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STRUCTURAL CHANGE IN THE RESEARCH AND EXPERIMENTATION TAX CREDIT: SUCCESS OR FAILURE?

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This study examines the availability and incentive effects of the Research and Experimentation tax credit following structural changes in the computation of the credit enacted in the Omnibus Budget Reconciliation Act of 1989 (OBRA89). We find that overall firm eligibility declined after OBRA89, but eligibility increased for firms in high-tech industries, relative to firms in other industries. Dynamic panel regressions indicate that median research and development spending intensity of high-tech (other) firms increased by approximately 15.9 (9.4) percent from 1986–1989 to 1990–1994. For firms that qualified for the credit, our estimates imply approximately $2.08 of additional research and development spending per dollar of revenue forgone.

Keywords: research and development, tax credits, research and experimentation tax credit, tax incentives

JEL Codes: H25, H32, O31, O38

I. INTRODUCTION

In 1989, the U.S. Congress enacted one of the most significant changes in the history of the tax credit for research and experimentation (generally and hereafter referred to as research and development or R&D) expenses by redefining the base amount used to calculate qualified incremental R&D expenditures that determine the credit amount. This study examines the effect of this policy change on both the availability of the R&D credit and its incentive effects. Motivation for providing a tax subsidy for R&D dates back to Arrow (1962) and others who argued that private investment in R&D represents a classic public goods problem in that it has significant positive externalities,

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which typically lead to underinvestment. Empirical evidence validates this argument; studies consistently show that social rates of return to R&D exceed the private return (Griliches, 1992). Thus, the bipartisan political support for a tax credit to subsidize R&D is not surprising. Despite this support, however, policymakers remain unsure about the R&D credit's availability and incentive effects, which results in repeated tinkering with the credit.[1]

The U.S. R&D credit has always been incremental in nature, implying that firms must spend more in the current year than some base amount to earn the credit.[2] Initially, a firm's base amount was defined as its average R&D spending in the three tax years prior to the year in which it was claiming the credit (referred to as the "moving average method"). Despite its simplicity, policymakers and academics criticized the moving average method because the marginal incentive effect provided by the credit in the first year was largely offset in the following three years and could even result in negative effective credit rates for rapidly growing firms (Eisner, 1985; Eisner, Albert, and Sullivan, 1984; Altshuler, 1988). In the Omnibus Budget Reconciliation Act of 1989 (OBRA89), Congress responded to this criticism by replacing the moving average base with a fixed-base percentage equal to the ratio of a firm's research expenses to its gross receipts for the period 1984–1988.

In this study, we examine two related questions regarding the effect of OBRA89's structural change in the R&D credit's design: (1) what was the effect of this change on firms' eligibility and qualification for the R&D credit,[3] and (2) what was the effect of this change on firms' R&D spending intensity? Motivation for the first question stems from Congress' belief that modifying the base amount to reflect firm-specific characteristics (other than prior R&D spending) would make the credit "widely available at the lowest possible revenue cost," thereby broadening eligibility for the credit and enhancing its fairness. However practitioners contend that, even under the new structure, the R&D credit "is not simple, certain, fair, or available to many businesses" (Grigsby and Westmoreland, 2001). Despite these concerns, no prior study we are aware of provides empirical evidence on the availability of the credit.

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[1] Former Treasury Secretary Paul O'Neill's remark: "You find somebody who says, 'I do more R&D because I get a tax credit for it,' you'll find a fool" candidly reflects an extreme view of policymakers' uncertainty regarding the R&D credit's incentive effect (Schlesinger and Phillips, 2001, p. 2). Further reflecting this uncertainty, the R&D credit remains a temporary provision after nearly three decades following its original enactment in 1981. Provisions in the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010 extended the credit through December 31, 2011, marking the 14th time the credit has been extended since its original enactment.

[2] This feature is not unique to the U.S. The survey by Hall and van Reenan (2000) identifies France, Japan, Korea, Spain, and Taiwan as also having an incremental R&D tax credit, although each uses a different formula for the tax base. In contrast, Canada has a permanent, non-incremental R&D credit; every dollar spent on R&D qualifies for the tax credit.

[3] We distinguish between "eligibility" and "qualification" for the R&D credit as follows (defined in greater detail later): Eligibility implies that the firm's spending on R&D satisfies the threshold defined by the tax laws for claiming the R&D tax credit. Qualification results from the firm meeting the eligibility requirements and having a tax status that allows it to claim the benefit of the tax credit.

Motivation for the second question stems from the widespread conjecture that the base redefinition substantially increased the credit's incentive effects (Swenson, 1992; Brumbaugh, 1993; Watson, 1996), perhaps even more than the original introduction of the credit (Hall and van Reenan, 2000). However, empirical evidence on this conjecture is limited and at best mixed. For example, studies using primarily pre-OBRA89 data suggest that a dollar of R&D credit stimulates a dollar of R&D spending in the short run and two dollars in the long run (Swenson, 1992; Berger, 1993; Hall, 1993).[4] In contrast, Klassen, Pittman, and Reed (2004) use post-OBRA89 data to create a matched sample of 110 U.S. and 58 Canadian firms and find that the U.S. R&D credit induces $2.96 of additional R&D spending for every dollar of taxes forgone, clearly much higher than previously estimated. Thus, the effect of the change in incentives from the most significant redesign of the U.S. R&D credit remains unexplored.

We base our empirical analysis on a sample of 2,540 firms (15,804 firm-years) that report R&D expenses and have at least one year of credit qualification during 1981–1994, the entire 14-year life of the credit prior to its first discontinuity in 1995. This period spans the OBRA89 change in the credit's structure, which serves as a natural experiment and provides an important source of exogenous variation in firms' incentives. Our results indicate that the OBRA89 structural changes decreased overall firm eligibility but increased overall firm qualification for the credit. Specifically, the percentage of firm-years eligible for the credit decreased from 78 percent before the OBRA89 changes to 70 percent after OBRA89. Conditional on eligibility, the percentage of firm-years qualified for the credit increased from 63 percent before the OBRA89 changes to 68 percent after OBRA89. The number of eligible high-tech (other industry) firm-years decreased by approximately 6 (14) percent from pre-OBRA89 levels, while the number of qualified high-tech (other industry) firm-years increased by approximately 11 (7) percent. Logit regression results that control for other factors confirm these univariate results.

Results of OBRA89's effect on firms' R&D spending intensity based on dynamic panel data regression models that control for various non-tax factors likely to affect R&D spending indicate that the median R&D intensity of high-tech (other) firms that qualified for the credit increased by approximately 15.9 (9.4) percent from 1986–1989 to 1990–1994. In contrast, OBRA89 did not have a statistically significant effect on the R&D spending intensity of non-qualified firms. Further analysis on subsamples reveals that both start-up and mature qualified firms increased R&D intensity following OBRA89, and high-tech start-up firms exhibited the largest increases, relative to mature firms in all industries. Additional tests that account for the incentives of multinational companies indicate that after OBRA89, qualified high-tech firms with excess foreign tax credit positions had larger increases in R&D intensity than firms with deficit foreign

[4] Hall (1993) is an exception in that her sample period covered 1980–1991, but that sample included only two years of post-OBRA89 data. She briefly mentions that R&D spending induced by the tax credit during 1990–1991 appeared to be on the order of $5 billion per year (as compared to an estimate of $2 billion per year in 1982). However, she then states that, "This number is almost too large to be credible …, and deserves further investigation as more data become available (Hall, 1993, p. 31)."

tax credit positions. Overall, our results imply that the post-OBRA89 R&D tax credit induced an estimated $2.08 of additional spending by qualified firms per revenue dollar forgone by the U.S. Department of the Treasury during 1990–1994.

We perform various sensitivity tests that include constructing alternative samples to address the changing industry composition of firms in our sample. We also hand-collect data on the actual amount of the R&D credit directly from financial statement tax footnotes to address the concern that we do not use tax returns (which are confidential) to determine qualified research expenditures (QRE). These tests support the assumptions used in determining firms' eligibility and qualification for the credit and reinforce our main findings.

II. THE R&D CREDIT

A. Overview

U.S. businesses receive tax incentives for R&D at both the federal and state levels. There are two explicit federal level subsidies for R&D. First, section 174 of the Internal Revenue Code (IRC) provides an immediate deduction or "expensing" for most "research and experimentation" expenditures.[5] The value of this deduction has varied over time for all firms with changes in the statutory corporate tax rate, as well as for individual firms as they move in and out of taxable status. Second, section 41 of the Code provides a credit for increased expenditures on certain types of R&D activities.[6] Firms electing to take the R&D credit are required to decrease the amount of R&D expenditures that can be deducted in arriving at taxable income by a percentage of the qualified R&D expenses on which the credit was claimed. At the state level, several U.S. states provide an additional tax credit for R&D conducted within the state. In this study, we focus on the incentive effects of only the federal R&D credit and discuss the implications of both the immediate deductibility of R&D expenditures and the state-level R&D credit in the research design section later.

Congress first enacted the R&D credit as a temporary provision in the Economic Recovery Tax Act of 1981. Since then, Congress has extended the credit repeatedly such that the credit was available continuously from its original enactment in 1981 through

[5] Taxpayers can also elect to amortize these expenditures over 60 months, but in practice, most firms immediately expense R&D. While the IRC does not define "research and experimentation" expenditures, Treasury regulations have generally interpreted them to mean, "R&D costs in the experimental or laboratory sense" (Treasury Regulations Section 1.174-2).

[6] IRC section 41(d) specifies that qualifying activities are those that are technological in nature, have an associated level of technological uncertainty, involve a process of experimentation, or have a permitted purpose. Examples of expenditures that qualify for the credit include wages for in-house R&D, supplies, contract research, and basic research payments. Hines (1993) identifies a third potential source of R&D subsidy at the federal level. Given the way the U.S. tax system interacts with most foreign countries, he shows that there is an implicit subsidy to the extent that R&D can be directed towards sales of foreign countries.

June 30, 1995, when it lapsed. After a one-year hiatus, Congress reenacted the credit effective July 1, 1996, again temporarily.[7]

B. The Structure of the R&D Credit and Changes under OBRA89

An important feature of the R&D credit is its incremental nature. Initially, the credit was equal to 25 percent of the excess of qualified research expenditures (QRE) in a given tax year over a firm's base amount. Congress defined the base as the greater of: (1) average QRE in the three previous tax years; or (2) 50 percent of the current year's QRE, as follows:

$$(1) \quad Base_{t \leq 1989} = \max\left[\left(\frac{1}{3}\sum_{k=1}^{3} QRE_{t-k}\right),\ 0.50 \times QRE_t\right].$$

Congress also made the credit nonrefundable and allowed firms to carry any excess credit back three years and forward 15 years.

Policymakers and practitioners criticized the moving average base for diminishing the credit's incentive because it created a "feedback effect" — each dollar spent on R&D in the current year limited a taxpayer's ability to claim the credit by 33 cents in each of the following three years. This increase in the subsequent year's base meant that firms always paying taxes had a zero effective tax credit rate (except for discounting), and rapidly growing firms often faced large negative credit rates (Altshuler 1988; Hall 1993). Consequently, the law indirectly encouraged firms to decrease their second and third years' R&D expenditures in order to maximize the credit in the fourth year.

