Closing the R&D Gap

by

Thomas Karier*

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*Eastern Washington University, 304 Patterson Hall, Mail Stop 36, Cheney, Washington 99004

Abstract

This study identifies a clear need for government policy to address the widening R&D gap between the United States, Japan and Germany. In 1991, the United States spent only 1.9 percent of its GDP on nondefense R&D compared to 3 percent for Japan and 2.7 percent for Germany. The possibility that this gap can be closed through tax incentives, such as the Research and Experimentation tax credit, appears highly unlikely. A detailed review of this credit shows that it had a relatively minor impact on R&D spending since its inception in 1981.

More direct policies are likely to be required if this gap is to be narrowed. Immediate gains can be made in the conversion of military R&D expenditures to address other public needs. While the federal government has reduced its real expenditures for military R&D since 1987, the corresponding increase in nondefense R&D has not kept up with GDP growth. The failure to convert military to nonmilitary R&D will only exasperate the current R&D gap and jeopardize U.S. shares of high technology markets.

Finally there is the question of how to improve the federal R&D program. In particular, the congressional practice of earmarking academic R&D funds and the Department of Defense's (DOD) policy of reimbursing independent R&D, lack accountability. Furthermore, nondefense R&D projects should be administered by the appropriate federal agency rather than by DOD which has inherited several as a result of economic conversion. Finally, a process needs to be established for evaluating the effectiveness of government R&D expenditures.

The R&D Gap

In 1953, private industry in the United States spent .6 percent of gross domestic product on research and development and there was little doubt that this would be sufficient to preserve the country's technological advantage. In 1993 private industry spent considerably more on R&D--1.3 percent of GDP--and yet there was much wider concern that this was not enough for the United States to compete successfully in international markets. This concern is based on comparisons of U.S. R&D spending with Germany and Japan.

It is reassuring, if only momentarily, to note that the U.S. spends more on total R&D than Germany, Japan, and France combined. Even as a share of Gross Domestic Product (GDP), the United States' share (2.6) does not compare adversely to that of Japan (3.0), Germany (2.8) or France (2.4).[1] Furthermore, there is at least one high-technology area in which the United States enjoys indisputable superiority--weapons production. This distinction has been achieved only after decades of massive federal outlays for weapons systems and R&D. A comparison of defense R&D relative to GDP in Figure 1 shows that United States expenditures have historically far exceeded those of Japan, Germany, and France.[2]

Figure 1 here.

The U.S. R&D deficiency, however, does not concern national defense. It is generally understood that if U.S. firms are to remain viable in today's markets they must have adequate investment in new technologies which in turn depends on investments in

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[1] All references to Germany refer only to West Germany. NSF, *Science & Engineering Indicators--1993*.

[2] Japan's expenditures are less than .1 percent but appear to be zero in the figure due to rounding error.

research and development. The best measure of this investment is nondefense R&D. In 1991 Japan spent 3 percent of its GDP on nondefense R&D compared to 2.7 percent for the former West Germany and a mere 1.9 percent for the United States.[3] There is a possibility that even this figure understates the R&D gap because it only excludes government funds for defense.[4]

Not only does the United States fall short of its two major competitors in this area, but the gap has been increasing. Figure 2 shows that in 1970 the United States, Japan and Germany all spent approximately the same share of GDP on nondefense R&D. Over the past two decades the share changed relatively little for the United States but rose significantly for the other two countries. The recent pattern also shows that the United States now spends almost the same share of GDP on nondefense R&D as France, placing it far below Japan and Germany.

Figure 2 here.

We may already be experiencing one of the effects of this R&D gap. The United States now imports significantly more high-technology commodities than it exports. The U.S. balance of trade on high-technology exports has fallen steadily from a surplus of $16 billion in 1981 to a deficit of $47 billion in 1992.[5] This dismal performance would be even worse if not for the significant trade surplus enjoyed by the aircraft industry, one which clearly owes some of its superior performance to its financial ties with the Department of Defense (DOD).

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[3] *Statistical Abstract of the United States, 1993.*

[4] Individual businesses spend some of their own funds on defense, often with the intention of winning government contracts. Some portion of these expenditures are currently reimbursed by the Department of Defense but may not be designated as government R&D funds.

[5] High-technology industries include aircraft, computer and office equipment, pharmaceuticals, communication equipment, electrical machinery, and instruments. NSF, *Science & Engineering Indicators--1993*: page 440.

From 1978 to 1985 there was reason to hope that the U.S. would close the R&D gap or at least prevent it from widening. An upsurge in real spending pushed private industry R&D from 1.0 percent of GDP in 1978 to 1.4 percent in 1985. But, whatever caused this boom appears to have run its course. Private industry expenditures leveled off after 1985 and slipped back to 1.3 percent of GDP by 1993. The current level and composition of R&D expenditures in the United States do not instill great confidence in the future ability of U.S. businesses to compete successfully in world markets.

While there may be considerable debate over the particular form of a national R&D policy, there is remarkably broad agreement on the need for one. It is widely recognized that research and development spending is discouraged by the fact that information and know-how can easily slip into the hands of rivals. In economic terms, new products, techniques and discoveries may have a low level of "appropriability." A patent system provides some protection but it is generally agreed to be inadequate, especially for fundamental discoveries with wide-ranging applications. If a private firm can't capture the entire benefit from a particular expenditure, in all likelihood, it will under invest in this activity. This fact makes R&D a classic example of a market failure, one that demands some form of government intervention.

