at approximately $2.0 billion.[44] Unfortunately, the precise tax value of R&E expensing is unknowable, since there is no line item for this feature on corporate tax forms. Firms total their miscellaneous tax deductions under a single line, and attach a list itemizing each deduction, presumably including section 174 amounts. The IRS does not tabulate data on individual miscellaneous deductions, and even if they did, the information would probably be of very limited value. Because most routine compensation may be expensed, it is likely that many firms—whether for administrative convenience or for lack of knowledge of the section 174 provisions—simply lump their deduction for research compensation together with the deduction for routine employee compensation. Moreover, the value of R&E expensing can vary with changes in the overall corporate tax rate. If a firm undertaking R&D investment faces the same corporate tax rate in all periods, the corporate tax rate does not affect that investment because the firm spends after-tax dollars on the investment and receives after-tax dollars as income. However, if the tax rate is changing for one reason or another, or if the firm is moving in and out of taxable status, then changes in the rate will begin to affect the cost of R&D capital faced by the firm.[45] The reduction of the corporate tax rate during the 1980s had a substantial impact on the cost of an R&D dollar, because it reduced the benefit of expensing (relative to other types of capital investment) by at least 12 percent (due to the fall in the corporate tax rate from 46 to 34 percent) and possibly more if the firm faced the alternative minimum tax of 20 percent.

III. Assessing the Effectiveness of the R&E Tax Credit

In principle, the best method for evaluating the effectiveness of the R&E tax credit is to weigh the return to society from the R&D generated by the policy against the opportunity cost of using the tax revenues for other purposes. If the social return from additional corporate research is very high, then Congress may be willing to give up more tax dollars than the actual research induced by the tax subsidy. On the other hand, if the social return is only slightly higher than the private return, then lowering the cost of research might cause the firm to do too much R&D; in these circumstances, even though the tax credit induces more corporate R&D than the lost tax revenue, higher social returns could be achieved by spending the tax revenue on some other activity.

No study ever has accomplished this type of comparison. Nor could one succeed, if attempted. Although the concept of a social rate of return to R&D is indisputable in theory, it cannot be measured easily in practice due to the intrinsic difficulties of establishing adequate price indices for the components of R&D costs specific to individual

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[44] According to Joint Tax Committee estimates. See Joint Committee on Taxation, Estimates of Federal Tax Expenditures for Fiscal Years 1995-1999 (prepared for the Committee on Ways and Means and the Committee on Finance, November 9, 1994). Based on these estimates, the CBO forecasts that the revenue cost of R&D expensing will rise gradually from $2.0 billion in 1995 to $2.3 billion in 1999. See U.S. Congress, CBO (1995); table 2 p.19.

[45] Fullerton and Lyon (1988); Hall (1991).

industries, determining a satisfactory time period within which to assess the productivity gains from R&D, measuring the depreciation rate of R&D capital stocks, and related problems.[46] Likewise, it is inherently difficult to determine the opportunity cost of the R&E tax credit's revenue value. How do the productivity gains from the R&D induced by the approximately $1.6 billion in 1992 R&E tax credits compare to the return to society of $1.6 billion in deficit reduction or some other public purpose? For all practical purposes, this question cannot be settled without considerable dispute.

Unable to reach any conclusion on the relative social rate of return to R&D induced by the tax credit, some analysts consequently have avoided any final assessment of whether the R&E tax credit is an effective and desirable policy instrument.[47] Most analysts simply assume that some form of R&D subsidy is necessary, given the reasonable premise that there are significant social gains from at least some private R&D.[48] Assuming some positive spillovers to society, assessing the effectiveness of the R&E tax credit subsequently becomes a matter of comparing the amount of corporate R&D spending induced by the credit to the dollar value of the credit's revenue cost. The ratio of these two quantities is the benefit-cost ratio: if it is greater than one, the tax credit is considered to be a more cost-effective way to achieve the given level of R&D subsidy; if it is less than one, a direct R&D subsidy would be more cost-effective.[49]

Although conceptually straightforward, existing cost-benefit studies of this sort involve complicated estimates and calculations, and most suffer from data inadequacies, methodological shortcomings, and other problems. The following section of this report outlines the principle methods of estimating the amount of R&D induced by the credit, as well as the methods of estimating the cost of the credit; the text then presents the findings from researchers who have used these methods, and identifies several unresolved empirical issues.

Measuring the Amount of R&D Induced by the Tax Credit

Conceptually, measuring the amount of R&D induced by a tax credit raises a counterfactual question: how much more R&D did firms do because of the tax credit than they would have done if there had been no credit? Counterfactuals cannot be observed,

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[46] For a survey of these issue, see Hall (1994).