Congress responded to this criticism in OBRA89 by replacing the moving average base with a fixed base percentage. This percentage was the minimum of 16 percent or the ratio of a firm's R&D expenses to its gross receipts for the period 1984–1988. Firms now determine the base amount as the greater of: (1) their fixed-base percentage

[7] The R&D credit continues to be temporary. Efforts to make the credit permanent, however, have not been lacking. For example, in his original "Agenda for Tax Relief," President George W. Bush listed making the research credit permanent as one of his administration's main goals, citing the "on-again, off-again nature of the credit" as an impediment to innovation and economic growth (http://www.whitehouse.gov/news/reports/taxplan.pdf). However, the Economic Growth and Tax Relief Reconciliation Act (EGTRRA) of 2001 subsequently enacted by Congress did not make the credit permanent. Even prior to the EGTRRA, legislators introduced several bills for this purpose and practitioners continue to assert that the lack of permanence dilutes the incentive effects of the credit (Grigsby and Westmoreland, 2001). Most recently, President Barack Obama stated: "This is a tax credit that returns $2 to the economy for every dollar we spend. Yet over the years, we've allowed this credit to lapse or we've extended it year to year — even just a few months at a time. Under my budget, this tax credit will no longer fall prey to the whims of politics and partisanship. It will be far more effective when businesses like yours can count on it, when you've got some stability and reliability" (Remarks at the White House, March 23, 2009. http://www.whitehouse.gov/the_press_office/Remarks-by-The-President-on-Investments-in-Clean-Energy-and-New-Technologies-3-23-09). However, the issue of the permanence of the credit is beyond the scope of this study.

multiplied by their average gross receipts in the previous four years, and (2) 50 percent of current year QRE, as follows:

$$(2) \quad Base_{t>1989} = \max\left[\left\{\left(\frac{1}{4}\sum_{k=1}^{4} Sales_{t-k}\right)\times \min\left(0.16,\ \frac{\sum_{j=1984}^{1988} QRE_j}{\sum_{j=1984}^{1988} Sales_j}\right)\right\},\ 0.50\times QRE_t\right].$$

Congress assigned start-up firms a fixed base of 3 percent.[8]

The desire to enhance the credit's incentive effect motivated the OBRA89 base modification. By adjusting each firm's base to an index other than prior-year R&D expenditures, Congress wanted to make the credit widely available at the lowest possible revenue cost. In explaining its rationale for the specific design of the credit, the Senate Finance Committee stated:[9]

> Because businesses often determine their research budgets as a fixed percentage of gross receipts, it is appropriate to index each taxpayer's base amount to the average growth in its gross receipts. By so adjusting each taxpayer's base amount, the committee believes the credit will be better able to achieve its intended purpose of rewarding taxpayers for research expenses in excess of amounts that would have been expended in any case. Using gross receipts as an index, firms in fast-growing sectors will not be unduly rewarded if their research intensity, as measured by their ratio of qualified research to gross receipts, does not correspondingly increase. Likewise, firms in sectors with slower growth will still be able to earn credits as long as they maintained research expenditures commensurate with their own sales growth.

The Committee added that adjusting a taxpayer's base by reference to its gross receipts also has the advantage of indexing the credit for inflation and preventing taxpayers from being rewarded for purely inflation-induced increases in research spending.

To be sure, the R&D tax credit regime instituted by OBRA89 is not free from criticism. Perhaps the main question is the continued use of a base period (1984–1988) that is now over two decades old.

III. RESEARCH QUESTIONS AND MODEL DEVELOPMENT

The change in the R&D credit's design enacted by OBRA89 and Congress' rationale for making this change motivates our two research questions: (1) what was the effect

[8] Congress defined start-up firms as firms that had fewer than three years of both gross receipts and qualified R&D expenses during the fixed base measurement period (1984–1988).

[9] Senate Finance Committee Report (Part 1 of 6 Parts) (October 13, 1989), 135 Cong. Rec. S13125 (October 12, 1989).

of the OBRA89 structural change on firms' eligibility and qualification for the R&D credit, and (2) what was the effect of the OBRA89 structural change on firms' R&D spending intensity?

A. The Effect of the OBRA89 Changes on Eligibility and Qualification for the R&D Credit

Given the congressional objective of making the credit as widely available as possible, we expect the overall eligibility of firms for the credit to increase after OBRA89. Further, given the Senate Finance Committee's rationale for indexing a firm's base amount to its average growth in gross receipts, we expect that the disincentive caused by the use of the moving average base will no longer affect firms with high growth potential after OBRA89. Therefore, we also expect an increase in the eligibility for the credit of high growth firms relative to other firms. In general, high growth firms have higher R&D spending but lower sales — characteristics typical of firms in high-tech industries that make large investments in intangible assets to fuel future revenue streams.[10] Hence, we implement our tests for this question by comparing firms in high-tech industries with firms in other industries. Various congressional reports indicate that lawmakers enacted the R&D credit primarily to benefit high-tech industries.[11]

The R&D credit (as well as most other tax credits) is non-refundable, implying that taxpayers stand to benefit only if they have a positive tax liability in the current period, except to the extent the credit can be carried back or forward. Thus, even though a taxpayer may be "eligible" for the credit, they must have a positive tax liability to "qualify" for it. From a policy perspective, the design of the R&D credit can only take into consideration firms' eligibility for the credit; however, qualification ultimately determines taxpayers' benefits. Hence, we also examine whether overall firms' qualifica-

[10] This statement is consistent with the characteristics of our sample. Specifically, the mean R&D expense for high-tech (other) firms is $41.66 million ($20.86 million), and the mean sales for high-tech (other) firms is $506 million ($831 million). Additionally, the mean sales growth and R&D expense growth for high-tech firms (18.27 percent and 25.29 percent, respectively) is larger than that of other firms (12.54 percent and 17.90 percent, respectively). All differences between high-tech and other firms are significant at the $p < 0.05$ level.

[11] For instance, the House and Senate hearings prior to the adoption of IRC section 44F (dealing with research excluded from the R&D tax credit) indicate that Congress wanted to encourage investment in high-tech R&D. Only representatives from high-tech industries (e.g., the American Electronics Association, the Semiconductor Industry Association, and the Computer & Business Equipment Manufacturer's Association) testified at these hearings. These hearings focused on the benefits that the credit would confer on technologically intensive industries. The testimony highlighted the need to stimulate R&D in high-tech industries in order to stimulate growth in these industries. Moreover, the witnesses testified that the technological innovations made by high-tech industries in turn benefited the economy generally. Finally, the members of high-tech industries testified that a tax credit would enhance their ability to compete with foreign competitors (Nellen, 2001).

tion for the credit differs between the pre- and post-OBRA89 periods and for high-tech firms relative to others.[12]

B. The Effect of the OBRA89 Changes on R&D Spending Intensity

1. Model Development

In the second stage of our analysis, we examine whether the structural change in the R&D tax credit after OBRA89 affected firms' R&D spending. Most prior empirical studies that evaluate the effectiveness of the R&D credit typically estimate the level of R&D spending (RD_{it}) as a function of a R&D credit dummy (C_{it} set to one when the credit is available) and firm-specific variables (y_{it}), such as past R&D spending, output, and cash flows, or

$$(3) \quad RD_{it} = \alpha_0 + \beta C_{it} + \gamma' y_{it} + \varepsilon_{it}.$$

However, policymakers often focus on R&D intensity (commonly measured as R&D expense divided by sales) rather than the level of R&D. Reinforcing this notion, the Senate Finance Committee specifically incorporated R&D intensity into the fixed-base calculation (by indexing a firm's base amount to its average growth in gross receipts) to better achieve the R&D credit's intended purpose of rewarding firms only for incremental research expenses.

The theory on how tax policy affects R&D intensity is not clear and only a few studies (e.g., Tillinger, 1991; Berger, 1993) have empirically estimated models of R&D intensity. Hall (1993) and Hall and van Reenan (2000) use a simple model to generate predictions of the credit's incentive effects on changes in R&D spending levels. We follow a similar model to generate predictions of how the OBRA89 change might affect the R&D credit's incentive effects as captured through R&D intensity. We present the model in Appendix A.

Two predictions follow from our model. Observation 1 implies that changes to the R&D credit that lower the marginal cost of making new qualified R&D investments should positively affect R&D intensity. Since the OBRA89 structural change broke the link between current and future R&D spending that existed pre-OBRA89 under the moving-average method, the effective rate of the credit post-OBRA89 should be relatively higher which, in turn, should increase firms' R&D intensities. Observation

[12] Lawmakers enacted an additional change to the R&D credit as part of the OBRA89 reforms (albeit unrelated to the structural change) that allows us to make a prediction regarding pre- and post-OBRA89 firm qualification. Specifically, IRC section 280C(c) further reduced the deduction for R&D expenses by the full amount of the R&D tax credit claimed in the same year. Reducing the R&D deduction increases taxable income relative to what it would have been absent the reduction, thereby improving the tax status (taxable vs. NOL) of firms at the margin. Tax status determines firm qualification; therefore, the higher IRC section 280C(c) reduction post-OBRA89 should increase firm qualification, all else equal.

2 predicts that OBRA89's positive impact on R&D intensity will be greater for firms with higher gross profit margins or growth rates of R&D stock, such as firms in high-tech industries.

2. Empirical Specification

To test the predictions regarding OBRA89's incentive effect, we estimate regression models of R&D intensity as a function of both tax and non-tax factors. Four design features of our empirical specification are noteworthy. First, given that OBRA89 represents a unique natural experiment, our research design is similar in spirit to other studies that used the enactment of the credit to help identify the incentive effects (Eisner, Albert, and Sullivan, 1983; Swenson, 1992; Berger 1993). However, while these studies use a R&D credit qualification dummy, we estimate regressions separately for firms grouped by their qualification status for the credit. We believe this specification better accounts for potential differences in the sub-samples that could likely impair interpretations of the tax variables of interest. Second, we use high-tech firms to examine the prediction that OBRA89 will have a larger effect on firms with high gross profit margins and growth rates of R&D stock.[13] Third, we include firm fixed effects, which reduce the potential for correlated omitted variables (e.g., knowledge depletion rates) and heterogeneity bias. Finally, since R&D investment is typically characterized as an autoregressive process, we have a dynamic model and the usual within-fixed-effects estimators are inconsistent. Hence, we utilize a system generalized method of moments (GMM) estimator for dynamic panel regression models that uses an instrumental variables approach (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998). The system GMM estimator is designed for panels containing fixed effects and idiosyncratic errors that may be potentially heteroskedastic and correlated within firms.

Our empirical model of R&D intensity is as follows (where subscript i is an index for firms, subscript j is an index for industries, and subscript t is an index for years):

$$(4) \quad R\&D\_INTENSITY = \alpha_0 + \delta_1 GDP_t + \delta_2 INDUSTRY\_R\&D_{jt} + \gamma_1 R\&D\_INTENSITY_{it-1} + \gamma_2 INTERNAL\_FUND_{it} + \gamma_3 LEVERAGE_{it} + \gamma_4 TOBIN'S\_Q_{it} + \gamma_5 SIZE_{it} + \phi_1 TAX\_RATE_{it-1} + \phi_2 OBRA_t + \phi_3 \left(OBRA_t \times TECH_{it}\right) + \mu_i + \zeta_{it}.$$

[13] To evaluate the appropriateness of high-tech firms satisfying these criteria, we use Lev and Souigiannis' (1996) algorithm that approximates the stock of R&D capital (G_{it}) for firm i in year t as a function of current and past R&D expense (RD_{it}) as follows: $G_{it} = RD_{it} + 0.8RD_{it-1} + 0.6RD_{it-2} + 0.4RD_{it-3} + 0.2RD_{it-4}$. For our sample firms, this algorithm yields R&D stock for high-tech (other) firms of \$118.80M (\$64.96M) and R&D stock growth of 27.12 percent (22.80 percent). Additionally, the mean gross profit margin for high-tech (other) firms is 43.18 percent (35.52 percent). All differences in these variables between high-tech and other firms are significant at the $p < 0.05$ level.

