Do Tax Credits Stimulate R&D Spending? The Effect of the R&D Tax Credit in its First Decade *

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Abstract

This paper examines the impact of the R&D tax credit between 1981-1991 using confidential IRS data from corporate tax returns. The key advances on previous work are an instrumental variables strategy based on tax law changes that addresses the simultaneity between R&D spending and its user cost and the use of new confidential data. Estimates imply that a ten percent reduction in the user cost of R&D leads the average firm to increase its research intensity—the ratio of R&D spending to sales—by 11 percent in the short-run. Long-run estimates imply that firms do face adjustment costs and further increase spending over the longer-run. Analysis of the components of qualified research shows that wages and supplies account for the bulk of the increase in research spending. Comparisons of the elasticity across firms of different sizes, industries, tax status, multi-national status and credit history are also made. Neither small nor young firms appear more responsive in the static analysis but the dynamic model reveals stronger short-run responses, suggesting that they may face lower adjustment costs or liquidity constraints in financing R&D. Long-run and retiming analyses show no evidence that firms allocate their qualified research spending over time to maximize their R&D tax credits. Elasticities of qualified and total research intensities from a smaller sample suggest firms respond to user cost changes largely by increasing their qualified spending, meaning that what R&D the federal credit deems qualified research is an important margin on which the credit affects firm behavior.

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1 Introduction

How much the U.S. is spending on R&D—relative to past levels and relative to other nations—attracts considerable attention from industry leaders, policymakers and researchers. In an attempt to stanch a decade-long decline in the GDP-share of private R&D spending, Congress adopted a tax credit for R&D expenditures in 1981. The Research and Experimentation Credit (R&D Credit) today awards firms that increase their research spending a tax credit of up to 20 percent of the expenditures, though effective credit rates have been both considerably higher and lower historically. This paper uses new data and an instrumental variables strategy to assess how effectively the R&D tax credit, along with existing expensing provisions, increases corporate research spending.

As the primary tax provision designed to encourage private R&D expenditures, the effectiveness of the federal R&D credit has been of interest to researchers since its inception. Despite the credit's higher statutory rate in its earliest incarnation, using confidential IRS data, Altshuler (1988) found that between 1981 and 1984 average effective credit rates were just a fraction—less than one-tenth—of the period's 25 percent statutory credit rate. Early work suggested that the credit had only modest effects. Eisner, Albert, and Sullivan (1984))[1] and Mansfield (1986)[2] examined spending patterns in the first years after the R&D credit was introduced and estimated insignificant and small credit responses. Later studies, most notably Hines (1993) and Hall (1993b), found that the R&D tax credit proffered considerable bang-for-the-buck. Hines (1993) explored the effect of changes in the allocation rules of R&D expensing on the R&D activity of multinational firms, exploiting variation in the fraction

[1] Eisner, Albert, and Sullivan (1984) found that spending on research that qualified for the R&D tax credit grew 25.7 (5.0) percentage points faster than unqualified research spending between 1980 and 1981. They found that difference in spending growth was statistically insignificant in 1982, suggesting that the policy change did not fundamentally alter spending patterns. Comparing changes in aggregate qualified and unqualified R&D spending implicitly assumes that absent the introduction of the R&D tax credit these types of R&D spending would have increased identically; systematic spending trend differences among firms with different R&D spending mixes would violate this assumption.

[2] Mansfield (1986) compared the experiences of the US, Canada and Sweden using firm-level survey data; executives of a stratified sample of firms were asked to estimate the effect of the relevant tax incentives on the firm's R&D expenditures. According to the executives, each dollar of forgone tax revenue resulted in 30 to 40 cents of induced R&D spending.

of U.S. R&D expenses firms can deduct against U.S. income to estimate the response of R&D spending to its after-tax price. His short-run estimates range from -1.2 to -1.6 and long-run estimates range from -1.3 to -2.0. Although the changes in the allocation rules are conceivably exogenous, Hines' tack relies on variation in the tax treatment of R&D expenditures across firms—an experiment that is different than the changes in the main statutory provisions of the R&D tax credit examined here. The closest antecedent to this paper is Hall (1993b), which used Compustat data from financial filings beginning in 1981 and ending in 1991. In her log first-difference specification, Hall uses cross-time within-firm variation in tax positions and marginal R&D tax subsidies to estimate a short-run elasticity of -1.5 (0.3) and a long-run elasticity of -2.7 (0.8).

More recent work examining the impact of state tax credits and international experiences has found more modest elasticities. Cross-country analysis by Bloom, Griffith, and Reenen (2002) suggests much lower short- and long-run user cost elasticities. In their preferred dynamic specification they estimate a -0.14 short-run elasticity and a -1.09 long-run elasticity.[3] Although some countries in their sample have incremental R&D credit regimes, where high spending firms receive higher credit rates, Bloom et al do not address this potential source of bias due to the aggregate nature of their data. Wilson (2009) uses variation in state tax preferences for R&D to estimate both the impact of a state's R&D policy on R&D conducted in that state and the impact on R&D in neighboring states.[4] His state-level analysis yields an elasticity estimate of 0.17 in the short-run and 0.68 in the long-run. Wilson assumes that all R&D subject to an incremental R&D tax credit receives the highest statutory rate, abstracting from simultaneity between R&D spending and R&D user costs due to data limitations.

[3]Because the user cost of R&D is a function of the interest rate, which is positively correlated with R&D spending, Bloom et al worry that OLS estimates of the user cost elasticity would be biased upward. They instrument the R&D user costs with the tax component of the user cost to address this endogeneity issue as well as attenuation bias concerns.

[4]Using state aggregate data he finds that R&D spending is negatively impacted by tax preferences in other states, suggesting that firms shift R&D to proximate states with lower R&D user costs. The magnitude of this response nearly offsets the in-state response of R&D to changes in the in-state user cost.

This paper re-examines the impact of federal tax advantages for R&D between the inception of the R&D tax credit in 1981 and 1991. Data after 1991 are excluded because the credit was allowed to first lapse in 1992. Since this and other lapses likely affected firms' expectations of the after-tax user cost of R&D, the analysis here is limited to only the first 11 years after the introduction of the research credit when firms' expectations regarding the credit were similarly stable. Furthermore, during this period the R&D credit underwent several substantial revisions that allow for an instrumental variables strategy based on tax changes. Unlike previous efforts to assess the impact of tax subsidies on R&D spending, this paper incorporates restricted-access IRS corporate return data. As explained in more detail below, the structure of the R&D tax credit makes a firm's marginal tax subsidy difficult to infer from annual R&D spending as reported in its public financial statements alone. Data from a firm's corporate tax return allows for accurate measurement of the tax subsidy each firm faces on its marginal R&D dollar each year and allows for unbiased assessment of the impact of the tax credit on R&D expenditures.

The main contributions of this paper are the use of IRS Statistics of Income (SOI) data that accurately describe marginal credit rates and a more direct correction for potential biases due to the simultaneity of R&D spending and marginal credit rates. Tax subsidy terms constructed using only publicly available Compustat data, and constructed using IRS data are compared and found to differ and the differences often vary from year to year. This finding at a minimum suggests potential measurement error in subsidy rates calculated using public use data. The potential for substantial mismeasurement raises questions about the many panel data strategies for estimating the elasticity of R&D spending using public data.

Using an instrumental variables strategy based on tax law changes to disentangle any potential simultaneity between R&D spending and its user cost, I estimate a short-run user cost elasticity for R&D spending. Estimates imply that a ten percent reduction in the user cost of R&D leads the average firm to increase its research intensity—the ratio of R&D spending to sales—by 11 percent in the short-run. Long-run estimates imply that firms do face adjustment costs and further increase spending over the longer-run. Analysis of the components of qualified research shows that wages and supplies account for the bulk of the increase in research spending. Comparisons of the elasticity across firms of different sizes, industries, tax status, multi-national status and credit history are also made. Neither small nor young firms appear more responsive in the static analysis but the dynamic model reveals that their short-run response is stronger, suggesting that they may face lower adjustment costs or liquidity constraints in financing R&D. Evidence from long-run and retiming analysis show no evidence that firms allocate their qualified research spending over time to maximize their R&D tax credits. Elasticities of qualified and total (qualified and non-qualified) research intensities from a smaller sample suggest that firms do respond to changes in the user cost largely by increasing their qualified spending, meaning that what R&D the federal credit deems qualified research is an important margin on which the credit affects firm behavior.

The paper proceeds as follows. Section 2 overviews the key provisions of the R&D tax credit and describes the restricted access IRS SOI data used in this study. The empirical model is laid out and estimation strategy is detailed in Section 3. Section 4 presents the results of the regression analysis. Section 5 assesses the policy implications and concludes.

2 Measuring R&D User Costs and R&D Expenditures

2.1 Federal Tax Subsidies and the User Cost of R&D

In addition to direct federal support for R&D, such as research performed by federal agencies and grants for basic and applied research, the federal government provides indirect support of private research through the tax code. Federal tax law offers two incentives for private R&D: a deduction for qualified research spending under Section 174 of the Internal Revenue Code (IRC), and a non-refundable tax credit for qualified research spending above a base amount under IRS Section 41. These two tax advantages reduce the after-tax price of R&D

investment; they are jointly referred to here as the "R&D tax credit" and their combined effect on the after-tax price of and impact on R&D spending is assessed.[5]

The tax credit is incremental in nature; it aims to reward research expenditures in excess of what the firm would have spent in the absence of the credit. As such, the credit defines a firm's base level of R&D spending and awards a tax credit equal to a fraction of spending above that base level. Originally, the credit was equal to 25 percent of qualified research expenditures (QREs)—which are expenses incurred in research undertaken to discover knowledge that is technological in nature for a new or improved business purpose—above the firm-specific base amount. A firm's base was its average nominal qualified R&D spending in the previous three years, or 50 percent of current spending, whichever was greater. Because a firm's base was a moving average of its past spending, adding qualified research spending in the current year increased the firm's base by one-third of the increase in each each of the subsequent three years. This 'claw-back' muted the credit's incentives effects; some firms were even left with negative marginal credit rates.

The tax credit was extended and its provisions were amended by several legislative acts after its introduction in 1981; they are detailed in Table 1. The credit was revamped in 1989 to address the dynamic disincentives for current qualified R&D spending created by the claw-back provision. The legislative overhaul altered the base formula, replacing the moving average with a base unrelated to recent R&D spending. The new formula for the base was the greater of 50 percent of current QREs and the product of the firm's average gross receipts in the previous four tax years and the firm's "fixed-base percentage," a measure of historic research intensity. A firm's fixed-base percentage is its ratio of total qualified R&D expenditures to total gross receipts between 1984 and 1988. Start-ups, firms lacking gross receipts or QREs for three of five years between 1984 and 1988, are assigned a three percent fixed-base percentage.

[5] Net Operating Loss (NOL) carry-forwards resulting from Section 174 expensing can be carried forward up to 20 years—five years longer than Section 41 tax credits can be carried forward. Although this discrepancy in carry-forward life has real implications for some firms, this level of detail is beyond the descriptive capability of the data used here and is ignored.

