Effectiveness of fiscal incentives for R&D: a quasi-experiment*

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DRAFT

Abstract

Governments implement tax incentives for R&D as a convenient way of addressing the externality problem caused by the public good nature of knowledge. With growing interest in R&D tax incentives, the question about their effectiveness has become ever more relevant. In the absence of an exogenous policy reform, the simultaneous determination of companies' tax positions and their R&D spending causes an identification problem. We are able to overcome this problem by exploiting a policy reform that took place in the UK. We use the population of corporation tax records that provide precise information on the amount of firm-level R&D expenditure that qualify for the tax incentive. Using difference-in-differences to estimate the effect of the policy, we find a positive and significant impact of R&D tax credits on firm level R&D spending, and an implied user cost elasticity estimate of around -2.5.

JEL Classification: H25, O31, O38
Keywords: Tax incentives, corporation tax returns, quasi-experiment

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1 Introduction

Investment in research and development (R&D) generates knowledge, which is a public good. Firms cannot reap the full benefits of their R&D activities due to this externality problem, and therefore invest in less R&D than the socially desirable level. Because the private sector under-invests in R&D in the absence of any intervention, governments have an incentive to stimulate R&D activity by the private sector through support policies (Arrow (1962)).

Today, many governments use fiscal incentives as one of their main policy tools to stimulate business R&D. In the recent years, the popularity of fiscal incentives have increased substantially. A larger number of governments offer fiscal incentives for R&D, the generosity of existing schemes have been on the rise and governments started to pay attention to the importance of implementing simpler schemes that are easier to administer (OECD (2014)). This increased popularity of fiscal incentive schemes brings about two novelties. First of all, evaluation studies have become ever more relevant, with elevated interest from the policy side to understand and quantify the impact of tax incentives in stimulating private R&D. Second, the recent policy reforms began to offer better evidence on effectiveness, with policy discontinuities helping to identify the policy impact at the micro level.

The review of the literature on fiscal incentives for R&D by Hall and Van Reenen (2000) underlines the main challenge in evaluating the impact on investment of tax incentives as: "...the intractability of finding exogenous variation in the user cost of capital (p.450)". This identification problem arises both in the context of incentives for physical investment and also for knowledge, that is, R&D investment. There is, therefore, a recent emphasis on quasi-experiments for evaluating R&D policy (for instance, Agrawal et al. (2014), Bronzini and Iachini (2014)).

For many years, R&D policy evaluations have been based on event and case studies

or large scale R&D and innovation surveys[1]. The recent rise in the availability of administrative data on tax returns and R&D tax credits offer a new source of information that carries the evaluation of R&D policy to a new level with better micro data (Recent examples are Rao (2014), Agrawal et al. (2014), Lokshin and Mohnen (2012)).

In this study, we exploit a simple quasi-experimental setting to identify the impact of an R&D tax incentive policy. In the absence of an exogenous policy reform, the simultaneous determination of companies' output, profits and their R&D spending cause an identification problem, which we are able to overcome using an exogenous reform that took place in the United Kingdom (UK). We use the population of corporation tax records that provide information on the amount of firm-level R&D expenditure that qualifies for the tax incentive. Using the administrative data on corporation tax also allows us to identify for each R&D active company their precise tax positions (for example, whether they have any taxable profits) and the corresponding rate of deduction for qualifying R&D expenditure against the taxable profit. By linking the tax record to the financial statement for each company and year, we observe in addition other contemporaneous, non-tax determinants of R&D investment such as firm size, profitability and growth rate, which allows us to disentangle the true effect of the credit from other confounding factors.

The UK introduced tax incentives for R&D in 2000 for small and medium sized companies (SMEs) and in 2002 for large companies. The SME scheme has been more generous than the large company scheme in terms of the percentage of allowable tax deduction, and a significant reform in 2008 expanded the SME definition by doubling the thresholds measured in employment size, turnover and total assets. As a result, a number of companies that would have been classified as large companies under the old system became qualified as SMEs and gained access to the more generous SME scheme. The reform resulted in differential changes in the user cost of R&D faced by SMEs compared to large companies,

[1]The methodology of R&D surveys generally following the OECD Frascati Manual ((OECD, 2003)) and the innovation surveys following the Oslo Manual (OECD (2005)). The studies based on these data sets have found moderate positive effects of tax incentive policies on R&D and innovation (Czarnitzki et al. (2011), Guceri (2014)).

whose user cost of R&D remained roughly stable in the years before and after the reform.

Our empirical strategy places these companies which 'became' SMEs in 2008 in the treatment group. The control group consists of those companies that 'remained large' throughout the sample period. There were additional R&D tax relief rate increases for both SMEs and large companies in 2008, along with changes to the statutory corporation tax rates, which are described in detail in Section 2. Incorporating all the relevant changes that took place in 2008, for a company that moved from large to SME status thanks to the SME definition change for the purpose of the R&D tax relief, the overall reduction in the tax component of the user cost of R&D capital amounts to 10-31 percent depending on the size and the precise tax position of the company. On average, the treated group firms experienced a reduction in their user cost of R&D by about 21 percent between 2007 and 2009. By comparison, the reform brought almost no change in the user cost of R&D capital for companies that remained as large companies[2].

We estimate the causal effect of the tax credit on qualifying R&D expenditure using a difference-in-difference (diff-in-diff) approach by exploiting the differential change in the R&D tax incentives in 2008 between the treated and the control groups. Crucially for the diff-in-diff approach to produce consistent estimates of the average impact of the policy on treated firms, we should expect that the changes in R&D over time follow parallel trends for the treated and the control groups in the absence of a policy change. We present the results from regressions with placebo policy interventions in each of the pre-reform years to support that the common trends assumption is not violated.

We find that treated companies on average increased their R&D spending by about 45 percent in response to the increased generosity of tax incentives in 2008. The positive and significant effect of the change in R&D tax incentive is robust to the inclusion of controls for non-tax determinants of R&D investment.

[2]Due to the reduction in statutory tax rates and a 5 percentage point increase in the enhanced deduction rate under the R&D tax relief which partly offset each other, the control group firms experienced a reduction in their user cost of capital of 0.3 percent, which we consider to be negligible. We discuss these policy changes in Section 2.

The policy reform in question in this paper was announced in Budget 2007, which was before its implementation in mid-2008. Descriptive evidence points to a slower increase in R&D spending by treated companies immediately after the announcement but there is no significant differential change in 2007 to support a definitive argument about companies' postponement of R&D projects. If the companies in fact shifted some R&D activity from the pre-reform to the post-reform period following the announcement, we risk spuriously finding an effect of the policy while some of what we are measuring would be the delayed R&D spending which would have nevertheless been carried out even in the absence of the policy change. In order to check the robustness of our results to anticipation effects, we remove the period of announcement and the first year of implementation from the sample and re-estimate the model. The point estimate drops moderately to 42 percent, but remains statistically significant.

Taking anticipation effects into consideration, the evidence from UK data supports that tax incentives for R&D have a statistically significant, positive effect on R&D investment on the intensive margin. Based on our difference-in-difference estimates, we can back out the implied estimate for the elasticity of R&D spending with respect to its user cost, which is around -2.5.

In the remainder of the paper, we first describe the policy set up in Section 2, followed by a discussion of the conceptual framework for the mechanism through which tax incentives may yield increases in R&D spending at the firm level (Section 3). Section 4 describes the data sources and summarises the data set used for the analysis. Section 5 explains the research design and reports the main results. Section 6 concludes.

2 Policy background

The UK introduced its first R&D tax incentive scheme in 2000, in an effort to address its 'productivity challenge' – a term that features frequently in many government documents and policy papers, referring to the UK private sector's modest performance in total factor

productivity in comparison to other developed countries such as the United States (US), France and Germany (See, for example, the Budget Report by HM Budget, 1999).