With this picture in mind, it is clearly time to evaluate the effectiveness of our national R&D policy. Can a new R&D policy contribute to closing the gap as it now exists? What changes would have to be made in our current R&D policy to make it more effective? These are two of the questions addressed in this report.

R&D Policy and Tax Incentives

The evolution of R&D policy in the United States has been primarily motivated by issues of national defense, not international trade. Consequently a major focus of R&D spending in this country has been on the production of sophisticated military equipment and weapons. In 1992, federal funds for defense R&D accounted for 29 percent of all R&D expenditures in the country.[6] More than one out of every four research dollars was spent on defense. While this figure may appear relatively high, it was once even higher. In 1960, during the middle of the cold war, one out of every two research dollars was spent on defense.[7]

Other than defense, which accounted for 59 percent of the federal government's R&D budget in 1992, several other areas received smaller amounts of public support including health, space research, energy and general science. Health received $10.1 billion in 1992 which accounted for 14.7 percent of the federal R&D effort. Next in line were space and energy which accounted for an additional 9.9 percent and 4.5 percent, respectively. General science accounted for another 3.9 percent. The remaining 8.4 percent of the budget was spread out over eleven areas including natural resources and the environment, transportation, agriculture, and education.[8]

Direct federal expenditures constitute only the most visible part of the national R&D policy. Less obvious is the fact that government procurment can stimulate industry R&D. This occurs when firms compete for valuable government contracts by spending their own funds on research and development. In some cases, firms may be reimbursed for the expense, often defined as *Independent Research and Development* and *Bids and Proposals*. In other cases firms may simply hope to recover the costs in the profits of future government contracts. As Frank Lichtenberg concluded in a detailed study of this issue, "government procurement as a whole has a positive and substantial effect on private R&D investment."[9]

In addition to direct expenditures on R&D and procurement, the federal government has attempted to stimulate private sector expenditures through selective tax incentives. One

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[6] NSF, *Science & Engineering Indicators--1993*, page 115.
[7] *Statistical Abstract of U.S.*, 1993, pages 598 and 595.
[8] NSF, *Science & Engineering Indicators--1993.*, page 363.
[9] Lichtenberg (1988).

of these is the full deduction permitted for research and experimentation expenditures (R&E) that dates back to the 1954 tax code. An alternative to full deduction would be to treat R&E like any other long term investment and spread the cost out for tax purposes over the estimated lifetime of R&E capital, an admittedly intangible asset. By allowing full deduction, a company with current tax liability benefits by not having to postpone (and discount) the deduction.[10]

The primary focus of this report, however, is on the effectiveness of the R&E tax credit, included in the Economic Recovery Act of 1981. The possibility of increasing or expanding the credit is one possible way of addressing the increasing R&D gap. Before considering this possibility, however, it is necessary to review the actual credit and evaluate its effectiveness.

The R&E tax credit originally allowed firms a 25 percent credit on qualified increases above a calculated base. By confining the credit to spending increases, the new law limited the impact on tax revenue but it also raised the difficult question of how to measure a spending increase. The simplest approach, comparing this year's expenditures to last year's, was rejected because it could encourage perverse strategies. For instance, consider a firm that expects to spend exactly the same amount on R&E every year. If it persists in this policy, it will receive nothing under this simple tax credit because its marginal expenditure is zero every year. If, however, it spends twice as much in one year and nothing the next, it will average the same expenditure per year but qualify for a much higher credit.

The new law addressed this issue by calculating the base as an average R&E expenditure for the previous three years with special provisions made for the first two.[11]

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[10] Leydon and Link (1992), page 159.

[11] In effect the base was equal to $(1/3)\sum_{i=-1}^{-3} RE_i$ for 1983, $(1/2)\sum_{i=-1}^{-2} RE_i$ for 1982, and $(1/2)RE_{i-1}$ for 1981 since the credit only applied to half the year. REi is research and experimentation expenditures in year i.

While this approach tends to limit the rewards for a one-time jump in R&E spending, it created other problems which economists were quick to point out. An additional $1.20 spent today would be rewarded by a 30 cent credit this year ($1.20 multiplied by .25), but it would also cause the credit to be reduced by 10 cents each year for the next three years as a result of increasing the base. The credit is saved from being a complete wash by the fact that firms prefer to have money today rather than tomorrow. The lower the discount rate, however, the lower the effective credit. In the extreme case of a discount rate equal to zero, the effective credit is zero as well. Figure 3 illustrates the effective credit for various discount rates calculated at the pre-1986 statutory credit rate of 25 percent and the post-1986 rate of 20 percent.[12] This built-in disincentive was quite clear to economists; whether it was as clear to businesses is another matter.

Figure 3 here.

The credit had several other features. One requirement specified that the base be at least 50 percent of current R&E expenditures. This reduced the credit for firms with especially fast growing research budgets. For any firm with current expenditures at least twice the base, each additional dollar of R&E expenditures automatically raised the base by 50 cents, thus reducing the value of the credit. This feature of the law was made even more restrictive in the 1989 reform.

