Testing for the Ratchet Effect in R&D Tax Credit

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Abstract

The U.S. congress enacted R&D tax credit policy in 1981 by Economic Recovery Tax Act in order to simulate private R&D. However, the design of the R&D credit was criticized for its ratchet effect. In 1989, the Omnibus Budget Reconciliation Act (OBRA) made a change in the design of R&D credit, which provides us an experiment to measure the ratchet effect. By applying an endogenous switching regression model to U.S. manufacturing firm data, we attempt to measure the ratchet effect of R&D credit on firms' R&D investment. According to the empirical results, the R&D tax credit policy has been effective with the price elasticity, -1.818, for the qualified firms, and the re-design of R&D credit improved the positive impact of R&D credit. In addition, our result suggests the existence of selectivity bias in the previous literature.

Keywords: R&D Tax Credit, ratchet effect, endogenous switching model
JEL classifications: H2, H3, C3

1. Introduction

Under asymmetric information, an agent has more information about its productivity than a principal. So incentive schemes can be used to induce the agent to do its best and reveal true information. However, if the principal revises the incentive scheme over time based on the agent's past performance –this is called the 'ratchet principle'-, the agent would tend to reduce current performance to avoid more demanding schemes in the future. This is the 'ratchet effect'. Examples of such interaction between a principal and an agent can be found in the setting of production targets of a nationalized economy, contracts between a social welfare maximizing regulator and firms, technology innovation by regulation, and so on (Banerjee and Gata, 2004; Dalen, 1995; Dearden et al., 1990; Weitzman ,1980).

We believe that another example of the ratchet effect can be found in the U.S. R&D tax credit policy during the 1980s. In 1981, the Congress of the United Stages enacted a tax credit for firms' R&D expenditures for four and a half years from July 1981 through December 1985 to encourage R&D spending in private sector and reduce the gap between social and private returns to R&D (Economic Recovery Tax Act). The credit allows firms to deduct from their tax liability an amount equal to 25 percent of their spending above a base-period amount. The base-period amount, which can be regarded as a target, is the (moving) average R&D spending for the previous three years. The firm can react strategically to the tax credit to account for its effect on future tax credit as the base-period amount depends on its past R&D spending. That is, firms may not increase their R&D spending much to avoid a reduction in future credits, which is so called, 'ratchet effect'. Most previous studies using the earlier or short period data show no impact or a weak impact of R&D tax credit on firms' R&D spending. Some economists and practitioners attributed it to the structure of the moving average base amount in the R&D credit.

While there have been many changes and extensions in the R&D tax credit, the important change is the re-definition of the base period in 1989. The Omnibus Budget

Reconciliation Act of 1989 (hereafter OBRA 1989) changed the base-period from the 'previous three years' to the fixed period (Jan 1, 1984-Dec 31, 1988). Since the R&D spending in the current year has no impact on the credit in the future years, the ratchet effect no longer exists. Therefore, this change provides us an experiment to measure the ratchet effect of R&D tax credit. However, no previous studies have empirically identified or measured the ratchet effect in R&D tax credit.

Despite much attention and lots of studies on the R&D tax credit, the empirical findings regarding the effectiveness of the R&D tax credit are somewhat mixed. In general, studies using the 1980s and early 1990s data show weak impact of R&D tax credit on firms' R&D, but recent studies focusing on a long period conclude that the tax credit has induced an increase in R&D spending by an amount that is significantly greater than the foregone tax revenue. The results from the previous studies indirectly confirm our belief on the existence of the ratchet effect in the R&D tax credit policy during the 1980s.

So we analyze the firm's R&D spending before and after the modification by applying regression methods to U.S. manufacturing firm data and attempt to measure the ratchet effect on firms' R&D investment. After correcting a selection bias by using an endogenous switching model, we find that the price elasticity of R&D for the qualified firms is -1.818, which is consistent with the results of previous literature. The OBRA 89 has positively affected R&D spending, which suggests the existence of the ratchet effect in R&D credit design during the pre-OBRA period.

Section 2 describes the R&D tax credit and briefly reviews the empirical literature on R&D tax credits. Section 3 describes data and shows descriptive statistics. Section 4 outlines our econometric model and Section 5 presents results. We conclude in Section 6.

2. R&E Tax Credit

2.1 Background

The R&D tax credit has been introduced in the U.S. since 1981 in order to give firms an incentive to increase private R&D by reducing the cost of capital for R&D.