R&D policy in the UK currently relies heavily on R&D tax incentives, which are now a combination of tax deductions and payable tax credits. According to the OECD R&D tax incentive statistics[3], about half of UK's funding for business R&D was channeled through tax incentives in 2012. Throughout our sample period, the R&D tax relief schemes were in the form of enhanced deductions, with the availability of cash refunds for loss-making SMEs. In 2000, the UK R&D tax relief was introduced as a scheme targeted to SMEs, which were then defined as companies with fewer than 250 employees, and either a balance sheet size of less than €27 million or sales of less than €40 million[4]. In 2002, the scheme was extended to larger firms, albeit at lower deduction rates.

Until 2008, the SME scheme allowed companies to tax deduct £150 for every £100 spent on qualifying expenditures on R&D and the large company scheme allowed a deduction of £125 for every £100. A cash credit was (and still is) available for SMEs which are in a loss-making position and the amount of cash paid to such SMEs amounted up to 16 percent of the total surrenderable loss of the claimant (see Appendix D for the details on cash benefits for SMEs). In April 2008, the large company deduction rate increased from 125 percent to 130 percent and the SME deduction rate increased from 150 percent to 175 percent. In 2011, the last year of our sample period, further changes were announced to the SME scheme, increasing the deduction rate to 200 percent. We present the relevant policy changes, along with those that took place after our sample period in Figure 1[5].

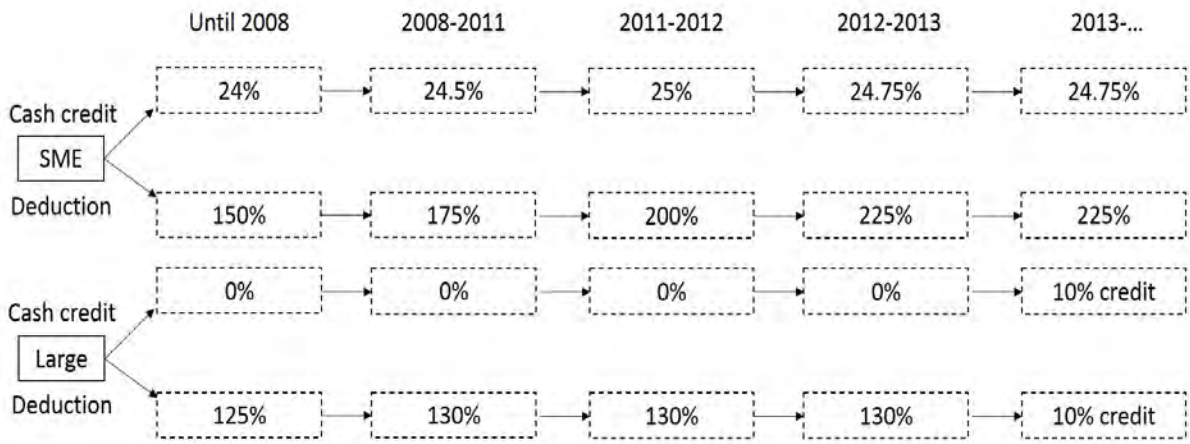
The tax price of R&D was not only affected by the R&D tax incentive over the period

[3]Available at http://www.oecd.org/sti/rd-tax-stats.htm

[4]The thresholds are defined in Euros as they are determined in accordance with the European Commission's definition of an SME due to the EU State Aid regulations. In 2005, the balance sheet size threshold increased to €43 million and the turnover threshold increased to €50 million. Unlike the 2008 reform, the 2005 definition change applied to other tax allowances and benefits for SMEs in addition to the R&D tax breaks, since it was a result of an EU-wide definition change.

[5]From 2013 onwards, an optional tax credit, which is directly deducted from the final tax liability of companies and is itself taxable, was introduced for large companies at a rate equivalent to the enhanced deduction rates (a taxable credit rate amounting to 10 percent of R&D expenditure). It was also announced that the large company scheme would completely switch to an above-the-line taxable credit from April 2016 onwards, and loss-making large companies are now also eligible for cash refunds.

Figure 1: Evolution of R&D tax relief deduction rates

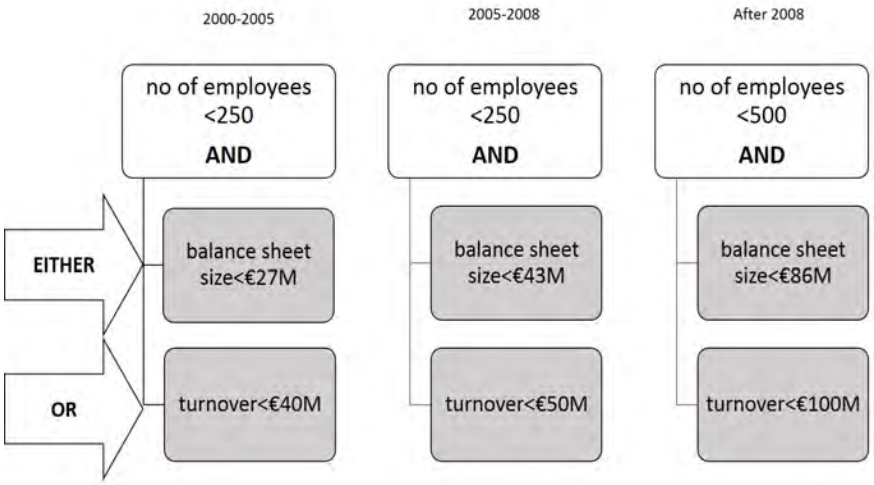


of interest for this study. A gradual change in the corporation tax rates also took place in the last decade. These changes in corporate tax rates are discussed in Appendix C. While the changes in the R&D enhanced deduction rates and the rates of corporation tax alter the tax price of R&D spending, the most dramatic reduction in the cost of marginal R&D investment for a group of firms was introduced in the August 2008 reform, which changed the definition of a small or medium sized enterprise (SME) used to determine eligibility for the more generous tax treatment of R&D by doubling all the thresholds for defining an SME. The pre-reform and the post-reform size thresholds can be observed in Figure 2.

Combining the effect of both the rate increases and the SME definition change, an SME that was previously labeled as 'large' before the reform could deduct, for every £100 of qualifying R&D, £125 against its taxable profit in financial year 2007-08 and £175 in 2009-10. Newly-qualified SMEs also became eligible to claim cash if they incur zero or negative taxable profits in the current financial year. We present further information on cash benefits in Appendix D.

Against the backdrop of all these tax-related reforms, the tax component of the user cost of R&D evolved as depicted in Figure 3. We calculate the tax component of the user cost as $\frac{1-A}{1-\tau}$, where A is the value of tax credits and depreciation allowances for £1

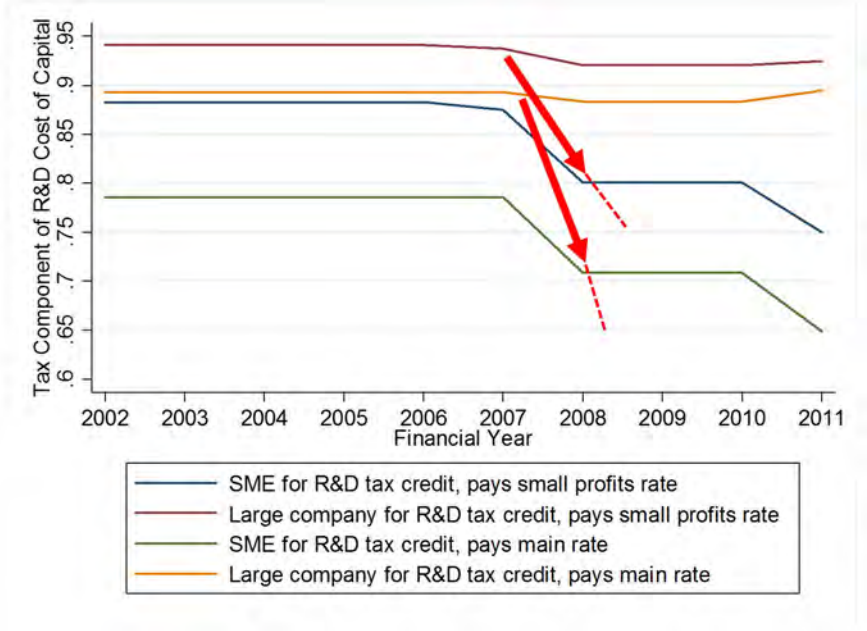
Figure 2: Size thresholds for SME tax credit



spending in R&D and τ is the statutory tax rate. This formulation suggests that the value of tax credits and allowances A be obtained by multiplying $1 + d$, where d is the deduction rate, by the statutory tax rate (for example, $A = (1 + 0.5)\tau$ for an SME in the pre-2008 period). The distinction between eligibility for the main rate or the small profits rate for corporation tax payments applies to all the companies, independent of whether they perform R&D or not, and the rate applicable to a certain company depends on its taxable profits in a given year.