[47] See, for example, U.S. Congress, GAO (1995a).

[48] On the social returns to R&D, see Griliches (1992), Mansfield (1965), and Bernstein and Nadiri (1988, 1989).

[49] This simple claim presumes either that the government can efficiently perform the R&D itself, or that the government can fund private R&D without substituting for private funds that would have been spent on industrial R&D regardless. Both of these presumptions are subject to debate.

and researchers consequently rely on various methods to estimating the level of R&D without the subsidy.

One of the two most common methods is to construct an equation that predicts the level of R&D investment as a function of past R&D, past output, expected demand, and other variables such as cash flow and different price variables. A dummy variable is included in the equation, equal to one when the credit is available and zero otherwise. The magnitude of the estimated coefficient of the dummy variable is equal to the amount of R&D induced by the presence of the credit. If this exercise is conducted using firm-level data, the best method is to measure the availability of the credit at the firm level—that is, taking account of the usability of the credit. If it is conducted at the macro-economic or industry level, the identification of the credit effect will come from the variation in R&D demand over time.[50]

The advantage of this method is its relative simplicity, for it eliminates the need to perform relatively complex computations of the actual level of the tax credit subsidy available to each firm. The disadvantage of this method is that the measurement is relatively imprecise, for at least three reasons. First, since firms benefit directly from the amount of R&D qualified to receive the tax credit, they have an incentive to shift or "relabel" spending categories in a way that maximizes the amount of qualified R&E; consequently, the "true" level of R&E induced by the credit may be overstated.

Second, all firms do not face the same magnitude of credit at any given point in time, due to variations in any given firm's taxable income position, whether it is subject to the Alternative Minimum Tax, whether it is subject to General Business Credit limitations, how much foreign income it repatriates, and so forth. Consequently, the R&D investment level and the tax price faced by the firm affect each other, and ordinary regression methodology is inappropriate under these circumstances.[51] For this reason, some analysts have relied on instrumental variables to estimate the price elasticity, albeit with the attendant loss of precision in estimation.

Finally, if the variable occurs over time, it is likely that other forces that strongly affect aggregate industrial R&D spending—such as global economic conditions, trade, and so forth—which are not included in the R&D equation may lead to spurious conclusions about the effectiveness of the tax credit.

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[50] Examples of this method include Eisner, Albert, and Sullivan (1983); Swenson (1992); Berger (1993); Baily and Lawrence (1992); McCutchen (1993).

[51] This is because R&D spending and the tax-adjusted price of R&D are jointly determined in any period by the actions of the firm and market, through their impact on both the cash flow and tax position of the firm. For example, although a lower tax-adjusted price of R&D might induce more R&D spending, *ceteris paribus*, more R&D spending may move the firm into an operating loss position, which will tend to increase the after-tax price of R&D. An effect like this would reduce the apparent responsiveness of R&D to the tax credit, but the estimated elasticity will not be the true price elasticity—that is, it will not correspond to one that would prevail in an environment with a different type of tax credit.

The second most common method for estimating the impact of the R&E tax credit also postulates a R&D equation that controls for the non-tax determinants of R&D, but instead includes a price variable that represents the marginal cost of R&D. This price variable is used to construct a measure of the sensitivity of R&D spending to changes in the price of R&D. Since the tax credit effectively lowers the price of R&D, it should induce firms to supply more R&D. Consequently, if the price variable includes the implicit tax subsidy given to R&D, then this measure should indicate how R&D spending responds to the R&D tax rate.[52]

Even if the price variable does not contain a measure of the tax subsidy, it is possible to use the measured price sensitivity of R&D to infer the response induced by a tax reduction of a given size. For example, if we estimate a price elasticity of -0.5 and the effective marginal R&E tax credit is .05, or a 5 percent reduction in cost, then the estimated increase in R&D spending from the tax credit will be 2.5 percent.[53]

The advantage of this method is that it is well-grounded in economic theory, and it is somewhat more accurate than the first method because it estimates the price response of R&D directly. However, it has its own disadvantages. Absent variations in tax treatment across firms and time, one is forced to use a constructed R&D price deflator as the price variable in an R&D demand equation. These deflators typically are a weighted average of R&D inputs, around half being the wages and salaries of technical personnel, and the other half being some kind of research materials and equipment index. The only real change in this variable is over time. This is a weak basis for estimating the price elasticity of R&D demand, since the estimates will depend strongly on the other factors in the model that vary over time. Some studies have circumvented this problem to a large extent by observing variation in the tax-adjusted cost of R&D across firms, instead of over time.[54]