The dependent variable *R&D_INTENSITY* is R&D intensity, measured as R&D expenses divided by sales.[14] We use μ_i to capture the firm fixed-effect and define the other right-hand side variables as follows (with *Compustat* data item numbers and coefficient sign predictions in parentheses):

GDP_t = Real gross domestic product (+)
$INDUSTRY\_R\&D_{jt}$ = Industry R&D intensity measured as *R&*D Intensity of all firms in firm *i*'s four-digit SIC code (+)
$R\&D\_INTENSITY_{it-1}$ = One-year lagged firm *R&D* Intensity (+)
$INTERNAL\_FUND_{it}$ = Internal funds, measured as [income before extraordinary items (#18) + R&D expense (#46) + depreciation (#14)] ÷ sales (#12) (+)
$LEVERAGE_{it}$ = Leverage, measured as long-term debt (#9) ÷ total assets (#6) (–)
$TOBIN'S\_Q_{it}$ = Tobin's *q*, measured as [(price (#199) × common shares Outstanding (#25)) + book value of preferred stock (#130) + long-term debt (#9) + short-term debt (#34)] ÷ total assets (#6) (?)
$SIZE_{it}$ = Firm size, measured as the natural logarithm of total assets (#6) (?)
TAX_RATE_{it-1} = One-year lagged simulated, after-financing marginal tax rate (Graham, 1996a, 1996b; Graham, Lemmon, and Schallheim, 1998) (+)
$OBRA_t$ = An OBRA89 indicator variable coded one for the years 1990–1994, and zero otherwise (+)
$TECH_{it}$ = A high-tech industries indicator variable coded one for firms in the following four-digit SIC classifications: Drugs (2833–2836), R&D Services (8731–8734), Programming (7371–7379), Computers (3570–3577), and Electronics (3600–3674), and zero otherwise (Kasznik and Lev, 1995) (+)

We include *TAX_RATE*, *OBRA,* and *OBRA×TECH* to capture the tax issues of interest.[15] The *OBRA* indicator variable and its interaction with *TECH* are the main test variables. A positive and significant estimate of ϕ_2 would be consistent with the prediction of our model's Observation 1 that the OBRA89 structural change positively impacted firms'

[14] We also use lagged sales as the scalar for R&D intensity. The inferences from all tests remain unchanged.

[15] Klassen, Pittman, and Reed (2004) also include state-level R&D credits, which differ from state to state, and could provide another source of variation to help isolate the credit's incentive effect. We do not consider the state-level credit because of data limitations. Specifically, firms' financial statements do not reveal the amount of R&D conducted in each state, which is necessary for calculating the state-level credits. To deal with this problem, Klassen, Pittman, and Reed (2004) assign their sample firms to the states (provinces in Canada) of their head office location, but this assumption adds noise to their incentive measure. In any event, their results for the U.S. observations do not change if they consider only the federal-level R&D credit.

R&D intensity. Similarly, a positive and significant estimate of ϕ_3 would be consistent with the prediction of our model's Observation 2 that OBRA89's positive effect on firms' R&D intensity is greater for the high-tech firms.

We also include the firm-specific, simulated, after-financing marginal tax rate (MTR) (*TAX_RATE*) based on Graham (1996a, 1996b). In addition to the tax credit, firms may deduct R&D expenditures in the year incurred, subject to the IRC section 280C(c) limitation. Thus, the firm's tax rate has an effect on the cost of the R&D dollar, with reductions in the tax rate reducing the benefits of expensing (relative to other capital investments). Even with no legislative changes in tax rates, changes in firms' taxable status will alter the cost of the R&D investment. Firms with lower MTRs likely have smaller R&D expenditures because of the increasing after-tax cost of R&D investment. Although the use of instruments in the GMM estimator mitigates the concern for endogeneity in tax status, we use lagged *TAX_RATE* as an additional endogeneity control for corporate tax status (Graham, 1996a, 1996b; Graham, Lemmon, and Schallheim, 1998).

The other explanatory variables fall into two broad categories: macroeconomic factors and firm-specific factors, including financial constraints. To account for macroeconomic factors we include two variables: the real gross domestic product (*GDP*) as an index of overall technological progress and industry-level R&D (*INDUSTRY_R&D*) to capture the within-industry influence of competitors.

In terms of the firm-specific variables, we first control for the nature of R&D investments that typically tend to be multi-period and characterized by large fixed costs with previous outlays/projects influencing decisions about current R&D expenditures by including prior-year R&D intensity in the model. Klassen, Pittman, and Reed (2004) argue that an autoregressive — instead of a random walk — process best describes the R&D expenditure decision, which also motivates including lagged *R&D_INTENSITY* instead of estimating a change specification.

An important financial constraint faced by firms on all investment projects, including R&D, is the availability of funds from internal and external sources. Myers and Majluf's (1984) model of financing hierarchy suggests that firms will prefer internally generated funds as they tend to be cheaper than external sources of financing. If, however, firms require external financing, they prefer debt to equity. Although there does not appear to be a general agreement on a single measure of firms' capital constraints, empirical studies have focused on cash flows and leverage (Rajan and Zingales, 1998). Thus, we include *INTERNAL_FUND*, a scaled measure of pre-R&D cash flows, to proxy for a firm's ability to finance R&D from internal funds, and *LEVERAGE*, the debt-to-asset ratio, to capture the impediments faced in obtaining additional debt financing to pursue R&D projects.

Finally, our model includes two other firm-specific attributes, Tobin's *q,* and firm size, that are likely to affect R&D spending. Prior literature often views Tobin's *q* (*TOBIN'S_Q*), commonly estimated as the market-to-book value of a firm, as a measure of investment opportunities or the stock of intangible assets. Berger (1993) cites studies that find that firms with greater values of *TOBIN'S_Q* conduct more R&D in levels; however, the effect of *TOBIN'S_Q* on R&D intensity is unclear. Likewise, a long literature explores the relationship between firm size and R&D activities. Schumpeter (1950) argues for a positive relationship between firm size and R&D investment because larger firms can afford bigger projects, wait longer for payoffs, and capture a bigger portion of the social returns to private R&D due to their relatively large market share. However, a returns-to-scale argument suggests a negative relationship between firm size and R&D intensity. Over the years, several studies have empirically attempted to reconcile these conflicting predictions (Schmookler, 1959; Cohen, Levin, and Mowery, 1987), with little consensus. Hence, we include the log of total assets (*SIZE*) as another control variable but do not make a sign prediction.

IV. DATA, SAMPLE SELECTION, AND DESCRIPTIVE STATISTICS

A. Data and Sample Selection Procedures

Our sample selection begins with all firms listed on the *Compustat* Industrial and Full Coverage Files that report R&D expense and that have at least one year of credit qualification during 1981–1994. Since the *Compustat* year 1994 includes fiscal years that end through May 31, 1995, and the credit lapsed on June 30, 1995, our sample period corresponds to within one month with the entire period during which the R&D credit was continuously available. From the initial sample, we delete firm-years missing data on variables included in the regression model. In addition, to remove the effects of outliers, we drop the highest and lowest 1 percent of the observations for each firm-specific regression variable in year *t*. The final sample consists of 15,804 firm-year observations representing 2,540 firms.

In order to perform tests of eligibility and qualification, we need to determine the qualified R&D expenses (QRE) of each firm. To be "eligible" for the credit, a firm's current year QRE must be greater than its base spending amount. However, actual values of QRE are only available from tax returns that are confidential. Hence, some prior studies (Eisner, Albert, and Sullivan, 1983; Baily and Lawrence, 1992; Swenson, 1992; Berger, 1993; McCutchen, 1993) assumed that QRE equals book R&D spending. Hall and van Reenen (2000) found that typically 50–73 percent of reported book R&D spending qualifies for the credit. Using tax return data to study income shifting by firms claiming the Puerto Rican tax credit under IRC section 936, Grubert and Slemrod (1998) found that the R&D expense reported on the tax returns of firms claiming the credit was, on average, 50 percent of their book R&D expense reported on *Compustat*. Accordingly, we assume that QRE equals 50 percent of *Compustat* R&D expense to determine eligibility, although sensitivity tests using 73 percent yield similar results for all reported tests.[16]

[16] Others corroborate the appropriateness of using 50 percent of *Compustat* R&D as a proxy for QRE. For instance, in testimony before the Oversight Subcommittee of the House Ways and Means Committee, Harry Penner of the Neurogen Corporation stated that approximately one-half of book R&D qualifies for the R&D credit (Penner, 1995).

To be "qualified" to use the credit, a firm must not only be eligible for the credit but must also have sufficient tax liability (currently or in preceding years) against which to use the R&D credit. Accordingly, we consider a firm "qualified" if it meets two conditions: (1) current year *TAX_RATE* is positive, and (2) total income tax expense minus the change in deferred taxes from the balance sheet sums to a positive amount for the current plus the three preceding years (Berger, 1993; Mills, Newberry, and Novack 2003). Using these conditions allows us to create a tax status variable that incorporates screens for both net operating losses (NOLs) and current tax expense, which recent research suggests provides a better mapping of tax status between financial statements and tax returns.[17]

Based on the above criteria for eligibility and qualification for the R&D tax credit, we classify our sample as follows: (1) of the total 15,804 firm-years in the sample, 11,991 (75.9 percent) are eligible for the credit, and (2) of the 11,991 eligible firm-years, 7,756 (64.7 percent) are qualified to use the credit.

B. Descriptive Statistics

Table 1 profiles our sample firms with descriptive statistics for various characteristics and a breakdown of their composition by industry. Panel A of Table 1 shows that qualified firms are larger, have greater pretax profits, and are more likely to pay taxes than both eligible firms that are not qualified for the credit and firms not eligible for the credit. The median sales, assets, and profit margins for qualified firms are $157.9 million, $128.6 million, and 8.9 percent, while the respective amounts for non-qualified firms (non-eligible firms) are $26.11 ($73.55) million, $27.52 ($59.56) million, and –4.3 (3.5) percent. The median MTR (*TAX_RATE)* for qualified firms is 35 percent compared with zero (19.2) percent for non-qualified (non-eligible) firms. Qualified firms also have higher R&D intensities than non-eligible firms. However, qualified firms have lower R&D intensities than non-qualified firms. This is consistent with Joos and Plesko (2005), who find firms that incur losses and have the lowest probability of loss reversal have higher R&D intensities, a pattern that became more pronounced during the 1990's.

