The elasticity of turnover with respect to firm-level R&D decreases by approximately one third. The regional spillover effect loses statistical significance among R&D investors. The magnitude of sectoral spillovers decreases by approximately half for both groups of businesses and loses statistical significance among businesses that conduct R&D. These results suggest that the indirect and spillover effects may be greater among larger businesses.

[99] The preferred model does not control for sector and region, as these characteristics are typically slow-changing if not time invariant. These are therefore likely to be eliminated in FE estimation. This robustness check is conducted to investigate whether results are sensitive to cases in which firms do change regions or sectors.

[100] It should be noted that the effect of inputs on turnover is not fully captured if the former are only lagged. So, although lagged inputs are likely to capture some of the effect of contemporaneous inputs, these remain noisy proxies.

[101] Indeed, the estimation sample that uses turnover as a dependent variable comprises 181,441 observations, while the estimation sample that uses total output includes only 107,790 observations.

A3 Technical Annex 3: Proportionality and Appropriateness

A3.1 Methodology

To gather evidence on the proportionality and appropriateness of the R&D tax relief scheme for SMEs (hereafter referred to as the scheme or SME scheme), primary research was undertaken to collect information on the 'internal margin' of R&D expenditure (the potential impact of changes within the scheme in its current form, for example, if the rate increased by 10 pp, how much would you spend on R&D?), as well as the 'external margin' (the potential impact of alternative incentives for R&D or improvements to the scheme, for example, what types of support or improvements would incentivise R&D expenditure?).

Quantitative surveys of claimants and non-claimants were designed and conducted. These were followed by qualitative interviews with claimants to provide context and a deeper understanding of quantitative results. The remainder of this section gives further details on both primary research approaches undertaken by OMB Research Ltd., an independent market research company.

A3.1.1 Quantitative survey

Questionnaire design

Computer Assisted Telephone Interviewing (CATI) was used for the quantitative data collection. The research comprised:

- 800 interviews with companies who have claimed R&D tax relief; and
- 400 interviews with a control group of similar companies who have not claimed R&D tax relief; of which
  - 91 had conducted R&D but not claimed under the scheme since 2015–16; and
  - 309 had not conducted R&D.

In the context of this report, the 91 businesses that had invested in R&D activities but not claimed under the scheme form the 'true' counterfactual group (because they also conduct R&D, these are likely to be the most appropriate set of businesses for comparisons with the claimants).

To assess the proportionality of the scheme, claimants were asked questions that followed a format similar to the double-bounded dichotomous choice questions used in willingness-to-pay studies. Specifically, each respondent was asked if they would change their R&D expenditure following a hypothetical increase in the additional deduction rate from 130% to 140%, as well as a hypothetical decrease from 130% to 120%.[102] Under each scenario, respondents who indicated that they would change their R&D expenditure were then asked to quantify (in percentage terms) how much more or less their business would spend on R&D activities.

To assess the appropriateness of the scheme, claimants were asked if their R&D spending would change if they received a grant or subsidy (equal to the amount of relief claimed) at the start of the financial year, instead of the R&D tax relief (which is received retrospectively). As above,

[102] The ordering of the two questions were changed at random across the claimants to avoid question order bias.

respondents who indicated that they would change their R&D expenditure were also asked the extent to which their spending would change (in percentage terms).[103]

General questions on R&D activities and expenditure were also included. Claimants were also asked questions relating to the functioning of the scheme. Non-claimants were asked questions on their awareness of the scheme and, in the case of non-claimants who did not undertake any R&D, the perceived barriers to conducting R&D and incentive mechanisms that may encourage R&D expenditure by them in the future.

The surveys were also used to obtain information on the indirect effects of the scheme and allow for comparisons between claimants and non-claimants. Specific questions focussed on the use of different Intellectual Property (IP) protections (for example, patents and copyrights) as well as the composition of turnover (that is, the split in turnover by the types of good, services, or processes sold). Moreover, to understand the impact of the scheme on market competitiveness, specific questions on the actual, or perceived, impact on market share were asked. These results are provided in Chapter 3.

Sampling and fieldwork

HMRC's administrative database was used as the sample source to identify claimants for interview. A stratified random sample was provided covering all claimants in financial years 2015–16 and 2016–17. The sample was selected to be representative of the claimant population for this period and information on turnover, sector, age of incorporation, and region were used to stratify the sample and set broad quotas.