In Figure 3, a representative company that is eligible throughout the period for the R&D tax relief for SMEs experiences a drop in its user cost due to the increase in the deduction rate from 150 percent to 175 percent. The increase in the deduction rate from 125 to 130 percent for large companies is partly offset by the decrease in the main statutory tax rate. The arrows indicate the transition for a company that was labeled as 'large' before the SME definition change and as 'SME' after this reform. A representative company that benefited from the definition change experienced a decrease in the R&D user cost by around 21 percent between 2007 and 2009 if paying at the small profits rate, and around 15 percent if paying at the main rate.

Figure 3: Tax component of the user cost of R&D on current spending



3 Conceptual framework

Based primarily on the neoclassical optimal capital accumulation framework presented in Hall and Jorgenson (1967) and Jorgenson (1963), and treating investment in R&D analogously to investment in physical capital, we may consider a simple conceptual background for the response of firms to R&D tax credits. Bond and Van Reenen (2007) review the literature on investment models of this type, and the notations here follow the convention adopted in their chapter.

We consider a Cobb-Douglas production function with R&D capital as the sole input[6]. Firms maximize the net present shareholder value subject to the law of motion for the accumulation of R&D capital. For each firm, the production function is:

$$F(K_t) = AK_t^{\alpha} \tag{1}$$

[6]Bloom et al. (2002), Mairesse and Mulkay (2013) provide applications with constant elasticity of substitution production functions in the R&D context.

The firms' optimization problem is:

$$V_t(K_{t-1}) = \max_{R_t} \{\Pi_t(K_t) + \beta_{t+1}\mathbb{E}_t(V_{t+1}(K_t))\} \tag{2}$$

$$\text{subject to } K_t = (1-\delta)K_{t-1} + R_t \tag{3}$$

where δ is the depreciation rate, V_t is the maximized current value of the firm, as a function of the knowledge capital accumulated in the firm denoted by K_{t-1}. Knowledge accumulates according to the law of motion expressed in Equation 3, with knowledge capital in time period t determined by the previous period's capital, net of depreciation, plus investment in new R&D, R_t. $\beta_{t+1} = \frac{1}{1+r_{t+1}}$ is the rate at which the firm discounts future revenue, with r_{t+1} being the risk free interest rate representing the outside option of the firm.

Several simplifications are made in the derivations that follow. We assume no depreciation, and no adjustment costs for simplicity, and the firm finances all R&D by retained earnings. In addition, we assume price-taking firms in both the markets for their input and their output. In the presence of taxes, the current revenue of the firm is:

$$\Pi_t(K_t, R_t) = (1-\tau)[p_t F(K_t) - p_t^K R_t] + c p_t^K R_t \tag{4}$$

where τ is the corporation tax rate applied to firm profits and c is the tax credit rate on R&D investment[7], p_t is the price of output at time t and p_t^K is the input price.

Substituting the constraint in the firm's objective function, we obtain the following first order condition, yielding that the marginal product of R&D capital is equal to its

[7]In the UK, as explained in later sections, the tax incentives for SMEs have been in the form of deductions rather than credits, but accounting for this fact using an equivalent rate of deduction in place of a credit does not alter the results expressed in this section.

user cost and pinning down the optimal level of R&D capital:

$$\frac{\partial V_t}{\partial K_t} = (1-\tau)[p_t F'(K_t) - p_t^K] + cp_t^K + \beta_{t+1}\mathbb{E}_t\left[(1-\tau)p_{t+1}^K - cp_{t+1}^K\right] \tag{5}$$

$$F'(K_t) = \frac{p_t^K(1-\tau-c)}{p_t(1-\tau)}(1-\beta_{t+1}\mathbb{E}_t\frac{p_{t+1}^K}{p_t^K}) \tag{6}$$

$$K_t^* = \left(\frac{1}{A\alpha}\frac{p_t^K}{p_t}\frac{(1-\tau-c)}{(1-\tau)}\left[1-\beta_{t+1}\mathbb{E}_t\frac{p_{t+1}^K}{p_t^K}\right]\right)^{\frac{1}{\alpha-1}} \tag{7}$$

We denote $\kappa = \frac{1}{A}\frac{p_t^K}{p_t}\frac{1}{(1-\tau)}\left[1-\beta_{t+1}\mathbb{E}_t\frac{p_{t+1}^K}{p_t^K}\right]$.[8]

The response of R&D capital to an increase in the generosity of tax credits is therefore captured by:

$$\frac{\partial K_t^*}{\partial c} = \left(\frac{1}{1-\alpha}\right)\left(\frac{\kappa}{\alpha}\right)^{\frac{1}{\alpha-1}}(1-\tau-c)^{\frac{1}{\alpha-1}-1} \tag{8}$$

Equation 8 shows that firms respond to reductions in their user cost via tax incentives by increasing their R&D capital, given that this partial derivative is always positive. In the empirical section, we use the flow variable for R&D instead of generating a conceptual 'R&D capital stock'. Given a short time series, the steady state assumption commonly used in the literature to initialize the R&D capital of the firm (in the spirit of Griliches (1979) and reviewed in Hall et al. (2009)) renders the R&D capital stock to be roughly proportional to the flow measure, using depreciation rates for R&D capital of 15 percent. Hall and Mairesse (1995) present a comparison of R&D flow and stock variables in the context of estimating production functions and demonstrate that the results do not change when between estimates that use stock and flow measures.

[8]We note that $\kappa > 0$, since $\beta_{t+1}\mathbb{E}_t\frac{p_{t+1}^K}{p_t^K}$, following from the definition of the discount factor $\beta_{t+1} = \frac{1}{1+r_{t+1}}$ where r_{t+1} is the nominal interest rate, ruling out negative real interest rates in expectation.

4 Data

4.1 Description of the data sets

We linked two data sets to create the panel used in this study: (i) the universe of UK corporation tax assessments from the HM Revenue and Customs (CT600), and (ii) annual company accounts from Bureau van Dijk's Financial Analysis Made Easy (FAME) Database.

The CT600 data set includes the population of company tax records and provides information on the precise tax position of a company including its taxable profit, loss brought forward, trading profit and losses, and turnover. It is also the source of information for our R&D tax credit variables, but the HMRC keeps a separate micro data set for R&D, feeding information from their specialist R&D units in addition to the CT600. We use the R&D spending data that is supplied by the HMRC which also constitutes the micro data set underlying the National Statistics publication on R&D tax credits. In the micro level R&D data, HMRC provides the amount of R&D tax deductions and cash credits claimed for the periods under study, whether the company claimed under the SME scheme or the large company scheme, if they are SME, whether they claimed cash or carried losses forward and the total amount of subcontracted R&D for an SME[9]. More than 90 percent of the tax records are matched with company accounts in FAME. The CT600 data currently covers the financial years from 2000-01 until 2011-12.

In the absence of the SME/Large company label in the administrative data, one may choose to use the information from FAME on the number of employees and balance sheet size of each firm, along with the turnover data from CT600, but these are not sufficient to accurately determine SME or large company status. Firm size alone does not determine eligibility for the SME scheme, as companies that are part of larger groups that exceed the thresholds are no longer eligible for the SME scheme. In addition, the number of

[9]SMEs that perform R&D as subcontractors can only benefit from the R&D tax relief under the under the large company scheme.