The R&D credit is an incremental tax credit because it is equal to 20% of the qualified research expenses paid or incurred for a tax year in excess of the taxpayer's base amount for that year.[1] During the period of 1981-1989, the base amount was the average of the past three years of the qualified research expenses while the base amount cannot be less than 50% of its qualified research expenses. However, the definition of the base amount, which is a moving average of the firm's qualified R&D for the three preceding years, has been criticized by many scholars and practitioners for its ratchet (or negative feedback) effect. Hall (1993) points out that it rewards incremental R&D spending, thus creating a ratchet effect which limits the rewards for sustained high R&D expenditures.

By accommodating the criticism on the R&D credit structure, the Omnibus Budget Reconciliation Act of 1989 (hereafter OBRA89) changed the moving average base amount to the fixed base percentage of the average annual gross receipts of the taxpayer for the four tax years preceding the tax year where the fixed base percentage is the average R&D intensity of 1984-1988, but subject to a maximum ratio of 0.16.[2] But again, the tax credit cannot be more than half of the current year's QREs can qualify for the research credit. The R&E credit can only be used to offset tax liability.[3]

With the first appearance of the R&D tax credit as temporary provision in 1981 and frequent amendment, it still remains as temporary provision. Currently it needs to be approved every year. It has been argued that the impermanent R&E tax credit adds uncertainty about

[1] During the period of 1981-1985, the statutory credit rate was 0.25, but since 1986 it became 0.20.
[2] However, a corporation is deemed a start-up company if it does not have both gross receipts and qualified expenses in at least three years after 1983 and before 1989. These start-up companies are currently assigned a fixed-base percentage of three percent.

returns of R&D and limits the credit's simulative impact. So, in 2009, the Obama Administration proposed to make the R&D tax credit permanent in his budget for Fiscal Year 2010.

2.2 Empirical Literature

Much attention has been paid on the impact of R&D credit policy and/or its alteration on firms' R&D spending. One of the main questions is how much more R&D spending has resulted from the R&D tax credit than they would have done if there had been no credit (Hall and Van Reenen, 2000). For empirical analysis, the base equation of R&D is either a reduced form or derived from an Euler equation in the profit maximization framework. Further, in order to capture the impact of R&D credit, some studies use a shift parameter for the credit that takes the value of 1 when the credit is available and used (Gupta *et al*. 2010). This method has a disadvantage in that it assumes that, when firm level data are used, all firms face the same magnitude of the credit. In addition, this shift parameter for the credit suffers from endogeneity problem. On the other hand, a price variable that captures the marginal cost of R&D can be used (Baily and Lawrence 1992; Collins, 1983; GAO 1989; Hall 1993; Hines 1993; Mansfield, 1986). The coefficient of the price variable can be interpreted as the response of R&D to its tax treatment and based on this, the price elasticity for R&D can be estimated. The limitation of this method is that R&D spending and the tax price are simultaneously determined and therefore, suffer from endogeneity problem. More R&D spending resulting in operating loss reduces the corporate tax rate that the firm faces, and this increases the tax price of R&D. So there may be underestimation of the responsiveness of R&D to the tax credit. Therefore, previous research uses instrumental variable regression or generalized method of moment.

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[3] A firm without tax liability in a current year may claim the credit against tax liabilities over the past 3 years or next 15 years.

The empirical findings regarding the effectiveness of the R&D tax credit are somewhat mixed. Billings, Glazunov and Houston (2001), Goolsbee (1998), and U.S. GAO (1996) fail to find significant empirical evidence for the effectiveness of the credit. On the other hand, Bloom *et al*. (2002), Hall (1993), Hall and Van Reenan (1999), and Mamuneas and Nadiri (1995) find statistically significant evidence for the effectiveness. The estimated price elasticity of R&D spending also varies. Bailey and Lawrence (1987, 1992), Eisner *et al*. (1983) and Mansfield (1986) report inelastic price elasticities in the range of –0.0 to –0.75, while Berger (1993), Hines (1993) and Wilson (2007) find pretty high elasticities in the range of –1.0 to –1.7. Eisner, *et. al.* (1984) attribute this result of no positive effect of the R&D credit partly to the credit's design and explain that it tends to dilute the incentive effect of the credit for firms that were increasing their R&D spending Atkinson (2007) and Tassey (2007) provides the intuitions for each side of the debate. Hall and Van Reenan (2000) surveys empirical studies on R&D and finds lower price elasticity of R&D during the 1980s, but higher price elasticity of R&D during the later years. Recent studies focusing on a long period conclude that the tax credit has induced an increase in R&D spending by an amount that is significantly greater than the foregone tax revenue. The results from the previous studies indirectly confirm our belief on the existence of the ratchet effect in the R&D tax credit policy during the 1980s.