For the control group (that is, companies that have not claimed under the scheme), the sample was sourced from Bureau van Dijk's FAME database using a stratified random sampling approach. The sample was selected to match the claimant profile based on turnover, sector, age, and region. The non-claimant sample was then screened to ensure they had not claimed R&D tax relief in the last three years. The unweighted sample responses contained 91 non-claimants who had carried out some form of R&D since 2015–16 but not claimed under the scheme (in other words, the counterfactual) and 309 non-claimants who had not undertaken any R&D related activities since 2015–16.

Overall, the co-operation rate and adjusted response rate for claimants were 70% and 39% respectively, and 43% and 23% for non-claimants respectively. A more detailed breakdown of sample outcomes for the claimant survey is provided in the table below.

Table 38 Sample outcomes for the claimant survey

	All sample	%	Valid sample	%
Complete interviews	800	28%	800	39%
Refusals	337	12%	261	13%
Screened out	233	8%		
Unresolved*	1266	44%	980	48%
Not available in fieldwork period	18	1%	14	1%

[103] Findings from the existing literature on the appropriateness of tax relief, relative to direct subsidies, as a mechanism to incentivise R&D expenditure, are provided in section A3.2 of Technical Annex 3.

	All sample	%	Valid sample	%
Bad numbers	254	9%		
Total sample	2908	100%	2055	100%
Ineligible (screen out/(complete + screen-out))		23%		
Co-operation rate (complete/(complete + refusal))		70%		
Unadjusted response rate (complete/all sample)		28%		
Adjusted response rate (complete/valid sample)				39%

Note: *At the end of fieldwork these records were recorded as not having completed an interview, but not having refused or been confirmed as an unusable contact. In the vast majority of cases these records had been called on 10 or more occasions.

Source: OMB Research

Fieldwork took place between 11th April and 7th June 2019. Prior to fieldwork commencing, the questionnaires were fully piloted via a cognitive test followed by a quantitative pilot. The average interview length for claimants was 19 minutes and for non-claimants 13 minutes.

An opt-out stage was also included for the sample of claimants drawn from the HMRC administrative database. This involved sending a letter to all selected respondents and inviting them to either email or call if they did not want to take part in the survey. Two weeks were allowed between mail out of the letter and the start of fieldwork.

Table 39 compares the target sample frame with the counts that were achieved by the fieldwork for both claimants and non-claimants.

Table 39 Target sample frame and actual counts for claimants and non-claimants

Table 39.a.1 Claimants by age

	Target	Complete	Difference	% complete
Total	800	800	0	100%
Established 2008 onwards	346	326	20	94%
Established before 2008	454	474	–20	104%

Source: OMB Research

Table 39.a.2 Claimants by turnover

	Target	Complete	Difference	% complete
Total	800	800	0	100%
Up to £500,000	292	303	–11	104%
£500,000–£2,500,000	277	302	–25	109%
Over £2,500,000	231	195	36	84%

Source: OMB Research

Table 39.a.3 Claimants by region

	Target	Complete	Difference	% complete
Total	800	800	0	100%
East Midlands	51	55	–4	108%
East of England	79	82	–3	104%
London	154	128	26	83%
North East	28	29	–1	104%
North West	89	80	9	90%
Northern Ireland	23	21	2	91%
Scotland	35	38	–3	109%
South East	126	137	–11	109%
South West	64	72	–8	113%
Wales	25	26	–1	104%
West Midlands	71	69	2	97%
Yorkshire and The Humber	55	63	–8	115%

Source: OMB Research

Table 39.a.4 Claimants by sector

	Target	Complete	Difference	% complete
Total	800	800	0	100%
Manufacturing	201	213	–12	106%
Wholesale and Retail	88	92	–4	105%
Information and Communication	211	189	22	90%
Professional, Scientific and Technical	154	166	–12	108%
Other	146	140	6	96%

Source: OMB Research

Table 39.b.1 Non-claimants by age

	Target	Complete	Difference	% complete
Total	400	400	0	100%
Established 2008 onwards	173	147	26	85%
Established before 2008	227	253	–26	111%

Source: OMB Research

Table 39.b.2 Non-claimants by turnover

	Target	Complete	Difference	% complete
Total	400	400	0	100%
Up to £500,000	146	156	–10	107%
£500,000–£2,500,000	139	118	21	85%
Over £2,500,000	115	126	–11	110%