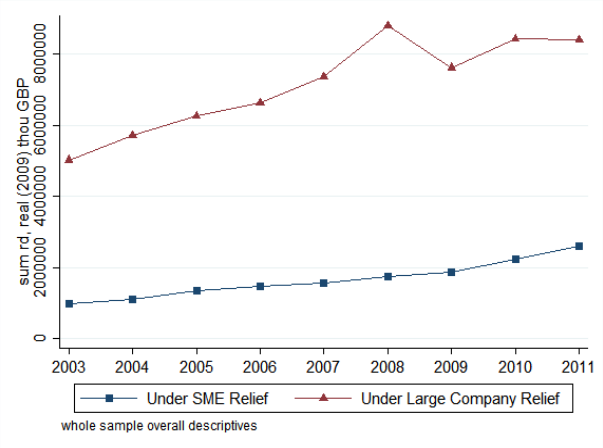
employees is missing for a large number of companies in FAME.

The HMRC Corporate Intangibles and R&D (CIRD) Manual identifies three main categories of qualifying expenditures for the purpose of the R&D tax relief. These include staffing costs, consumables (such as water and electricity) and software directly used in R&D[10].

According to the ONS estimates, the total current R&D spending by all UK businesses amounted to around £13.4 billion in 2005, which increased to around £15.6 billion in 2009 (in nominal terms). The ratio of total qualifying R&D spending that is observed in HMRC data to the aggregate current spending in BERD published by the ONS has risen from just over 50 percent to more than 60 percent between 2005 and 2009.

Figure 4 presents the evolution of qualifying R&D spending over time by companies which claimed R&D tax relief in 2003-2011, with a breakdown between R&D by large companies and SMEs.

Figure 4: Qualifying R&D across groups, values in real (2009) thousand GBP



[10]Subcontracted R&D and contributions by the companies to research undertaken at independent research institutions (academic or other research institutions which are not connected to the firm) qualify under the large company scheme if they are relevant for the company's main activity.

4.2 Descriptive statistics

We define a company as 'treated' if it carried out qualifying R&D or subcontracted work in at least one of the years before 2008, and also in at least one of the years after 2008, and (i) is labeled as 'large' in the last of such pre-reform years with positive R&D and, (ii) is labeled as 'SME' in the first of such post-reform years with positive R&D[11].

Following a similar approach, we construct a control group of large companies. Specifically, a company is included in the large control group if it carried out qualifying R&D in at least one of the years before 2008, and also in at least one of the years after 2008, and (i) is labeled as large in the last of such pre-reform years with positive R&D and, (ii) is labeled as large in the first of such post-reform years with positive R&D. This approach therefore addresses an intensive margin question, estimating the policy effect for companies which were already performing qualifying R&D in the pre-reform period. We are unable to address the extensive margin question as we do not know their SME or large status unless they are already spending in R&D.

Table 1: Number of observations in regression samples

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Treatment	127	135	146	151	154	163	169	172	166
Control	896	937	952	969	1,000	1,015	1,043	1,029	988

Table 1 shows the number of observations in treated and control groups. The number of treated observations is smaller than the number of observations in the control group. It can be seen that the sample sizes are different for the two groups, and we later use matching to achieve two groups of similar sizes with similar characteristics to verify the results that we obtained using the full sample.

The broad sectoral distribution of companies is very similar across treated and control groups, with 50 to 60 percent of the companies in manufacturing sectors on average[12].

[11] We do not take the 2008 status into account, since the size definition change was introduced in August 2008, which is in the middle of the tax year.

[12] Note that since we do not have any information on the breakdown of these companies' fields of research

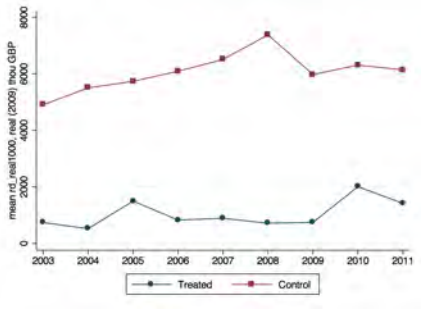
In the treatment and control groups of interest, the majority of companies in the service sector belong to the two-digit SIC (2003) categories of either 'research and development (73)' or 'computer and related activities (72)'. Companies in these service sector categories mainly engage in research and development and produce intellectual property or contractual arrangements with other companies that purchase their R&D services as final outputs.

Figure 5 presents average firm characteristics by treatment and control groups. The top panel traces the evolution of R&D spending in levels, and we do not observe any particular pattern to suggest the violation of the common trends assumption for the levels of R&D. In Figure 5a, we observe a small blip in the mean of the treated group in 2005, and a blip in the mean of the control group in 2008, which do not appear in the comparison of the medians of the same variable. The level of mean and median R&D spending, sales and trading profit seem to be higher in the control group relative to the treated group, which is a natural result of the grouping strategy that we have taken in this paper.

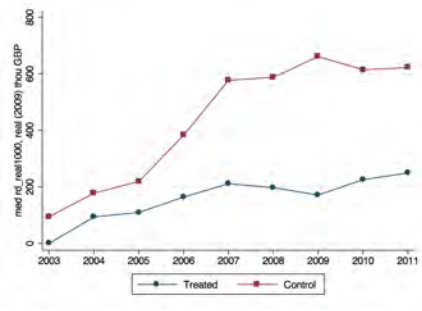
If many firms are in a loss-making position, or if they are in different tax brackets, then the value of the differential change in the enhanced deduction may vary across the groups, and this could mask the identifying variation in the user cost generated by the policy reform. To rule out this possibility, we calculate for each company-year observation a measure of the user cost of R&D capital to assess whether variation in the tax component of the user cost of capital indeed resembles the pattern depicted in Figure 3. Figure 6 verifies the identifying variation in the tax component of the user cost triggered by the eligibility reforms in 2008. On average, treated firms experienced a decline in their tax component of the cost of capital from 0.96 in 2007-08 to 0.75 in 2009-10, whereas that of the large control group remained at around 0.95.

and development activity, we can comment only on the sector of their final product.

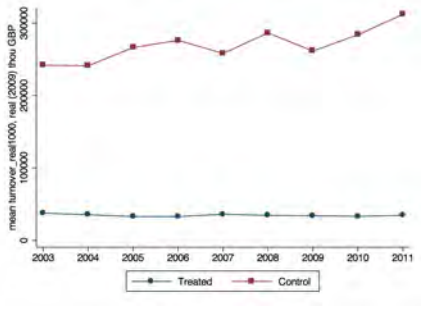
Figure 5: Firm characteristics across groups, values in real (2009) thousand GBP