For firms lacking both taxable income and the ability to take advantage of the three year carry back provision, the value of the credit is further diminished. While the credit can be carried forward up to 15 years, the act of delaying the benefit erodes its value due to discounting and uncertainty. The credit also offers very little incentive for firms which are otherwise planning to reduce R&E expenditures. Before they can begin to take advantage

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[12] The effective credit rate (k) depends on the stated credit rate (K) and the discount rate according to the following formula: $k = K - K[\frac{1}{3}\frac{1}{(1+r)^{-1}} + \frac{1}{3}\frac{1}{(1+r)^{-2}} + \frac{1}{3}\frac{1}{(1+r)^{-3}}]$

of the credit, they must first increase spending up to the base level. Altogether, the net effect of each of these qualifications is to further reduce the effective credit.

The original credit was extended and modified with the Tax Reform Act of 1986. The most important change in the law was to reduce the statutory credit rate from 25 percent to 20 percent and narrow the definition of qualified research. On the other hand, qualified expenses for basic research paid to colleges and other tax exempt organizations received a 20 percent tax credit.[13]

Having been extended several times, the tax credit was significantly revised in 1989. In order to provide a stronger incentive, the base calculation was changed from a three-year moving average to one employing a fixed ratio of R&E expenditure to total receipts--essentially the firm's average during the period 1984 to 1988.[14] The new base calculation eliminated the penalty which, economists had pointed out, diminished the incentive for a firm to increase R&D. Businesses could now increase their R&D expenses without fear that future credits would be reduced. As long as firms maintained a ratio of R&D to sales above their 1984 to 1988 average, they would be likely to qualify for the credit. Depending on the discount rate, this change has the effect of greatly increasing the pecuniary incentive for R&D spending.[15]

The new law also phased in a progressively higher base limitation which reduces the reward to exceptional growth in R&E. In the original law, only 50 cents of a dollar spent on R&E qualified for the credit once total expenditures exceeded 200 percent of the base. By 1995, only 25 cents of an additional dollar would qualify for the credit once

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13 Internal Revenue Service, *Corporate Returns*, 1986, page 100. *Revenue Reconciliation Act of 1989*, Senate Committee on Finance, 101st Congress, Oct. 12, 1989, GPO, page 39.

14 The fixed ratio is equal to the firm's historical ratio of R&D expenditures to sales from 1984 to 1988. The base is then calculated as the product of this ratio and average receipts over the four preceding years. The ratio was set at 3 percent for start-up companies and special provisions were made to develop a fixed ratio for these firms and those without sufficient records of R&E expenses or receipts in the 1980s.

15 For example, assuming a discount rate of 10 percent, the effective credit on an additional dollar of R&D spending increases from 3.4 percent to 20 percent. This is approximately a six-fold increase in the effective credit.

expenditures exceeded 125 percent of base.[16] It is this form of the law that was renewed by the Budget Reconciliation Act of 1993 and extended to June 30, 1995.[17] The new law greatly increased the R&D incentive by eliminating the rolling base but at the same time reduced the relative incentive for very large increases in R&D.

U.S. Industry R&D: The Historical Record

At least since 1953, R&D expenditures by private industry have risen faster than both the underlying inflation rate and gross domestic product. As a result, real industry R&D and industry R&D shares of GDP have increased as shown in Figures 4 and 5. In 1953, industry R&D was only .6 percent of GDP compared to 1.4 percent in 1985. Figure 5, however, reveals more than a simple upward trend. After remaining relatively constant over the 1970s, R&D shares rose quite rapidly between 1978 and 1985. During this brief period, R&D boomed in the U.S., coinciding with a similar expansion in Japan and Germany. But spending in U.S. industry peaked in 1985 and began to drift downward, still remaining above the 1970s level.

Figures 4 and 5 here.

Any national R&D policy should be based on a solid understanding of what determines industry R&D--one that can account for the 1978 to 1985 expansion. There are, as is often the case in economics, a number of competing explanations. The first is the already-mentioned investment tax credit which took effect in June 1981. Furthermore, one

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16 Where the base was required to be at least 50 percent of current qualified R&E expenditures up to 1990, the minimum was gradually raised to 75 percent by 1995. *Revenue Reconciliation Act of 1989*, Committee on Finance, 1989.

17 "Summary of the Revenue Provisions of the Omnibus Budget Reconciliation Act of additional dollar of R&D spending increases from 3.4 percent to 20 percent. This is approximately a six-fold increase in the effective credit.

could claim that the end of the boom in 1986 was related to tax reform which reduced the size of the credit and at the same time tightened the criteria for qualified research.

There are also grounds for skepticism. It appears from the graph that the beginning of the R&D expansion can be placed at 1978 or 1979, at least two years before the tax credit was passed. The credit was evidently not the only factor in the R&D increase. It would also be surprising if the relatively small changes made to the law in 1986 could abruptly alter the pattern of R&D spending. The credit was only reduced from 25 to 20 percent and was extended to cover funding for university basic research.

Timing is one problem with the credit explanation, magnitude is the other. The R&D expansion in the early 1980s is simply much bigger than what could have been expected from the credit alone. For example, suppose we attributed the entire increase in industry R&D shares from 1980 to 1985 to the tax credit. Could the credit have caused a 25.8 percent increase in annual R&D spending?[18] The problem is that this figure is about twice the size of even the most optimistic estimate of the credit's impact. In summary, the credit appeared to be too late, persisted too long, and was too small to account for the R&D boom of the early 1980s. This is not the same as saying that the credit had no effect but only that other factors are clearly important.