The incremental nature of the R&D tax credit renders a firm's marginal credit rate a non-monotonic function of its research spending: firms that fail to exceed their bases receive no subsidy, firm's that exceed their bases but do not spend more than twice their base receive the full statutory subsidy rate and firms that exceed twice their bases receive half the statutory credit rate on their marginal spending. This complicates the empirical analysis as explained in Section 3.

2.2 R&D Expenditures

The empirical analysis makes use of restricted-access IRS Statistics of Income (SOI) data that have not previously been used to estimate the user cost elasticity of R&D. The IRS SOI data are drawn from a panel sample of corporate tax returns. The data for each firm-year observation comes from the firm's basic tax return, Form 1120. Data items relating to R&D spending are pulled from Form 6765. The data report the firm's annual qualified R&D expenditures, base amount, tentative R&D tax credit, and limitations due to insufficient tax liabilities among other details. Only IRS SOI data describe qualified spending and provide enough detail to accurately measure the actual credit rates firms face on their marginal dollar of R&D spending. R&D expenses reported in financial filings and publicly available through Compustat conform to a broader definition of R&D that includes both R&D conducted abroad and domestic research expenditures that do not qualify for the R&D tax credit because they fail to meet the experimental and technological criteria of the credit.[6]

If firms respond to changes in subsidies for qualified R&D by changing their qualified and non-qualified spending shares, determining a firm's marginal credit rate using public data describing the sum of qualified and non-qualified R&D spending will lead to a biased measure of the user cost. For example, if firms increase the qualified share of their spending when subsidies are high, the marginal credit rate could be understated if this disproportionate

[6]The accounting definition of R&D includes all the categories that comprise IRS QREs but is less strict in terms of the experimental and technological nature of these expenditures. For example, expenses related to testing and the modification of alternative products is classified as R&D for accounting purposes but generally do not qualify for the R&D tax credit.

increase in qualified spending lifts the firm's spending above its base, or the effective credit rate could be overstated if the increase in qualified spending leaves the firm above twice its base level. Because a firm's credit rate is determined by its relative QREs, changes in the composition of spending can affect credit rates. Using the broader measure of R&D will result in non-classical mis-measurement of the user cost. Only SOI data can overcome this measurement issue. In addition, because financial data do not describe unused previously earned tax credits, the present value of currently earned R&D tax credits may be overstated; overstating the value of the credit understates the price of R&D, potentially under-estimating the magnitude of the tax-price elasticity.[7]

Table 2 details the differences between the true marginal credit rate as detailed in the IRS SOI data and the marginal credit rates inferred from the broader measure of R&D reported in financial filing data from Compustat. Because the IRS SOI data includes both public and private firms and does not oversample large firms, only a small set of firms appear in both the Compustat and IRS SOI data. There are a total of 686 common firm-year observations between 1981 and 1991. The impact of taxes on the user cost is different in the two data sets and the differences vary from year to year. In 1981 the claw-back provision actually increase user costs for the average firm in the merged sample from 1 to 1.038 while according to the less accurate Compustat data the average firm enjoyed a subsidy that reduced its user cost to 88.8 percent of the pre-tax subsidy user cost. This difference is partly because a substantially larger fraction of firms faced negative marginal credit rates than the Compustat data suggest, 45.6 versus 11.8 percent.[8] In general, the Compustat data suggest that more firms–from 2.7 to nearly 22 percentage points more, depending on the year–qualify for an R&D tax credit than actually do. In nearly every year between 1982 and 1989 the Compustat data imply

[7]This lack of information on other tax credits is even more important after 1986 when the R&D tax credit was folded into the General Business Credit (GBC). The GBC not only caps the total amount of credits that can be used in any year but also prescribes the order in which they must be used. A firm that has a lot of higher priority credits would value currently earned R&D credits less.

[8]The unusually high fraction of firms that had negative credit rates in 1981 may be due by delays in increasing research spending in reaction to the credit's introduction. Firms may not have been able increase their spending enough to qualify for a credit in 1981 but every dollar they did spend increased base amounts in subsequent years, leading to negative marginal credit rates.

lower user costs, that more firms receive credits and that more firms face negative marginal credit than the accurate IRS SOI data detail. The IRS SOI data show that the reformulation of the base starting in 1990 coincided with a reduction in the fraction of firms earning an R&D tax credit—a pattern consistent with the Compustat-based findings of (Gupta, Hwang, and Schmidt 2011)—and a modest increase in the user cost not apparent in the Compustat data. The fact that the Compustat data suggest such different effects of the R&D tax credit provisions and the fact that these differences vary so widely from year to year bring into the question the appropriateness of using data from financial filings to determine R&D tax subsidies which depend so crucially on comparisons of spending patterns over time.

But for all the detail and accuracy the IRS SOI data afford, they have limitations as well. First, is the issue of censoring. A firm likely only reports the details of its research spending in years when it applies for the R&D tax credit; in years where it will not earn a credit, it is unlikely to complete Form 6765. Thus in years when the firm does not apply for a credit, its qualified spending is not known (SOI data report missing values as zeros.) So as not to drop these observations, I assign firms that have previously claimed the R&D credit, but did not complete Form 6765 a zero marginal credit rate. Effectively, I assume that firms are not leaving potential R&D tax credits on the table. Only firms that have ever claimed the R&D tax credit, that is filed a form 6765 as part of its 1120 are included in the sample used in the analysis. The qualified spending of these 'missing' firms remains unknown, however. It is treated as it appears in the data, as a zero, but this likely understates R&D spending; robustness checks that limit the sample to only those firms that complete Form 6765 each year and analysis that also makes use of public data provide checks for this treatment. Second, IRS data only report qualified research expenditures. Although these are exactly the type of expenditures that are needed to accurately calculate the marginal credit rate, we are not only interested in the impact of tax subsidies on these expenditures. If firms respond to larger tax subsidies by shifting their R&D spending from unqualified to qualified spending, we should interpret the impact of the R&D tax credit differently than if they are increasing total research spending. IRS data do not provide any sense of how a firm's non-qualified spending responds to subsidies for qualified spending. Analysis using both the IRS SOI and Compustat data, though in a substantially limited sample, is conducted to assess the importance of this limitation.

3 Empirical Model and Estimation Strategy

3.1 Empirical Model

Firms are viewed to dedicate personnel and purchases to R&D to develop new products and services that increase sales. The output Y_{it}, of firm i in time t is generated via a production function with a constant elasticity of substitution (γ) between R&D services and all other inputs. The profit maximization first-order conditions yield a standard factor demand equation for R&D services as a function of its ex ante user cost, $R_{it} = \theta Y_{it} \rho_{it}^{-\gamma}$, where θ is the CES distribution parameter and ρ_{it} is the user cost of R&D. Note that γ captures both the elasticity of substitution and the user cost elasticity of R&D. Tax subsidies that reduce the user cost will increase the firm's use of R&D as an input factor—estimating this response is the focus of this paper.

The standard Hall and Jorgenson (1967) user cost of capital formula can be extended to reflect both the federal tax deduction and tax credit for R&D.[9] A firm that is taxable at marginal rate τ_{it} can expense its R&D spending in the current year and earn a tax credit at marginal rate c_{it}, which is indexed by firm because the marginal R&D tax credit rate is a function of the firm's R&D spending.[10] A nontaxable firm with l_{it} years of tax losses cannot use the R&D expensing provision to offset income until those losses are exhausted. Similarly, a firm with insufficient tax liabilities to fully apply any R&D credit earned this

[9] Hall (1993b), Bloom, Griffith, and Reenen (2002) and Wilson (2009) similarly extend the standard investment user cost of capital to measure the user cost of R&D.

[10] The corporate tax rate is indexed by firm to account for the progressivity of federal corporate taxes. Some small firms subject to a marginal tax rate less than 35 percent do spend on R&D; their R&D credit rates reflect their lower marginal tax rates.

year will carry its credit forward m_{it} years. Firms are assumed to discount the future at a common real interest rate, r_t, and purchase R&D at price p_t^K. Thus, the relevant user cost of R&D capital, ρ_{it}, for firm i at time t is:

$$\rho_{it} = \frac{\left(r_t + \delta - \pi_t^K\right) p_t^K \left(1 - \tau_{it+l_{it}} \left(1 + r_t\right)^{-l_{it}} - c_{it} \left(1 + r_t\right)^{-m_{it}}\right)}{\left(1 - \tau_{it+l_{it}} \left(1 + r_t\right)^{-l_{it}}\right)} \tag{1}$$

where π_t^K is the time-varying growth rate of R&D input prices.[11] Since wages comprise the bulk of R&D spending, π_t^K should closely track wage growth for scientists and engineers. Note that when firm i is taxable l_{it} and m_{it} will be zero.

During the 1980s many changes were made to the provisions of the R&D tax credit, including changes in the statutory rate and recapturing provisions. The impact of these changes on the marginal R&D credit rate are detailed in Appendix A. The user cost of capital for each firm in each year is carefully calculated using these provisions and assuming a 3 percent real interest rate, a 15 percent depreciation rate and that π_t^K is equal to science and tech wage inflation.

It should be noted that the input into the firm's production function is R&D services flowing from an unobserved stock of R&D capital. Researchers proxy for the unobservable service flow by assuming that R&D services in a given year are proportional to either R&D investment or the R&D capital stock in that year, which they typically calculate using a perpetual inventory method and a constant rate of geometric decay. Papers that compare the flow and stock proxies, such as (Hines 1993), (Wilson 2009) and (Hall 1993b), find very similar results. Given the inherent difficulty in measuring the depreciation rate of a firm's R&D stock—and potential variation in the depreciation rate across industries—and the difficulty posed by the fact that IRS data only provide R&D expenditures in years when the firm applies for a tax credit, I opt to use R&D investment as the proxy, as is commonly done in the literature.

[11] The credit rate, c_{it}, enters the relation linearly because the depreciation base is not typically reduced by the amount of the credit.

Although log-linearizing the factor demand equation would prescribe a log-log regression model that uses the logarithm of R&D spending as the outcome of interest, this paper assesses how changes in the tax subsidies for research spending affect firm research intensities—the ratio of R&D expenditures to sales. A firm's research intensity is a reasonable outcome of interest for a number of reasons. First, research intensity is a commonly used measure of innovation spending in the academic literature, such as (Cohen and Klepper 1992), (Jaffe 1988) and (Pakes and Schankerman 1984) , industry publications and government agency reports, such as the National Science Foundation (Board 2012) and the Congressional Budget Office (Austin 2006). The fixed-base percentage of the R&D credit itself uses research intensity to formulate a research benchmark. Second, any procedure for creating a stock measure for R&D capital involves great uncertainty as to how spending translates into a stock of innovation capital or how this capital depreciates. Examining the effect of tax subsidies on scaled research expenditures has the meaningful advantage of transparency. Third, and perhaps most importantly, the more accurate IRS SOI data contain a number of zeros–both because firms do not report research spending every year and the IRS reports missing data as zeros and because firms report zero spending in some years. Of course, in the cases where the missing data are assumed to be zeros, the mis-measurement could bias the estimates; regressions that use only firms that report in all years confirm the baseline results. Finally, given the assumed CES production technology, the elasticity of research intensity with respect to the user cost is also γ, meaning that the analysis here will give us similar insight into the price-sensitivity of R&D investments.