3. Data

3.1 Variables and Data Source

We use a sample of U.S. manufacturing firms from Standard and Poor's *Compustat* database during the period of 1981-2008.[4] We include all the observations as long as there are no missing data.[5] The sample consists of 24,036 firm-year observations representing 4,204 firms. In the empirical analysis, firms are divided into two groups: firms that are eligible and qualified for the R&D tax credit (Qualified firms) and the rest of firms (Non-Qualified firms).[6] The most appropriate data for these criteria are individual corporate tax return data from IRS, which it is confidential. So instead the *Compustat* database is used. However, as Hall (1993) points out, there are two drawbacks in using *Compustat* database: (a) lack of data on the fraction of total R&D spending which is qualified under the R&E tax credit and (b) lack of data on tax status of the firm.

Therefore, for the R&E spending, we assume that every additional dollar spent on R&D has the same composition of qualified and unqualified expenditures as the average and that 50% of total R&D spending is qualified for R&E credit.[7] Based on this assumption, we calculate the R&D credit which is equal to 25(or 20) percent of the excess of the qualified research expenditure in a given tax year over a firm's base amount plus 20% of the basic research payments to a qualified research organization. The Omnibus Budget Reconciliation Act of 1989 (OBRA89) made a change in the calculation formula of the base amount. Before and after OBRA 89, the bases are defined as follows:

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[4] Since the R&D credit came to halt from July 1995 to June 1996, the data from YR1995 and 1996 were omitted in the final sample to avoid the complexity of the tax and R&D credit calculation.

[5] Hall (1993) restricts data to firms with at least four years of continuous data and Gupta *et al.* (2010) restricts data to firms with at least one year of credit qualification. However, we include all the observation in order to identify a possible bias in the estimates occurring from sample selection problems.

[6] Gupta *et al.*(2010) distinguish 'eligibility' and 'qualification.' If a firm invests more R&D than the base amount, the firm is 'eligible.' If an eligible firm has a tax liability, the firm is 'qualified' for the R&D tax credit.

7 Hall and van Reenen (2000) state that typically 50 to 73 percent of reported book R&D spending qualifies for the credit. Hall (1993) and Gupta *et al.* (2010) assume that QRE equals 50 percent of Compustat R&D expense to determine eligibility.

$$Base = \max[(\frac{1}{3}\sum_{k=1}^{3} QRE_{t-k}), 0.5 \cdot QRE_t] \qquad \text{before OBRA 89}$$

$$Base = \max[(\frac{1}{4}\sum_{k=1}^{4} Sales_{t-k}) \cdot \min(0.16, \frac{1}{5}\sum_{j=84}^{88} \frac{QRE_j}{Sales_j}, 0.5 \cdot QRE_t] \qquad \text{after OBRA 89}$$

where *QRE*= qualified research expenditure, and *SALES*=sales.

For tax status of a firm, we calculate firm's taxable income based on the *Compustat* data and calculate each firm's corporate tax rate based on the IRS corporate tax rate table. Based on Graham and Kim (2009), firm's taxable income is calculated as follows:

$$\text{Taxable Income} = \text{OIADP} + \text{NOPI} - \text{XINT} - (\text{TXDI/TOPTAX}) + (\text{XIDO/(1-TOPTAX)}) + \text{SPI}$$

where *OIADP*=Operating Income After Depreciation (DATA178), *NOPI*=Non-operating Income (DATA61), *XINT*= Interest and Related Expense (DATA15), *SPI*=Special Items (Data17), *TXDI*= Income Taxes (DATA50), *XIDO*=Extraordinary Items and Discontinued Operations (Data48), *TOPTAX*= top corporate tax rate.[8]

As to the tax price of R&D, we use the following formula from Hall (1993).

$$\theta_t = p_t^R (1 - T_t (1 + r)^{-Jt} \tau - \eta_t ERC_t)$$

Where p_t^R =the price of R&D investment absent taxes, T =dummy which indicates whether a firm has taxable income in the current year. J =the number of years before any loss carry forwards will be exhausted, τ =corporate tax rate, η = the share of qualified R&D expenditure, *ERC*=the effective rate of R&E tax credit.

[8] The parenthesis shows *Compustat* data code for each variable.