An alternative explanation is foreign competition. Firms can respond to foreign competition in a number of different ways; they can simply concede market share; they can cut prices; or they can increase expenditures on advertising and R&D in an effort to attract customers. An increase in foreign competition in many areas of the U.S. economy could be one of the factors behind the R&D boom. One indicator of the intensity of foreign competition is the level of U.S. nonpetroleum imports. Figure 6 shows the relationship

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[18] This is based on a change in the R&D share of GDP of .29 percentage points from 1980 to 1985. This ratio multiplied by 1980 GDP ($2,708 billion) and divided by total industry R&D spending in 1980 ($30.9 billion) yields the 25.8 percent increase. If we assume that the effective credit was approximately 5 percent, the implied long run elasticity with respect to R&D prices is 5.2 percent, far greater than the range of 2 to 2.7 estimated by Hall (1993).

between nonpetroleum import intensity and industry R&D shares. Import intensity rose quite rapidly during two periods: 1975 to 1980 and 1982 to 1988. Except for a brief lapse related to the twin recessions of 1980 and 1982, the rapid influx of imports from 1975 to 1988 parallels the R&D boom from 1978 to 1985. There is a possibility that at least part of the R&D boom was related to increased foreign competition.

Figure 6 here.

Another possible explanation is related to military procurement. The Department of Defense will typically solicit proposals for the design of a new weapons system from private businesses. These "design competitions" require extensive preparation and R&D on the part of participants who are willing to incur such expenses because they hope to be selected as the primary contractor. Although firms may later be reimbursed for these expenditures, they are still typically reported as industry R&D. This means that these expenditures are included in the R&D boom from 1978 to 1985.

There was in fact a similar expansion in military purchases during this period. DOD procurement rose from approximately 1.0 percent of GDP in 1977 to 1.8 percent in 1986 as illustrated in Figure 7. The slide in procurement after 1986 corresponds closely with a similar pattern in industry R&D. There is also the fact that the military expansion in the 1980s included many high technology weapons systems such as AWACs, Stealth Bombers, and Star Wars.[19]

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[19] If rising DOD procurement in the early 1980s stimulated private R&D, why didn't falling DOD procurement during the 1950s and 1960s cause the reverse to occur? During this time, the United States was simultaneously demobilizing from the Korean War and W.W.II and mobilizing for the cold war. It is quite possible that although DOD procurement was being cut at this time, a greater emphasis was being placed on sophisticated weapons systems produced by private industry. Some of the early reduction in procurement was related to the shift from personnel to weapons systems. There were in fact nearly one million fewer military employees in 1975 than in 1955. *Statistical Abstract of the United States*, 1979, page 353.

Figure 7

Another event which could have affected R&D spending in some industries was the energy crisis. Rising energy prices in the 1970s eventually motivated many firms to improve their energy efficiency which required the development and installation of new equipment and production methods. Figure 8 shows the historic pattern in energy prices relative to industry R&D shares.[20] There is little indication that industry R&D responded to the initial energy crisis in 1974 but the R&D boom does correspond with the second upswing in energy prices in 1979. Energy prices began to subside in 1981, preceding a similar change in R&D by four years. One could construe from this graph that R&D spending did respond to the energy crisis but only with a significant lag.

Figure 8 here.

We are left with the problem of determining which of the above reasons are primarily responsible for the R&D boom in the early 1980s. If it was the credit, then we have identified an effective policy tool for stimulating industry R&D. If it was military procurement, then we have identified another government action that can affect private R&D. If it was foreign competition or rising energy prices, then we must take these into account in our national R&D policy. The investigation of this question involved three different types of statistical studies described below. Each was designed to investigate some particular aspect of this problem.

Time-Series Evidence

[20] Energy prices are represented by the ratio of the producer price index for fuels, power, and related products to the overall producer price index.

How much did the R&E tax credit, imports, defense spending, and energy prices contribute to the industry R&D boom? One way to estimate these contributions is by estimating a time-series model which analyses the movement of industry R&D intensity over time. This type of study was conducted using data from 1953 to 1992 and described in full detail in the Appendix. R&D intensity is expected to be a function of the R&E credit (identified by the years the credit was in place), import intensity (U.S. nonpetroleum imports divided by GDP), defense procurement (again divided by GDP) and relative energy prices.

The results show that the complete model explains approximately 95 percent of the variation in R&D intensity. For the entire period, only the credit and imports appeared to have a significantly positive effect on industry R&D as a share of GDP. During the more recent period, from 1970 to 1992, both these variables were again statistically significant as were defense spending and energy prices.

It is instructive to look at the estimated impact of the R&E credit. According to the full model, the ratio of industry R&D to GDP was .12 percentage points higher during the period covered by the credit. In 1980, this would have translated into a 10.5 percent increase in R&D spending.[21] This is a large gain assuming the effective credit was no more than 5 percent, but still within the range of earlier studies. There is a problem, however. The high correlation between the credit and other variables makes it difficult to have much confidence in these estimates. The correlation between the credit variable and imports is especially high at .82 and still relatively high for defense procurements and energy prices (.54 for both). In such a situation it is admittedly difficult to accurately sort out the individual contribution of each variable.

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[21] Multiplying .0012 by 1980 GDP ($2,708 billion) and dividing this by industry R&D spending in 1980 ($30.9 billion) yields 10.5 percent. Assuming a 5 percent effective credit, the elasticity estimated in this test is 2.1, which falls within Hall's estimated range of 2.0 to 2.7.