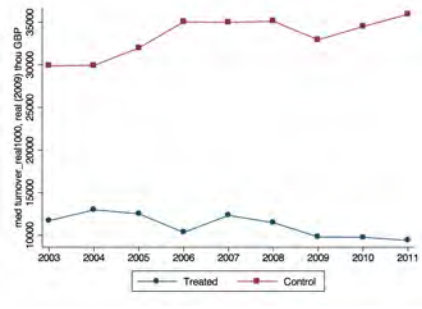
(a) Mean R&D spending



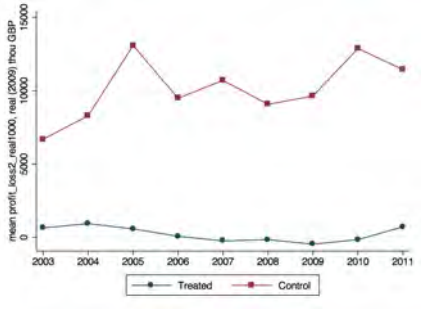
(b) Median R&D spending



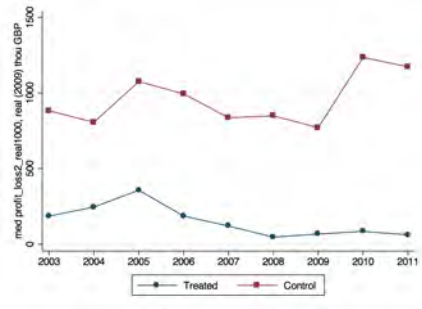
(c) Mean sales



(d) Median sales



(e) Mean net trading profit

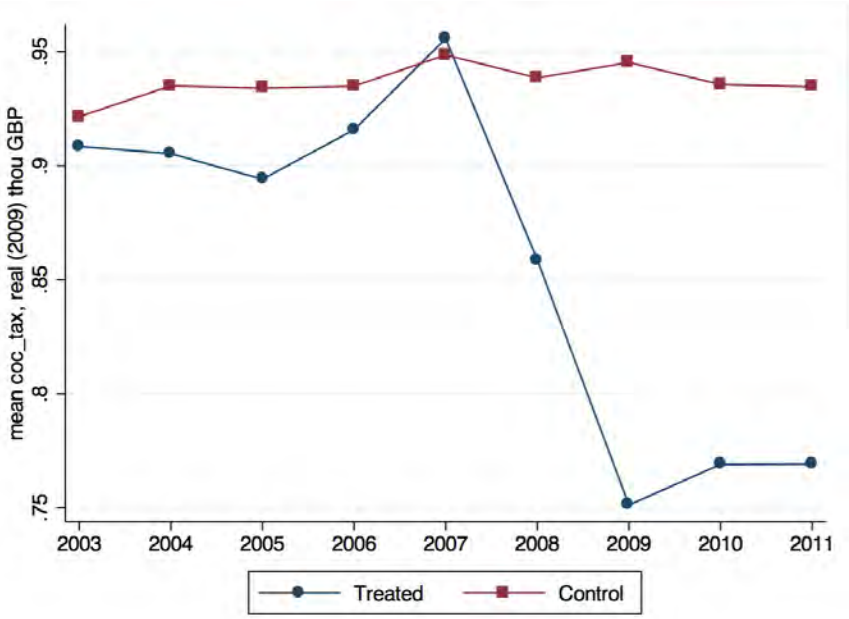


(f) Median net trading profit

5 Results

The conceptual framework presented in Section 3 suggests a log-linear relationship between R&D spending and its user cost. We attribute the interaction term on a difference-in-difference specification to be capturing the reduction in the user cost of R&D for the treated group of companies in the following model where we identify the causal effect of

Figure 6: Average user cost of capital across treatment and control groups, tax component



the 2008 reform on R&D spending:

$$\mathbb{E}[R_{it}|D_{it}, \mathbf{x}_{it}] = \exp(\gamma + \delta_D D_i + \delta_I D_i T_t + \mathbf{x}'_{it}\beta_x + \phi_t + \nu_{it}), \tag{9}$$

where R_{it} is the level of qualifying R&D spending for company i in year t in 2009 prices. D_i is a dummy that takes on a value of 1 for the treated observations and 0 for the control observations. T_t is a dummy that takes on a value of 1 for years 2008 onwards and 0 otherwise. The coefficient δ_I on the interaction term $D_i T_t$ captures the differential change in qualifying R&D spending between pre- and post-2008 periods for the treatment group compared to the control group. The null hypothesis of no impact of the change in the generosity of the tax credit on R&D spending in the treated group relative to that in the control group corresponds to $\delta_I = 0$. Time-invariant unobserved firm heterogeneity is captured by the inclusion of firm-fixed effects (later in the estimation stage) and aggregate macroeconomic shocks that are common to all companies, including the effect of the great recession, are controlled for in all specifications by the set of time fixed effects ϕ_t. Other non-tax determinants of firm-level R&D spending including the firm's growth rate

of turnover and measures of firm size can be included in the $\mathbf{x}$ vector as additional controls.

Companies do not claim tax credits continuously every year. There is anecdotal evidence on companies which alternate staff functions between R&D and non-R&D ones depending on the availability of suitable projects[13]. In the CT600 data set, if we consider all the companies with some R&D spending during the observed period, only 40 percent claim R&D tax credits continuously in all the years and the remaining ones stop claiming at least once.

For data characterised with many zeros, Silva and Tenreyro (2006) propose a simple pseudo-maximum-likelihood (PML) estimator (following Gourieroux et al. (1984)) to achieve consistency in estimating the parameters on the log-linear model. In their paper, Silva and Tenreyro (2006) demonstrate that in the log-linear specification, the OLS estimates are severely biased and inconsistent and that the PML estimates perform very well on simulated data.

In Table 2, Column (1) presents the baseline specification with no controls, and captures the mean differences between treatment and control groups. The row labeled 'Diff-in-diff' provides the estimates for the main coefficient of interest which captures the differential effect of the policy reform on average R&D spending in the treated group relative to average R&D spending in the control group. The coefficient 'Treatment' represents the estimate for the δ_D parameter and captures the difference in the average qualifying R&D spending between the treated and control groups in the absence of treatment. This coefficient is negative and significant in all columns, suggesting that, on average, companies in the treated group undertook a lower amount of R&D spending than their counterparts in the large control group. We then gradually add control variables, first, instead of the pre-/post-reform dummy, we add year fixed effects in Column (2), followed by two-digit sector dummies (Column (3)). In Column (4), we include a firm size proxy, that is the total assets in real terms (lagged), and in Column (5), we add the rate of growth of real

[13]This argument was put forward by the HMRC and Treasury teams that participated in the seminar on 6 November 2014.

Table 2: Baseline regression results

[TABLE HERE]

Table 3: Baseline results, removing 2007 and 2008 fiscal years

[TABLE HERE]

turnover (lagged). In all these regressions, the diff-in-diff coefficient is significant at the 5 percent level, indicating a differential increase in R&D spending for treated firms of around 46 percent. The first 5 columns in the table do not take into account unobserved time invariant firm-specific characteristics that may be correlated with treatment status. When we add firm fixed effects to the regression, we observe around a 10 percentage point increase in the size of the diff-in-diff coefficient, and the estimate becomes more precise, with all the additional control variables in Column (9).

Next, we test firms' reaction to the early announcement of the policy. Firms may react to the announcement of the policy before its implementation by: (i) postponing their R&D spending to the post-treatment period when it becomes cheaper to do so, (ii) starting to invest early on in preparation for a long term R&D project, (iii) postponing merger and acquisition decisions to until after the policy change, or (iv) strategically adjusting the firm size to keep benefiting from the SME scheme both before and after the policy change. Given our reduced form approach, it is not possible to disentangle these different factors at play, but at least we may be able to limit the effect of such strategic behaviour on our estimates. Removing the years 2007-2008 would address the issues that may arise from back-loading the R&D investment as in (i), or front-loading the R&D investment as in (ii), because of the timing of policy announcement. Removing only 2008 yields similar results. In Table 3, we observe that the coefficient size in the preferred specification (Column (9)) is 42 percent, and significant at the 5 percent level. The estimates are more imprecise, possibly because of the smaller sample size in comparison to the results presented in Table 2.

If there is a strategic timing issue of mergers and acquisitions as in (iii) above, then

the acquired firm is not captured by either treatment or control groups, since they will fail to satisfy the intensive margin condition of having been in the data set and performed R&D at least once both before and after the reform. Finally, the strategic adjustment of firm size to always benefit from the more generous SME scheme is the downsizing effect discussed in Garicano et al. (2013). The predictions in the paper by Garicano et al. (2013) suggest that some less productive firms may 'bulge' just below the threshold for eligibility to the SME scheme, which means that they will initially keep employment below 250 and then expand to a larger size, perhaps not as much as 500 employees but to a larger size than 250. The number of companies that grow just after the announcement or the implementation of the policy is fewer than the disclosure threshold, not allowing us to present an analysis of the behaviour of these companies. These firms would possible have remained as SMEs both before and after the reform, ruling them out as treated or control group because they would have consistently remained below the SME threshold.

The 42 percent increase in qualifying R&D spending in response to around an average 17 percent drop in the tax component of the user cost translates to a user cost elasticity estimate of around -2.5. This is a sizeable effect of the policy, which is on the higher end of the estimates found in the literature. It is, on the other hand, in line with the findings from a recent HMRC evaluation (Fowkes et al. (2015)). We identify several reasons for this large effect of the policy: (i) the UK policy is simple for firms to understand and react quickly, (ii) medium sized companies may be reacting more to the policy than other sub-groups studied in the existing literature, precisely the reason why the UK Government wanted to extend the more generous tax incentives to medium sized companies, (iii) qualifying spending responds more to the reduction in the user cost of 'qualifying R&D', and companies might be increasing their qualifying R&D at the expense of non-qualifying R&D. Because the UK's legal framework governing micro data does not allow us to match the tax returns to the R&D survey, we are not able to investigate the relationship between qualifying and non-qualifying R&D. If these two categories are substitutes, then we may expect

companies to reallocate existing spending, and we would be over-estimating the effect. On the other hand, the qualifying and non-qualifying R&D components are more likely to be complements, as the definition of 'qualifying spending', as described in Section 4, defines spending categories rather than activities, such as researcher salaries and supplies.