The effective credit rate (*ERC*) measures the net present value of the current benefit and the reductions in future benefits resulting from the firm spending an additional dollar on R&E (GAO, 1989). Therefore, while the statutory credit rate has been 25(or 20) %, the effective credit rate are reported to be much smaller.[9]

For the effective credit rate (ERC), we use the GAO(1989)'s formula as follows:

$$ERC_t = \rho_t((1+r)^{-s} Z_t - (1/3)\{(1+r)^{-(1+J_{t+1})}(Z_{t+1} > 0.5) + (1+r)^{-(2+J_{t+2})}(Z_{t+2} > 0.5) + (1+r)^{-(3+J_{t+3})}(Z_{t+3} > 0.5)\} \qquad \text{for t=81 to 89}$$

$$ERC_t = ERC_t(1-0.5\tau_t) \qquad \text{for t=89}$$

$$ERC_t = \rho_t(1+r)^{-s}{}_t(1-\tau_t)Z_t \qquad \text{for t>89}$$

where ρ =statutory credit rate, *Z*=0,0.5, 1 depending on whether R&D spending during the year is below the base level, more than twice the base level, and between one and two times of the base level, respectively. *S*= the (negative) number of years I will do so with a max of 3 if the firm can carry back the credit.

Lastly, in order to capture the ratchet effect, we use the dummy variable that takes the value of 1 during the period of 1981-1989 and 0 otherwise.

3.2 Descriptive Statistics

Table 1 shows the total, mean and median of firms' R&D expense and R&D intensity and Table 2 shows the effective credit rate over years. While the effective credit rate show a dramatic increase from 1990 due to the OBRA 89, firms' R&D intensity as well as total R&D spending of the firms in the sample have been growing slowly over time. That is, we do not observe the timely responsiveness of R&D spending to the revision of the R&E tax credit policy, which we may interpret as a failure of the revision of the R&E tax credit. However, as Hall (1993) notes, we need to take into account both other factors such as recessions and tax

[9] The effective rate is considered to be lower than this statutory rate, in part because the credit reduces the expenses available for deductions under the R&E expensing allowance (Billings *et al*. 2001,

system changes. So we investigate the impact of the revised R&E tax credit with more rigorous regression analysis in the next section.

Table 3 shows descriptive statistics of the variables used in the regression. Based on firm's qualification as well as eligibility for R&E tax credit, firms are classified into two groups. Firms are eligible for the R&E tax credit if firm's R&D spending exceeds its base spending amount, and further, are qualified to apply for the R&E tax credit if it has tax liability against which to use the R&E tax credit. Based on these criteria, there are 14,767 eligible and qualified firm-year observations out of total 31,988 firm-year observations.[10] We find that firms eligible and qualified for the R&E credit are larger in terms of sales (*SALE*) and assets (*SIZE*) than the rest of the firms. Eligible and qualified firms also show higher R&D spending (R&D) but the R&D growth rate (*RDXGR*) is slower. Their R&D intensity (*RDI*), ratio of R&D to sales, is lower because it is likely due to their larger sales. When we classify firms into three groups, we find that eligible and qualified firms have higher median R&D intensity than ineligible firms, they have lower median R&D intensity than non-qualified firms. This is consistent with Joos and Plesko (2003) that find firms that incur losses and have the lowest probability of loss reversal have larger R&D intensities, a pattern that strengthens during the 1990s. This is also consistent with Gupta *et al*. (2010) using the same *Compustat* data.

Guenther 2005).

[10] The total number of observations used in the regression is smaller since some observations are dropped due to missing data.

4. Model

We assume that a firm makes its R&D investment decision to maximize the future stream of profit, considering all the adjustment costs, as in Hall (1993). As a result such an optimization, the equilibrium R&D amount is specified by the following equation.

$$RD_{it} = \alpha P_{it} + \beta ' X_{it} + \gamma D_{it} + u_{it} \qquad (1)$$

where RD_{it} is firm *i*'s R&D investment at year *t*, P_{it} is the tax price of the R&D, X_{it} is a vector of exogenous variables affecting the R&D investment of firm i at year t, and D_{it} is a dummy variable taking 1 after OBRA 1989. The dummy variable is included for a test on the effectiveness of the tax policy change by OBRA 1989.[11]

There are two methodological problems in estimating the R&D equation (1). First, the tax price, P_{it}, is an endogenous variable. If the firm spends more on R&D, the effective tax rate goes down due to the R&D tax credit. Thus, the price of R&D, which is a negative function of the effective tax rate, has a reverse causality from the R&D spending. The previous studies employ the lagged tax prices as proxies or instruments to handle this endogeneity problem.[12]