Panel B of Table 1 presents mean R&D intensities and MTRs by broad industry groups. Industries with the largest mean R&D intensities include pharmaceuticals (28 percent), professional services (18 percent), computers (11 percent), and financial institutions (15 percent). These four industries also have four of the five lowest mean MTRs (19, 16, 19, and 18 percent, respectively) in the sample. Following OBRA89, qualified firms' mean R&D intensities increased by 41 percent on average, with the largest increases occurring in the transportation/utilities (101 percent), retail: wholesale

[17] Graham's (1996a, 1996b) simulated MTR uses the entire NOL carryback/carryforward schedule (18 years). However, Graham gathers NOL information from *Compustat* and studies show that *Compustat* NOL data contains certain inaccuracies (Kinney and Swanson, 1993; Manzon, 1994). Mills, Newberry, and Novack (2003) find that using additional *Compustat* data for U.S. current income tax expense reduces the error related to *Compustat's* reporting of an NOL carryforward where no U.S. tax NOL exists.

(100 percent), financial (81 percent), and professional services (71 percent) industries.[18] Average MTRs of qualified firms decreased by almost 37 percent following OBRA89, in part due to the statutory rate decreases enacted under the Tax Reform Act of 1986.

Overall, firms eligible to use the credit have higher R&D intensities than ineligible firms, both before OBRA89 (7.03 percent versus 3.75 percent) and after (13.26 percent versus 3.91 percent). Consistent with the statutory tax rate decreases enacted under the Tax Reform Act of 1986, eligible firms' MTRs decreased from 26.88 percent before OBRA89 to 18.70 percent after OBRA89, and ineligible firms' MTRs declined from 20.08 percent to 16.26 percent over the same period. Firms qualified to use the credit have lower R&D intensities and larger MTRs than nonqualified firms, both before and after OBRA89.

In addition, the increase (decrease) in R&D intensities (MTRs) of eligible firms after OBRA89 occurred for both the high-tech and other industry groups (not tabulated). The average high-tech (other) industry R&D intensity increased from 11.52 percent to 20.42 percent (4.90 percent to 8.19 percent). The average high-tech (other) industry MTRs decreased from 23.13 percent to 16.40 percent (28.66 percent to 20.34 percent).

V. RESULTS

A. Tests of OBRA89's Effect on Firms' Eligibility and Qualification for the R&D Credit

1. Full Sample Results

Table 2 reports results of univariate tests of eligibility and qualification for the R&D credit by period and industry.[19] As Panel A of Table 2 shows, overall eligibility for the credit declined from nearly 79 percent of the firm-years in the pre-OBRA89 period to 70 percent after OBRA89. This decline is statistically significant; the post-OBRA89 estimated odds of eligibility for the R&D tax credit are 0.64 times [*CI* = (0.593, 0.689)] the pre-OBRA89 estimated odds. Panel B of Table 2 shows that the decline in eligibility is significantly less pronounced for high-tech firms compared to other firms; high-tech

[18] During that period, financial institutions invested heavily in new IT infrastructure. Conversations with tax practitioners from major CPA firms confirm the aggressiveness of tax consultants in helping major financial institutions and retailers claim IT development/software related costs for federal R&D credits. Increases in R&D spending in the utility industry during that period also correspond to the increases in federal energy R&D budgets and funding.

[19] We use sample odds ratios ($\hat{\theta}$) to examine the changes in likelihood of eligibility and qualification for the credit between the pre- and post-OBRA89 tax regimes. The value $\theta = 1$ serves as a baseline for comparison. When $1 < \theta < \infty$ ($0 < \theta < 1$), the odds of success are higher (lower). Agresti (1996) shows that in large samples, such as ours, statistical inference based on the natural log of the odds ratio ($\hat{\theta}$ln) results in a conservative test, reduces skewness, and produces a sampling distribution closer to normality. The confidence interval (*CI*) of $\ln\theta = \ln\hat{\theta} \pm z_{\alpha/2} ASE(\ln\hat{\theta})$, and we transform the endpoints using the exponential function to form a confidence interval for θ. In a 2 × 2 table, $\theta = n_{11}n_{22}/n_{21}n_{12}$, where n_{ij} = the frequency in cell$_{ij}$, *ASE* = the *asymptotic standard error* $\sqrt{1/n_{11} + 1/n_{12} + 1/n_{21} + 1/n_{22}}$.

Table 1

Descriptive Statistics

Panel A: Sample Profile

	Eligible and Qualified Firm-Years n = 7,756			Eligible and Non-Qualified Firm-Years n = 4,235			Non-Eligible and Non-Qualified Firm-Years n = 3,813		
Variable	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
R&D_EXPENSE	40.32	132.2	5.405	15.17	61.73	1.856	16.22	65.83	1.507
ΔR&D_EXPENSE	0.276	0.467	0.166	0.346	0.715	0.155	–0.100	0.393	–0.108
SALES	948.7	2284	157.9	352.5	1276	26.11	676.7	1973	73.55
ΔSALES	0.176	0.276	0.117	0.180	0.520	0.062	0.040	0.267	0.025
R&D_INTENSITY	0.053	0.055	0.036	0.159	0.246	0.069	0.038	0.058	0.020
LEVERAGE	0.126	0.118	0.101	0.155	0.152	0.115	0.158	0.138	0.135
TOBIN'S_Q	1.537	1.105	1.177	1.695	1.578	1.079	1.125	0.880	0.871
MARKET/BOOK	2.371	1.920	1.813	2.945	3.539	1.647	1.894	2.236	1.263
PRETAX_MARGIN	0.101	0.080	0.089	–0.050	0.114	–0.043	0.023	0.104	0.035
SIZE	4.954	1.911	4.857	3.522	1.894	3.315	4.327	1.977	4.087
TAX_RATE	0.332	0.158	0.350	0.124	0.185	0.000	0.192	0.191	0.192

Table 1 (continued)

Descriptive Statistics

Panel B: R&D Intensity (RDI) and Marginal Tax Rates (MTR)

				Pre-OBRA89				Post-OBRA89			
	Full Sample n = 15,804			Qualified n = 5,102		Non-Qualified n = 2,967		Qualified n = 2,654		Non-Qualified n = 1,268	
Industry	n	RDI	MTR	RDI	MTR	RDI	MTR	RDI	MTR	RDI	MTR
Mining and construction	104	5.49	20.92	2.78	37.00	3.42	0.02	3.26	27.01	21.64	0.00
Food	288	0.93	36.31	0.58	41.72	1.66	23.86	0.67	29.96	11.38	26.11
Textiles, printing, and publishing	828	1.63	30.20	1.23	40.69	1.87	11.76	1.88	29.55	12.44	2.51
Chemicals	903	4.17	30.84	2.85	41.47	8.85	8.03	3.23	29.93	30.03	1.16
Pharmaceuticals	889	28.47	19.36	7.84	38.58	38.76	3.53	10.42	26.93	70.72	1.23
Extractive industries	220	3.88	27.14	2.44	42.36	10.64	9.03	2.33	22.95	9.96	0.06
MFG: rubber, glass, etc.	653	2.15	28.31	1.89	41.04	2.89	7.72	1.90	29.96	7.33	0.02
MFG: metal	849	2.04	25.01	1.59	40.28	2.84	7.69	1.87	29.01	9.45	7.11
MFG: machinery	1,461	4.15	21.79	3.48	36.64	6.41	6.33	4.22	26.17	8.73	3.66
MFG: electrical equipment	1,689	6.70	21.53	5.25	39.02	9.18	4.35	7.26	25.19	12.72	4.09
MFG: transportation equipment	737	2.48	27.06	2.62	39.61	2.33	13.92	2.85	27.84	2.48	12.39
MFG: instruments	2,471	8.92	20.82	6.44	37.42	11.21	7.32	7.56	25.47	22.33	3.79
MFG: other	249	2.48	22.89	2.25	39.44	2.82	4.02	2.96	22.40	4.48	6.01
Computers	3,375	10.53	19.43	7.92	36.41	14.01	4.38	11.28	24.23	18.07	2.78
Transportation & utilities	107	6.95	21.68	1.88	40.41	16.47	8.18	3.79	13.08	15.73	2.28

Retail: wholesale	234	5.25	24.93	1.36	39.25	10.47	6.77	2.72	29.90	19.21	3.45
Retail: other	54	2.55	23.98	1.02	43.36	3.92	7.60	1.81	13.26	2.83	0.00
Financials	113	15.24	17.72	5.28	40.12	23.98	4.17	9.55	28.04	33.26	0.00
Personal services	198	4.08	14.57	2.39	37.00	6.86	3.13	3.25	12.26	8.85	1.47
Professional services	219	17.58	16.37	3.66	38.11	20.64	8.15	6.28	22.86	54.67	0.00
Other	163	13.18	20.21	3.92	43.58	20.90	2.62	7.56	28.86	31.62	1.94

Notes: Panel A presents descriptive statistics for our sample of 15,804 firm-years (2,504 firms). We define the variables as follows: *R&D_EXPENSE* = R&D expense (in $millions); Δ*R&D_EXPENSE* = change in R&D expense (in $millions); *SALES* = net sales (in $millions); Δ*SALES* = change in net sales (in $millions); *R&D_INTENSITY* = R&D intensity, defined as: R&D Expense/Sales; $INTERNAL\_FUND_t$ = internal funds (a proxy for a firm's pre-R&D cash flow), measured as (income before extraordinary items + depreciation + R&D expense) ÷ sales; *LEVERAGE* = long-term debt to assets; *TOBIN'S_Q* = Tobin's *q*, measured as [(price × common shares outstanding) + book value of preferred stock + long-term debt + short-term debt] ÷ total assets; *MARKET/BOOK* = Market-to-book ratio, measured as [(price × common shares outstanding] ÷ common shareholders' equity; *PRETAX_MARGIN* = Pretax profit margin, measured as (pretax income) ÷ sales; *SIZE* = Log(total assets); *TAX_RATE* = simulated MTR (Graham, 1996a, 1996b; Graham, Lemmon, and Schallheim, 1998).

In Panel B, we define industries according to the following four-digit SIC Codes (in parentheses): Mining and Construction (1000–1999, excluding 1300–1399); Food (2000–2111); Textiles, Printing, and Publishing (2200–2796); Chemicals (2800–2824, 2840–2899); Pharmaceuticals (2830–2836); Extractive Industries (1300–1399, 2900–2999); MFG: Rubber, Glass (3000–3299); MFG: Metal (3300–3499); MFG:Machinery (3500–3599, excluding 3570–3579); MFG:Electrical Equipment (3600–3699 excluding 3670–3679); MFG:Transportation Equipment (3700–3799); MFG:Instruments (3800–3899); Computers (3570–3579, 3670–3679, and 7370–7379); Transportation & Utilities (4000–4999); Retail: Wholesale (5000–5199); Retail:Other (5200–5999); Financial Institutions, Insurance, and Real Estate (6000–6999); Personal Services (7000–7999, excluding 7370–7379); Professional Services (8011–8999).