Source: OMB Research

Table 39.b.3 Non-claimants by region

	Target	Complete	Difference	% complete
Total	400	400	0	100%
East Midlands	26	18	8	69%
East of England	39	28	11	72%
London	77	77	0	100%
North East	14	16	–2	114%
North West	44	42	2	95%
Northern Ireland	11	11	0	100%
Scotland	18	26	–8	144%
South East	63	69	–6	110%
South West	32	37	–5	116%
Wales	13	11	2	85%
West Midlands	35	33	2	94%
Yorkshire and The Humber	28	32	–4	114%

Source: OMB Research

Table 39.b.4 Non-claimants by sector

	Target	Complete	Difference	% complete
Total	400	400	0	100%
Manufacturing	101	106	–5	105%
Wholesale and Retail	44	51	–7	116%
Information and Communication	105	84	21	80%
Professional, Scientific and Technical	77	77	0	100%
Other	73	82	–9	112%

Source: OMB Research

Weighting

Non-response bias weights were generated following the fieldwork to weight the sample to match the target sample frame. Table 40 provides a breakdown of the unweighted and weighted profile. The weights were based on the characteristics of turnover, age of incorporation, and sector.

Table 40 Unweighted and weighted profile

Table 40.a Age of incorporation

	Unweighted base	Unweighted %	Weighted base	Weighted %
Established 2008 onwards	326	41%	337	42%
Established before 2008	474	59%	463	58%

Source: OMB Research

Table 40.b Turnover

	Unweighted base	Unweighted %	Weighted base	Weighted %
Up to £500,000	303	38%	301	38%
500,000–£2,500,000	302	38%	274	34%
Over £2,500,000	195	24%	225	28%

Source: OMB Research

Table 40.c Sector

	Unweighted base	Unweighted %	Weighted base	Weighted %
Manufacturing	213	27%	201	25%
Wholesale and Retail	92	12%	90	11%
Information and Communication	189	24%	203	25%
Professional, Scientific and Technical	166	21%	153	19%
Other	140	18%	153	19%

Source: OMB Research

The analysis has been conducted applying the weights. Applying weights can increase or decrease both the point estimate of a statistic (for example, a mean) and variance around it, potentially leading to changes in the statistical significance of the differences between the two groups (claimants and non-claimants).

The advantage of applying weights is that any differences between the target sample frame and the composition of the actual sample are adjusted for. That is, the effects calculated with the weights applied reflect those we would expect of the target population. Conversely, the main disadvantage is that respondents that are underrepresented are given a high weight, which can increase noise in the sample data caused by potential outliers (and result in higher standard errors), making it more difficult to detect statistically significant effects.

As the sampling approach used a proportionate random sample there was no need to also factor in a design weight. As non-claimants were identified using the same sample frame as claimants, the same weighting is attributed to these respondents.

A3.1.2 Qualitative interviews

The qualitative phase consisted of 20 face-to-face interviews with claimants who had taken part in the CATI survey (and agreed to be recontacted). Care was taken to ensure a good mix of different business profiles (for example, age, turnover, and sector), as well as a range of experiences and impacts among the businesses recruited for the qualitative phase. All interviews were conducted by senior qualitative researchers and lasted approximately 60 minutes. A semi-structured discussion guide aided the interviews. The main areas of discussion included:

- Business processes to determine R&D budget and expenditure;
- Main sources of funding for R&D projects;
- Experiences with the application process for applying for the relief; and
- Understanding of the effect (if any) of the relief on R&D expenditure.

A3.2 Analysis of other survey questions

A3.2.1 R&D activities and expenditure

R&D expenditure of non-claimants

The most common reason (76%) for not undertaking R&D was lack of relevance to business activities (Table 41). A substantial proportion (40%) of respondents were utilising R&D by other businesses. Lack of funds to finance R&D was cited by 29% of respondents, just ahead of a lack of specialised staff, know-how or facilities (28%). Approximately one tenth of respondents cited another reason for not undertaking R&D (among these businesses, a common reason was that R&D activities were conducted by another company within the same enterprise group).