Anecdotal evidence suggests that there is a degree of heterogeneity in firm responses to R&D tax credits. We explore various dimensions of possible heterogeneity, such as companies that have continuous positive R&D spending as opposed to those that 'stop-and-go', loss-making versus profitable firms, as well as differences across firm growth quartiles based on average growth in the pre-treatment period and firm age quartiles. The specification used for each of these dimensions of possible heterogeneity takes the following general form:

$$\begin{aligned}\mathbb{E}[R_{it}|D_{it}, \mathbf{x}_{it}] = \exp(\gamma + \delta_D D_i + \delta_T T_t + \delta_I D_i T_t + \delta_D^H D_i H_i + \delta_T^H T_t H_i + \delta_I^H D_i T_t H_i \\ + \mathbf{x}'_{it}\beta_x + \nu_{it})\end{aligned} \tag{10}$$

In the specification in Equation 10 each of the key variables 'Treatment', 'Post2009' and 'Diff-in-diff' are interacted with the dimension of heterogeneity. H is a dummy variable that captures the dimension of heterogeneity. More specifically, in each of the four different regressions (i)-(iv), H is a variable that takes a value of unity if the company: (i) performs strictly positive R&D in all years after it started reporting any R&D and zero otherwise, (ii) reports a trading loss in each of the periods 2005, 2006 and 2007 and zero otherwise, (iii) is in the highest growth quartile based on turnover growth averages in the pre-reform period and zero otherwise, (iv) is in the lowest age quartile (young firm) and zero otherwise. For example, in (i) therefore, the variables that are uninteracted with H capture the coefficients for the companies that are intermittent in their R&D spending, and then the coefficients that are interacted with H capture the surplus for the consistent performers of R&D over intermittent performers of R&D. The triple interaction term $D_i T_t H_i$ captures the differential effect of the policy reform for the firms that are in the group of consistent

performers of R&D relative to the intermittent performers of R&D, and δ_I^H.

Perhaps surprisingly, none of these distinctions offer significant differential effects of one group over another. One reason may be that the firm sizes are not large enough to offer sufficient power to detect any differential impact within sub-groups under the treated group companies. The regression results can be found for these separate groups in Appendix E.

We check the validity of the common trends assumption by implementing placebo reforms in each of the pre-reform years in our sample, namely, all the years over 2003-2007. We do not find any impact of the policy in these periods, and the results are presented in Appendix F.

Finally, we address the control group size being larger than the treated group in terms of the number of observations. We first employ a Mahalanobis distance matching procedure to pair control group companies with each treatment group firm on their pre-reform period characteristics and run the diff-in-diff specifications as explained earlier in this section. For the matching procedure, we use closeness between treated and control observations in their pre-reform period means of profit margin (net trading profit as a share of turnover), fixed assets (real) and turnover growth rate[14]. We use these covariates because they are separate from the criteria used to determine eligibility to treatment and they are available for a large set of the observations in our sample. We obtain bootstrapped standard errors through 100 replications of this procedure. Based on the results with the preferred specification with all control variables and firm and year fixed effects, the PML estimator yields a diff-in-diff coefficient of around 87 percent which is highly significant. This point estimate is much larger than that found using the full sample. As discussed, the matching sample is constructed by focusing on a narrow sample based on a set of covariates which are selected rather arbitrarily. We therefore refer to our results from the matching procedure as supportive evidence for a positive effect of the policy, but we refrain from drawing our

[14]Software package used for this purpose is Stata's user-written 'mahapick' command written by David Kantor Kantor (2006).

main conclusions based on the magnitude of this point estimate.

6 Conclusion

Until 2000s, exogenous policy reforms to evaluate R&D policy have not been easily available. The increased popularity of R&D tax incentive policies around the world, coupled with the increased generosity of existing schemes now enable better identification of the policy impact. The simplicity of the UK R&D tax incentive system, and an important exogenous UK policy reform has allowed us to estimate the impact of R&D tax incentive policies in supporting R&D spending by the private sector.

Medium sized companies are very important in boosting the overall innovation performance of the private sector[15]. Guided by this observation, the UK Government obtained state aid clearance from the EU to expand the more generous R&D tax relief for SMEs to encompass companies that have between 250 and 500 employees, doubling the thresholds required for eligibility to the SME scheme in 2008. This reform reduced the user cost of R&D capital for the relevant medium sized companies by up to 31 percent. The precise magnitude of the reduction in the user cost depended on the tax positions of individual companies and varied amongst the firms that were eligible for the definition change.

We used the universe of companies that claimed R&D tax relief in the HMRC Corporation Tax returns panel data set to explore the effects of this policy reform. The use of administrative data is advantageous over survey data for this purpose, to identify the companies that changed status from pre-reform to post-reform period, and also to quantify the exact increase in qualifying R&D spending.

We defined the treatment group as those firms which were previously benefiting from the R&D tax relief for large companies and which became eligible for the more generous SME scheme in 2008. Benchmarked against a comparable control group whose cost of

[15]As an example, UK Government documents refer to the report by Cereda et al. (2005), which presents evidence for the strong performance of medium sized companies in research and development intensity based on data from the Community Innovation Surveys.

R&D capital remained roughly stable across time, this study found that the treated firms increased their qualifying R&D spending by about 42 percent. In response to the 17 percent reduction in the tax component of the user cost, the 42 percent increase in R&D spending translates to a user cost elasticity estimate of around -2.5. This is a sizeable effect. We offer several possible reasons for this large effect of the policy: (i) the UK policy is simple for firms to understand and react to quickly, (ii) medium sized companies may be reacting more to the policy than other sub-groups studied in the existing literature, (iii) qualifying spending responds more to the reduction in the user cost of 'qualifying R&D' as opposed to total R&D.

A Tables in Section 5

Table 2: Baseline regression results

	1	2	3	4	5	6	7	8	9
Treatment	-1.942***	-1.947***	-1.853***	-1.842***	-1.828***				
	(0.272)	(0.272)	(0.335)	(0.332)	(0.331)				
Diff in diff	0.458**	0.462**	0.459**	0.459**	0.445**	0.533**	0.541***	0.546***	0.546***
	(0.215)	(0.215)	(0.218)	(0.217)	(0.220)	(0.210)	(0.208)	(0.209)	(0.209)
Post 2008	0.015					0.073			
	(0.073)					(0.063)			
Total assets				0.000	0.000			0.000**	0.000**
(£'000)				(0.000)	(0.000)			(0.000)	(0.000)
Revenue growth					0.000				0.000
					(0.000)				(0.000)
Year fixed effects?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm fixed effects?	No	No	No	No	No	Yes	Yes	Yes	Yes
Sector fixed effects?	No	No	Yes	Yes	Yes	No	No	No	No
N	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212

Robust standard errors in all regressions
First lags of real balance sheet size and real revenue growth rate
* significance at 10 %, ** significance at 5 %, *** significance at 1 %

Table 3: Baseline results, removing 2007 and 2008 fiscal years

	1	2	3	4	5	6	7	8	9
Treatment	-1.801***	-1.804***	-1.687***	-1.674***	-1.649***				
	(0.315)	(0.315)	(0.355)	(0.352)	(0.351)				
Diff in diff	0.319	0.321	0.309	0.307	0.282	0.407**	0.415**	0.420**	0.420**
	(0.208)	(0.208)	(0.210)	(0.210)	(0.218)	(0.203)	(0.202)	(0.202)	(0.202)
Post 2008	0.094					0.166**			
	(0.082)					(0.071)			
Total assets				0.000	0.000			0.000*	0.000*
(£'000)				(0.000)	(0.000)			(0.000)	(0.000)
Revenue growth					0.000				0.000
					(0.000)				(0.000)
Year fixed effects?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm fixed effects?	No	No	No	No	No	Yes	Yes	Yes	Yes
Sector fixed effects?	No	No	Yes	Yes	Yes	No	No	No	No
N	7,848	7,848	7,848	7,848	7,848	7,848	7,848	7,848	7,848