Table 2

R&D Tax Credit Eligibility and Qualification

Panel A: R&D tax credit eligibility and qualification — by period

	Eligible		Not-Eligible		Qualified		Not-Qualified	
Period	Firm-Years	%	Firm-Years	%	Firm-Years	%	Firm-Years	%
Pre-OBRA89 (1981–1989)	8,069	78.84	2,166	21.16	5,102	63.23	2,967	36.67
Post-OBRA89 (1990–1994)	3,922	70.43	1,647	29.57	2,654	67.67	1,268	32.33
All firm-years (1981–1994)	11,991		3,813		7,756		4,235	
	$\hat{\theta} = 0.64^{**}$				$\hat{\theta} = 1.22^{**}$			

Panel B: R&D tax credit eligibility and qualification — by industry and period

	Eligible		Not-Eligible		Qualified		Not-Qualified	
Industry and period	Firm-Years	%	Firm-Years	%	Firm-Years	%	Firm-Years	%
High-tech industry								
Pre-OBRA89 (1981–1989)	2,597	82.50	551	17.50	1,489	57.34	1,108	42.66
Post-OBRA89 (1990–1994)	1,626	77.47	473	22.53	1,036	63.71	590	36.29
All tech firm-years	4,223		1,024		2,525		1,698	
	$\hat{\theta} = 0.73^{**}$				$\hat{\theta} = 1.31^{**}$			

Other industries								
Pre-OBRA89 (1981–1989)	5,472	77.21	1,615	22.79	3,613	66.03	1,859	33.97
Post-OBRA89 (1990–1994)	2,296	66.17	1,174	33.83	1,618	70.47	678	29.53
All other firm-years	7,768		2,789		5,231		2,537	
All firm-years (1981–1994)	11,991		3,813		7,756		4,235	
	$\hat{\theta} = 0.58$**				$\hat{\theta} = 1.23$**			
	$\chi^2_{BD} = 7.81$**				$\chi^2_{BD} = 0.54$			

Notes: This table presents descriptive statistics and univariate tests of differences in firm eligibility and qualification for the R&D tax credit by period and industry membership. We define eligibility and qualification for the R&D tax credit as follows: *Eligible* = Implies that the firm's spending on R&D satisfies the threshold defined by the tax laws for claiming the R&D tax credit; *Qualified* = Implies that the firm meets the eligibility requirements and that the firm's tax status allows it to claim the benefit of the tax credit. We consider a firm "qualified" if its *Marginal Tax Rate* > 0 and its total tax liability for the current and prior three years exceeds zero (Berger, 1993; Graham, 1996a; Mills, Newberry, and Novack, 2003). We designate a firm as "high-tech" if it is in any one of the following four-digit SIC codes: 2833–2836, 3570–3577, 3600–3674, 7371–7379, and 8731–8734 (Kasznik and Lev, 1995). $\hat{\theta}$ = the sample odds ratio, defined as $\hat{\theta} = n_{11}n_{22}/n_{21}n_{12}$, where n equals the frequency in each cell. χ^2_{BD} = the Breslow-Day chi-square statistic. Asterisks denote significance at the 1% (*), 5% (**), and 10% (***) (two-tail) levels.

firms are roughly 0.73 times [*CI* = (0.636, 0.837)] as likely to be eligible for the R&D credit following OBRA89, while other firms are about 0.58 times [*CI* = (0.528, 0.631)] as likely to be eligible (χ^2_{BD} = 7.81, p = 0.000).[20]

Although we do not have specific hypotheses regarding firm qualification for the R&D credit, the increased reduction in the amount of QRE that could be expensed post-OBRA89 (from 50 percent of the R&D credit claimed to 100 percent) had the effect of increasing a firm's taxable income. All else equal, the greater a firm's taxable income, the more likely it will be qualified to take the credit. Consistent with this notion, overall qualification for the credit significantly increased from 63 percent of firm-years to nearly 68 percent; firms were about 22 percent [$\hat{\theta}$ =1.22; *CI* = (1.123, 1.32)] more likely to be qualified for the credit following OBRA89. High-tech firms have a larger increase over the two periods relative to the other firms — the percent of high-tech (other) firms qualified for the credit pre-OBRA89 is 57 (66) percent, compared with 64 (70) percent in the post-OBRA89 period. The odds ratios indicate that high-tech firms are approximately 31 percent [$\hat{\theta}$ =1.31; *CI* = (1.15, 1.48)] more likely to be qualified for the credit following OBRA89, while other firms are approximately 22 percent more likely to be qualified [$\hat{\theta}$ =1.22; *CI* = (1.10, 1.36)]. However, the difference in qualification odds is not significant (χ^2_{BD} = 0.54, p = 0.46).

To control for various firm-specific characteristics that may confound the univariate inferences, we estimate the following pooled logistic regression model that examines the likelihood of eligibility and qualification for the R&D credit during 1981–1994:

$$(5)\quad STATUS_{it} = \alpha_0 + \delta_1 GDP_t + \gamma_2 SALES\_GROWTH_{it} + \gamma_3 R\&D\_GROWTH_{it} + \gamma_4 SIZE_{it} + \phi_1 TAX\_RATE_{it} + \phi_2 OBRA_t + \phi_3 \left(OBRA_t \times TECH_{it}\right) + \varepsilon_{it},$$

where *STATUS* = one if a firm-year is either eligible or qualified for the R&D tax credit and zero otherwise; *SALES_GROWTH* = annual sales growth, defined as the change in sales divided by prior sales; *R&D_GROWTH* = annual R&D expense growth, defined as the change in R&D expense divided by prior R&D expense, and *GDP*, *SIZE*, *TAX_RATE*, *OBRA*, and *TECH* are defined previously. We include *SALES_GROWTH* and *R&D_GROWTH* to capture the structural aspects of the credit calculation.

Table 3 lists coefficient estimates first, followed by robust standard errors. The models appear to have good overall fit with the model χ^2 statistics significant at the 0.01 level in each regression and pseudo R^2 statistics indicating that (5) explains approximately 23 (35) percent of the likelihood of eligibility (qualification) for the R&D credit during the pre- and post-OBRA89 tax regimes.

In the eligibility regression for the full sample (column 1), the coefficient on *OBRA* is negative and significant (ϕ_2 = –0.2837, *se* = 0.0831), while the coefficient on

[20] The paramter χ^2_{BD} is the Breslow-Day (1980) chi-square statistic, which has the Pearson form $\Sigma((n_{ijk} - \hat{\mu}_{ijk})^2/\hat{\mu}_{ijk})$ with $df = K - 1$; it tests the null hypothesis that the odds ratio between two groups is the same.

Table 3

Logistic Regression Results of R&D Tax Credit Eligibility and Qualification Status

	FULL Sample		BALANCED Sample		1994 Sample	
	Eligible [1]	Qualified [2]	Eligible [3]	Qualified [4]	Eligible [5]	Qualified [6]
GDP	–0.0003*	0.0006*	–0.0001	0.0008*	–0.0001	0.0006*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
SALES_GROWTH	1.037*	0.4924*	0.7130**	2.588*	1.111*	0.4017*
	(0.0888)	(0.0695)	(0.3495)	(0.5385)	(0.1376)	(0.0982)
R&D_GROWTH	3.4307*	–0.1430*	6.5439*	–0.2352	1.9244*	–0.1802*
	(0.1842)	(0.0438)	(0.5206)	(0.1714)	(0.2430)	(0.0676)
SIZE	–0.0124	0.2715*	0.0951*	0.1953*	0.0219	0.2796*
	(0.0169)	(0.0194)	(0.0346)	(0.0426)	(0.0360)	(0.0372)
TAX_RATE	1.142*	6.380*	2.012*	6.438*	1.387*	6.262*
	(0.1570)	(0.1659)	(0.2752)	(0.3617)	(0.3061)	(0.3085)
OBRA	–0.2837*	0.3299*	–0.3306*	0.4750*	–0.5625*	0.3848*
	(0.0831)	(0.0872)	(0.1327)	(0.1826)	(0.1285)	(0.1148)
OBRA×TECH	0.4899*	–0.0308	–0.0941	–0.0247	0.8493*	0.0976
	(0.1283)	(0.1033)	(0.2632)	(0.2580)	(0.1676)	(0.1355)
n	15,804	11,991	5,166	3,851	4,962	3,719
Wald χ^2	777.0*	1712*	345.3*	340.3*	238.9*	542.5*
Pseudo R^2	0.1993	0.2745	0.2779	0.2297	0.1537	0.2378

Notes: This table presents results of logistic regressions of firm eligibility and qualification for the R&D tax credit. Regression coefficients are listed first, followed by robust standard errors. We define eligibility and qualification for the R&D tax credit as listed in the notes for Table 2. We define the samples as follows: *FULL Sample* = The original unbalanced sample used in the main analysis of the paper; *BALANCED Sample* = a balanced panel that includes all firms present in our sample for the entire 14-year period (1981–1994); and *1994 Sample* = all firms in our sample during the final year of our sample period (1994), back to their earliest year of inclusion in the *Compustat* database. We define the variables as follows (omitting subscripts): *GDP* = gross domestic product; *SALES_GROWTH* = sales growth, measured as (sales – lagged sales) ÷ lagged sales; *R&D_GROWTH* = R&D expense growth, measured as (R&D expense – lagged R&D expense) ÷ lagged R&D expense; *SIZE* = natural log of total assets; *TAX_RATE* = lagged simulated MTR (Graham, 1996a, 1996b; Graham, Lemmon, and Schallheim, 1998); *OBRA* = an indicator variable set to one for years $t > 1989$ (i.e., years after the "structural change" of the R&D tax credit provision); *OBRA×TECH* = the interaction of *OBRA* and an indicator variable set to one for firms in the following four-digit SIC categories: 2833–2836, 3570–3577, 3600–3674, 7371–7379, and 8731–8734 (Kasznik and Lev, 1995). Asterisks denote significance at the 1% (*), 5% (**), and 10% (***) levels.

OBRA × *TECH* is positive and significant (ϕ_3 = 0.4899, *se* = 0.1283). Interpreted using estimated odds ratios, the significantly negative coefficient on *OBRA* indicates that the post-OBRA89 estimated odds of eligibility for the R&D tax credit are 0.75 times the pre-OBRA89 estimated odds. This decline in overall firm eligibility for the R&D credit is inconsistent with OBRA89's goal of making the credit widely available. Even though overall eligibility declined after OBRA89, the positive *OBRA* × *TECH* coefficient indicates that the estimated odds of eligibility for the R&D tax credit for high-tech firms post-OBRA89 are 1.63 times the odds for other firms. This result is consistent with the statute's goal of benefiting rapidly growing firms that were more prone to face negative credit rates under the pre-OBRA89 structure.

In the full sample qualification regression (column 2), the coefficient on *OBRA* is positive and significant (ϕ_2 = 0.3299, *se* = 0.0872), implying that the post-OBRA89 estimated odds of qualifying for the R&D tax credit are 1.4 times the pre-OBRA89 estimated odds. However, *OBRA* × *TECH* is not significant (ϕ_3 = –0.0308, *se* = 0.1033), which suggests that credit qualification between high-tech firms and firms in other industries is not markedly different between the pre- and post-OBRA89 regimes.

2. *Alternative Sample Results*

A potential concern with our eligibility findings is that the sample composition in the pre- and post-OBRA89 periods may have changed. The United States experienced a manufacturing exodus that began in the mid-1980s and manufacturers comprise over 40 percent of our sample. To address this concern, we replicate our eligibility and qualification tests on two alternative samples. First, we form a balanced panel that includes only those firms present in our sample for the entire 14-year period. The *BALANCED* sample has 5,166 firm-year observations from 365 firms. Second, we form a sample of those firms present in the final year of our sample period, and include data on these firms back to the earliest year of their inclusion in the database (*1994*). The *1994* sample has 4,962 observations, with the number of firms increasing over time. To keep the two alternative samples distinct, we exclude the *BALANCED* sample firm-years from the *1994* sample.