A third and completely different research method is an event study, where the effect of a policy is inferred by comparing behavior before and after a change in policy is announced. Event studies typically assume that the policy being studied (such as the introduction of a tax credit) is a surprise to the economic agents it affects. They are usually conducted using financial market data, although not in every case. In the case of the tax credit, an event study could take the form of comparing the market value of R&D-oriented firms before and after the tax credit legislation was considered and passed, or of comparing R&D investment plans for the same time period before and after the legislation.[55] This method generally has the great advantage of observing actual behavioral outcomes, obviating the need for the problematic estimation techniques involved in the first two methods described above. The disadvantage of this method is

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[52] Examples of this method include Baily and Lawrence (1992); Hall (1993); and Hines (1993).

[53] See Collins (1983); GAO (1989); and Mansfield (1986).

[54] Hall (1993); and Hines (1994).

[55] An example of the former method is Berger (1993); an example of the latter is Eisner, as reported in Collins (1983).

that it is typically difficult to determine the significance of the given policy change relative to numerous other factors, some known and some not, that could affect the outcome.

The remaining possible techniques for evaluating the R&E tax credit involve interview and survey data. Interview data can provide rich detail about how individual firms respond to factors, such as the tax credit, that may affect their R&D planning. This method has been used surprisingly sparingly, given the inability of other methods to view the R&E tax credit amid the complex array of factors that affect firm-level R&D strategies.[56] The obvious disadvantage of interview data is the researcher's inability to determine which behavioral patterns are unique and which are common. A possible antidote to this problem is to combine focused interviews with a survey instrument, which could be used to test propositions across a wide range of cases. To OTA's knowledge, no one ever has used this method.

Measuring the Costs of the R&E Tax Credit

The second component of a benefit-cost analysis of the R&E tax credit is the computation of total cost. In principle, the total social cost consists of the net tax revenue loss due to the credit, the opportunity cost of using the tax revenue for other purposes, and the costs of administering the credit (both to the firm and to the Internal Revenue Service). In practice, the cost computed has been simply the gross tax credit claimed, inaccurate as this may be.[57] At best this has been done by simply adding up the credits claimed by the firms that use the credit[58], sometimes adding in the unused credits that have been used to offset prior-year liabilities.[59] Occasionally, estimates have been produced relying only on representative or average firm behavior; this method is likely to produce erroneous results given the extreme heterogeneity in the data. Either way, this type of analysis ignores the fact that the existence and use of the R&E tax credit may have implications for the overall tax position of the firm, so that the net change in tax revenue because of the credit is not captured by simply adding up the credits.

The second omission in the conventional computation is the administrative cost of the tax credit. The 1989 GAO Study, updated in 1995 for Congressional testimony, makes it clear that these costs can be high, but offers no estimate of their magnitude.[60] The IRS does not appear to keep any data on the administrative costs of implementing the R&E tax credit, although OTA interviews indicate that the administrative costs may be

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[56] This background paper relies to a certain extent on interview data. See also Mansfield (1986).

[57] See the above discussion regarding the size and distribution of R&E tax credits.

[58] Mansfield (1986); and Hall (1993).

[59] GAO (1989).

[60] GAO (1989); GAO (1995a); and GAO (1995b).

driven up substantially by vagueness in the definition of qualified research. Another possible source of administrative friction concerns the performance of research by outside subcontractors, where the IRS appears to have taken the position that the tax credit should flow to the organization that will pay for the R&D "in the normal course of events," rather than to the organization that bears the risk of the investment.[61]

Individual firms also bear considerable costs in using the R&E tax credit. At some point in time, any firm that seeks to use the tax credit will need to set up an administrative system for collecting sufficient data to stand up to IRS documentation criteria for the R&E tax credit. This is a one-time cost that may or may not be significant, depending on existing accounting methods used by the firm.[62] However, the regular administration of the credit may involve significant additional costs, again largely due to uncertainty in the scope of qualified research.[63] OTA interviews indicate that these costs can be substantial for some firms: some firms indicated that they frequently question the net worth of using the tax credit, given the costs of administering it, the frequent battles with the IRS over the scope of qualified research, and the downward adjustment in the credit after auditing. Other observers suggested to OTA that many firms do not apply for the credit at all, due to its administrative costs and uncertain utility. Again, the magnitude of this problem is difficult to determine, and probably could only be estimated through surveys of R&D performing firms.