Robust standard errors in all regressions
First lags of real balance sheet size and real revenue growth rate
* significance at 10 %, ** significance at 5 %, *** significance at 1 %

B Data Appendix

We use the total qualiyfing R&D spending numbers provided in the R&D micro data sets that are linked to the CT600. Calculation of qualifying R&D for each company was provided by the HMRC R&D statistics team. Combining information on enhanced R&D expenditure, total amount of subcontracted R&D and whether the company is SME or large, we are able to back out the total qualifying R&D spending of each company in a given year. Specifically, we scale down the total annual R&D enhanced expenditure for a company by the deduction rate in the corresponding year, in line with the HMRC calculations[16]. For example, an SME that reports £30,000 of enhanced deduction and £25,000 of SME claim under the large company scheme as sub-contractor before the 2008 rate changes must have undertaken a total qualifying R&D of £30,000∗(100/150)+£25,000∗(100/125) =£40,000.

C Changes in the corporate tax rate in the UK in 2000s

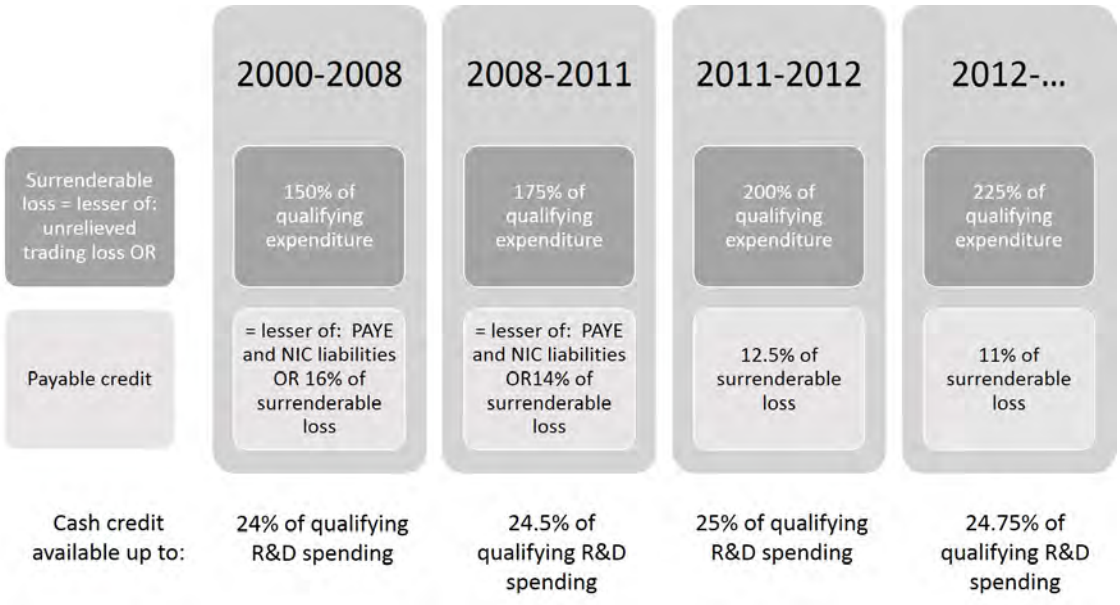
Between 2002 and 2006, the main rate for corporation tax was 30 percent, and the small profits rate, which applied to companies with taxable profit less than £300,000, was 19 percent. Between 2000 and 2005, there was also the 'starting rate' rule, which allowed initially a 0 percent rate on companies with taxable profits less than £10,000. This rate was then increased to 10 percent until the end of the scheme in 2005. For taxable profits between £300,000 and £1.5 million, marginal tax relief fractions apply. In the 2006-07 financial period, the small profits rate increased to 20 percent, and then to 21 percent in 2007-08. In 2007-08, the main rate dropped from 30 percent to 28 percent, and then in 2011-12, to 26 percent. These reductions were followed by further annual drops to 24 percent, then to 23 percent, finally reaching 21 percent in 2014-15.

[16]See Research and Development Tax Credits Statistics published by the HMRC

D Cash credits for SMEs

From its inception, the SME scheme has featured a cash component for companies which do not have taxable profits and hence cannot benefit from the enhanced deduction in the year in which the R&D expenditure has been made. HMRC provides a cash refund up to 24 percent of the amount of the total R&D spending of the firm in cash, which is an amount capped by the PAYE or NIC liabilities of the company. If the company is not cash constrained, it has an incentive to carry forward its losses and use the full deduction amount in a future period when it becomes profitable, however, a company with liquidity constraints would choose the cash option which can be claimed immediately. The calculation of the cash amount changed over time, which is depicted in Figure 7, but the total amount of cash available to a company was kept at around 24-25 percent of total R&D spending across periods of different enhanced deduction rates.

Figure 7: Cash Credit Rates for Loss-making R&D Performers



E Heterogeneous firm responses to the policy

Table 4: Heterogeneous responses to the policy, consistent performers of R&D

	1	2	3	4	5	6	7	8	9
Treatment, NC	-2.069***	-2.072***	-1.981***	-1.963***	-1.940***				
	(0.362)	(0.362)	(0.423)	(0.420)	(0.415)				
Diff in diff, NC	1.496***	1.498***	1.338***	1.344***	1.321***	0.715**	0.718**	0.729**	0.731**
	(0.347)	(0.347)	(0.338)	(0.339)	(0.344)	(0.320)	(0.315)	(0.317)	(0.317)
Post 2008, NC	-0.735***					0.096			
	(0.220)					(0.153)			
Post 2008 * C	1.150***	1.150***	0.933***	0.942***	0.942***	-0.03	-0.034	-0.028	-0.024
	(0.246)	(0.246)	(0.209)	(0.210)	(0.210)	(0.167)	(0.163)	(0.165)	(0.165)
Treatment * C	0.275	0.271	0.295	0.282	0.259				
	(0.398)	(0.397)	(0.501)	(0.499)	(0.494)				
Diff in diff * C	-1.816***	-1.811***	-1.514***	-1.526***	-1.503***	-0.455	-0.448	-0.455	-0.459
	(0.410)	(0.410)	(0.391)	(0.393)	(0.397)	(0.363)	(0.356)	(0.357)	(0.357)
Total assets				0	0			0.000**	0.000**
(£'000)				(0.000)	(0.000)			(0.000)	(0.000)
Revenue growth					0				0
					(0.000)				(0.000)
Year fixed effects?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm fixed effects?	No	No	No	No	No	Yes	Yes	Yes	Yes
Sector fixed effects?	No	No	Yes	Yes	Yes	No	No	No	No
N	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212
Number of consistent in treated	630	630	630	630	630	630	630	630	630
Number of not consistent in treated	753	753	753	753	753	753	753	753	753
Number of consistent in control	4,639	4,639	4,639	4,639	4,639	4,639	4,639	4,639	4,639
Number of not consistent in control	4,191	4,191	4,191	4,191	4,191	4,191	4,191	4,191	4,191

Same remarks as in previous regression tables

NC: not consistent performer of R&D, C: consistent performer of R&D; definition of 'consistent': R&D positive in each period after take up

Table 5: Heterogeneous responses to the policy, companies that incur consecutive losses