As reported in Table 3, the results of the regressions on eligible and qualified firm-years using the *1994* sample (columns 5 and 6, respectively) yield inferences similar to the full sample results. However, the analysis of the *BALANCED* sample indicates that mature high-tech firms were not more likely to be eligible or qualified (columns 3 and 4, respectively) to receive the credit after OBRA89, relative to firms in other industries ($\phi_3^{BALANCED=Eligible}$ = –0.0941, *se* = 0.2632; $\phi_3^{BALANCED=Qualified}$ = –0.0247, *se* = 0.258). One interpretation of these findings is that the increased eligibility of high-tech firms after OBRA89, relative to firms in other industries, was due primarily to firms that are in the early, high growth stages of their life cycle.[21]

[21] The *BALANCED* sample includes more established, mature firms, whose growth potential is often limited. Therefore, OBRA89 is less likely to affect these firms. Conversely, the *1994* sample includes high growth start-up firms. Average sales growth, market-to-book ratio, and dividend payout ratio for the *BALANCED* (*1994*) subsample was 8.7 percent, 2.03, and 52.20 percent, respectively (21.75 percent, 2.81, and 33.06 percent, respectively). The differences in these variables between the two samples are significant at the $p < 0.05$ level.

B. Tests of OBRA89's Effect on Firms' R&D Spending Intensity

Table 4 presents results of the dynamic panel, system-GMM estimates of R&D intensity, estimated separately by qualification status for eligible firms. The regression coefficients, which are generated using a one-step GMM estimator, are listed first, followed by robust standard errors in parentheses.[22] We evaluate the specification of each regression with the Hansen test of over-identifying restrictions and the Arellano-Bond test for second-order serial correlation. We fail to reject the null hypothesis of both tests, which indicates that the instruments in each regression are valid and each regression exhibits no second-order serial correlation.[23]

1. *Full Sample Results*

The first column of results focuses on the R&D intensity of eligible firms that were qualified for the R&D credit during 1981–1994. The variables that capture the tax factors that affect R&D spending all have the predicted sign. The coefficient on *TAX_RATE* is positive, but insignificant.[24] The interaction term *OBRA* × *TECH* is significantly positive ($\phi_3 = 0.715$, $se = 0.2328$), which indicates that qualified high-tech firms increased their R&D intensities by an additional 0.72 percent after OBRA89 relative to qualified firms in other industries. The coefficient estimate for *OBRA* is also positive and significant ($\phi_2 = 0.2849$, $se = 0.1143$), indicating that R&D intensities of other firms increased by 0.28 percent on average post-OBRA89. Using untabulated descriptive statistics, these results indicate that the median level of R&D intensity for high-tech (other) firms qualified

[22] One-step GMM estimators use weight matrices that are independent of estimated parameters, whereas the efficient two-step GMM estimator uses a consistent estimate of the weighting matrix, taking the residuals from the one-step estimate. Though asymptotically more efficient, the two-step GMM presents estimates of the standard errors that tend to be severely downward biased. Windmeijer (2005) solves this problem using the finite-sample correction to the two-step covariance matrix, which can make two-step robust GMM estimates more efficient than one-step robust estimates (Roodman, 2009a). However, simulation studies suggest modest efficiency gains from using the two-step estimator (Bond, 2002).

[23] The system GMM estimator uses lagged differences of the independent variables as instruments for a levels regression and lagged levels of the independent variables as instruments for the differenced regression. In order to control for potential endogeneity, we treat all of the firm-specific control variables as if they were endogenous (i.e., potentially correlated with past and present errors). In particular, we use industry dummies and levels of the *R&D_INTENSITY*, *INTERNAL_FUND*, *LEVERAGE*, *TOBIN'S_Q*, *SIZE*, and *TAX_RATE* dated ($t - 2$), ($t - 3$), and ($t - 4$) as instruments for the equation in first differences and first differences of the same variables dated ($t - 1$) as instruments for the levels regression. In the empirical growth literature, concern has intensified in recent years that many instrumental variables used in applications of system GMM may be invalid, weak, or both (Roodman, 2009a, 2009b; Bazzi and Clemens, 2009). A standard test for weak instruments in system GMM regressions does not exist, but Roodman (2009a) suggests that the number of instruments be limited to the number of groups (all of our regressions, except for the regression in column three of Table 5 that examines the incentives of non-qualified, excess FTC firms, meet this limitation). In addition, our results are robust to reducing the number of instruments in the difference regression by restricting the number of lagged levels used as instruments. Specifically, we use industry dummies and levels of firm-specific control variables dated ($t - 2$) and ($t - 3$), and, ($t - 2$).

[24] When we partition the sample based on industry (i.e., high-tech vs. other industries), the coefficient on TAX_RATE_{t-1} for qualified high-tech firms is 1.42 ($p = 0.008$) and the coefficient on TAX_RATE_{t-1} for qualified firms in other industries is 0.56 ($p = 0.000$), which suggests that high-tech firms have greater R&D spending tax incentives.

Table 4

Dynamic Panel Regressions of Eligible Firms' R&D Intensity

	FULL Sample		BALANCED Sample		1994 Sample	
	Qualified [1]	Non-Qualified [2]	Qualified [3]	Non-Qualified [4]	Qualified [5]	Non-Qualified [6]
GDP	–0.0002	0.0005	–0.0001***	0.0005***	–0.0004	–0.0011
	(0.0001)	(0.0004)	(0.0001)	(0.0003)	(0.0004)	(0.0008)
INDUSTRY_R&D	5.449*	11.85**	0.8073	2.260	6.873**	3.717
	(1.516)	(6.210)	(0.6046)	(3.190)	(3.238)	(8.957)
R&D_INTENSITY	0.4560*	0.4610*	0.8556*	0.4073**	0.3556**	0.4275*
	(11.59)	(11.78)	(4.660)	(21.02)	(16.12)	(13.44)
INTERNAL_FUND	2.605	–5.822*	6.041**	3.847	–7.784***	–9.708*
	(4.755)	(2.076)	(2.539)	(3.398)	(4.558)	(2.997)
LEVERAGE	1.322	–0.8160	2.143***	0.0120	–2.796	1.107
	(1.716)	(3.789)	(1.272)	(1.737)	(1.949)	(3.942)
TOBIN'S_Q	–0.5926*	–0.5386	–0.1023	0.0897	–0.5095*	–0.4797
	(0.1572)	(0.4255)	(0.0930)	(0.2737)	(0.1959)	(0.5107)
SIZE	0.0625	–0.7155	–0.2608*	–0.1135	0.1683	–0.0579
	(0.2174)	(0.6139)	(0.1012)	(0.2507)	(0.2960)	(0.8012)
TAX_RATE	0.9535	4.539*	0.8670**	2.878*	0.5155	2.544
	(0.6199)	(1.160)	(0.3686)	(0.7255)	(1.210)	(2.398)

OBRA	0.2849*	–0.4791	0.3060*	–0.7235**	–0.1788	–0.1317
	(0.1143)	(0.4240)	(0.0750)	(0.3627)	(0.2471)	(0.8158)
OBRA × TECH	0.7150*	–0.7762	–0.0516	0.6010	1.2661*	–0.0573
	(0.2328)	(0.9725)	(0.1253)	(0.6568)	(0.4150)	(1.353)
n	6,495	2,985	2,874	668	1,939	961
Instruments	480	423	232	178	386	312
Wald χ^2	209.46*	41.50*	1069.12*	40.67*	74.35*	68.14*
AR(2)	–0.14	–0.28	–1.64	–1.60	0.26	0.63
Hansen	490.09	360.13	179.77	137.10	239.11	213.20

Notes: This table presents results of fixed effects, system-GMM dynamic panel data regressions (coefficient estimates in the first row and robust standard errors in parentheses in the second row) of R&D intensity. We use industry dummies and levels of the *R&D_INTENSITY*, *INTERNAL_FUND, LEVERAGE, TOBIN'S_Q*, *SIZE*, and *TAX_RATE* dated (t –2), (t –3), and (t –4) as instruments for the equation in first differences and first differences of the same variables dated (t –1) as instruments for the levels regression. The sample consists of all firm-years eligible for the R&D tax credit (i.e., current year qualified R&D expenditures exceed the statutory base amount), and we estimate the model separately for firms that qualified/did not qualify for the credit. We consider a firm "qualified" if it is eligible for the credit and its *TAX_RATE* > 0 (Berger, 1993; Graham, 1996a; Mills, Newberry, and Novack, 2003). The AR(2) is the Arellano-Bond test for second-order serial correlation and the Hansen test is the test for over-identifying restrictions. We define the samples as listed in Table 3. We define the variables as follows (omitting subscripts): *R&D_INTENSITY* = R&D intensity, defined as: R&D Expense/Sales; *GDP* = gross domestic product; *INDUSTRY_R&D* = industry R&D intensity, measured as the average R&D intensity of all firms in firm *i's* four-digit SIC code; *INTERNAL_FUND* = internal funds (a proxy for a firm's pre-R&D cash flow), measured as (income before extraordinary items + depreciation + R&D expense) ÷ sales; *LEVERAGE* = long-term debt to assets; *TOBIN'S_Q* = Tobin's q, measured as [(price × common shares outstanding) + book value of preferred stock + long-term debt + short-term debt] ÷ total assets;. *SIZE* = natural log of total assets; *TAX_RATE* = lagged MTR (Graham, 1996a, 1996b; Graham, Lemmon, and Schallheim, 1998); *OBRA* = an indicator variable set to one for years $t > 1989$ (i.e., years after the "structural change" of the R&D tax credit provision); *OBRA × TECH* = the interaction of *OBRA* and an indicator variable set to one for firms in following high-tech, four-digit SIC categories: 2833–2836, 3570–3577, 3600–3674, 7371–7379, and 8731–8734 (Kasznik and Lev, 1995). Asterisks denote significance at the 1% (*), 5% (**), and 10% (***) (two-tail) levels.

for the credit increased by approximately 15.9 (9.4) percent from 1986–1989 to 1990–1994.[25]

In general, the variables that capture the non-tax factors associated with R&D intensity are consistent with our expectations and the results found in prior studies. A notable exception is *TOBIN'S_Q*, which is negative and significant (γ_4 = –0.5926, *se* = 0.1572).

The second column of results focuses on the R&D intensity of eligible firms that did not qualify for the R&D credit during 1981–1994. In contrast with the results for qualified firms, the coefficients on the structural tax factor variables, *OBRA* and *OBRA×TECH,* are not significant for this sub-sample, indicating that non-qualified firms' R&D intensity did not respond to the structural changes enacted in OBRA89. The results for the other variables are not surprising, except for the coefficient on *TAX_RATE*, which is significantly positive. Further, the magnitude of the coefficient on *TAX_RATE* for non-qualified firms is far greater than that for qualified firms. This result further reinforces the positive role taxes play *at the margin* for R&D investment decisions. Since the tax status of non-qualified firms does not allow them to claim the R&D credit, the present value of the R&D credit for these firms would increase dramatically if they transitioned into a tax-paying status.

As a final check on the importance of tax factors in determining R&D intensity, we compared the explanatory power of the R&D intensity regressions for qualified and non-qualified firms. The higher Wald χ^2 statistic for the qualified firms' regression (209 compared with 42 for non-qualified firms), in conjunction with the results for the structural tax variables, presents compelling evidence that the OBRA89 structural changes to the R&D credit had a positive effect on qualified firms' R&D intensity.