Table 41 Reason for not undertaking R&D (non-claimants who do not undertake R&D)

Reason for not undertaking R&D	Percentage
R&D not relevant to business activities	76%
No need to conduct R&D due to previous R&D	20%
No need to conduct R&D due to very little competition	18%
Lack of funds to finance R&D	29%
Difficulties in obtaining govt grants or subsidies	17%
Lack of specialised staff, know-how or facilities	28%
Legal or administrative burden	12%
Utilising existing R&D by other businesses	40%
Uncertain market demand for potential innovation	16%
Other reason	11%

Note: Number of respondents (weighted) = 311 (non-claimants who did not conduct R&D) – some of which answered 'Don't know' to various questions. 3 answered 'Don't know' for 'R&D not relevant to business activities', 9 answered 'Don't know' for 'No need to conduct R&D due to previous R&D', 9 answered 'Don't know' for 'No need to conduct R&D due to very little competition', 6 answered 'Don't know' for 'Lack of funds to finance R&D', 19 answered 'Don't know' for 'Difficulties in obtaining govt grants or subsidies', 5 answered 'Don't know' for' Lack of specialised staff, know-how or facilities', 3 answered 'Don't know' for 'Legal or administrative burden', 12 answered 'Don't know' for 'Utilising existing R&D by other businesses', 19 answered 'Don't know' for 'Uncertain market demand for potential innovation' and 5 answered 'Don't know' for 'Other reason' and are excluded. Results refer to the financial years of 2015–16 to 2017–18. Figures are rounded.
Source: London Economics' analysis of quantitative survey data

While more than one fifth of non-claimants spent very low amounts on R&D (that is, less than £5,000), most non-claiming businesses spend 'intermediate amounts' on R&D: approximately 45% spend between £20,000 and £100,000 on R&D (Table 42). Less than 10% of non-claimants spend over £1,000,000.

Table 42 R&D expenditure (non-claimants who undertake R&D)

R&D expenditure	Percentage
Less than £5,000	22%
Over £5,000 and up to £10,000	5%
Over £10,000 and up to £20,000	5%

R&D expenditure	Percentage
Over £20,000 and up to £50,000	24%
Over £50,000 and up to £75,000	8%
Over £75,000 and up to £100,000	13%
Over £100,000 and up to £250,000	6%
Over £250,000 and up to £500,000	8%
Over £500,000 and up to £1,000,000	3%
Over £1,000,000	7%

Note: Number of respondents (weighted) = 56 (non-claimants who undertake R&D). 32 answered 'Don't know' and are excluded. Results refer to the most recent financial year in which R&D was undertaken. Figures are rounded.
Source: London Economics' analysis of quantitative survey data

R&D project stage of development

For both claimants and non-claimants, the majority of research projects were in intermediate stages such as development and design (Table 43) (note that multiple responses could be chosen, so all frequencies sum up to more than 100%).

Table 43 Stage of development R&D is relevant to, by claimants and non-claimants

Stage	Claimants	Non-claimants
Project initiation	68%	57%
Project specification	71%	61%
Design	87%	80%
Development	92%	80%
Implementation	76%	66%
Testing or demonstration	78%	71%
Operation	63%	58%

Note: Number of respondents (weighted) = 864; of which 778 were claimants and 86 were non-claimants. 22 claimants answered 'Don't know' and 2 non-claimants answered 'Don't know' and are excluded. Results refer to the most recent financial year in which R&D was undertaken. Figures are rounded.
Source: London Economics' analysis of quantitative survey data

A3.2.2 Application to the scheme

Non-claimants

Of non-claimants who undertake R&D, 79% did not apply for HMRC's tax relief scheme in the most recent financial year in which R&D was undertaken.[104]

Advance Assurance

Advance Assurance is used to give companies a guarantee that any R&D claims will be accepted if they are in line with what was discussed and agreed and claimed within the first three accounting

[104] Reasons for not applying or for why applications were unsuccessful are not reported on due to small sample sizes.

periods. Only 13% of claimants were aware of Advance Assurance, and of these only 7% applied for it (Table 44). Of those who did apply for Advance Assurance, 81% were successful in their application. The most common reason for not applying was that respondents did not see any benefit from applying (45% of respondents). Almost on quarter (23%) of respondents did not apply because it was not recommended by an accountant or adviser.

Table 44 Reason for not applying for Advance Assurance (claimants)

Reason for not applying	Percentage
Did not see any benefit	45%
Not recommended by accountant or adviser	23%
No time to complete application	9%
Did not know about AA	-
Not eligible	-
Other	27%

Note: Number of respondents (weighted) = 70 (claimants aware of Advance Assurance but did not claim it). 11 answered 'Don't know' are excluded. Figures are rounded.
Source: London Economics' analysis of quantitative survey data

A3.2.3 Indirect effects

Business objectives

Increasing turnover was considered 'high-priority' by the majority of both claimants and non-claimants (67% and 71% respectively) (Table 45). A marginally higher proportion of claimants (61%) classify increasing their market share as 'high-priority' compared to non-claimants (56%). Reducing costs is highly important for a much larger proportion of non-claimants (54%) than non-claimants (38%). Increasing profit margins is a high priority to 65% of claimants but fewer non-claimants (54%).