The second methodological issue is related to the grouping of the firms according to their qualification status of R&D tax credit. If a firm spends higher R&D expenditure than the base amount, and has a tax liability, the firm is 'qualified' for the R&D tax credit.[13] Thus the firms in the data are divided into two groups: qualified firms and non-qualified firms. It is reasonable to assume that the R&D behaviors of the firms are different between the groups. To this end, the previous studies have separately estimated an R&D equation such as (1) for each group, qualified firms and non-qualified firms. Unfortunately, such a practice is not proper. As the firms decide whether they would be qualified for the R&D credit, the grouping is a typical example of self-selection. It is well known that a separate estimation of such a self-selected

[11] The test can also be viewed as a test on the existence of the ratchet effect in the period before OBRA 1989.
[12] Gupta *et al* (2010) is an example of proxy estimation, and Hall (1992) is an example of instrumental variable estimation.

group results in biased estimates. The endogenous switching model as follows can solve the problem.

$$I_{it} = \delta' Z_{it} + e_{it} \tag{2}$$

$$RD^q_{it} = \alpha_1 P^q_{it} + \beta_1' X^q_{it} + \gamma_1 D^q_{it} + u_{it}, \qquad \text{if } I_{it} = 1 \tag{3}$$

$$RD^n_{it} = \alpha_2 P^n_{it} + \beta_2' X^n_{it} + \gamma_2 D^n_{it} + v_{it}, \qquad \text{if } I_{it} = 0 \tag{4}$$

where $I_{it} = 1$ if the firm *i* is qualified for the R&D tax credit at time *t*, and $I_{it} = 0$ otherwise. Z_{it} is a vector of the variables determining the endogenous switching, and the error vector [e_{it}, u_{it}, v_{it}]′ is assumed to have a multivariate normal distribution with zero means and a variance matrix of $\begin{bmatrix} \sigma_e^2 & \sigma_{eu} & \sigma_{ev} \\ \sigma_{eu} & \sigma_u^2 & 0 \\ \sigma_{ev} & 0 & \sigma_v^2 \end{bmatrix}$.[14] We assume there is no cross-firm correlation or serial correlation in the errors. The superscripts *q* and *n* on the variables in (3) and (4) stand for 'qualified' and 'non-qualified,' respectively.

The endogenous switching model (2) – (4) does not resolve the endogeneity problem of P_{it}. To remedy the problem, we specify an extra equation of the tax price for each group.

$$P^q_{it} = \phi_1 RD^q_{it} + \theta_1' W^q_{it} + \eta_{it}, \qquad \text{if } I_{it} = 1 \tag{5}$$

$$P^n_{it} = \phi_2 RD^n_{it} + \theta_2' W^n_{it} + \varepsilon_{it}, \qquad \text{if } I_{it} = 0 \tag{6}$$

where W_{it} is a vector of variables affecting the firm *i*'s tax price of R&D investment at time *t*. The error terms, η_{it} and ε_{it}, are assumed to be correlated with the switching equation error term, e_{it}. Similar to the RDI equations (3) and (4), the error vector [e_{it}, η_{it}, ε_{it}]′ is assumed to

[13] Gupta *et al.* (2010) distinguish 'eligibility' and 'qualification.' If a firm invests more R&D than the base amount, the firm is 'eligible.' If an eligible firm has a tax liability, the firm is 'qualified' for the R&D tax credit.
[14] We can alternatively assume that the error terms u and v are also correlated. In that case, the estimation of the model needs to be 3SLS or FIML (Full Information Maximum Likelihood).

have a multivariate normal distribution with zero means and a variance matrix of $\begin{bmatrix} \sigma_e^2 & \sigma_{e\eta} & \sigma_{e\varepsilon} \\ \sigma_{e\eta} & \sigma_\eta^2 & 0 \\ \sigma_{e\varepsilon} & 0 & \sigma_\varepsilon^2 \end{bmatrix}$. We assume that $\mathrm{cov}(u_{it}, \eta_{it}) = \mathrm{cov}(u_{it}, \varepsilon_{it}) = \mathrm{cov}(v_{it}, \eta_{it}) = \mathrm{cov}(v_{it}, \varepsilon_{it}) = 0$.