As firms may have generally different research intensities the estimation equation is first-differenced to remove any unobservable firm-level differences. Because aggregate macroeconomic factors such as technology opportunities, changes in U.S. patent policy and IRS regulations, and aggregate demand will affect firm R&D decisions, year fixed effects are added to the model to absorb these potentially confounding factors. Thus, the estimation equation is:

$$\left[\frac{R_{it}}{S_{it}} - \frac{R_{it-1}}{S_{it-1}}\right] = \alpha + \gamma\left[\rho_{it} - \rho_{it-1}\right] + \chi_t + \epsilon_{it} \tag{2}$$

Table 3 presents key descriptive statistics for the variables used in the analysis. During the sample period, the average firms marginal R&D expenditures are subsidized by the tax credit, reducing their user cost of R&D to $0.90 per dollar of R&D. The average belies substantial heterogeneity. Although the R&D tax credit reduces the user cost for firms through the 75th percentile, 3.23 percent of firms actually face a user cost higher than unity due to the perverse incentives created by the claw-back provisions of the R&D credit prior to the 1990 reformulation. Figure 1 provides more insight into the dispersion of user costs over time. The average firm spends roughly $8 million on qualified research, though the distribution is heavily right skewed. The top decile of firms accounts for more than 97 percent of all R&D expenditures. The top five percent account for 92 percent and the top percentile itself contributes nearly 73 percent of all qualified research in the sample. This skewness is also apparent in the distribution of research intensities. While the average firms R&D-to-sales ratio is 2.93 percent (conditional on non-zero qualified research), the median firms research intensity is only 1.36 percent and the the ratio rises to 7.55 percent at the 90th percentile; the unconditional distribution shows a similar pattern. Firms average roughly $1 billion in sales and $65 million and $62 million in tax and book profits respectively. The average firm has approximately $1.9 billion in assets, though assets, like research spending is heavily rightward skewed with the top percentile of firms having more than 600 times the assets of the median firm. While the average firm has more than $30 million in foreign tax credits, only the top 25 percent of firms have any appreciable amount credits.

3.2 Estimation Strategy

As was explained in Section 2, a firm's R&D tax credit rate is a non-monotonic function of its R&D spending. A firm's marginal R&D credit rate and it R&D spending level are jointly determined; the user cost of capital, ρ_{it}, is correlated with ϵ_{it}. For example, if there is a positive shock to R&D spending ($\epsilon_{it} > 0$) then, due to the structure of R&D tax credit, the marginal credit rate could mechanically increase if the firm was otherwise below its base or decrease if the firm was otherwise above its base. An OLS regression of equation (2) would therefore lead to a biased estimate of the behavioral elasticity.

To disentangle this endogeneity I rely on an instrumental variables strategy similar to those Auten and Carroll (1999) and Gruber and Saez (2002) use in studying individual taxpayer decisions. The strategy to build instruments for the user cost variable, ρ_{it}, is to compute ρ_{it}^{S}, the marginal user cost the firm would face in year t if its real R&D spending did not change from the previous year. The natural instrument for the actual change in the tax factor of the after-tax user cost, (ρ_{it}/ρ_{it-1}) is the difference in the firm's "synthetic" user cost under current law and their actual lag user cost, $\left(\rho_{it}^{S}/\rho_{it-1}\right)$. The instrument by construction eliminates the effect of R&D spending changes on the change in tax price so that the synthetic change in tax price only reflects the exogenous changes in the provisions of the R&D tax credit. It is the exogenous changes in the effective tax price of R&D due to changes in the corporate tax code and provisions of the R&D credit that are the source of identification of the behavioral response. First-differencing purges firm-specific correlation in the evolution of R&D spending while time fixed effects purge changes in R&D spending common across all firms. The resulting residual variation in the tax-price that identifies the estimated elasticity arises from within-firm changes in the tax-price of R&D relative to the changes experienced by the average firm.

Only observations from years when there was a change in tax policy are used in the analysis.[12] The key exclusion restriction is that the constructed synthetic tax factor does not affect R&D spending other than through the actual tax factor, conditional on firm and year fixed effects. In later regressions, as explained in Section 4, a spline in lagged R&D

[12] The years used are 1986, 1987, 1988, 1989 and 1990. For a summary of the changes made to the R&D tax credit in these years, please see the Appendix or Table 1. The introduction of the credit cannot be used as QRE data is not available in the pre-period

spending is added as a control to account for reasons other than the tax price why firms in different parts of the R&D spending distribution might experience different patterns of R&D growth. These added controls tighten the exclusion restriction; the identifying assumption now only assumes that the R&D spending distribution is not evolving on its own in a way that is correlated with the year-specific changes in the tax treatment of R&D. Given the strong nonlinearities of the firm-specific credit function, this assumption seems reasonable.

4 Results

If the tax credit is effective in increasing R&D outlays, we should see research intensities increase in response to higher effective credit rates. Table 4 presents the main results of the empirical analysis. The outcome of interest for all columns is the one-year change in research intensity. The first column reports OLS estimates of equation (2) while Columns (2) - (8) report IV estimates. All regressions are weighted by real annual sales, though the estimates are statistically invariant to alternative weights such as real total assets. The specification reported in Column (2) instruments for the endogenous tax variable with the synthetic tax subsidy constructed from two-year lagged R&D spending as described in Section 3.[13] Comparing Columns (1) and (2) makes clear that the simultaneity of the tax credit and R&D expenditures leads to substantial under-estimation of the responsiveness of research spending to the tax credit—instrumenting for the tax variable yields an estimate that is statistically dissimilar and three times larger in magnitude. The results of Column (2) suggest that research intensities are very responsive to changes in the firm's credit rate; a ten percent increase in the firm's tax subsidy leads to a nearly 11 percent increase in the firm's research intensity. The average research-to-sales ratio is approximately 4.56 percent for firms in the baseline IV sample, conditional on engaging in research that year.

Column (3) adds a five-knot spline in the previous years R&D spending to better control

[13] In the corresponding first-stage regression, the predicted tax subsidy, that is the synthetic tax instrument, is a very strong predictor of the actual tax subsidy rate, with an F-stat above 82.

for underlying changes in the R&D spending distribution that may confound the analysis. Mean reversion, for example, could be particularly problematic in examining the response to an incremental credit. A spline in two-year lagged R&D spending is also added to the instruments. Controlling for any potential mean-reversion or other changes in the distribution has no appreciable impact on the estimated tax-price elasticity. Outlier observations are dropped in Column (4); dropping the three percent most-research intense firms (that report the required information to be in the sample) does not affect the point estimate, though it does increase the estimated elasticity due to the decrease in average R&D-to-Sales ratios in the trimmed sample. Since the firms with the very highest research intensities tend to have low sales they have little impact on the weighted regression despite having an average research-to-sales ratio in excess of one.[14]

Column (5) adds industry fixed effects. Two-digit SOI industry codes are used. The sample spans 68 industries. The highest R&D-to-sales ratios are found in non-electrical machinery manufacturing (category 35), chemicals and allied product manufacturing (28), business services (73), electrical and electronic equipment manufacturing (36) and), instrument manufacturing (38).[15] The addition of industry fixed effects has no substantive impact on the estimated elasticity, meaning that industry-level changes do not account for the increases in R&D spending we see in years when firms have higher effective R&D tax credit rates.

Column (6) tests the validity of using the two-year lag of R&D spending to construct the synthetic tax instrument. Serial correlation in the error term of equation (2) will lead to an inconsistent estimated elasticity. Weber (2011) suggests using longer lagged variables to construct the synthetic, or predicted tax change, instrument, to assess how problematic serial correlation may be though the potential is reduced here by the use of two-year rather than one-year lags to construct the tax instrument. The specification reported in Column

[14]Dropping only the top percentile of firms yields a similar coefficient estimate of -0.056 (0.018).

[15]The top percent most research intense firms were dropped as they skew the averages; for these dropped firms the average R&D-to-Sales ratio exceeds 12.

(6) adds an instrument constructed from the four-year lag in R&D spending. Although the estimated elasticity is slightly smaller, -0.982 (0.302), it is statistically and economically indistinguishable from the baseline.[16]

If a firm does not qualify for an R&D tax credit it likely will not file a Form 6765 and thus likely does not disclose the details of its research activities (though approximately ten percent of firms that include form 6765 in their filing report zero R&D spending). Column (7) assesses the impact of selective reporting by limiting the sample to only those firms that report R&D spending in all years. The sample of 9,935 observations describing 1,987 firms is substantially smaller, but the estimated elasticity, -0.770 (0.215) is similar.

Firms end their fiscal years in all months of the year. Tax policy is largely tied to the calendar year, but it is possible that firms may choose to allocate research spending into different tax years to show certain increases or decreases in research spending in their financial reports. Column (8) reports results from an estimation that uses only firms with December fiscal year ends. Though the sample is roughly half the size of the baseline sample, the estimated elasticity, -1.028 (0.368), is nearly identical.

Firms claiming an R&D tax credit must categorize their research expenditures into one of five categories of spending. Table 5 reports the impact of tax subsidies on the different types of qualified research spending. All regressions are of the same specification as equation (2) but replace the ratio of total qualified R&D spending-to-sales on the left-hand side with the ratio of each category of spending to firm-wide sales. Wages comprise nearly two-thirds (66.6 percent) of all qualified research expenditures. Supplies make up the next largest share (19.0 percent). Contracted research, where a third party performs a qualified research service and is paid by the taxpayer firm regardless of the success, follows, accounting for 11.7 percent of total research spending. For tax credit purposes contract research payments are included at 65 percent of the actual expense. Payments to universities and other eligible

[16] More directly using the Difference-in-Sargan test to assess the exogeneity of the synthetic tax instrument constructed from the two-year lag (relative to the instrument constructed using the four-year lag of R&D spending), the p-value of the Difference-in-Sargan test is 0.581, meaning that I cannot reject the exogeneity of the two-year lag instrument.

nonprofit organizations for the conduct of basic research comprise roughly 3.7 percent of research expenditures. Rent comprises less than one percent of research spending.

Qualified spending broken down by category was unavailable for 1990, so the number of observations in Table 5 is only 15,340. Column (1) reports the effect of the tax subsidy on the ratio of total QREs to sales for this smaller sample.[17] The coefficient estimate is very similar to those of Table 4, though the elasticity is somewhat larger due to lower average research intensities in this sample. As Column (2) shows spending on wages and salaries, which accounts for the majority of research spending, is very responsive to the tax subsidy. A ten percent tax subsidy leads to a 15 percent increase in the wages-to-sales ratio, which averages 2.1 percent in the sample. Spending on supplies (Column (3)), responds similarly, with an estimated elasticity of -1.83 (0.57), though supplies comprise less than 20 percent of R&D spending. Though they account for much less spending, rent, contracted research and university or non-profit bases spending all show similar, high, tax-price responsiveness (Columns (4)-(6)).[18] Incentive to increase research spending, it appears, boost expenditures in proportion to existing spending ratiosmarginal research expenditures do not appear to have a markedly different mix of inputs than existing research. Thus, the research credit in effect mostly accrues to the wages and salaries of R&D employees.