Table 45 High priority business objectives, by claimants and non-claimants

Objective	Claimants	Non-claimants who undertake R&D
Increasing turnover	67%	71%
Increasing market share	61%	56%
Reducing costs	38%	54%
Increasing profit margin	65%	54%

Note: Number of respondents (weighted) = 889; of which 800 were claimants and 89 were non-claimants who conducted R&D – some of which answered 'Don't know' to various questions. 4 answered 'Don't know for 'Increasing your turnover', 13 answered 'Don't know' for 'Increasing your market share', 8 answered 'Don't know' for 'Reducing your costs' and 5 answered 'Don't know' for 'Increasing your profit margin' and are excluded. The share of businesses assigning 'high priority' to a given objective was computed as a percentage of all businesses that had assigned either low, medium or high priority to a given objective. Results refer to the most recent financial year in which R&D was undertaken. Figures are rounded.
Source: London Economics' analysis of quantitative survey data

Anticipated impact of R&D on market share

There is no marked difference in the anticipated increase in market share due to R&D between claimants and non-claimants. Over a third of both claimants (38%) and non-claimants (37%) expected market share to increase by more than 10% (Table 46).

Table 46 Anticipated increase in market share due to R&D, by claimants and non-claimants

Anticipated increase in market share	Claimants	Non-claimants who undertake R&D
1-5%	35%	38%
6-10%	27%	25%
More than 10%	38%	37%

Note: Number of respondents (weighted) = 641; of which 586 were claimants and 55 were non-claimants. 64 claimants answered 'Don't' know' and 2 non-claimants answered 'Don't know' and are excluded. This question was asked to respondents who anticipated market share to increase as a result of its R&D expenditures. Results refer to the most recent financial year in which R&D was undertaken. Figures are rounded.
Source: London Economics' analysis of quantitative survey data

Lack of commercial success of R&D

The most important reasons why claimants' R&D projects were not commercially successful are that the project was not intended to have commercial application (18%) and a lack of funding (16%) (Table 47). Competitor products were cited by 12% of respondents, while for 11% the project was not feasibly commercialisable.

Table 47 Reason for R&D projects not being commercially successful (claimants)

Reason for R&D projects not being commercially successful	Percentage
R&D project wasn't intended to have immediate commercial application	18%
Lack of funding	16%
Competitor products or services were better marketed	12%
R&D activities achieved their objective(s) but were not feasible to commercialise	11%
General economic conditions in the sector	4%
Other	40%

Note: Number of respondents (weighted) = 32 (claimants whose R&D projects were not commercially successful). 3 answered 'Don't know' and are excluded. Figures are rounded.
Source: London Economics' analysis of quantitative survey data

A3.2.4 Business characteristics

Only 3% of claimants merged or took over another business (Table 48). This compares to almost 10% of non-claimants (both types). Considering the closing, sale or outsourcing of tasks, there was no marked difference between claimants and non-claimants that undertook R&D (24% of claimants and 22% of non-claimants). In contrast, this was reported by a lower percentage of businesses that did not undertake R&D (16%). A smaller proportion of claimants established new subsidiaries (6%) compared to 15% and 9% of non-claimants who respectively did and did not undertake R&D.

Table 48 Mergers, closures, sale, outsourcing or establishment of new subsidiaries, by respondent type

	Claimant	Non-claimants who undertake R&D	Non-claimants who do not undertake R&D
Merge with or take over another business	3%	9%	9%
Close, sell or outsource some of the tasks or functions of your business	24%	22%	16%
Establish new subsidiaries in the UK or in other countries	6%	15%	9%

Note: Number of respondents (weighted) = 1,200; of which 800 were claimants, 89 were non-claimants who conducted R&D and 311 were non-claimants who did not conduct R&D– some of which answered 'Don't know' to various questions. 7 claimants answered 'Don't know' for 'Merge with or take over another business', 10 respondents answered 'Don't know' for ' Close, sell or outsource some of the tasks or functions of your business' (9 of which were claimants and 1 of which was a non-claimant that did not conduct R&D) and 4 answered 'Don't know' for 'Establish new subsidiaries in the UK or in other countries' (3 of which are claimants and 1 of which is a non-claimant that did not conduct R&D) and are excluded. Results refer to the most recent financial year in which R&D was undertaken or between April 2015 and March 2018 for non-claimants who did not undertake R&D activities. Figures are rounded.
Source: London Economics' analysis of quantitative survey data

A3.3 Summary of findings from other topics explored in the qualitative interviews

A3.3.1 The R&D process and factors affecting R&D activity

SMEs report different approaches to organising and funding R&D activity, depending to some extent on size, and to a greater degree on the importance of R&D in their overall business model.