2. Alternative Sample Results

We also estimate (4) for the *BALANCED* and *1994* samples, which allows us to examine the effect of OBRA89 on firms at different stages of their life-cycle (the *BALANCED* sample includes established, mature firms and the *1994* sample includes start-up firms). Columns 3 and 4 of Table 4 present the results of estimating (4) for qualified and non-qualified *BALANCED* sample firm-years, respectively. For qualified firm-years, the coefficient estimate for *OBRA* is positive and significant (ϕ_2 = 0.3060, *se* = 0.075) and the coefficient estimate for *OBRA×TECH* is insignificant (ϕ_3 = –0.0516, *se* = 0.1253). These results indicate that the R&D intensities of other (high-tech) established firms increased by 0.30 (0.25) percent on average post-OBRA89. In contrast, the coefficient estimate on *OBRA* for non-qualified mature firm-years is negative and significant (ϕ_2 = –0.7235, *se* = 0.3627); non-qualified, mature, other (high-tech) firms' R&D intensities decreased by 0.72 (0.12) percent following OBRA89.

[25] The median R&D intensity from 1986–1989 for high-tech (other) firms was 6.28 (3.02) percent. The coefficient estimates from (4) indicate the average increase in R&D intensity was approximately 0.9999 (ϕ_2 + ϕ_3) for high-tech firms and 0.2849 (ϕ_2) for other firms, which is approximately 15.9 percent (0.9999/6.28 = 0.1593) or 9.4 percent (0.2849/3.02 = 0.0944) of the median pre-OBRA89 R&D intensity of high-tech or other firms, respectively.

In the qualified *1994* sample (column 5), the coefficient estimate for *OBRA* is negative and insignificant ($\phi_2 = -0.1788$, $se = 0.2471$) and the coefficient estimate for $OBRA \times TECH$ is positive and significant ($\phi_3 = 1.2661$, $se = 0.4150$). R&D intensities of qualified start-up firms in high-tech industries increased 1.08 percent ($\phi_2 + \phi_3$) on average following OBRA89, while the R&D intensities of qualified start-up firms in other industries decreased slightly. The insignificant coefficients on *OBRA* and $OBRA \times TECH$ in column 6 indicate that OBRA89 had little to no effect on the R&D intensities of non-qualified start-up firms. Overall, the results in Table 4 indicate that the response to the structural reforms introduced by OBRA89 varied considerably based on industry membership, tax status, and firm life-cycle effects.

3. The Effect of the Foreign Tax Credit

Multinational firms provide an additional source of variation in R&D intensity (Hines, 1993). After 1986, multinational firms with excess foreign tax credits (FTCs) (those whose foreign income is on average taxed at rates exceeding the U.S. statutory tax rate) faced higher tax costs of performing R&D in the United States, while firms with deficit FTCs (those whose foreign income is on average taxed at rates less than the U.S. tax rate) were unaffected. U.S. R&D expense allocation rules are similar to those for interest. Since 1986, U.S. multinational firms with excess FTCs receive partial interest deductions for domestic borrowing. U.S. multinational firms with deficit FTCs receive the full benefits of interest deductions for domestic borrowing, since any interest expenses allocated against their foreign-source incomes nevertheless reduce U.S. tax liabilities that they would otherwise incur. Using a sample of 116 multinational firms from 1984–1989, Hines (1993) compares changes in the growth rate of R&D spending by firms with excess and deficit FTCs and finds that R&D spending levels of firms with excess FTCs grew more slowly than that of deficit FTC firms. Additionally, Hines (1995) finds that American-owned foreign affiliates that locate in countries with high withholding taxes on royalty payments are more R&D-intensive. In a similar vein, foreign firms with United States investments are more R&D-intensive if they are subject to higher royalty withholding tax rates.[26]

To identify firms with excess FTCs, we create a dummy variable equal to one when a firm's foreign tax rate, calculated as current foreign tax expense divided by foreign pretax income, is greater than the U.S. statutory rate and zero otherwise.[27] We then estimate (4) for eligible firms by qualification and FTC status. The results, in columns 1 and 2 of Table 5, indicate that the effect of the OBRA89 structural changes for qualified

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[26] Because our sample excludes foreign firms, we partially control for this additional source of tax rate variation documented for multinational firms.

[27] The U.S. corporate statutory tax rate varied considerately during our sample period (1981–1994). From 1981–1986, the rate was 46 percent, in 1987 the rate was 40 percent, from 1988–1992 the rate was 34 percent, and from 1993–1994 the rate was 35 percent. Of the 3,828 firm-years with foreign operations, 1,374 firm-years have excess FTCs and 2,454 firm-years have deficit FTCs.

Table 5

Dynamic Panel Regressions of Eligible Firms' R&D Intensity by Foreign Tax Credit (FTC) Position

Variable	Qualified Firm-Years		Non-Qualified Firm-Years	
	Excess FTC [1]	Deficit FTC [2]	Excess FTC [3]	Deficit FTC [4]
GDP	–0.0002	–0.0002	0.0003	0.0006
	(0.0003)	(0.0001)	(0.0010)	(0.0004)
INDUSTRY_R&D	5.483*	4.880*	14.45***	–10.32
	(1.937)	(1.892)	(8.745)	(10.62)
R&D_INTENSITY	0.3387*	0.3887*	0.3666***	0.8763*
	(13.55)	(20.07)	(22.20)	(10.76)
INTERNAL_FUND	5.062***	–4.627	–3.246	–7.512**
	(2.912)	(4.816)	(7.984)	(4.138)
LEVERAGE	–2.292	–1.110	0.6780	4.654
	(1.518)	(1.611)	(2.687)	(5.311)
TOBIN'S_Q	–0.5219*	–0.3375*	0.1132	11.60***
	(0.2124)	(0.1725)	(0.6864)	(0.7120)
SIZE	0.1408	–0.2043	–1.237**	0.0071
	(0.3957)	(0.3277)	(0.6112)	(0.5415)
TAX_RATE	–2.361**	–0.9577	–0.7661	2.886*
	(0.9953)	(0.7476)	(2.182)	(1.124)
OBRA	0.1057	–0.0588	–0.1414	–0.6688
	(0.1395)	(0.1417)	(0.9594)	(0.6064)
OBRA×TECH	0.5598**	0.4990***	–1.3297	0.5966
	(0.2877)	(0.2981)	(2.2370)	(1.155)
n	1,190	1,805	184	649
Instruments	257	304	144	236
Wald χ^2	221.8*	82.29*	91.37*	177.7*
AR(2)	–0.93	–0.94	–1.36	–0.40
Hansen	225.7	268.0	104.23	200.0

Notes: See notes for Table 4. Asterisks denote significance at the 1% (*), 5% (**), and 10% (***) levels.

firms with excess FTCs was larger than that for firms with deficit FTCs. Specifically, the coefficient on *OBRA* is insignificant for firms with both excess FTCs ($\phi_2 = 0.1057$, $se = 0.1395$) and deficit FTCs ($\phi_2 = -0.0588$, $se = 0.1417$). The coefficient on *OBRA* × *TECH* is positive and significant for firm-years with excess FTCs ($\phi_3 = 0.5598$, $se = 0.2877$) and positive and marginally significant for firm-years with deficit FTCs ($\phi_3 = 0.499$, $se = 0.2981$). The coefficient for high-tech firms with excess FTCs ($\phi_2 + \phi_3 = 0.6655$) is positive and significant ($\chi^2 = 5.94$, $p = 0.015$), while the coefficient for high-tech firms with deficit FTCs ($\phi_2 + \phi_3 = 0.4402$) is positive and marginally significant ($\chi^2 = 2.35$, $p = 0.125$). Therefore, it appears that qualified, high-tech firms with excess FTC positions had the largest increase in R&D spending post-OBRA89. This result suggests that the spending patterns documented by Hines (1993) may have shifted after OBRA89.

4. Economic Consequences of OBRA89

In Table 6, we present estimates of the additional R&D spending generated by the structural changes of OBRA89 per dollar of revenue cost (colloquially referred to as the "bang-per-buck" of the credit). According to data obtained from the IRS Statistics of Income (SOI), the cost of the R&D tax credit for qualified firms during 1990–1994 averaged about \$1.79 billion per year, while QRE during this period averaged approximately \$29 billion.[28] If we estimate (4) without the *OBRA* × *TECH* interaction, the coefficient estimate for *OBRA* is 0.0046, which implies that overall R&D intensity increased 14.85 percent over the median pre-OBRA89 R&D intensity of 3.08 percent. The increase in R&D intensity implies that the \$29 billion of QRE was \$3.72 billion higher than what it would have been absent the OBRA89 structural change. Therefore, our estimates imply that the credit induced about \$2.08 (3.72/1.79) of additional R&D spending by qualified firms per revenue dollar foregone during 1990–1994.

C. Sensitivity Analysis — Use of Financial Statement Data

Because we do not have access to tax return data, we must estimate the R&D credit from information found in firm financial statements. To examine whether our algorithm for calculating the R&D credit's components provides reasonable estimates, we conduct some simple out-of-sample tests using R&D tax credit data hand-collected from the effective tax rate (ETR) reconciliation of the income tax footnote in firms' financial statements. Our hand-collected sample, drawn from Schmidt (2004), consists of 104

[28] The SOI have data for the amount of R&D tax credit claimed (our measure of the cost of the credit) for each year of our sample period. However, data for QRE are missing from 1986–1991 and we have been unable to obtain this data from any source. We estimate QRE each year from 1986–1991 using the percentage change in the amount of R&D tax credit claimed. Table 5 contains the data used to make the QRE estimates.

Table 6

Estimates of Additional R&D Spending Generated Per Dollar of Post-OBRA89 R&D Tax Credit

	IRS SOI Data			
Year	Qualified R&D Expense ($Billion)	R&D Credits ($Billion)		Qualified Firm-years
				n = 6,495
1994	50.67	2.423		
1993	38.93	1.857	1. Median Pre-OBRA89 R&D Intensity	0.0308
1992	38.35	1.515	2. Average Increase in R&D Intensity, 1990–1994	0.0046
1991	33.92[1]	1.547	3. % Increase in R&D Intensity Post-OBRA89	0.1485
1990	33.13[1]	1.547		
1989	28.71[1]	1.341	4. Average Qualified R&D Expenditures, 1990–1994	28.73
1988	27.34[1]	1.277	5. R&D Intensity Absent the Credit	25.01
1987	22.55[1]	1.053	6. Credit Induced R&D Intensity	3.715
1986	27.66[1]	1.292		
1985	34.86	1.628	7. Average Cost of the R&D Credit, 1990–1994	1.785
1984	31.46	1.589	8. Additional R&D Intensity per Revenue Dollar Foregone	$2.081
1983	28.72	1.277		
1982	26.43	0.839		
1981	13.54	0.639		

Notes: This table presents estimates of additional R&D spending generated per dollar of R&D tax credit claimed during the Post-OBRA89 period (1990–1994). We obtain median Pre-OBRA89 R&D intensity (Line 1) from untabulated descriptive statistics. We obtain the average increase in R&D spending amounts (Line 2) from the OBRA coefficient of equation (4) after excluding the *OBRA*TECH* interaction (untabulated). We obtain average qualified R&D expenditures (Line 4) and the average cost of the R&D credit (Line 7) from the IRS SOI data reported in the left side of the table. We compute R&D intensity absent the credit (Line 5) as (Line 4 ÷ (1 + Line 3)).