Industry Evidence

One of the major drawbacks of a simple time-series test is that it fails to consider the variation within industries. This is particularly important here because R&D intensity varies so widely among industries as does DOD procurement and imports. The top five R&D spending industries are for office, computing, and accounting machines; motor vehicles and equipment; aircraft and missiles; communication equipment; and drugs.[22] Together, these five industries accounted for 52 percent of all industry R&D but only 19 percent of sales in manufacturing in 1989. DOD procurement is even more unevenly distributed with the top two industries, aircraft and missiles; and communication equipment receiving approximately 69 percent of all orders in 1987.[23] If the hypothesis in this report is correct then one would expect to find the largest increases in R&D spending in those industries with the largest increases in DOD procurement and foreign imports.

Regression analysis, described in more detail in the Appendix, shows that this is in fact the case. This test is based on a sample of 25 industries covering all of manufacturing from 1969 to 1989. R&D intensity, defense procurement, and imports are all divided by industry shipments rather than GDP, but otherwise the tests are similar.[24] In this study, R&D intensity was consistently higher in those industries with high ratios of imports and DOD procurement to shipments. There was, however, no compelling evidence that R&D was significantly higher during the years when the R&E tax credit was in place. For all industries, the model explained 99 percent of the variation in R&D intensity over this twenty-one year period.

Separate tests were undertaken to investigate the role of these variables in specific industries with relatively high R&D expenditures (greater than 1 percent of industry

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22 NSF, "Research and Development in Industry, 1990."
23 U.S. Dept. of Commerce, "Shipments to Federal Government Agencies, 1987."
24 The energy price variable was also omitted since it was not particularly important in the time-series data and there is no cross-sectional dimension to it.

shipments). In these separate regressions, imports had a positive and significant effect in 6 industries (including motor vehicles), DOD procurement had a positive and significant effect in 5 industries (including aircraft and missiles), and the R&E credit had a significant and positive effect in only one industry. But even this single positive result is questionable because R&D spending in this industry, aircraft and missiles, is so heavily dependent on defense orders.

The results of the industry analysis appears to support the view that military procurement and imports are largely responsible for the R&D boom in the early 1980s. The role of the R&E credit remains in doubt. Relative to these other factors, it does not appear to have had a particularly significant effect on industry R&D spending.

Company Evidence

One specific concern about the R&E credit is that the beginning of the R&D boom actually preceded the implementation of the tax credit by approximately three years. The question has been raised as to whether the increase in R&D intensity following the passage of the credit was in fact any larger than the increase that preceded it.[25] In order to answer this question, I collected a sample of 221 firms from Compustat database with R&D spending greater than $25 million from 1978 to 1985--the duration of the R&D boom.

One of the advantages of company data that has been exploited by other researchers is the detailed information about financial positions of firms.[26] It is possible in these datasets to distinguish between those firms which are most likely to benefit from the credit, and those which are not. In particular, firms with a history of net losses are less likely to be able to use the credit immediately, especially if they have no current or past tax liability.

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25 Mansfield (1984).

26 See for example Hall (1993) and Swenson (1992).

I used the company data set to test whether R&D spending was any larger after the credit and more specifically, if it was larger for those firms with the most to gain from the credit.

The results of this exercise are described in the Appendix. The hypothesis is that certain factors contributed to an underlying increase in R&D intensity from 1978 to 1985 which then experienced an acceleration from 1981 to 1985 under the R&E credit. The nature of this hypothesis is illustrated in Figure 9. There is an underlying growth rate in R&D intensity represented by slope *a* which then increases by an amount equivalent to *b* due to the credit.[27] The analysis in the Appendix provides estimates of *b* which, to the extent that the R&E credit was effective, would be expected to be positive and statistically significant.

Figure 9 here.

Estimates of *b* using the entire sample are positive but not statistically significant. It does not appear, at least for this sample, that R&D spending significantly accelerated after 1980 due to the R&E credit. Additional tests were conducted to exclude those firms with the least likelihood of qualifying for the credit due to a lack of tax liability. In one test, firms were excluded from estimates of *b* if they had losses in the current year. In another, firms were excluded if their accumulated net income in the current and previous three years was negative. Each of these tests allows for the fact that the firms most likely to take advantage of the credit are those with current or past tax liability. In every one of these tests, estimates of *b* decreased rather than increased. Consequently, the firms that had the greatest potential for benefiting from the R&E credit did not appear to significantly accelerate their R&E spending after 1980 relative to the average firm.

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[27] The model is a spline function of the form: $R\&D/Sales = a_0 + aY_t + b(Y_t - Y_c)C_t + e$. In this model, R&D intensity is a function of time (Y_t). The variable Ct is equal to one when the credit was in force (1981 and on) and Yc is equal to 1980. R&D intensity increases at the rate of *a* per year until 1981 when it accelerates (or decelerates) by an amount proportional to *b*.

The results of this research and those of others suggests several tentative conclusions.[28] While part of the period associated with the R&D boom overlaps the R&E credit, the actual relationship is far more complicated. It would be difficult to conclude that the R&E tax credit had a large positive effect on industry R&D. The R&D boom began two to three years before the credit was passed and ended while the credit was still in place. Alternatively, this analysis suggests that the industry R&D boom was linked to a rapid expansion in imports and defense spending and to a lesser extent, energy prices.

Some analysts suggested from the start that the reason the R&E credit was not likely to have a large effect was because of the disincentives built into the rolling base. The effective subsidy for any increase in R&D spending was greatly reduced by including it in calculations of future spending thresholds. What begins as an official 20 to 25 percent credit may shrink to a 3 to 5 percent effective credit depending on the discount rate and other qualifications.