Factors affecting R&D spending

Decisions on whether to invest in R&D are made by balancing the potential long-term value of the project (and how likely that value is to be realised or how likely the R&D activity is to be successful) against the level of investment involved. Availability of funds (that is, cashflow) and resources (that is, can the business afford to divert staff time away from directly productive tasks?) are additional factors, which, for smaller businesses, will determine when or whether activity takes place.

"Sometimes we have to self-fund our development…the decision is weighed up by the likelihood of the job coming to fruition. We test the market, we pitch, and we assess the competition, and we assess the zeitgeist. Then we might think this will be a good investment."

Business in information and communication sector, 0–4 employees, North West

In the case of small businesses (especially those with a less secure cashflow situation), availability of funds plays a role in determining whether projects go ahead, but if a strong business case can be made for investment, businesses are willing to find funding through other means (bank loans) to carry them out.

A number of businesses (those reporting no impact of the R&D tax credits) explained that their decisions to undertake R&D were usually not dependent on availability of funds and that they will only carry out R&D if and when it is deemed to be clearly beneficial or necessary.

The process and organisation of R&D spending

While there are differences in approach, the majority of the sample report a need for agility in financial spending. As such, R&D activity and spending is often approached in an ad hoc manner, with decisions made on a project-by-project basis about whether to allocate time or money to particular projects.

"It is very project-focused…we search for projects that are R&D focused and related to our core product development."

Business in information and communication sector, 5–19 employees, North West

"If there is something that looks viable and we have cash available, I'll go after it."

Business in manufacturing sector, 20–49 employees, West Midlands

"Board meetings happen regularly. Decisions about R&D are made as and when issues come up, like opportunities."

Business in information and communication sector, 20–49 employees, London

"The key question is 'can we afford to do this now?'"

Business in information and communication sector, 0–4 employees, London

Some businesses followed a more formal process and incorporated these decisions into their regular budget planning. Larger businesses in the sample were more likely to have some form of dedicated R&D budget than smaller businesses and were more likely to have a degree of formal planning around their R&D activity. Nevertheless, some smaller businesses that had a very strong focus on R&D also adopted a more formal approach.

A3.3.2 Funding of R&D activities

Main sources of funding

R&D is usually funded through profits or cash reserves.

"How do I fund development? From the company profits. So whatever we've made on the last job is rolled into the next one. The downside to this is that if you are not bringing in more work, you then start to dip into your development fund, just to keep the company going until the next job comes in."

Business in information and communication sector, 0–4 employees, North West.

Government or other public sector grants are not commonly used although, as mentioned in section 4.4 of this report, a small proportion of innovation-led businesses reported a reliance on grants and subsidies.

Businesses built on an innovative idea or scientific or technological advancement (especially those who had not operated at a profit when first set-up) reported more overt planning of R&D budgets, building in availability of external funding into their budget forecasts.

"If we manage to get a grant, that will be the big factor determining whether we do something or not in many cases. But if we can afford it, we will fund it ourselves, it depends how important it is, and how big an opportunity it represents."

Business in information and communication sector, 20–49 employees, London.

Hypothetical impact of grant funding

While in principle the idea of accessing matched-funded grants was appealing to some (and was said to have the potential to encourage greater overall business investment), concerns regarding the administrative burden of access remain a potential barrier to use.

"We are control freaks really…quite rightly there are lots of terms and conditions and reporting that goes with it, so we would not feel as in control as we would like."

Business in information and communication sector, 5–19 employees, South East.

A3.3.3 Collaboration and outsourcing

R&D collaboration was also avoided (or simply not considered), by most in the sample. This is due to a desire to maintain control of R&D and any intellectual property and commercial success it may result in.