Findings from Existing Research on the R&E Tax Credit

Table 3 summarizes the results of the many studies of the U.S. R&E tax credit that have been performed since its inception in 1981.[64] The table presents two standardized results from these quite disparate studies, one regarding the sensitivity of R&D spending to price changes (for a typical firm in the sample), and the other regarding a final estimate of the benefit-cost ratio of the credit. In some studies, the available data is insufficient or not present, requiring either an approximation or no estimate at all.

Table 3 indicates that the first wave of estimates (those using data through 1983) differ substantially from the second (those using data through 1988 and later) in two

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[61] U.S. Government Brief, filed September 3, 1993, in *Fairchild Industries, Inc. v. United States*, 30 Fed. Cl. 839, as quoted in Stoffregen (1995).

[62] In all likelihood these one-time costs are relatively signficant, since the accounting of R&D for book purposes is insufficient for purposes of the R&E tax credit.

[63] See Stoffregen (1995).

[64] Excellent surveys already exist of this evidence. See Collins (1983), Brown (1984), Baily and Lawrence (1987), Cordes (1989), Harhoff (1994), and Penner, Smith, and Skanderson (1994). Rather than repeating these surveys, this background paper focuses instead on the methodologies used, in an attempt to see where they might be improved as well as to find points of consensus among the disparate results.

respects: First, they tend to have lower or non-reported tax price elasticities of R&D (only the later study by McCutchen of large pharmaceutical firms is an exception, and the R&D equation in this study appears to be misspecified[65]); second, they are typically not based on the publicly reported SEC data maintained by Compustat, but on internal Treasury tax data, surveys and interviews, and, in one case, an early Compustat file. This makes it slightly difficult to ascertain whether the differences in results are because the response to the credit varied over time, or because the type of data used was substantially different. Unfortunately, the only early study that used a large set of firms from Compustat contains methodological problems that make it difficult to determine the effect of the tax credit.[66]

Later work using firm-level data from the 1980s tends to reach the same conclusion—the sensitivity of total R&D spending to the rate at which it is taxed, known as the tax price elasticity of R&D, has been approximately one, and perhaps slightly higher. Simply put, the R&E tax credit encouraged at least a dollar of new R&D spending for each dollar in lost tax revenue. Several recent studies have reached this conclusion, each using a different data source within an R&D demand equation containing lagged R&D, current and lagged output, and occasionally other variables such as cash flow.[67]

In short, the available literature reaches a relatively common finding: the firm-level publicly-reported R&D data indicates that the R&E tax credit produces a dollar-for-dollar increase in reported R&D spending, on the margin. This finding is not necessarily inconsistent with earlier studies, to the extent that it took some time in the early years of the credit for firms to adjust to its presence, so the elasticity was somewhat lower during that period.[68] Coupled with the weak incentive effects of the early design of the credit, this low short run elasticity implied a weak response of R&D spending in the initial years, causing researchers to interpret it as zero or insignificant.

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[65] It is difficult to pull the elasticities out of the estimated coefficients in this paper because it appears that R&D intensity was regressed on the absolute size of the claimed tax credit, a specification that implies a very large effect at the high end of the size distribution. McCutchen also presents results using a dummy variable specification, and these indicate an excessively large increase of 19 percent in R&D spending in 1982-1985 over the 1975-1980 period that is attributed to the tax credit. With a marginal effective tax credit of about 5 percent, this would imply a tax price elasticity of about 4, which is far higher than most estimates. One possible explanation for these discrepancies is that the tax credit variable in the study includes the effects of other unmeasured factors that may have pushed up spending in the pharmaceutical industry during the 1980s.

[66] Eisner, Albert, and Sullivan (1983).

[67] See Berger (1993), Hall (1993), Hines (1993), and Baily and Lawrence (1987, 1992).

[68] This is confirmed by interview data reported in Collins (1983), based on interviews with R&D executives in 14 major R&D-performing companies by the Industry Studies Group, National Science Foundation. Among other findings, they report that "As of Spring 1982, some R&D executives did not fully understand the tax credit." (Collins (1983); p. 8).