The heterogeneity of firm responses to changes in the tax subsidy are investigated in Tables 6A-6D. In the more than two decades since the credit was introduced many attempts have been made to better target the credit at smaller firms through restructuring the credit and creating new versions of the credit. Table 6A examines how firms of different sizes respond to the research credit. Firms are divided into five quintiles by real total assets, with Column (1) corresponding to the firms with the lowest level of assets.[19] Although the

[17]The regressions reported in tables 4-9 all drop the one percent most research intense firms as their ratioson average 35.5are extremely atypical. The results are not sensitive to dropping the top two, three or five percent of firms instead.

[18]Data regarding research payments to universities and other eligible nonprofit organizations for the conduct of basic research were not reliably available after 1986, hence only one year of data is included in the Column (5) regression.

[19]The results are very similar when firms are divided by quintiles of real sales instead.

estimated tax-price elasticities are all significant and vary from -1.165 for the smallest firms to -2.937 in the case of the fourth quintile, the standard errors are generally too large to draw strong conclusions. It is true, however, that there is no evidence that smaller firms are more sensitive to tax subsidies (taking any possible discounting due to delayed use into account); if anything the point estimates suggest that larger firms are more responsive to tax subsidies. Since the top two quintiles of the asset distribution account for 95.6 percent of all qualified research expenditures (the top quintile alone accounts for 88.7 percent), targeting small firms does not appear to be the most efficient way to boost total corporate research spending.

In recent years there have also been attempts to bolster innovation in certain industries, particularly, manufacturing. How the research intensity elasticity varies by industry is assessed in Table 6B. Subsidizing incremental research spending has no discernible impact on the R&D budgets of firms in the agriculture or financial, insurance, and real estate (FIRE) industries, which together account for less than one percent of qualified research spending. Research spending in the retail industry responds to the tax subsidy, but much less than firms in other industries, with an estimated elasticity of only -0.35 (0.036). Transportation firms are the most responsive with an elasticity of -3.866 (0.487) and interestingly spend much more of the R&D dollars on contracted and university- or other non-profit-sited research. Fifty percent of firms in the transport industry spend more than 16.7 percent of the research budget on contracted research and 25 percent spend more than 35 percent of their budgets on university- or other non-profit-sited research. Manufacturing firms, who are majority of claimants and claim the majority of credit dollars, are more responsive than average with an elasticity of -2.26 (0.23), and spending patterns very much like the sample average. In general, firms in a wide array of industries are highly responsive to the tax subsidy for R&D spending, suggesting that additional incentives targeted at particular industries could boost their R&D spending.

Although firms that do not owe taxes in the year they earn a credit can carry the credit forward (or even backward), they are likely less valuable to firms who are not taxable.[20] Columns (2) and (3) of Table 6C examine whether or not firms who are and are not taxable differ in their response to the subsidy provided by the R&D credit. Statistically the elasticities are indistinguishable, but the point estimates suggest that if anything non-taxable firms are even more responsive than taxable firms. Interestingly, as Columns (4) and (5) show, the non-taxable firms that are the most responsive are the subset that return to profitability the next year. These firms are statistically significantly more responsive than taxable firms (and the baseline in Column (1)).

Advocates for the R&D tax credit in part argue that it will help keep U.S. multi-nationals from off-shoring R&D. This concern may be warranted: between 2004 and 2009 U.S. multinationals nearly doubled R&D employment overseas while domestic R&D employment by these same companies increased by less than 5 percent (Board 2012). Off-shore R&D was less prevalent in the 1980s, so comparisons from that era may not be entirely applicable today. Columns (6) and (7) of table 6C examine whether firms that operate abroad respond differently to tax subsidies for R&D. Firms with zero foreign tax credits are considered domestic firms while firms with foreign tax credits are considered multi-national firms.[21] The vast majority of firms in the sample—nearly 80 percent—operate only in the U.S. Point estimates suggest that domestic firms are in fact more responsive than multinational firms, but the difference is not statistically significant. There is no evidence that in the 1980s the overall response was driven by multinational firms, suggesting that the overall response was not driven by firms who were simply re-locating their R&D to qualify for the credit.

There has been concern that start-up firms and younger firms are less incentivized by the research credit. This concern has led to the introduction of the Alternative Simplified Credit

[20]As explained in the appendix, credit rates are appropriately discounted when they are carried forward or backward.

[21]Multi-national status was determined based on foreign tax credits because data from form 1118, schedule B, which details foreign taxable income are not available 1990. If there are firms that have foreign taxable income that does not result in foreign tax credits that can be used to offset income taxes, using foreign tax credits to determine multi-national status may lead to mis-measurement. The analysis was repeated for years prior to 1990 using foreign taxable income rather than foreign tax credits, and the results are nearly identical.

which reverts to the old moving average base and targets firms that cannot adequately substantiate QREs for traditional or start-up calculation methods or generate fixed-base-percentages that significantly limit their credit under the general R&D tax credit. Columns (8) and (9) of Table 6C examine whether younger and older firms differ in their elasticities. The estimated elasticities, -1.897 (0.789) and -1.676 (0.595), suggest that younger firms may be marginally more responsive but the difference is statistically insignificant.[22]

Table 6D examines whether firms responded differently to the credit over time. Column (1) repeats the baseline fixed effects regression over all years, while Columns (2)-(6) report results from individual years. Each year, the tax subsidy had a significant impact on R&D spending decisions. Comparing the estimates across years the elasticity estimates are larger later; the estimated elasticity is only -0.83 (0.27) in 1986 and -2.24 (1.09) in 1990. The point estimates suggest that firms may be learning and responding more to the incentives of the R&D tax credit over time. The standard errors are too large, however, for the differences in elasticity to be statistically significant. Interestingly, it appears that the substantial re-design of the credit in 1990 did not curb or enhance the appeal of the credit.

The estimates presented in Tables 4-6D are comparable to estimates from (Hall 1993b) and (Hines 1993), but nonetheless imply a degree of price responsiveness that may raise questions as whether part of the response is driven by the timing of R&D expenditures. Due to the incremental structure of the R&D tax credit, firms face strong incentives to bunch their expenditures to exceed their bases. Table 7 reports results from regressions that investigate how firms with different histories of R&D tax credit eligibility vary in terms of their responsiveness to current incentives. If firms are engaging in re-timing of expenditures, we would expect that firms who have recently faced lower tax subsidy rateseither because they failed to exceed their base or exceeded twice their base to be more responsive to current subsidies. Column (1) repeats the baseline where the elasticity of research spending with respect to the tax subsidy is -1.67 (0.55). Column (2) limits the sample to only those firms

[22]The results are not affected by different cut-offs for young vs. old firms such as three, four or five years.

that were ineligible for a credit the previous year. Though the elasticity is considerably larger, the smaller sample leads to a much larger standard error making the difference statistically meaningless. The sample in Column (3) consists of only firms that were subject to the base limitation, which effectively halved their credit subsidies. The elasticity estimated, -1.84 (0.59), is nearly the same as the baseline. In other words, firms that faced lower credit rates in the previous year are not discernibly more responsive to the R&D tax subsidy this year. Column (4) investigates the counter-case, asking whether firms that enjoyed the full subsidy on marginal spending the previous are less responsive this year. The point estimate, -1.20 (0.38) is lower than the baseline, but not statistically dissimilar. Column (5) looks at firms who were ineligible for a credit the previous year but are now eligible for a research credit; these firms are no more responsive to the tax subsidy than other firms. Column (6) examines firms who were subject to the minimum base limitations last year but eligible for their full credit this year; the estimated elasticity, -1.78 (0.429), suggests again that firms who have the strongest incentives to move expenditures to the current year are not more responsive than other firms. Taken together the results presented in Table 7 make clear that there is no discernible evidence that firms with different eligibility histories respond differently to tax subsidies, that is there is no evidence of retiming of actual or reported QREs to maximize total R&D credits.

The above analyses all examine the short-run impact of how changes in the user cost of R&D affect research spending. If there are adjustment costs or frictions associated with adjusting R&D spending, as has been shown by (Bernstein and Nadiri 1986), (Hall, Griliches, and Hausman 1986) and (Hall 1993a), there may be meaningful costs associated with large changes in a firm's R&D spending. Such adjustment costs would lead firms to only partially adjust their R&D intensities in response to the tax-driven changes in the user cost. To allow for partial adjustment of R&D, I extend the static model of equation (2) by including the lagged dependent and independent variables:

$$\left[\frac{R_{it}}{S_{it}} - \frac{R_{it-1}}{S_{it-1}}\right] = \alpha + \gamma\left[\rho_{it} - \rho_{it-1}\right] + \lambda\left[\frac{R_{it-1}}{S_{it-1}} - \frac{R_{it-2}}{S_{it-2}}\right] + \eta\left[\rho_{it-1} - \rho_{it-2}\right] + \chi_t + \epsilon_{it} \quad (3)$$

The long-run user cost elasticity is given by $(\gamma + \eta) / (1 - \lambda)$. Table 8 presents estimates of equation (3) for the full sample, Column (1), and subsamples of interest, Columns (2)-(11). In the dynamic model, the short-run coefficient is somewhat smaller than in the static model of equation (2), -0.048 rather than -0.056, though the difference is not statistically significant. The coefficients on both lagged variables are statistically significant and suggest the firms only partially adjust their R&D spending in the short-run and make the full adjustment over time. The long-run elasticity, -1.163, exceeds the short-run elasticity, but is not meaningfully or statistically different than the short-run elasticity estimated in the static model. Columns (2) and (3) compare the results for domestic and multi-national firms. The results suggests that firms with and without operations abroad are similarly responsive to tax credits for R&D in both the short- and long-run. Small and large firms, in terms of real total assets, are compared in Columns (4) and (5). While large firms respond in the short-run and continue to adjust their R&D spending in the long-run, smaller firms only show a statistically significant response in the short-run that is similar to the response estimated with the static model. This may be because large firms run much larger research programs that are slower and more costly to adjust. Columns (6) and (7) examine two particular industries that exhibited unusually high elasticities in the static model: transportation and manufacturing. Transportation firms exhibit a short-run response similar the static model, but continue to adjust R&D spending in the long-run, leading to a larger long-run elasticity. Interestingly, manufacturing firms show a similar response in the short-run, but do not continue to adjust spending over time, yielding a very similar short- and long-run elasticity and a dynamically estimated long-run elasticity that is similar to the static estimate. This implies that manufacturing firms do not face the same R&D adjustment costs of other firms.