If the credit failed to have a more prominent impact because of this penalty, why didn't R&D pick up after the penalty was eliminated in the 1989 reform? Industry R&D has remained a relatively stable 1.3 percent of GDP since 1989, slightly below its 1985 level. In most economic models, the switch to a fixed ratio in the credit calculation should have greatly magnified the incentive to invest. One possible conclusion from all this is that the credit is not especially important in determining R&D spending. Another possibility is that the added incentive of eliminating the rolling base was exactly offset by tightening the base limitation. Recall that the 1989 tax bill limited the full value of the credit to expenditures exceeding the base by 25 percent or less. Beyond 25 percent the credit was reduced by a factor of four. How many firms this might have affected is not at all clear.

Even if the R&E credit did stimulate additional R&D, it has been questioned whether the additional spending was as large as the tax revenue foregone. Edwin Mansfield concluded in his early study that "the extra R&D stimulated by the tax credit

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[28] Mansfield (1986, 1984) and Eisner (1985, 1984)

seems to have been considerably less than the revenue lost to the Treasury."[29] The size of the allowable R&E credit is reported in Table 1 for 1981 to 1991.

Table 1 here.

Mansfield was also one of the first to point out that the tax credit created an incentive for firms to redefine related activities as research and experimentation so that they could qualify for a larger credit. He concluded that a considerable amount of the initial increases in R&E spending was caused by this slight of hand rather than real spending increases.

National R&D Policy

This report began by identifying a large and growing gap between nondefense R&D spending in the U.S. and that of Japan and Germany. If the United States is to look forward to a future which includes a solid share of the world's high technology markets, it must close this gap. International competition will, in all likelihood, stimulate industry R&D but there is probably little hope of actually closing the gap without a reorientation of U.S. R&D policy. To this end the government must introduce policies which either stimulate private industry expenditures or expand government funded R&D. How can public policy be reoriented to address these challenges?

While private industry in the United States provides 46.9 percent of total R&D funds, the comparable shares are 59.9 percent for Germany and 72.7 percent for Japan.[30] There is obviously room for U.S. firms to increase their share of the nation's R&D effort. But other than the R&E credit, there are few public policies which are even intended to

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29 Mansfield (1984).
30 NSF, *Science & Engineering Indicators--1993*, page 377 and 378.

encourage more industry R&D. Given the research in this report, it is difficult to believe that a stronger credit would do much good. The best argument one could make in its favor, however, is that the credit would have had a positive effect after 1989 if not for the higher base limitation. If the experiment with the credit is to be continued, an obvious improvement would be to reverse the base limitation introduced in the 1989 tax bill. Instead of reducing the effective credit for R&D spending exceeding 25 percent of the base, the credit would be increased.[31]

If this change is to make any difference, it must be demonstrated that substantial numbers of firms are likely to increase R&D spending by 25 percent or more. The evidence for the 1978-1985 period suggests that this number is not insignificant. In fact, approximately 40 percent of all R&D increases during this time originated in firms with individual increases of 25 percent or more.[32] It would appear that a significant number of firms could potentially benefit from removing the base limitation penalty.

Before pursing this policy, at least two objections must be overcome. First, any expansion of the R&E credit is likely to entail lost revenue, a problem that was not addressed in the original legislation creating the credit. In fact, one could claim that the R&E credit was initially unfunded, contributing to larger federal budget deficits.[33] In today's environment it is more difficult to justify expanding the R&E credit, or even keeping it, if it means higher deficits or fewer public goods.

This raises the important question of who should pay for the credit. Recall that its purpose is to remedy a market failure, the chronic under investment in R&D due to

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[31] A very similar problem existed with the old utility price structure called *declining block rates*. With lower prices at higher levels of consumption, this policy encouraged consumption rather than conservation. Modern price structures are more likely to contain *increasing block rates* which encourage conservation.

[32] This is based on a sample averaging 525 firms from 1978 to 1985. In this sample, 60 percent of all increases in R&D were from firms with 0 to 25 percent R&D growth rates, 37 percent for firms with 25 to 100 percent growth rates, and 3 percent for firms with more than 100 percent growth rates. Source: Compustat.

[33] The discussion here treats the tax credit as a microeconomic policy intended to correct a market failure. If the purpose is to stimulate the macroeconomy through deficit spending then the issue of funding is irrelevant.

uncertainty and lack of appropriability. In theory, firms do not invest sufficiently in R&D because much of the benefit will be captured by other firms. To the extent that the credit precipitates some firms to increase their R&D funding, others will benefit without paying a cent. Ideally one would want those corporations benefiting as free riders to pay the cost of providing the incentive. While it is probably impossible to target specific free riders for tax purposes, it would not be inappropriate to finance the R&E credit with a slightly higher corporate profit tax. This would provide funds to finance the current R&E credit as well as any expansion in the credit.

The second objection to strengthening the R&E credit is more fundamental--it may not work. The results of my research provide few reasons to be optimistic. It is hard to imagine that any change in the credit would spark enough industry R&D to actually close the gap.

There is another way that the government can and does stimulate industry R&D. An important lesson of this analysis is that government procurement can stimulate private expenditures.[34] Up until now this has been proven primarily through military procurement, which accounted for 87.3 percent of all manufacturing sales to the federal government. Other federal agencies are relatively small consumers of industrial goods. In 1987, NASA was responsible for 2.8 percent of all federal government orders from manufacturing, DOE's share was 1.1 percent, and all other federal agencies together amounted to an 8.8 percent share.[35] There is currently no other federal agency that compares with DOD in its capacity to issue large contracts for high technology products.