We estimate the simultaneous equation endogenous switching regression model (2) – (6) by the selectivity-corrected two-stage least squares proposed by Lee, Maddala, and Trost (1980). First, the binary regression model (2) is estimated by the probit MLE, and the inverse Mill's ratio is computed. Second, the equations (3) – (6), along with the proper inverse Mill's ratio as an additional explanatory variable, are estimated by the two-stage least squares.. The variables included in Z_{it} are: the industry dummies from the firm's two-digit *SIC* code, log of the firm's total assets (*SIZE*), log of the real GDP of the year (*RGDP*), the growth rate of sales (*SLRGR*), the growth rate of the firm's R&D expenditure (*RDXGR*), the after-OBRA dummy variable (*OBRA*), and log of the tax price of R&D expenditure (*PRICE*). As the tax price of R&D expenditure is an endogenous variable, the direct estimation of equation (2) will produce biased estimates. To avoid such biases, we make the 'reduced form' switching equation by substituting equations (3) – (6) into equation (2). The binary dependent variable of the probit regression is whether the firm is qualified for R&D tax credit (*QUALIFIED*).

The dependent variable for the R&D equations (3) and (4) is the log of the R&D intensity, which is the firm's R&D spending divided by the firm's sales. The explanatory variables included in X_{it} are: the industry dummies, log of the lagged RDI (*LRDI*), log of the firm's total assets (*SIZE*), log of the real GDP of the year (*RDGP*), log of Tobin's *Q* of the firm, log of the firm's internal funds (*FUND*) as a proxy for the firm's cash flow, log of the firm's long-term debt to total assets (*LTDA*), the OBRA dummy (*OBRA*), and log of the tax price (*PRICE*).

The dependent variable for the tax price equations (5) and (6) is the log of the firm's tax price. The explanatory variables included in W_{it} are: log of the firm's lagged tax price

(*LPRICE*), log of the firm's taxable income (*TI*), the OBRA dummy (*OBRA*), and log of the R&D intensity (*RDI*).

5. Estimation Results

Table 4 presents the estimation results for the switching rule (2). As explained in the previous section, the switching rule is estimated in the 'reduced form' to avoid the endogeneity bias from the tax price, P_{it}.[15] Thus, the estimated coefficients in Table 4 may reflect compound effect of the explanatory variables, indirectly through the tax price and the R&D intensity (RDI). The overall fit of the reduced form equation seems good. The correct prediction rate of the binary status is 80.42%, and all the explanatory variables are statistically significant at 5% level, except the growth rate of sales (SLSGR). It turns out that the probability of being qualified for the R&D tax credit increases with the growth rate of R&D (RDXGR), Tobin's Q (Q), and the taxable income (TI). The previous year's RDI (LRDI), total assets (SIZE), real GDP (RGDP), internal funds (FUND), long-term debt to total assets (LTDA), and the previous year's tax price (LPRICE) turn out to lower the probability of being qualified for the R&D tax credit. The coefficient of OBRA is not easy to explain, as the effect of OBRA has three different paths: the OBRA's direct effect on the qualification status, its indirect effect through the tax price, and its indirect effect through the R&D intensity. Table 4 shows that the combined effect lowers the probability of being qualified for the R&D tax credit.

Table 5 shows the estimation results of equations (3) and (4).[16] The findings are as follows. First, the OBRA dummy variable is positive and significant in both the qualified firms and non-qualified firms. This implies that the ratchet effect of the pre-OBRA period was significant. Not only the qualified firms but the non-qualified firms tend to increase their

[15] The estimated coefficients for the industry dummies are omitted to conserve the space.
[16] Again, the estimated coefficients for the industry dummies are omitted to conserve the space.

R&D spending after OBRA.[17] Second, the R&D intensity is found to be elastic to the tax price. As shown in Table 5, the estimated price elasticity for the qualified firms is −1.818, which confirms the findings by Hines (1993), Berger (1993), and Wilson (2007). On the other hand, the non-qualified firms show a positive elasticity of 2.362. This counter-intuitive result could be resolved once we put the interaction term (PRICE*OBRA). But as PRICE is an endogenous variable, such an inclusion is tricky. Some pilot estimation incorporating the interaction term gives some promising result. Third, Table 5 shows that the selectivity bias from endogenous switching is significant. That the inverse Mills ratios (IMR) are highly significant implies all the regression coefficient could be biased without such correction. The other explanatory variables show pretty reasonable estimates, if there are a few exceptions.

6. Conclusion

The U.S. congress enacted R&D tax credit policy in 1981 as Economic Recovery Tax Act in order to simulate private R&D. However, the design of the R&D credit was criticized for its ratchet effect. In 1989, the Omnibus Budget Reconciliation Act (OBRA) made a change in the design of R&D credit, which provides us an experiment to measure the ratchet effect. Previous literature provides mixed results on the impact of R&D credit policy. Further, while some studies that cover longer period including after the OBRA show a positive impact of R&D credit, there is few studies that measure the ratchet effect. Therefore, we attempt to measure the ratchet effect by applying a regression method to U.S. manufacturing firm data during the period of 1981-2008. We also attempt to overcome the endogenity problem with the R&D credit eligibility and the tax price of R&D using an endogenous switching model.