Policy stimulus may in fact be more effective in the manufacturing industry. Taxable and non-taxable firms are compared in Columns (8) and (9). Estimates from the dynamic model suggest that non-taxable firms are much more responsive and that much of the response is immediate. This may be because non-taxable firms are generally more liquidity constrained and the tax credits may provide much needed financing for R&D. Similarly, comparing the results in Columns (10) and (11), which describe young and older firms, respectively, young firms are more responsive, especially in the short-run. Liquidity constraints are more common for start-ups and other young firms and may be one of the drivers here, too. The fact that long-run elasticities are in general larger than the short-run impacts estimated in the dynamic model (and the static model for that matter), suggests that adjustment frictions are real for many firms. In another sense, this result also suggests that firms are not retiming reported QREs to maximize R&D tax credits–such retiming would lead to long-run responses that are smaller than short-run responses as firms reduce R&D expenditures is less tax favorable periods.

The final table examines the small set of firms found in both the Compustat and IRS data that have enough lagged data to construct the synthetic tax price instrument used in the estimation procedure. Only 234 firm-year observations, describing 80 firms, can be matched and have the requisite data to construct the instrument. The merged sample offers the opportunity to examine how accurately measured changes in the user cost driven by tax subsidies, as measured in the IRS SOI data, affect research spending that qualifies for the R&D tax credit (from the IRS SOI data) and total research spending (from the Compustat data). The Compustat R&D spending variable encompasses research that qualifies for the R&D tax credit as well as research spending that does not because it does not meet the experimental and technological criteria of the credit or because it is conducted abroad. Qualified spending comprises roughly 68 percent of total research spending. Table 9 reports results from OLS and IV estimations of equation (2) using qualified and total research intensities on the left-hand side of the equation. Columns (1) and (2) report the effect of changes in the user cost on qualified R&D spending while Columns (3) and (4) assess the impact on total R&D. Interestingly, instrumenting doubles the elasticity estimate regardless if the outcome is qualified or total R&D. Comparing the IV estimates of Columns (2) and (4), qualified research is more responsive to the tax subsidy than total R&D. The difference is statistically significant. In a sense these results suggest that when the federal government decides what types of research to subsidize, it gets just that. The credit drives spending in qualified categories, suggesting that how the government defines 'qualified spending' may be an important margin on which it affects firm behavior. It is important to note that the merged sample is small; because the merged sample is so small, the pattern of these estimates is better taken as suggestive rather than definitive. They do show, however, that firms appear to respond to tax subsidies for R&D by increasing their spending that qualifies for the credit much more than R&D spending overall.

5 Conclusions and Policy Implications

This paper uses new restricted-access data from corporate tax returns to assess the impact of tax credits on R&D expenditure decisions. An instrumental variables strategy that relies on tax policy changes disentangles the simultaneity of incremental credit rates and R&D spending. The empirical findings demonstrate that a firm's research intensity—the ratio of R&D expenditures to sales–responds to changes in the user cost of R&D. Estimates imply that a ten percent reduction in the user cost of R&D leads the average firm to increase its research intensity—the ratio of R&D spending to sales—by 11 percent in the short-run. Long-run estimates imply that firms do face adjustment costs and further increase spending over the longer-run.

Analysis of the components of qualified research shows that wages and supplies account for the bulk of the increase in research spending. Comparisons of the elasticity across firms of different sizes, industries, tax status, multi-national status and credit history are also made.

Neither small nor young firms appear more responsive in the static analysis but the dynamic model reveals that their short-run response is stronger, suggesting that they may face lower adjustment costs or liquidity constraints in financing R&D. Evidence from long-run and retiming analysis show no evidence that firms allocate their qualified research spending over time to maximize their R&D tax credits. Elasticities of qualified and total (qualified and non-qualified) research intensities from a smaller sample suggest that firms do respond to changes in the user cost largely by increasing their qualified spending, meaning that what R&D the federal credit deems qualified research is an important margin on which the credit affects firm behavior.

As the research credit is only ever temporarily extended, its provisions are frequently considered by policymakers. Recently the Obama Administration and members of Congress have proposed increasing the credit rate of the Alternative Simplified Credit (ASC), a research tax credit firms can permanently opt for in lieu of the traditional research credit assessed here, from 14 to 17 percent. The ASC was introduced in 2007 for firms that cannot adequately substantiate QREs for the traditional, including start-up provisions, calculation methods, or generate fixed-base-percentages that significantly limit the credit. Currently the ASC provides a credit equal to 14 percent of the current year qualified research expenses that exceed 50 percent of the average qualified research expenses for the 3 preceding taxable years. The credit calculations presented here suggest that enhancing the ASC would leave more firms with negative credit rates in some years as the claw-back provision would mute incentives for marginal R&D spending in some years. Furthermore, recent analysis by the Government Accountability Office (Office 2009) found that the ASC provides windfalls to some firms but reduces incentives for new research. Given the high and robust user cost elaticities estimated here, any policy shift that would lead to lower credit rates could substantially reduce corporate research spending. Redirecting tax expenditures away from the traditional credit and toward the ASC should be considered carefully.

The empirical findings reported here suggest that research intensities are elastic in both the short- and long-run but there are important considerations regarding broader interpretations. First, the analysis here uses changes in the provisions of the research credit during the 1980s to identify the user cost elasticity' research patterns from up to 32 years ago may not represent current R&D patterns in terms of shares of spending by firms in different industries, of different sizes, of different domiciles, etc. Second, throughout the analysis firms' expectations of the future R&D tax credit are ignored. During its first decade the research credit was always renewed before it expired. Since then, the credit has been allowed to lapse several times, most of the time being put into place retroactively, but on one occasion in 1995 the credit was simply allowed to expire for a year. In the current, less predictable fiscal environment, firms' expectations regarding the future of the R&D credit may impact how they react to the subsidy while it is place. Estimates from an era of greater certainty may not be fully applicable today. Future research that assesses how policy certainty, or as it may be uncertainty, affects research credit responses would be useful to policymakers as they decide whether a longer-term commitment to the research credit is worth the budgetary cost.

Appendix: Details of the R&D Tax Credit

The Section 41 credit, known legislatively as the Research and Experimentation Tax Credit, was introduced as part of the Economic Recovery Tax Act of 1981, allowing firms to earn a tax credit on spending they were already able to expense under the existing Section 174 expensing provision. The credit is available for qualified research expenditures, which were defined as salaries and wages, certain property and equipment rental costs and intermediate materials expenses incurred in research undertaken to discover knowledge that is technological in nature for a new or improved business purpose. The tax credit was initially effective beginning July 1, 1981 and ending December 31, 1985.

In its original form the incremental tax credit was equal to 25 percent of qualified research expenditures (QREs) above a firm-specific base amount. A firm's base was its average nominal qualified spending on R&D in the previous three years, or 50 percent of current spending, whichever was greater. For the first nine years of the R&D tax credit the firm's base was defined as:

$$B_{it} = \text{Base for R\&D Credit} = max\left[\frac{1}{3}\left(R_{it-1} + R_{it-2} + R_{it-3}\right), 0.5R_{it}\right] \text{ for } t\text{=1981-1989} \tag{4}$$

where R_{it} is qualified R&D spending by firm i in year t.

Because a firm's base was a moving average of its past spending, additional qualified research spending in the current year increased the firm's base by one-third of the increase in each of the subsequent three years. This 'claw-back' muted the credit's incentive effects; some firms were even left with negative marginal credit rates.

The marginal credit rate between 1981 and 1988 is:

$$
c_{it} = \begin{cases}
0 & \text{if } R_{it+m} < B_{it+m} \text{ for } m = 0\text{–}3 \\
-s_t \left\{ \frac{1}{3} \sum_{m=1}^{3} (1+r_t)^{-(m+k_{it})} \right\} & \text{if } R_{it} < B_{it} \text{ and } B_{it+m} < R_{it+m} \\
 & \text{and } R_{it+m} < 2B_{it+m} \text{ for any } m = 1\text{–}3 \\
s_t \left\{ (1+r_t)^{-j_{it}} - \frac{1}{3} \sum_{m=1}^{3} (1+r_t)^{-(m+k_{it})} \right\} & \text{if } B_{it+m} < R_{it+m} < 2B_{it+m} \\
 & \text{for any } m = 0\text{–}3 \\
s_t \left\{ \frac{1}{2} (1+r_t)^{-j_{it}} - \frac{1}{3} \sum_{m=1}^{3} (1+r_t)^{-(m+k_{it})} \right\} & \text{if } R_{it} > 2B_{it} \text{ and } B_{it+m} < R_{it+m} \\
 & \text{and } R_{it+m} < 2B_{it+m} \text{ for any } m = 1\text{–}3
\end{cases}
$$

where s_t is the statutory credit rate, k_{it} is the number of years until any tax losses are exhausted, j_{it} is the number of years the credit must be carried forward (it will be negative if it can be carried back), and r_t is the real interest rate. The negative summation term in the above equation represents the claw-back provision.

In the credit's original incarnation, a firm's marginal credit rate was highest when its current year qualified R&D spending, R_{it}, exceeds its current base amount, B_{it}, but is anticipated to not exceed its base in the following three years. Spending less than its base amount, the firm would not be eligible for credits in the next three years and thus not subject to the claw-back provision. In this case, if it has sufficient tax liabilities to fully offset its R&D tax credit, the firm's marginal credit rate is the statutory credit rate, s_{it}, or half the statutory credit rate if its current year spending exceeds twice its base. In terms of the preceding equation, if the firm is eligible for the full statutory rate, its current spending would exceed its base but be less than twice its base, and sufficient tax liabilities would mean j_{it} is zero. If the firm expected its qualified spending in the subsequent three years to be below its base amounts, the second summation term would be zero. From 3.5 to 9.5 percent of firms (5 to 16 percent of firms earning a credit) between 1981 and 1990 had marginal credit rates equal to the statutory rate, depending on the year.

Because a firm's base can never be less than half of current expenditures, when R&D spending exceeds twice its historically defined base, the redefined base is increased 50 cents for every additional dollar of R&D spending. When this is the case, the first additive term of the preceding equation is halved, and the maximum marginal credit rate is reduced from 25 percent to 12.5 percent.

A firm that claimed the tax credit but had insufficient current-year tax liabilities to offset was allowed to carry the excess credit back up to three tax years and/or forward up to 15 tax years (j_{it} can range from -3 to 15). Carrying back (forward) the credit increases (decreases) the present value of the R&D credit.

The Tax Reform Act of 1986 extended the credit through 1988, but also reduced the statutory credit rate from 25 to 20 percent.[23] This rate reduction was not motivated by any careful assessment of the tax credit, but was instead part of one of the primary goals of TRA86—reducing the differences in tax burdens among major business asset categories (CRS 2007). The tax credit was extended through 1989 by the Technical and Miscellaneous Revenue Act of 1988, which also reduced the total tax preference for R&D by requiring firms to reduce the tax credit they claim by half the value of any deductions they claim under Section 174.[24] This partial recapture of the credit effectively cut a firm's marginal credit rate from 20 percent to 16.6 percent if its qualified R&D spending exceeded its base by less than 100 percent, and from 10 to 8.3 percent if its qualified R&D spending exceeded its base

[23]TRA86 also folded the tax credit into the General Business Credit under IRC Section 38, subjecting the credit to a yearly cap. The tax credit was also expanded to include research contracted to universities and certain other nonprofits. The definition of QREs was also changed so that it applied to research aimed at producing new technical knowledge deemed useful in the commercial development of new products and processes. These changes in the definition of QRE are beyond the capability of the data, including the IRS data, used here as research expenditures are only reported in terms of contemporaneous definitions.