Out-sourcing R&D is quite common as it provides access to specialist expertise and avoids the need to employ more staff. But it is considered expensive, and so is avoided where possible by some businesses

A3.3.4 Application process for tax relief

Those completing the applications themselves often describe the first attempt as challenging, as the data requirements are complex, and guidance can lack clear examples of exactly how information should be presented or submitted. Most described subsequent applications as much easier (once a process and templates has been established). The most common 'complaint' across the sample was the ambiguity around what can be considered in-scope.

"I wouldn't even know where to start…If it was just an easy online tool, people like us could look to apply for themselves."

Business in manufacturing, 5–18 employees, South East.

A3.3.5 Impact of tax relief

Impact of relief on R&D projects going ahead

The reduction in Corporation Tax contributes to overall financial health and cash-flow. As such, tax credits will contribute to the decision whether to invest or not, but other factors will also play a role, sometimes making the exact impact of tax relief difficult to quantify.

The knowledge that relief will be available for activity is factored into decisions about whether to allocated staff time or other expenditure to specific R&D projects (or wider business projects which include a significant element of R&D). Some businesses calculate the 'actual' cost of R&D, based on the level of deductions they can get. This can make the difference between R&D activity being deemed viable or justifiable or not.

Examples were provided of R&D investment being made which would not otherwise have been made because of the cost reduction and therefore reduced risk associated with such activity.

"[R&D tax relief] might well make a difference as to whether a [project goes ahead] at all."

Business in manufacturing sector, 5–19 employees, West Midlands

However, it is important to note that, in most cases, businesses do not make detailed calculations, factoring the exact level of relief: more often, the businesses have a broad idea of the 'savings' involved. Furthermore, businesses explained that they could not rely on tax relief being approved. Therefore, while they were encouraged to invest (more), they would not do this unless they could afford to 'take the hit', if the tax relief was not available later.

While R&D tax credits can be seen to have an impact on R&D activity for some businesses, this is not always the case. As explained above, businesses reporting no impact explained that their decisions to undertake R&D were usually not dependent on availability of funds but on the benefits or necessity of conducting R&D. As such, R&D tax credits are considered a 'nice bonus' and nothing more.

"If there were no R&D credits, it would not affect or change what we do in the slightest."

Business in transportation sector, 5–19 employees, West Midlands

"It's not driving it, it is helping. We have got to do a certain amount anyway…If we came up with a blindingly good idea, we would do it anyway. We would find other sources of funding if we could not afford it…a few years ago we got some investment from another private business."

Business in information and communication sector, 5–19 employees, South East.

Often, these businesses explained that the relief for R&D tax credits went back into the general 'cash pot' for the business and was therefore used for other types of investment such as marketing, new plant, and staff. They felt that, as such, the relief was having a positive impact on their business overall.

Where tax relief had made the difference between projects going ahead or not, the level of relief would need to change significantly to result in a different decision either way. Businesses would be willing to shoulder any additional cost associated with marginal reductions themselves.

Impact of relief on the level of R&D activity

R&D tax relief has a definite impact on the level of R&D activity undertaken, and investment in it for some businesses.

"[If no tax credit funds were available] the projects would be on a smaller scale and take longer to filter into the business... you might do a trial of X size with the R&D in place, but only Y size without it in place…it would be slower to market."

Business in agriculture sector, 100–249 employees, West Midlands.

"Two years ago, we didn't know about R&D tax relief, so we had no official budget for R&D and no record-keeping for R&D. Now we know we can get relief, we are more willing to put a lot more money into R&D and we think about it more than we used to."

Business in wholesale and retail sector, 5–19 employees, South East.

Some businesses report a 'queue' of potential R&D activity, which they are certain will benefit their business, but which can only take place when staff are available to do it. In these cases, tax relief has an impact on the level of activity taking place, by contributing to the availability of profits, which may allow more time to be spent on R&D.

"We treat it [tax relief] as a source of income and a boost to our profits. If we didn't have it, we would still do R&D, but more slowly."

Business in manufacturing, 5–19 employees, London.

Yet, considering the impact of changes in the level of relief, businesses explained that marginal increases or decreases were unlikely to have an impact. When considering changes from 130% to 120% or 140%, some businesses were not aware of the impact of this in real terms, so were unable to predict the impact, but assumed it would be very small or nil.

"It [change in the deduction rate] would have to be moderate to significant for us to re-evaluate and really up-scale something [that] we were doing…anything that is an extra 50% or 60% would be welcomed."

Business in wholesale and retail sector, 5–19 employees, South East.