	1	2	3	4	5	6	7	8	9
Treatment, NL	-2.519***	-2.520***	-2.474***	-2.460***	-2.444***				
	(0.277)	(0.277)	(0.399)	(0.396)	(0.396)				
Diff in diff, NL	0.574***	0.575***	0.547***	0.549***	0.533***	0.415***	0.427***	0.424***	0.423***
	(0.172)	(0.171)	(0.177)	(0.177)	(0.181)	(0.159)	(0.159)	(0.159)	(0.160)
Post 2008, NL	-0.163					0.086			
	(0.104)					(0.084)			
Post 2008 * L	0.793***	0.793***	0.595**	0.606**	0.605**	-0.045	-0.044	-0.067	-0.068
	(0.292)	(0.292)	(0.255)	(0.254)	(0.254)	(0.119)	(0.119)	(0.121)	(0.121)
Treatment * L	1.448***	1.435***	1.618***	1.608***	1.591***				
	(0.355)	(0.356)	(0.459)	(0.457)	(0.457)				
Diff in diff * L	-0.586	-0.571	-0.383	-0.395	-0.378	0.224	0.217	0.242	0.245
	(0.463)	(0.462)	(0.441)	(0.441)	(0.444)	(0.365)	(0.363)	(0.364)	(0.364)
Total assets				0.000	0.000			0.000***	0.000***
(£'000)				(0.000)	(0.000)			(0.000)	(0.000)
Revenue growth					0.000				0.000
					(0.000)				(0.000)
Year fixed effects?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm fixed effects?	No	No	No	No	No	Yes	Yes	Yes	Yes
Sector fixed effects?	No	No	Yes	Yes	Yes	No	No	No	No
N	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212
Number of lossmaking in treated	317	317	317	317	317	317	317	317	317
Number of other in treated	749	749	749	749	749	749	749	749	749
Number of lossmaking in control	1,447	1,447	1,447	1,447	1,447	1,447	1,447	1,447	1,447
Number of other in control	5,935	5,935	5,935	5,935	5,935	5,935	5,935	5,935	5,935

Same remarks as in previous regression tables

NL: not lossmaking, L: lossmaking; definition of 'lossmaking': trading loss in all of 2005, 2006 and 2007

Similar results are obtained if the split is made using companies which incurred trading loss in all of 2005, 2006 and 2007

Table 6: Heterogeneous responses to the policy, young firms

	1	2	3	4	5	6	7	8	9
Treated, old	-1.932***	-1.926***	-1.769***	-1.761***	-1.761***				
	(0.299)	(0.299)	(0.397)	(0.394)	(0.394)				
Diff in diff, old	0.423	0.416	0.407	0.41	0.41	0.485*	0.486*	0.492*	0.492*
	(0.282)	(0.282)	(0.279)	(0.279)	(0.279)	(0.264)	(0.264)	(0.265)	(0.265)
Post 2008	0.081					0.096			
	(0.083)					(0.069)			
Post2008 * Young	-0.454	-0.454	-0.38	-0.375	-0.375	-0.208	-0.169	-0.165	-0.166
	(0.355)	(0.355)	(0.288)	(0.287)	(0.287)	(0.151)	(0.161)	(0.161)	(0.161)
Treatment * Young	-0.051	-0.105	-0.384	-0.37	-0.313				
	(0.383)	(0.383)	(0.594)	(0.594)	(0.566)				
Diff in diff * Young	0.357	0.412	0.462	0.448	0.39	0.322	0.334	0.329	0.329
	(0.465)	(0.468)	(0.402)	(0.401)	(0.423)	(0.340)	(0.336)	(0.336)	(0.336)
Total assets				0	0			0.000**	0.000**
(£'000)				(0.000)	(0.000)			(0.000)	(0.000)
Revenue growth					0				0
					(0.000)				(0.000)
Year fixed effects?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm fixed effects?	No	No	No	No	No	Yes	Yes	Yes	Yes
Sector fixed effects?	No	No	Yes	Yes	Yes	No	No	No	No
N	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212
Number of young in treated	321	321	321	321	321	321	321	321	321
Number of old in treated	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062
Number of young in control	1,254	1,254	1,254	1,254	1,254	1,254	1,254	1,254	1,254
Number of old in control	7,575	7,575	7,575	7,575	7,575	7,575	7,575	7,575	7,575

Same remarks as in previous regression tables

Definition for "young": in 2007, bottom quartile in the age distribution

F Placebo tests

Table 7: Placebo reform, 2004

	1	2	3	4	5	6	7	8	9
Treatment	-1.895***	-1.895***	-1.735***	-1.726***	-1.725***				
	(0.569)	(0.569)	(0.616)	(0.614)	(0.614)				
Diff in diff (2004)	0.156	0.154	0.083	0.084	0.093	0.145	0.147	0.146	0.146
	(0.563)	(0.563)	(0.574)	(0.574)	(0.573)	(0.574)	(0.574)	(0.574)	(0.574)
Post 2004	0.237***					0.312***			
	(0.077)					(0.070)			
Total assets				0.000	0.000			0.000**	0.000**
(£'000)				(0.000)	(0.000)			(0.000)	(0.000)
Revenue growth					0.000				0.000
					(0.000)				(0.000)
Year fixed effects?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm fixed effects?	No	No	No	No	No	Yes	Yes	Yes	Yes
Sector fixed effects?	No	No	Yes	Yes	Yes	No	No	No	No
N	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212

Same remarks as in previous regression tables

Table 8: Placebo reform, 2005

	1	2	3	4	5	6	7	8	9
Treatment	-2.118***	-2.118***	-1.959***	-1.949***	-1.950***				
	(0.389)	(0.389)	(0.449)	(0.447)	(0.447)				
Diff in diff (2005)	0.425	0.425	0.347	0.348	0.359	0.441	0.444	0.444	0.443
	(0.355)	(0.355)	(0.373)	(0.373)	(0.370)	(0.363)	(0.363)	(0.363)	(0.363)
Post 2005	0.192***					0.250***			
	(0.068)					(0.061)			
Total assets				0.000	0.000			0.000**	0.000**
(£'000)				(0.000)	(0.000)			(0.000)	(0.000)
Revenue growth					0.000				0.000
					(0.000)				(0.000)
Year fixed effects?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm fixed effects?	No	No	No	No	No	Yes	Yes	Yes	Yes
Sector fixed effects?	No	No	Yes	Yes	Yes	No	No	No	No
N	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212

Same remarks as in previous regression tables

Table 9: Placebo reform, 2006

	1	2	3	4	5	6	7	8	9
Treatment	-1.749***	-1.751***	-1.632***	-1.621***	-1.621***				
	(0.368)	(0.367)	(0.412)	(0.410)	(0.410)				
Diff in diff (2006)	-0.003	0.000	-0.035	-0.035	-0.023	0.019	0.024	0.029	0.029
	(0.226)	(0.227)	(0.233)	(0.233)	(0.231)	(0.219)	(0.219)	(0.218)	(0.218)
Post 2006	0.172**					0.227***			
	(0.068)					(0.061)			
Total assets				0.000	0.000			0.000**	0.000**
(£'000)				(0.000)	(0.000)			(0.000)	(0.000)
Revenue growth					0.000				0.000
					(0.000)				(0.000)
Year fixed effects?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm fixed effects?	No	No	No	No	No	Yes	Yes	Yes	Yes
Sector fixed effects?	No	No	Yes	Yes	Yes	No	No	No	No
N	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212

Same remarks as in previous regression tables

Table 10: Placebo reform, 2007

	1	2	3	4	5	6	7	8	9
Treatment	-1.815***	-1.818***	-1.709***	-1.696***	-1.672***				
	(0.315)	(0.315)	(0.365)	(0.363)	(0.362)				
Diff in diff (2007)	0.100	0.104	0.079	0.077	0.053	0.139	0.145	0.151	0.151
	(0.173)	(0.173)	(0.176)	(0.176)	(0.184)	(0.169)	(0.168)	(0.168)	(0.168)
Post 2007	0.148**					0.205***			
	(0.066)					(0.058)			
Total assets				0.000	0.000			0.000**	0.000**
(£'000)				(0.000)	(0.000)			(0.000)	(0.000)
Revenue growth					0.000				0.000
					(0.000)				(0.000)
Year fixed effects?	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm fixed effects?	No	No	No	No	No	Yes	Yes	Yes	Yes
Sector fixed effects?	No	No	Yes	Yes	Yes	No	No	No	No
N	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212	10,212

Same remarks as in previous regression tables

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