[17] Gupta et al (2010) present a mixed result about the effect of OBRA. The inconsistency of their results could be due to the selectivity bias from the endogenous switching.

The empirical results show that the growth rate of R&D, Tobin's Q, and taxable income increase the probability of being qualified for the R&D credit while previous year's R&D expenses and tax price, firm size (in terms of total assets), internal funds, long term debt ratio lower the probability of being qualified for the R&D credit. In addition, contrary to our expectation, we find that OBRA lowers the probability of being qualified for the R&D credit. However, we need to consider that the OBRA's combined impact on R&D credit status resulting from the indirect impact of OBRA on tax status and R&D expenses as well as the direct impact of OBRA on R&D credit status. Further, we find that the price elasticity of R&D for the qualified firms is quite elastic, 1.818, which is consistent with the results of previous literature. We also find the OBRA positively affect R&D spending, which suggests the existence of the ratchet effect in R&D credit design during the pre-OBRA period. These results come after the correcting the selection bias by using an endogenous switching model where the inverse Mill's ratio is highly significant. This result suggests that previous literature might have suffered from bias in their estimates.

The R&D tax credit has been in existence in many countries to encourage R&D spending. This paper shows that R&D tax credit is an effective instrument in stimulating R&D and that its design is important in its effectiveness. There are many issues that need to be studied further. First, As Hall (1993) points out, tax instruments cannot be viewed in isolation. It is important to look at the whole corporate tax system as they affect firm's decision on R&D spending as a whole. Therefore, interaction with other tax credits requires further study. Second, firms' R&D investment is a long-term strategy. So it may be difficult to achieve the effectiveness of a short-term tax policy and hence to have a correct measure of the effectiveness of the R&D tax credit.

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Table 1 U.S. Manufacturing Firms 1980-2007

Year	Number of Firms	R&D expense (billion$) Sum	R&D expense (million$) Mean	R&D Intensity (percent) Mean	R&D expense (million$) Median	R&D Intensity (percent) Median
1980	1319	26.47	20.07	6.23	1.12	1.75
1981	1071	25.50	23.81	20.94	1.57	2.20
1982	1118	27.95	25.00	20.44	1.60	2.92
1983	1115	28.62	25.66	264.28	1.68	3.11
1984	1127	34.21	30.36	19.06	1.69	3.34
1985	1167	40.64	34.82	35.90	1.64	3.60
1986	1169	43.76	37.44	31.03	1.60	3.79
1987	1192	47.24	39.63	49.95	1.67	3.58
1988	1184	53.90	45.53	36.06	2.09	3.47
1989	1217	49.06	40.31	67.95	2.07	3.51
1990	1399	72.27	51.66	63.02	2.50	3.63
1991	1505	78.67	52.28	597.67	2.36	3.98
1992	1648	71.69	43.50	216.84	2.81	3.94
1993	1258	92.39	73.44	217.55	5.53	4.98
1994	1331	102.18	76.77	389.12	5.28	4.92
1995	1475	110.40	74.85	469.09	5.32	5.39
1996	1483	117.91	79.50	482.07	6.40	5.43
1997	1427	126.00	88.30	383.64	7.28	5.91
1998	1463	143.36	97.99	375.95	7.30	7.05
1999	1416	146.48	103.44	208.66	7.66	6.35
2000	1387	177.59	128.04	369.26	8.52	6.51
2001	1300	156.36	120.27	610.26	8.28	6.20
2002	1280	152.95	119.49	472.49	8.55	6.67
2003	1207	170.94	141.62	419.30	8.11	6.20
2004	1155	177.44	153.63	869.77	9.03	6.63
2005	1082	173.10	159.98	1954.28	9.33	7.59
2006	996	191.96	192.73	1050.63	10.49	6.45
2007	931	201.89	216.85	624.14	11.88	6.18
2008	843	187.11	221.96	1133.91	13.44	5.68

(Unit: Million dollars)

Note: R&D intensity is the ratio of R&D expense to sales.