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[34] As Lichtenberg (1988) has demonstrated, this arises primarily through design and technical competitions in which firms compete with each other for the purpose of winning production contracts. His results, however, apply only to competitive contracts. Noncompetitive contracts, often issued as a follow-on to existing contracts, actually had the opposite effect--reducing industry R&D. Since competitive procurement had a relatively stronger impact, the overall effect of government procurement on R&D remained positive.

[35] U.S. Department of Commerce, "Manufacturer's Shipments to the Federal Government, 1987."

As defense priorities subside, there is a growing need for public goods in other areas, such as transportation, energy, education, environmental protection, and health care. At least some consideration should be given to expanding the procurement capacity of other agencies for high technology projects. It is conceivable that an expansion of government procurement awarded on the basis of design competition could stimulate considerable private R&D in each of these nondefense areas.

The possibilities in these areas are limited by funding, not lack of good ideas. The Department of Education may find it useful to purchase high resolution television monitors or computers for schools, the National Institute of Health may wish to purchase equipment for medical research, the Department of Energy may attempt to develop solar cells and storage batteries for government buildings, or the Department of Transportation may want to assist in the development of modern commuter systems. These purchases would not only contribute to improving the quality of public goods but could replace the impetus for industrial R&D once provided by DOD. These technological alternatives should be given serious consideration as replacements for canceled weapons systems .

Even with an increase in industry R&D, there is probably little hope of closing the gap without an increase in direct government expenditures on nondefense R&D. One part of this reorientation is already underway, the conversion of military research to other purposes. Some programs, such as the Technology Reinvestment Project (TRP), provide funds for expanding the competitiveness of defense-dependent industries and supporting "dual-use" technologies, those benefiting both defense and nondefense interests.[36] There are also the "cross-cutting" R&D initiatives which bring several federal agencies together to coordinate broad areas of research under the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET).[37]

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[36] NSF, *Science & Engineering Indicators--1993*, page 115.
[37] NSF, *Science & Engineering Indicators--1993*, page 108.

The primary problem with recent conversion efforts are that they have been relatively small. Figure 10 shows recent trends in federal contributions to R&D for defense and nondefense purposes. Relative to GDP, R&D for defense has clearly declined since 1987 but without a corresponding increase in nondefense shares. If conversion efforts are to contribute to the national R&D effort, federal R&D for nondefense must grow much faster.

Figure 10 here.

A second problem with recent conversion efforts is that several new R&D projects have been retained by DOD even though they may have little to do with defense. While the Department's spending on military R&D has subsided in recent years, civilian research has grown rapidly, reaching $1.9 billion in 1993. Many of these projects, which focus on health, energy, transportation, or manufacturing would be better placed in the appropriate federal agency such as the National Institutes of Health, the Department of Energy, Transportation, or Commerce. Included in this list is $100 million for Sematech, the much discussed research joint venture between private businesses and DOD. But this was only one of 35 different projects identified by the G.A.O. which range from medical research on AIDS and breast cancer ($57 million and $210 million respectively) to the national aero-space plane technology program ($141 million).[38]

Some projects will undoubtedly require a coordinated effort among several agencies, requiring a "cross-cut" initiative, but too often these merely serve to preserve DOD's dominant role. An advantage of involving more government agencies in this process is to foster competition for public funds. Each agency would be compelled to

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[38] U.S. General Accounting Office, "DOD Budget: Department of Defense Support for Domestic Civil Activities."

demonstrate valuable and constructive results in order to vie with other agencies for congressional funding.

Conversion will require more than simply replacing one type of R&D with another. Important issues will have to be addressed concerning where federal R&D efforts will be directed, how they will be administered, and which agency will be the funding source. Several principles, however, should be useful in guiding the expansion of nondefense R&D. First, Congress should continue to determine the functional distribution of research funds. The decision of how much money to place in health research versus computer chip technologies for example must be based on open public discussions. This also means that Congress should not be involved in specific allocation of research money. Recent objections have focused on the congressional practice of earmarking academic research projects for particular districts. While these funds remain a relatively small part of the overall federal research effort, it has grown rapidly in recent years. Academic R&D funds earmarked by Congress rose from $247 million in 1990, to $470 million in 1991 and $707 million in 1992.[39] It is difficult to defend the merit of R&D dollars that are granted through any process other than design competitions or some form of competitive peer review.

Equally difficult to defend is the current government policy of reimbursing firms for independent R&D, conducted primarily by defense contractors. In the modern era, it makes little sense for the government to underwrite R&D that it played no role in developing nor enjoys any control over. In testimony before the Senate Armed Services Committee and Joint Economic Committee in 1975, Admiral H.G. Rickover concluded that "The current IR&D [Independent R&D] program does not provide benefits to the Government anywhere near the cost."[40] His proposal to eliminate the practice remains

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39 NSF, *Science & Engineering Indicators--1993*, page 139.

40 Statement before the Senate Armed Services Committee and The Joint Economic Committee, September 29, 1975.

equally appropriate today. Independent R&D reimbursement, which costs the federal government more than $2 billion a year, should be discontinued.[41]

Not only is it important that the process for distributing R&D dollars be defensible but there must be an impartial assessment of the effectiveness of particular lines of research. It is much easier to distribute funds for R&D than to demonstrate that they are being well-spent. For this purpose, it would be necessary to establish a review process that would do more than determine whether the funds were spent legally. A professional review should also be able to determine whether the research produced any valuable discoveries or innovations. This type of evaluation, which is occasionally conducted by the General Accounting Office, should be incorporated as an integral part of the federal R&D effort.