Table 3: Empirical Studies of the Effectiveness of the R&E Tax Credit

Eisner, Albert, and Sullivan, 1983	Mansfield, 1986	Swenson, 1992	Berger, 1993	Baily and Lawrence, 1987, 1992	Hall, 1993	McCutchen, 1993	Hines, 1993
1981-82	1981-1983	1981-88	1981-88	1981-89	1981-91	1982-85	1984-89
1980	not relevant	1975-80	1975-80	1960-80?	1980	1975-80	not relevant
IcGraw-Hill surveys Compusat IRS ind.	Stratified random survey	Compustat	Compustat	NSF R&D by ind	Compustat	IMS data and 10Ks	Compustat +
-600 firms for R&D 3.4-digit ind for tax	110 firms	263 firms (balanced)	263 firms (balanced)	12 2-digit inds.	800 firms (unbalanced)	20 large drug firms	116 multi-nationals
Dummy R&D equation compared pre- and ost-IRTA; same for R&D above/below base	*Survey* Asked if R&D tax incentive increased spending	*Dummy* Log R&D demand eqn. FE spec.	*Dummy/Event* R&D intensity eqn. FE spec.	*Dummy/Elasticity* Log R&D demand eqn with tax price or credit dummy	*Elasticity* Log R&D demand eqn with tax price var.	*Dummy* Research intensity eqn by strategic grp with tax credit	*Elasticity* R&D demand eqn with tax price for sec 861-8
R&D lag 1&2, Current & lag sales, CF		Log S, change in LT Debt lag 1&2	Lag R/S, Ind. R/S, Inv/S, Ind. Inv/S CF/S, Tobin's q. GNP	Lag R&D, current and lag output (logs)	Lag R&D, current and lag output (logs)	Past NCFs, Divers. CF/Sales, %drug sales	Dom. & for. tax price; dom. to for. sales; ind, firm dummies
insig.	0.35?	?	1.0-1.5	0.75 (0.25)	1.0-1.5	0.28-10?	1.2-1.6
NA	0.30 to 0.60	NA	1.74	1.30	2.00	0.29-0.35	1.3-2.00

dologies described in row 5.

However, the evidence used to reach these conclusions rests upon the response of total R&D spending to changes in the tax-adjusted cost of qualified R&E, not total R&D. Qualified R&E typically accounts for anywhere from 50 to 73 percent of total R&D spending.[69] These studies also rely on rather questionable tax status data, where the effective tax credit rate faced by the firm is inferred using information in the Compustat files on operating losses and taxable income over the relevant years. And where aggregate data are used, no attempt has been made to correct for the usability of the credit. It is probably unreliable to infer the qualified R&E spending by multiplying total R&D reported on the SEC 10-K form by a common correction factor (such as 0.6) and inferring the tax status by looking at the 10-K numbers.[70] The only study that has used the true (and confidential) corporate tax data is that by Altshuler, and unfortunately for our purposes here, it focuses on the weak incentive effect implied by the credit design rather than evaluating the actual R&D induced.[71]

Using a tax price inferred from Compustat data to assess the responsiveness of total R&D spending to tax changes raises two quite distinct problems that deserve further investigation. First, as discussed above, the estimates based on public data involves numerous uncertainties, and may even be misleading. Second, because these estimates are based on the response of reported R&D to the credit itself, they may overestimate the true response of R&D spending to a change in price. This is sometimes called the "relabeling" problem. If a preferential tax treatment for a particular activity is introduced, firms have an incentive to make sure that anything related to that activity is now classified correctly, whereas prior to the preferential treatment, they may have been indifferent between labeling the current expenses associated with R&D as ordinary expenses or R&D expenses. There is some suggestive evidence reported in Eisner, Albert, and Sullivan (1986) concerning the rate of increase in qualified R&E expenditures between 1980 and 1981, when the credit took effect. Using a fairly small sample of firms surveyed by McGraw-Hill, they were able to estimate that the qualified R&D share grew greatly between 1980 and 1981, less so between 1981 and 1982. This is consistent with firms learning about the tax credit, and shifting expenses around in their accounts to maximize the portion of R&D that is qualified. It is also consistent with the tax credit having the desired incentive effect of shifting spending toward qualified activities, although the speed of adjustment suggests that accounting rather than real changes are responsible for some of the increase.

One way around the relabeling problem is to use a method of estimating the inducement effect that does not rely directly on the responsiveness of R&D to the tax

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[69] See U.S. GAO (1989); Altshuler (1989); Penner, Smith, and Skanderson (1994); and Cordes (1989).

[70] Appendix IV of the GAO (1989) study reports on a match of 800 corporations with IRS data to Compustat, yielding 219 corporations with complete data for 1980-1985. The year-to-year spending growth rates for R&D were found to differ significantly across the two files, leading to significant differences in the estimated credit rate. They did not even consider using the tax status data on Compustat, so we have no comparison using tax numbers.

[71] Altshuler (1989).