[24]Firms could alternatively reduce the depreciation basis of their R&D expenses by the value of the credit; this was less tax advantageous since losses have longer carry-forward periods than credits. Firms are assumed to have reduced the value of their credit rather than the value of their deduction.

by more than 100 percent. The marginal credit rate in 1989 is:

$$c_{it} = \begin{cases} 0 & \text{if } R_{it+m} < B_{it+m} \\ & \text{for } m = 0\text{-}3 \\ -s_t\left(1-\frac{1}{2}\tau_{it}\right)\frac{1}{3}\sum\limits_{m=1}^{3}(1+r_t)^{-(m+k_{it})} & \text{if } R_{it} < B_{it} \text{ and } B_{it+m} \leq R_{it+m} \\ & \text{and } R_{it+m} < 2B_{it+m} \text{ for any } m = 1\text{-}3 \\ s_t\left(1-\frac{1}{2}\tau_{it}\right)\left\{(1+r_t)^{-j_{it}} - \frac{1}{3}\sum\limits_{m=1}^{3}(1+r_t)^{-(m+k_{it})}\right\} & \text{if } B_{it+m} \leq R_{it+m} < 2B_{it+m} \\ & \text{for any } m = 0\text{-}3 \\ s_t\left(1-\frac{1}{2}\tau_{it}\right)\left\{\frac{1}{2}(1+r_t)^{-j_{it}} - \frac{1}{3}\sum\limits_{m=1}^{3}(1+r_t)^{-(m+k_{it})}\right\} & \text{if } R_{it} \geq 2B_{it} \text{ and } B_{it+m} \leq R_{it+m} \\ & \text{and } R_{it+m} < 2B_{it+m} \text{ for any } m = 0\text{-}3 \end{cases}$$

where τ_{it} is the marginal tax rate, s_t is the statutory credit rate, k_{it} is the number of years until any tax losses are exhausted, j_{it} is the number of years the credit must be carried forward (it will be negative if it can be carried back), and r_t is the real interest rate. The additional corporate tax rate term, $\left(1-\frac{1}{2}\tau_{it}\right)$, in the marginal credit formula for 1989 reflects the recapture of half of the deduction. In 1989 the credit was revamped. The claw-back provision created dynamic disincentives for current qualified R&D spending, leading to negative marginal credit rates for some firms and lower than statutory rates for many others. Addressing this concern, the Omnibus Budget Reconciliation Act of 1989 altered the base formula, replacing the moving average with a base unrelated to recent R&D spending. The new formula for the base was the greater of 50 percent of current qualified spending, and the product of the firm's average gross receipts in the previous four tax years and the firm's "fixed-base percentage," a measure of historic research intensity. The firm's fixed base percentage is its ratio of total qualified R&D expenditures to total gross receipts between

1984 and 1988, subject to a 16 percent ceiling. The base formula from 1990 on is:

$$B_{it} = max\left[\frac{1}{4}\sum_{m=1}^{4} G_{it-m}\min\left(\left(\sum_{n=1984}^{1988} R_{in}/\sum_{n=1984}^{1988} G_{in}\right), 0.16\right), \frac{1}{2}R_{it}\right] \tag{5}$$

where G_{it} is gross receipts or sales and R_{it} is the qualified R&D expenditures of firm i in year t. As the base definition changed, the tax credit subsidy on the marginal dollar of R&D spending changed as well. Beginning in 1990 the marginal credit rate is:

$$c_{it} = \begin{cases} 0 & \text{if } R_{it} < B_{it} \\ s_t\left(1-\tau_{it}\right)\left(1+r_t\right)^{-j_{it}} & \text{if } B_{it} < R_{it} < 2B_{it} \\ \frac{1}{2}s_t\left(1-\tau_{it}\right)\left(1+r_t\right)^{-j_{it}} & \text{if } R_{it} > 2B_{it} \end{cases}$$

where again, s_{it} is the statutory R&D credit rate in year t, r_t is the interest rate, τ_{it} is the firm's marginal corporate tax rate, and j_{it} is the number of years of tax losses.

Start-ups, firms lacking gross receipts or QREs for three of the five years between 1984 and 1988, were assigned a three percent fixed-base percentage. OBRA89 extended the credit through 1990 and required firms to reduce their Section 174 deduction by the entire amount of research credits claimed. The Omnibus Budget Reconciliation Act of 1990 and Tax Extension Act of 1991 extended the research credit through 1991 and 1992 respectively. Pay-as-you-go rules adopted as part of OBRA90 were a major obstacle to more lasting extension (CRS 2007). From its inception until 1992 the credit was always extended before it expired. The first of several retroactive extensions occurred in 1993 after the credit was allowed to lapse in 1992. Even the retroactive extension covered only the last two quarters of 1992. Because this and other lapses likely affected firm expectations, the analysis here is limited to just the first 11 years of the R&D tax credit. Table 1 provides a summary of the legislative history of the R&D tax credit.

If at the time of R&D investment corporate tax rates are expected to remain constant in the future, they have no impact on R&D spending decisions—firms expect to expense their investments and pay taxes on the income from those investments at the same rate. The 1980s, however, were a time of changing corporate tax rates. The value of the Section 174 expensing provision was reduced by the Tax Reform Act of 1986; as the corporate tax rate was reduced to 40 percent in 1987 and to 34 percent in 1988, the benefit of expensing fell in parallel. If firms expected these reductions in the corporate tax rate, they would have invested in R&D with a higher cost of capital in mind. These corporate tax rate changes and their impact on the after-tax cost of R&D are assumed to have been unexpected by firms and are part of the analysis presented here. Taken together, changes in the expensing provision and tax credit significantly affected the user cost of qualified R&D; their joint impact on the user cost of the marginal dollar of R&D spending is assessed.

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Figure 1: User Costs of R&D By Year

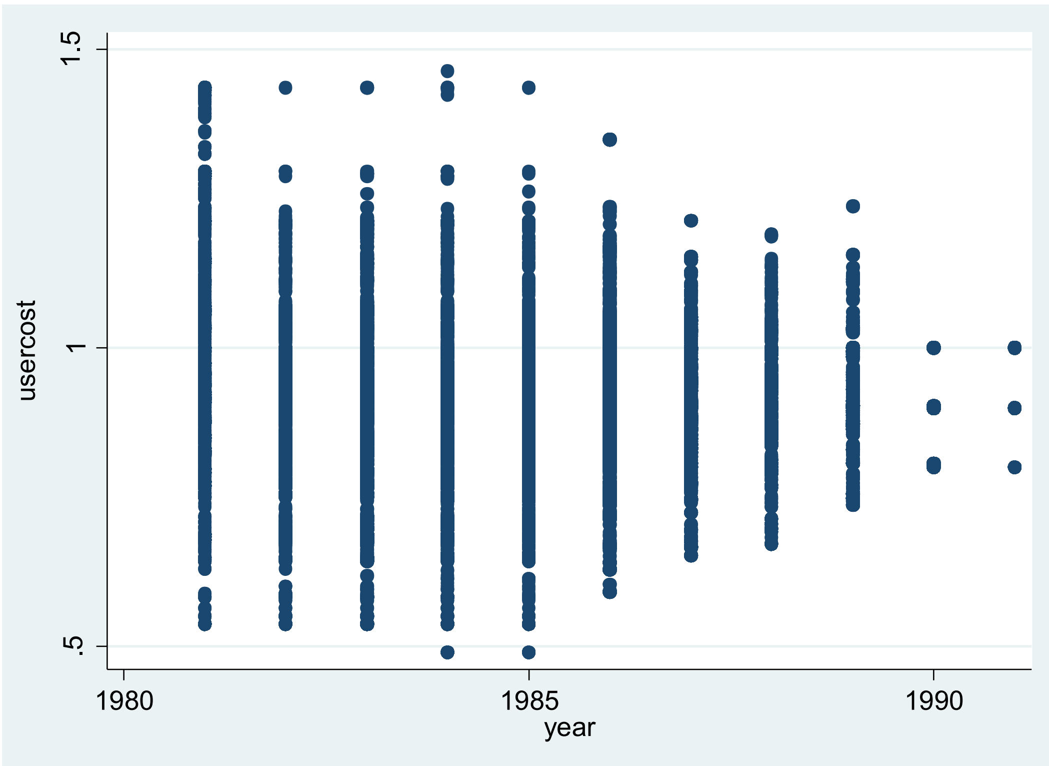

Table 1: Legislative History of the Federal Research and Experimentation Tax Credit, 1981-2013

	Credit Rate*	Corporate Tax Rate	Definition of Base	Qualified Research Expenditures	Sec. 174 deduction**	Foreign Allocation Rules	Carryback/Carryforward
July 1981 to Dec 1981	25%	48%	Maximum of previous 3-year average or 50% or current year	Excluded: research performed outside US; humanities and soc. science research; research funded by others	None	100% deduction against domestic income	3 years/15 years
Jan 1982 to Dec 1985	Same	46%	Same	Same	Same	Same	Same
Jan 1986 to Dec 1986	20%	34%	Same	Definition narrowed to technological research. Excluded leasing	Same	Same	Same
Jan 1987 to Dec 1987	Same	Same	Same	Same	Same	50% deduction against domestic income; 50% allocation	Same
Jan 1988 to Apr 1988	Same	Same	Same	Same	Same	64% deduction against domestic income; 36% allocation	Same
May 1988 to Dec 1988	Same	Same	Same	Same	Same	30% deduction against domestic income; 70% allocation	Same
Jan 1989 to Dec 1989	Same	Same	Same	Same	-50% credit	64% deduction against domestic income; 36% allocation	Same
Jan 1990 to Dec 1991	Same	Same	1984-1988 R&D to sales ratio times current sales (max of 16%); 3% of current sales for startups	Same	-100% credit	Same	Same
Jan 1992 to Dec 1993	Same	Same	Startup rules modified	Same	Same	Same	Same
Jan 1994 to June 1995	Same	35%	Same	Same	Same	50% deduction against domestic income; 50% allocation	Same
July 1995 to June 1996	0%	Same	None	-	-	Same	Same
July 1996 to June 1999	20%	Same	1984-1988 R&D to sales ratio times current sales (max of 16%); 3% of current sales for startups	Same as before lapse	-100% credit	50% deduction against domestic income; 50% allocation	Same
July 1999 to June 2004	Same	Same	Also includes research undertaken in Puerto Rico and U.S. posessions.	Same	Same	Same	Same
July 2004 to Dec 2005	Same	Same	Same	Same	Same	Same	Same
Jan 2006 to Dec 2007	Same	Same	Same	Transition rules altered slightly and alternative credits modified as outlined on next sheet.	Same	Same	Same
Jan 2008 to Dec 2013	Same	Same	Same	Same	Same	Same	Same

* In all years the firm can apply the credit rate to 50% of current QREs if the base amount is less than 50% of current QREs.