(1) The data for qualified R&D from 1986–1991 are missing. We estimate the missing qualified R&D expenses using the percentage change in R&D credits. For example, 1986 QRE = $34,856,703 * [1 + ((1,292,012/1,627,997) – 1)] = $27,662,998.

firm-years from 1995–1999 with non-zero R&D tax credit amounts.[29] For each of the 104 firm-years, we estimate the amount of the R&D credit using the actual credit amounts reported in the ETR reconciliation ($CREDIT_{ETR}$) and compare those estimates to our R&D credit amounts calculated using the R&D expense in Compustat ($CREDIT_{CST}$).

The two credit amounts are very similar; the mean (median) $CREDIT_{CST}$ is 2.25 (0.68), while the mean (median) $CREDIT_{ETR}$ is 2.22 (0.43). The difference between the means is not statistically significant ($t = 0.03$, $p = 0.98$). Moreover, the Pearson and Spearman correlations between $CREDIT_{CST}$ and $CREDIT_{ETR}$ are 0.39 and 0.71, respectively (both statistically significant at $p < 0.00$). The correlations between $CREDIT_{CST}$ and $CREDIT_{ETR}$ for high-tech firms are higher ($\rho_P = 0.85$, $p < 0.00$ and $\rho_S = 0.68$, $p < 0.00$) than those of the full sample, while those for firms in other industries are similar to the full sample ($\rho_P = 0.41$, $p = 0.0137$ and $\rho_S = 0.83$, $p < 0.00$). This analysis mitigates concerns regarding the measurement of the R&D credit from financial statement data, although we cannot rule out that the out-of-sample test results may be period-dependent.

VI. SUMMARY AND CONCLUSIONS

Despite bipartisan support in Congress for a tax credit for R&D, policymakers remain uncertain and skeptical about its incentive effects. Prior research has yielded a wide range of estimated incentive effects, making the R&D credit a focus of ongoing policy debates. In this study, we examine whether the structural changes to the R&D tax credit enacted in OBRA89 had an effect on the number and type of firms eligible for and qualified to use the credit. In addition, we examine the incentive effect of the R&D tax credit for eligible firms and whether the incentive effect changed after the implementation of OBRA89. We choose the OBRA89 legislative change because Congress fundamentally modified the credit's structure with the intent to make it widely available at the lowest possible revenue cost and to enhance the incentive effect for firms that maintained research expenditures commensurate with their own sales growth. Thus, OBRA89 provides a natural experiment that can inform the policy debate.

Our study is the first to document an overall decrease in firm eligibility for the R&D credit after OBRA89. However, the structural changes attenuated the feedback effect present in the moving average base, a disincentive that disproportionately affected high-tech firms. Consequently, high-tech firms were more likely to be eligible for the credit, relative to firms in other industries, despite the overall eligibility decrease. We also find that eligible firms were more likely to be qualified to use the credit after OBRA89. Although firms in other industries are more likely to be qualified to use the credit both before and after OBRA89, the percentage of high-tech firms qualified to

[29] Schmidt (2004) compiled income tax footnote disclosures from the financial statements of 2,200 firm-years, of which 104 disclosed information about the R&D tax credit. The 104 sample firm-years have mean (median) sales of $1.09 billion ($150 million), mean (median) assets of $1.15 billion ($181 million), mean (median) pretax profit margin of 15 (14) percent, and a mean (median) marginal tax rate of 27 (35) percent.

use the credit increased approximately 11 percent after OBRA89. Therefore, the differences in the types of firms qualified to use the credit narrowed considerably after OBRA89.

Our regression results show that after OBRA89, R&D intensities varied considerably based on industry membership, tax status, and firm life-cycle effects. The median R&D intensity of high-tech (other) firms that qualified for the credit increased by approximately 15.9 (9.4) percent from 1986–1989 to 1990–1994. In contrast, OBRA89 did not have a statistically significant effect on the R&D spending intensity of non-qualified firms. Further analysis on subsamples reveals that both start-up and mature qualified firms increased R&D intensity following OBRA89; high-tech start-up firms exhibited the largest increases relative to mature firms in all industries. Additional tests that account for the incentives of multinational companies indicate that after OBRA89, qualified high-tech firms with excess foreign tax credit positions had larger increases in R&D intensity than firms with deficit foreign tax credit positions. From a cost-benefit perspective, our regression estimates imply that the R&D tax credit induced approximately $2.08 of additional R&D spending per revenue dollar forgone by the U.S. Treasury in the post-OBRA89 period.

Early studies that focus on the effect of the credit after its introduction in 1981 report spending effects in the range of $0.40–$1.74. Hall and van Reenan (2000) ultimately conclude that the pre-OBRA89 R&D credit produces roughly a dollar-for-dollar increase in R&D spending. However, Hall (1993) estimated that anywhere from 17–30 percent of firms faced negative effective credit rates under the moving average base, and that percentage likely fell to zero after OBRA89. Further, Hall and van Reenan's (2000) simulation results show that the large heterogeneity among firms' effective credit rates narrowed considerably after OBRA89. In addition, the median effective rate of the credit more than doubled to over 10 percent after the structural change from the 4–5 percent range pre-OBRA89. Together, these results are consistent with the relatively large effects of the R&D credit we find in this study.

Although the base modification introduced under OBRA89 removed the perverse spending incentives that existed under the moving average base, the fixed base percentage is not without its problems. The fixed base is definitely fixed; it has been 22 years since the base for the primary credit has been modified. As a recent U.S. General Accountability Office (GAO) (2009) study notes, there is little reason to believe that the ratio of research spending to gross receipts from 1984–1988, when multiplied by the most recent four year average of gross receipts, accurately approximates the taxpayer's true base. Thus some of the credit dollars are a "… windfall to the taxpayer for doing something that it was going to do anyway" (GAO-10-136 Highlights) which is inconsistent with the goal of supporting incremental research (GAO, 2009, p. 5). An additional problem with the primary credit's base is the difficulty taxpayers have substantiating their base computations, and this has become a leading issue of contention between primary credit claimants and the IRS. Finally, product mix and research strategies change over time; using a base from the mid-1980s arguably requires firms to continue unrealistic levels of research spending in order to receive the credit.

The additions of the alternative credit calculation elections, such as the alternative incremental credit and the alternative simplified credit, use a "rolling-average" base of the three preceding taxable years, similar to the pre-OBRA89 calculation. Although the use of these alternative methods is voluntary and aimed to remove some administrative burden, this study informs the debate over the potential implications of using these alternative methods. Our results suggest that a change back to a rolling average method may actually decrease R&D intensity. To address the problems with the credit's design, the GAO (2009) study suggests eliminating the regular credit and using a modified base for the alternative simplified credit. However, that policy prescription awaits detailed analysis of the type undertaken in this study.

Given the large effect documented by this and concurrent studies (e.g., Klassen, Pittman, and Reed, 2004), another policy consideration should be the temporary status of the credit. Since many countries have permanent R&D credits, making the credit permanent would strengthen incentives for long-term innovation and make the United States more competitive abroad. This is also an issue we leave for future research.

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APPENDIX A

Denoting the growth rate of the R&D stock as v and the knowledge depletion rate as d, Hall and van Reenan (2000) show that in a steady state the level of R&D spending at time t (RD_t) is related to the level of R&D stock (G_t) as follows (with firm subscripts omitted)

$$\text{(A1)} \quad RD_t = (d+v)G_{t-1}$$
$$G_t = \left[\frac{1}{d+v}\right]RD_{t+1} \equiv \varphi RD_{t+1}.$$

Further assume that the level of previous sales (i.e., $RD_t = k \times S_{t-1}$, where k = R&D intensity) determines the level of current year R&D spending, future sales are a function of the current R&D stock (i.e., $S_{t+1} = F(G_t)$), and a firm's production function F is increasing and concave ($F' > 0$ and $F'' < 0$, respectively). Therefore, a manager's investment decision at time t is to choose the R&D intensity parameter (k) to maximize the firm's future profit (π) at $t + 1$

$$\text{(A2)} \quad \max_k \pi_{t+1} \equiv \left(S_{t+1} \times m - RD_{t+1} - A_{t+1}\right) \times \left(1-\tau_{t+1}\right)$$
$$= \left[F(G_t) \times m - k \times S_t - A_{t+1}\right] \times \left(1-\tau_{t+1}\right)$$

where m is the constant gross profit margin, A is other operating expenses, and τ is the MTR. For simplicity, we assume $A_{t+1} = 0$.

The choice of the R&D intensity parameter (k) in the above optimization problem depends in part upon the structure of the base amount used in computing the R&D credit (i.e., a fixed base or a moving-average base). For example, in a regime with a fixed base R&D credit structure, a significant increase in R&D intensity in period t decreases the MTR in $t + 1$ (i.e., $\partial\tau_{t+1}/\partial k < 0$). Conversely, in a regime with a moving average base structure, an increase in the current period R&D intensity k either increases the MTR at $t + 1$ (i.e., $\partial\tau_{t+1}/\partial k < 0$) or has a neutral effect (i.e., $\partial\tau_{t+1}/\partial k = 0$). The first order condition from maximizing (A2) implies

$$\text{(A3)} \quad \left[F'\frac{\partial G_t}{\partial k}m - S_t\right] \times \left(1-\tau_{t+1}\right) = \left[\frac{\partial \tau_{t+1}}{\partial k}\right] \times \left(mS_{t+1} - RD_{t+1}\right).$$

Note, from the assumed relationship between R&D spending and the stock of R&D in (A1) we have $G_t = \varphi \times RD_{t+1} = \varphi \times k \times S_t$.

Thus, (A3) implies

$$\text{(A4)} \quad S_t\left(F'\varphi m - 1\right) \times \left(1-\tau_{t+1}\right) = \left[\frac{\partial \tau_{t+1}}{\partial k}\right] \times \left(mS_{t+1} - RD_{t+1}\right).$$

Let k^* be the optimal R&D intensity resulting from maximizing (A2). Assuming a firm's gross margin exceeds its R&D spending (i.e., $mS_{t+1} - RD_{t+1} > 0$), the value of k^* depends on the sign of $\partial\tau_{t+1}/\partial k$. Denote $\Delta = \partial\tau_{t+1}/\partial k$. The concavity of the production function F implies that the optimal R&D intensity $k^*_{\Delta<0} > k^*_{\Delta=0} > k^*_{\Delta>0}$. Therefore, we have the following two observations:

Observation 1: *A firm's optimal R&D intensity in a tax regime where the structure of the base amount used in computing the R&D tax credit leads to lower future MTRs* (*i.e.,* $\Delta < 0$) *is greater* *than the optimal R&D intensity in a tax regime where the structure of the base amount used in computing the R&D tax credit leads to constant* ($\Delta = 0$) *or higher* ($\Delta > 0$) *future MTRs.*

Observation 2: *In a tax regime where the structure of the base amount used in computing the R&D tax credit leads to a lower future MTR* ($\Delta < 0$), *the induced increases in the R&D intensity of firm one is greater than that of firm two if* $m_1 > m_2$ *or* $v_1 > v_2$ *(i.e.,* $\partial^2 k^* / \partial\Delta\partial m > 0$ *and* $\partial^2 k^* / \partial\Delta\partial v > 0$).

Proof: A concave production function (F) implies Observations 1 and 2.