Table 2 The R&E Tax Credit in Practice

Year	Number of Firms	Effective Credit Rate(%)	
		Mean	Median
1980	1319	0.00	0.00
1981	1071	1.18	0.49
1982	1118	4.50	4.28
1983	1115	3.98	4.28
1984	1127	4.77	4.28
1985	1167	4.69	4.28
1986	1169	2.93	3.42
1987	1192	2.51	3.42
1988	1184	2.69	3.42
1989	1217	2.17	2.84
1990	1399	9.23	13.20
1991	1505	8.59	13.20
1992	1648	8.56	13.20
1993	1258	8.48	13.00
1994	1331	7.94	13.00
1997	1427	8.07	13.00
1998	1463	7.88	13.00
1999	1416	7.85	13.00
2000	1387	8.17	13.00
2001	1300	8.29	13.00
2002	1280	8.28	13.00
2003	1207	8.28	13.00
2004	1155	8.23	13.00
2005	1082	8.56	13.00
2006	996	8.47	13.00
2007	931	8.67	13.00
2008	843	9.01	13.00

Note: Since the R&D credit came to halt from 1995 to June 1996, the data from YR1995 and 1996 were omitted in the final sample to avoid the complexity of the tax and R&D credit calculation.

Table 3 Descriptive Statistics

	Both Eligible and Qualified Firms N=14,767			The Rest Firms N=17,221		
	Mean	S.D.	Median	Mean	S.D.	Median
ERC	0.11	0.05	0.13	0.03	0.08	0.05
PRICE	0.58	0.07	0.59	0.91	0.14	0.98
R&D	142.47	591.84	8.66	38.87	263.49	2.24
RDXGR	0.32	1.24	0.15	0.57	12.32	0.02
SALE	3065.59	11167.49	289.10	1275.12	9677.56	17.83
SLSGR	0.28	3.34	0.12	1.77	77.96	0.03
RDI	8.53	220.60	3.40	714.48	10878.02	6.64
SIZE	5.63	2.36	5.56	3.59	2.57	3.36
FUND	0.15	2.30	0.14	-5.99	101.51	0.03
LTDA	0.15	0.17	0.11	0.26	5.52	0.07
Q	1.86	2.22	1.32	6.69	108.64	1.34
OIADP	376.03	1548.95	30.18	91.41	1070.69	-1.01
NOPI	43.11	261.34	1.44	17.30	280.76	0.20
SPI	-20.71	272.16	0.00	-25.38	360.71	0.00

where ERC=effective credit rate, PRICE= tax price of R&D, R&D=R&D spending, RDXGR=R&D growth rate, SALE=sales, RDI=ratio of R&D spending to Sales, SIZE= total assets, FUND=internal funds, LTDA= ratio of long-term debt to assets, Q=Tobin's Q, OIADP= Operating Income after Depreciation , NOPI= Non-operating Income, SPI=Special Items .

Table 4 Estimation Results of Equation (2) (Dependent Variable: Qualified=1, 0)

Variable	Coeff	SE	P-value
Constant	0.526	0.273	0.054
SLSGR	-.644170D-04	0.000	0.869
RDXGR	0.005	0.002	0.013
LRDI	-0.045	0.008	0.000
SIZE	-0.055	0.023	0.016
RGDP	-0.484	0.065	0.000
Q	0.209	0.016	0.000
FUND	-0.103	0.011	0.000
LTDA	-0.020	0.006	0.001
OBRA	-0.168	0.032	0.000
LPRICE	-1.755	0.045	0.000
TI	0.262	0.006	0.000
# of OBS	24,036		
Correct Prediction Rate	0.8042		

Table 5 Estimation Results of Equations (3) and (4) (Dependent Variable=RDI)

	(3) RDI of Qualified Firms			(4) RDI of Non-qualified Firms		
Variable	Coeff	SE	P-value	Coeff	SE	P-value
Constant	-1.582	0.263	0.000	-0.813	0.265	0.002
LRDI	0.833	0.006	0.000	0.790	0.006	0.000
SIZE	0.046	0.017	0.008	-0.024	0.017	0.152
RGDP	-0.027	0.039	0.484	-0.056	0.063	0.370
Q	-0.018	0.010	0.057	0.044	0.015	0.002
FUND	0.171	0.011	0.000	0.102	0.008	0.000
LTDA	-0.006	0.003	0.034	0.008	0.005	0.147
OBRA	0.034	0.016	0.030	0.278	0.038	0.000
PRICE	-1.818	0.194	0.000	2.362	0.324	0.000
IMR	0.165	0.027	0.000	-0.481	0.090	0.000
# of OBS	12,234			11,802		
R^2	0.8251			0.8201		