** Section 174 of the IRC provides an immediate deduction for most research and experimentation expenditures. Taxpayers can also elect to amortize these expenditures over 60 months, but in practice most firms immediately expense R&D. However, the IRC does not define what qualifies as R&D expenditures. Treasury regulations have generally interpreted them to mean "R&D costs in the experimental or laboratory sense."

Note: Based on Hall (1994), the Senate Budget Committee's 2006 Tax Expenditures compendium and Thomas legislative summaries.

Table 2: Average User Costs, Credit Receipt Rates and Shares With Negative Credit Rates by Year, Merged Sample of Compustat and IRS SOI Data

			Compustat Data			IRS Data		
	Year	Observations	User Cost (Tax Subsidy Impact)	Fraction Receiving R&D Tax Credit	Fraction with Negative Marginal Credit Rates	User Cost (Tax Subsidy Impact)	Fraction Receiving R&D Tax Credit	Fraction with Negative Marginal Credit Rates
Regime 1: Statutory rate of 25% and expensing, clawback	1981	68	0.888	0.779	0.118	1.038	0.706	0.456
	1982	72	0.930	0.736	0.167	0.861	0.639	0.111
	1983	73	0.952	0.712	0.247	0.826	0.685	0.082
	1984	74	0.934	0.689	0.230	0.821	0.581	0.122
	1985	43	0.939	0.651	0.163	0.873	0.465	0.116
Regime 2: Statutory rate of 20% and expensing, clawback	1986	66	0.931	0.652	0.061	0.923	0.439	0.106
	1987	61	0.966	0.623	0.230	0.891	0.426	0.098
	1988	60	0.935	0.683	0.133	0.909	0.467	0.100
Regime 3: Statutory rate of 20% OR expensing, clawback	1989	57	0.929	0.667	0.140	0.894	0.474	0.053
Regime 4: Statutory rate of 20% or expensing, NO clawback	1990	55	0.879	0.636	0.000	0.913	0.418	0.000
	1991	57	0.907	0.526	0.000	0.907	0.368	0.000

Note: The sample consists of all firms that can be successfully merged by Employer Identification Number between the Compustat and IRS datasets and report enough data to be included in later regression analysis. The tax component of the user cost formula takes both expensing provisions and the research credit into account, in addition to reflecting any losses that reduces the value of tax advantages. In the Compustat sample firms receiving R&D tax credits are all firms that report current year R&D expenses that exceeed their calculated base amounts. In the IRS sample all firms who report a tentative R&D tax credit are considered credit recipeints. Negative marginal credit rates arose for firms prior to the revamping of the credit in 1990 when they failed to qualify for a credit in the current year but their current year spending increased base amounts for the subsequent three years when they did qualify for the credit.

Table 3: Descriptive Statistics, IRS SOI Data

	Mean	25th Perc.	Median	75th Perc.	90th Perc.	99th Perc.	St Dev	Observations
Tax Term	0.90	0.87	0.90	0.91	1.00	1.05	0.07	19,920
Qualified R&D	7.97	0.00	0.00	0.27	4.37	141.7	106.6	19,920
Qualified R&D if > 0	27.01	0.52	1.87	7.30	27.1	453.2	195.0	5,876
Qualified R&D Intensity	0.01	0.00	0.00	0.00	0.02	0.12	0.03	19,920
Qualified R&D Intensity if > 0	0.03	0.00	0.01	0.04	0.08	0.20	0.05	5,876
Sales	1,027	24.5	101	386	1,707	16,412	5,379	19,920
NI Tax	65.1	0.1	3.4	20.8	103	1,268	400	19,920
NI Book	62.9	0.0	1.7	14.5	86.4	1,286	468	19,920
Total Assets	1,899	11.4	62.5	300	1,869	38,238	12,870	19,920
Foreign Tax Credits if > 0	30.4	0.06	0.72	6.62	40.6	559	193	4,027

Note: The sample consists of all firm-year observations from the IRS SOI data that report sufficient data to be included in later regression analysis. The sample is trimmed of the top percentile of reseach intensities.

Table 4: User-cost Elasticity of Firm R&D Intensity
[Dependent Variable: Δ (Qualified R&D/Sales)]

	OLS (1)	IV (2)	IV (3)	IV (4)	IV (5)	IV (6)	IV (7)	IV (8)
Δ User-cost	-0.023	-0.056	-0.054	-0.056	-0.057	-0.055	-0.040	-0.054
	(0.005)	(0.018)	(0.019)	(0.018)	(0.019)	(0.017)	(0.015)	(0.019)
1(year = 1987)	0.012	-0.004	-0.004	-0.004	-0.004	-0.005	-0.004	-0.004
	(0.013)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
1(year = 1988)	0.003	-0.001	-0.001	-0.001	-0.001	-0.001	-0.021	0.000
	(0.016)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.032)	(0.002)
1(year = 1989)	0.010	-0.001	-0.001	-0.001	-0.001	-0.001	-0.005	-0.001
	(0.012)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.024)	(0.001)
1(year = 1990)	0.010	0.000	-0.001	0.000	0.000	-0.001	-0.004	0.000
	(0.013)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.028)	(0.001)
User-cost Elasticity	-0.461	-1.069	-1.030	-1.917	-1.090	-0.982	-0.770	-1.028
	(0.110)	(0.350)	(0.369)	(0.323)	(0.272)	(0.302)	(0.215)	(0.368)
Observations	23,296	19,928	19,928	19,816	19,928	18,227	9,935	10,648
Firms	6,999	6,289	6,289	6,274	6,289	5,936	1,987	3,476

Notes: All regressions include a constant. All data converted to real dollars using the GDP index. Column (1) presents OLS results while columns (2)-(8) instrument for the endgogenous tax subsidy using predicted subsidy rates. Column (2)is the baseline IV estimate. Column (3) adds a 5-knot spline in the two-year lag of R&D spending. Column (4) drops the three percent most research intense firms. Column (5) adds industry fixed effects. Column (6) adds an synthetic tax instrument constructed from the four-year lag in R&D spending. Column (7) includes only firms that report in all years while column (8) restricts the sample to firms with December fiscal year ends. Standard errors clustered at the two-digit industry level according to SOI industry codes; these data span 68 industries. All regressions are weighted by real annual sales.

Table 5: User-cost Elasticity of Qualified Research Components
[Dependent Variable: Δ (Component/Sales)]

	Baseline	Wages & Salaries	Supplies	Rent	Contracted	University
	(1)	(2)	(3)	(4)	(5)	(6)
Δ User-cost	-0.054	-0.036	-0.011	-4.62E-04	-0.005	-0.001
	(0.016)	(0.011)	(0.003)	(1.20E-04)	(0.001)	(0.000)
1(year = 1987)	-0.004	-0.003	-0.001	7.72E-05	-2.60E-04	-
	(0.002)	(0.002)	(4.06E-04)	(3.28E-05)	(2.05E-04)	-
1(year = 1988)	-0.001	-0.001	2.07E-04	9.28E-05	1.02E-04	-
	(0.001)	(0.001)	(5.13E-04)	(3.75E-05)	(1.03E-04)	-
1(year = 1989)	-0.001	-0.001	6.01E-05	1.06E-04	-7.68E-05	-
	(0.001)	(0.001)	(3.64E-04)	(3.66E-05)	(1.13E-04)	-
1(year = 1990)	-	-	-	-	-	-
	-	-	-	-	-	-
User-cost Elasticity	-1.624	-1.497	-1.828	-1.937	-1.903	-1.156
	(0.484)	(0.462)	(0.567)	(0.503)	(0.539)	(0.351)
Observations	15,340	15,340	15,340	15,340	15,340	3,138
Firms	5,902	5,902	5,902	5,902	5,902	3,138

Notes: All regressions include a constant. All data converted to real dollars using the GDP index. Component data are not available for 1990; research conducted by universities and non-profits is only available until 1986. Standard errors clustered at the two-digit industry level according to SOI industry codes; these data span 68 industries. All regressions are weighted by real annual sales.

Table 6A: Heterogeneity of User-cost Elasticity: Firm Size
[Dependent Variable: Δ (Qualified R&D/Sales)]

	First Quintile (1)	Second Quintile (2)	Third Quintile (3)	Fourth Quintile (4)	Fifth Quintile (5)
Δ User-cost	-0.066	-0.105	-0.059	-0.093	-0.053
	(0.018)	(0.023)	(0.015)	(0.029)	(0.018)
1(year = 1987)	-0.007	-0.003	-0.001	-0.003	-0.005
	(0.003)	(0.002)	(0.001)	(0.002)	(0.003)
1(year = 1988)	-0.003	-0.001	-0.010	0.000	0.000
	(0.002)	(0.002)	(0.009)	(0.001)	(0.001)
1(year = 1989)	-0.001	-0.002	-0.001	-0.002	-0.001
	(0.004)	(0.002)	(0.001)	(0.001)	(0.001)
1(year = 1990)	-0.002	0.000	0.001	0.000	0.000
	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)
User-cost Elasticity	-1.165	-2.678	-1.855	-2.937	-2.478
	(0.313)	(0.578)	(0.473)	(0.909)	(0.867)
Observations	3,984	3,985	3,984	3,985	3,982
Firms	2,223	2,104	2,036	1,759	1,422

Notes: All regressions include a constant. All data converted to real dollars using the GDP index. The sample is divided by quntiles of real total assets. Standard errors clustered at the two-digit industry level according to SOI industry codes; these data span 68 industries. All regressions are weighted by real annual sales.

Table 6B: Heterogeneity of User-cost Elasticity: Industry

[Dependent Variable: Δ (Qualified R&D/Sales)]

	Baseline	Agriculture	Mining	Construc.	Manufac.	Trans.	Wholesale	Retail Trade	FIRE	Services
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Δ User-cost	-0.056	-2.791	-0.048	-0.021	-0.080	-0.020	-0.024	-0.003	3.760	-0.099
	(0.018)	(143.515)	(0.009)	(0.004)	(0.008)	(0.003)	(0.004)	(0.000)	(30.610)	(0.031)
1(year = 1987)	-0.004	-0.143	-0.005	-0.002	-0.009	0.000	-0.001	0.000	0.373	-0.004
	(0.002)	(7.375)	(0.002)	(0.001)	(0.002)	(0.000)	(0.001)	(0.000)	(2.981)	(0.003)
1(year = 1988)	-0.001	-0.152	-0.005	-0.002	-0.001	0.000	-0.001	0.000	0.378	-0.004
	(0.001)	(7.789)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(3.024)	(0.003)
1(year = 1989)	-0.001	-0.145	-0.002	-0.003	-0.003	-0.001	-0.001	0.000	0.386	-0.007
	(0.001)	(7.437)	(0.001)	(0.001)	(0.002)	(0.000)	(0.001)	(0.000)	(3.083)	(0.003)
1(year = 1990)	0.000	-0.028	-0.002	-0.001	-0.001	0.000	-0.001	0.000	0.345	-0.004
	(0.001)	(1.487)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(2.753)	(0.003)
User-cost Elasticity	-1.069	-77.801	-3.053	-1.685	-2.261	-3.866	-1.211	-0.349	135.845	-1.494
	(0.350)	(3999.96)	(0.571)	(0.278)	(0.232)	(0.487)	(0.200)	(0.036)	(1105.87)	(0.467)
R&D Shares:										
Wages	0.666	0.532	0.595	0.668	0.692	0.293	0.647	0.635	0.667	0.761
Supplies	0.190	0.309	0.239	0.218	0.207	0.083	0.165	0.165	0.110	0.120
Rent	0.007	0.002	0.005	0.001	0.005	0.007	0.011	0.014	0.011	0.016
Contracted	0.117	0.124	0.136	0.087	0.081	0.528	0.144	0.171	0.204	0.097
University	0.037	0.000	0.000	0.000	0.013	0.402	0.081	0.004	0.002	0.010
Observations	19,928	159	291	440	11,942	1,114	1,903	1,007	1,562	1,502
Firms	6,289	57	108	153	3,955	343	666	352	586	588

Notes: All regressions include a constant. All data converted to real dollars using the GDP index. The sample is divided by major SOI industry category. Standard errors clustered at the two-digit industry level according to SOI industry codes; these data span 68 industries. All are regressions are weighted by real annual sales.