"It [10%] is not a big enough increase. It might relieve me a bit, but I don't think in this case it would increase my output by that much more."

Business in information and communication sector, 5–19 employees, London.

Impact of relief on the type of R&D

In some cases, making a tax credit claim had provided a boost to the business' financial health and resulted in a change in mindset around R&D. They had been both encouraged by the potential to save money, and enabled by the money they had already saved to be more ambitious and take on either larger, or more challenging projects.

Impact of the tax relief on approach to risk taking;

As explained above, by reducing the cost of R&D, the tax relief reduces the level of risk attached to certain projects. A number of businesses stated that the existence of the tax relief helped tip the balance of risk versus benefits in a positive direction.

"Previously we were only doing projects that we knew had a really strong commercial viability, such that the risks were really low…but essentially anything that is that low risk is not going to be that innovative."

Business in manufacturing, 5–19 employees, South East.

A3.4 Findings from the existing literature on the appropriateness of tax relief relative to direct subsidies

This section considers the evidence on the appropriateness of tax relief relative to direct subsidies as a means of providing firms with a financial incentive to carry out R&D.

R&D investment policy can take two forms. R&D tax relief can be used to subsidise the cost of R&D expenditure, serving to narrow the gap between the private and social rates of return on, and incentivising greater, R&D expenditure. Direct, lump-sum subsidies of R&D can be used to the same effect.

However, R&D tax relief is more market-oriented than direct subsidies. R&D tax relief allows firms to choose R&D expenditure levels and receive a proportionate subsidy of R&D costs. Direct, lump-sum subsidies may not allow firms such discretion in choosing R&D expenditure levels: once the size of the lump-sum subsidy has been set, any marginal increase in R&D expenditure above the planned level will be unsubsidised.

There are relatively few studies (in-fact, the literature search only identified two studies) that provides a direct comparison of R&D tax relief and direct subsidies. The primary evaluation issue is that the criteria for eligibility into tax relief and direct subsidy schemes may differ. Some direct subsidy schemes may target high social or low private return projects, for example, and these may well have lower benefit-cost ratios than tax relief schemes when benefits are measured at the firm (that is, private) level. To the extent that eligibility into schemes is not observed or controlled for, comparisons across schemes is made challenging.

Carboni (2011) uses a survey of manufacturing firms in Italy that identifies firms' R&D funding sources, including tax relief and public grants, to investigate their impacts. The author finds that tax relief is more effective than direct subsidies in incentivising R&D.

In this research, the issue of differing eligibility criteria across schemes is addressed using propensity score matching, where each firm receiving public financial support for R&D is twinned with an unsupported firm that, based on a range of observable characteristics, is similar. Comparisons of R&D expenditure across the groups of supported and unsupported firms are then made to determine its responsiveness to different support schemes. Assuming the observable characteristics control for scheme eligibility differences well enough, the aforementioned comparisons are valid.

Carboni (2011) also investigates the impact of the receipt of direct subsidies on the use of other funding sources to understand the relationships between public support, financing and the attitude towards R&D in the firms. The results show that businesses in receipt of direct subsidies commit greater internal and external finance to R&D. The same analysis was not undertaken for tax relief.

Hægeland and Møen (2007) investigate the relationship between the Norwegian R&D tax credit scheme and other innovation policy instruments. They find that each public kroner spent on tax credits for firms investing below the 4 million cap on intramural R&D increases private intramural R&D by 2.68 kroner. This estimate builds on an assumption of zero additionality for firms above the 4 million cap. The authors find that the additionality of subsidies awarded through the Research Council and Innovation Norway is 2.07 and 1.53 respectively. The additionality of grants awarded by ministries and other public agencies was estimated to be 0.64; whereas, the additionality of R&D subsidies from the EU was estimated to be 0.75.

The Hægeland and Møen (2007) study does not take differences in the eligibility criteria across schemes into account. As the authors state, the grants are directed to high social or low private return projects so the estimated additional R&D expenditure may not fully reflect all benefits, especially for granted-funded projects.

At the macro-level, Falk (2006) investigates the determinates of R&D expenditure across a panel of OECD countries over the period 1975–2005. He finds that tax relief significantly drives up aggregate R&D business expenditure. A system GMM approach is used in light of the presence of endogenous regressors and persistence in the R&D expenditure data. The finding is robust to the use of alternative estimation techniques. Direct R&D subsidies, on the other hand, did not significantly impact R&D expenditure across all but one specification.

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