Table 6C: Heterogeneity of User-cost Elasticity: Taxable vs. Non-Taxable Firms, Domestic vs. Multi-National Firms
[Dependent Variable: Δ (Qualified R&D/Sales)]

	Baseline	Taxable	Non-Taxable	Non-Taxable, Taxable in t+1	Non-Taxable Taxable in t+1, t+2	Domestic	Multi-National	<10 years old	≥10 years old
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Δ User-cost	-0.056	-0.052	-0.119	-0.169	-0.169	-0.071	-0.053	-0.077	-0.053
	(0.018)	(0.018)	(0.026)	(0.038)	(0.039)	(0.024)	(0.020)	(0.032)	(0.019)
1(year = 1987)	-0.004	-0.004	-0.007	-0.010	-0.010	-0.005	-0.004	-0.001	-0.005
	(0.002)	(0.003)	(0.002)	(0.005)	(0.006)	(0.004)	(0.002)	(0.004)	(0.003)
1(year = 1988)	-0.001	0.000	-0.005	-0.002	-0.003	0.000	-0.001	0.002	-0.001
	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.001)	(0.002)	(0.003)	(0.001)
1(year = 1989)	-0.001	-0.001	-0.004	-0.004	-0.002	-0.001	-0.002	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.002)	(0.002)	(0.005)	(0.001)
1(year = 1990)	0.000	0.000	-0.003	-0.003	-0.003	0.000	-0.001	0.000	0.000
	(0.001)	(0.001)	(0.002)	(0.004)	(0.004)	(0.001)	(0.002)	(0.003)	(0.001)
User-cost Elasticity	-1.667	-1.625	-2.813	-3.942	-4.150	-2.066	-1.643	-1.897	-1.676
	(0.545)	(0.553)	(0.611)	(0.892)	(0.955)	(0.708)	(0.606)	(0.789)	(0.595)
Observations	19,920	12,446	7,474	1,928	1,621	15,893	4,027	4,292	15,628
Firms	6,288	4,579	3,404	1,826	1,586	5,466	1,579	1,836	4,948

Notes: All regressions include a constant. All data converted to real dollars using the GDP index. Firms are classified as 'Taxable' if they have positive taxable income and 'Non-Taxable' if they do not. Firms are deemed 'Multi-National' if they have positive foreign tax credits and 'Domestic' if they do not, though the results are not sensitive to classification based on positive foreign taxable income. Standard errors clustered at the two-digit industry level according to SOI industry codes; these data span 68 industries. All regressions are weighted by real annual sales.

Table 6D: Heterogeneity of User-cost Elasticity: Differences by Year
[Dependent Variable: Δ (Qualified R&D/Sales)]

	Baseline	1986	1987	1988	1989	1990
	(1)	(2)	(3)	(4)	(5)	(6)
Δ User-cost	-0.056	-0.028	-0.067	-0.078	-0.075	-0.074
	(0.018)	(0.009)	(0.024)	(0.025)	(0.024)	(0.036)
User-cost Elasticity	-1.667	-0.827	-1.933	-2.425	-2.261	-2.240
	(0.545)	(0.266)	(0.756)	(0.758)	(0.714)	(1.090)
Observations	19,920	3,138	2,961	4,586	4,655	4,580

Notes: All regressions include a constant. All data converted to real dollars using the GDP index. The sample is divided by year, thus precluding year fixed effects. Standard errors clustered at the two-digit industry level according to SOI industry codes; these data span 68 industries. All regressions are weighted by real annual sales.

Table 7: User-cost Elasticity and Evidence of Re-Timing
[Dependent Variable: Δ (Qualified R&D/Sales)]

	(1)	(2)	(3)	(4)	(5)	(6)
Δ User-cost	-0.056	-0.054	-0.055	-0.045	-0.044	-0.054
	(0.018)	(0.024)	(0.018)	(0.014)	(0.021)	(0.013)
1(year = 1987)	-0.004	-0.011	0.001	-0.008	-0.013	0.010
	(0.002)	(0.008)	(0.001)	(0.003)	(0.010)	(0.005)
1(year = 1988)	-0.001	-0.001	0.001	0.000	0.000	0.010
	(0.001)	(0.003)	(0.001)	(0.002)	(0.003)	(0.012)
1(year = 1989)	-0.001	-0.003	0.001	-0.001	-0.003	0.010
	(0.001)	(0.004)	(0.001)	(0.001)	(0.004)	(0.014)
1(year = 1990)	0.000	0.000	0.001	-0.001	0.002	0.009
	(0.001)	(0.003)	(0.001)	(0.001)	(0.003)	(0.007)
User-cost Elasticity	-1.667	-2.862	-1.844	-1.200	-1.987	-1.783
	(0.545)	(1.259)	(0.594)	(0.381)	(0.956)	(0.429)
Observations	19,920	307	14,980	4,633	270	1,053
Firms	6,288	266	5,495	2,270	264	1,005

Notes: All regressions include a constant. All data converted to real dollars using the GDP index. Column (1) repeats the baseline. Columns (2)-(6) divide the sample by previous R&D tax credit history. Standard errors clustered at the two-digit industry level according to SOI industry codes; these data span 68 industries. All regressions are weighted by real annual sales.

Table 8: Long-run User-cost Elasticity of Firm R&D Intensity
[Dependent Variable: Δ (Qualified R&D/Sales)]

	Baseline (1)	Domestic (2)	Multi-nat. (3)	1st Quint (4)	5th Quint. (5)	Transport. (6)	Manufac. (7)	Taxable (8)	Non-tax. (9)	< 10 years (10)	≥ 10 years (11)
Δ User-cost	-0.048	-0.060	-0.053	-0.065	-0.044	-0.021	-0.082	-0.042	-0.125	-0.093	-0.045
	(0.017)	(0.026)	(0.020)	(0.015)	(0.017)	(0.003)	(0.037)	(0.015)	(0.028)	(0.036)	(0.016)
Δ User-cost$_{t-1}$	-0.018	-0.017	-0.012	-0.008	-0.019	-0.004	-0.015	-0.021	-0.016	-0.029	-0.018
	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)	(0.001)	(0.011)	(0.006)	(0.005)	(0.014)	(0.007)
Δ (Qualified R&D/Sales)$_{t-1}$	-0.706	-0.733	-0.252	0.029	-0.767	-0.057	-0.220	-0.901	-0.034	-0.170	-0.739
	(0.227)	(0.227)	(0.043)	(0.107)	(0.241)	(0.064)	(0.086)	(0.064)	(0.037)	(0.121)	(0.224)
1(year = 1987)	-0.004	-0.005	-0.003	-0.006	-0.005	0.000	-0.008	-0.003	-0.00702	-0.001	-0.004
	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.001)	(0.004)	(0.002)	0.002098	(0.004)	(0.002)
1(year = 1988)	0.000	0.000	-0.001	-0.003	0.000	0.001	-0.001	0.000	-0.005	0.002	0.000
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)	(0.001)
1(year = 1989)	0.000	-0.001	-0.001	0.000	0.000	-0.001	-0.002	0.001	-0.005	0.001	0.000
	(0.001)	(0.002)	(0.001)	(0.004)	(0.001)	(0.000)	(0.001)	(0.001)	(0.002)	(0.006)	(0.001)
1(year = 1990)	0.000	0.000	-0.001	-0.002	0.000368	0.001	-0.001	0.001	-0.004	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.003)	0.000737	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)	(0.001)
Long-Run	-0.039	-0.044	-0.052	-0.075	-0.036	-0.023	-0.079	-0.033	-0.137	-0.105	-0.036
Long-Run User-cost Elasticity	-1.163	-1.303	-1.634	-1.361	-1.732	-4.544	-2.244	-1.046	-3.330	-2.623	-1.159
Observations	19,108	15,147	3,961	3,715	3,869	1089	11462	12244	6864	3965	15143
Firms	6,024	5,214	1,549	2,076	1,377	335	3,775	4,502	3,149	1,690	4,800

Notes: All regressions include a constant. All data converted to real dollars using the GDP index. The results above come from estimating equation (3), which includes the lagged dependent and independent variables. The estimation uses the full sample in column (1) and notable sub-samples in columns (2)-(11). Standard errors clustered at the two-digit industry level according to SOI industry codes; these data span 68 industries. All regressions are weighted by real annual sales.

Table 9: User Cost Elasticity of Qualified vs. Total Research Spending, Merged Sample of Compustat and IRS SOI Data
[Dependent Variable: Δ (Qualified R&D/Sales) or Δ (Total R&D/Sales)]

	Qualified		Total	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Δ User-cost	-0.065	-0.148	-0.019	-0.038
	(0.023)	(0.026)	(0.004)	(0.011)
1(year = 1987)	-0.003	-0.010	0.001	-0.001
	(0.002)	(0.004)	(0.004)	(0.004)
1(year = 1988)	0.004	0.000	0.001	0.000
	(0.005)	(0.006)	(0.002)	(0.002)
1(year = 1989)	-0.006	-0.005	0.000	0.001
	(0.003)	(0.003)	(0.001)	(0.001)
1(year = 1990)	0.001	0.000	-0.002	-0.003
	(0.003)	(0.004)	(0.003)	(0.002)
User-cost Elasticity	-1.617	-3.670	-0.469	-0.955
	(0.579)	(0.641)	(0.101)	(0.281)
Observations	234	234	234	234
Firms	80	80	80	80

Notes: All regressions include a constant. All data converted to real dollars using the GDP index. The sample consists of all firms that can be successfully merged by Employer Identification Number between the Compustat and IRS datasets and report enough data to construct the instrument. The user cost for all regressions is constructed using the accurate IRS SOI data. For Columns (1) and (2) the research intensity variable is constructed from IRS SOI data that only describe qualified research spending. For Columns (3) and (4) the research intensity variable is constructed using Compustat data from financial filings that describe total R&D, that is qualified and non-qualified R&D. Standard errors clustered at the two-digit industry level according to SOI industry codes; these data span 68 industries. All regressions are weighted by real annual sales.