Finally it should be noted that government agencies have all experimented with different types of methods for funding R&D. In some cases, grants are issued to individual academic researchers to conduct specific experiments or research while in others, the government has embarked on joint efforts with private businesses, requiring specified levels of spending or performance by private firms. Up to this point, no particular method has proven superior to any other in producing socially useful innovations. It is conceivable that a better system of assessing the results of federally funded research would shed more light on the effectiveness of these various alternatives.

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[41] NSF, *Science & Engineering Indicators--1993*, page 360.

Appendix A: Accounting for the Industry R&D Boom: 1978-1985

Why did industry R&D increase so rapidly from 1978 to 1985 and how much did the R&E tax credit have to do with it? These are the questions addressed in this Appendix which utilizes a number of different statistical tests. The first one is a time-series analysis which attempts to model changes in industry R&D as a share of GDP from 1953 to 1992. It is expected that this variable is determined by the level of international competition, the level of defense procurement, energy prices, and the R&E credit.

Time-Series

International competition is measured by the ratio of U.S. nonpetroleum imports divided by GDP.[42] The annual level of procurement for the Department of Defense was also divided by GDP to represent changes in intensity over time.[43] Energy prices were equal to the ratio of the producer price index for fuels, related products and power to total producer price index.[44] The variable for the R&E credit was equal to one in the years that the credit applied, 1981 and thereafter. Finally, industry R&D was equal to the annual funds provided by industry for R&D, again divided by GDP.[45]

The results of ordinary least squares regressions for the entire period, 1953 to 1992, are reported in Table 2. Because of the presence of strong serial correlation, each of the estimates include corrections for autocorrelation. In the first regression, the credit variable is not statistically significant. In the second regression, column 2, both the credit and import variable are statistically significant, the former at the 5 percent level and the

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[42] *Economic Report of the President*, February 1994.
[43] *Statistical Abstract of the United States*, various years.
[44] *Economic Report of the President*, February 1994, p. 344.
[45] NSF, *Science & Engineering Indicators--1993*, page 333 and *Statistical Abstract of the United States*, various years.

latter at the 1 percent level. Coefficients on the defense variable and energy prices are not statistically significant.

Table 2 here.

The results are different, however, when the time frame is limited to the more recent 1970 to 1992 period. The credit variable is now highly significant whether it is included alone in column 3 or with additional explanatory variables as in column 4. The magnitude of the variable also increases in the full model, indicating that the industry R&D ratio to GDP is .12 percentage points higher during the period of the credit. In this specification, import intensity and defense orders are also highly significant, both at the 1 percent level. The implication is that higher imports or defense purchases tend to increase the level of industry R&D. Energy prices are also significant in this model, at the 5 percent level, suggesting higher R&D during the energy crisis.

Why was defense spending highly significant in the recent period but not the longer period dating back to 1953? Going back to the earlier period, defense procurement experienced a major reduction following W.W.II and the Korean War. Much of this reduction was related to the demobilization of a very large standing army, one that was gradually replaced by more sophisticated weapons systems including nuclear missiles. The initial decline in DOD procurement probably coincided with an increase in high technology procurement and would not have had a depressing effect on industry R&D. On the other hand, much of the military buildup in the 1980s was focused specifically on high technology areas including the Strategic Defense Initiative. Within this context it is not surprising that an expansion of DOD procurement could stimulate industry R&D in the 1980s but a decrease in procurement in the 1950s and 1960s would have no equivalent impact.

The results of this test suggest that the credit did have a positive and significant effect on industry R&D spending. There are, however, grounds to be skeptical. The problem is that several of the explanatory variables are highly correlated, even in the period from 1970 to 1992. The correlation between defense spending, energy prices and R&D spending is high but it is especially high between imports and R&D spending with a correlation coefficient equal to .82. The close correspondence between imports and the R&E credit makes it particularly difficult to determine the independent contribution of each variable.

Industry Study

Another approach to this question is to study changes in R&D spending in specific industries. For this purpose, data were collected for twenty-five industries from 1969 to 1989. Sources of the data are reported in Table 3. Industry categories were based on those of the National Science Foundation contained in their reports on industry R&D spending. Although these industries cover all of manufacturing they represent an amalgam of two and three digit industries based on the Standard Industrial Classification.

Table 3 here.

Other data, for defense spending and imports, were aggregated from the three digit level to the NSF industry code. Significant revisions were made in the Standard Industrial Classification in 1987, requiring some adjustment for later years. Fortunately the Census of Manufactures reported DOD Shipments from manufacturing in 1987 in both the new and old classification system, making it possible to adjust post-1986 data. Furthermore, the Department of Commerce did not report DOD shipments for specific industries after 1987 nor for the years 1985 and 1986. The defense data for these years were estimated by interpolation using known estimates of total DOD procurement in each year.[46] R&D data were also missing for some industries, especially during the earlier years of the period. These were also estimated by means of interpolation.[47]

Estimates of this model for all twenty-five industries from 1969 to 1989 are presented in Table 4. The estimates are from ordinary least squares, corrected for autocorrelation. The full model, including each variable, is presented in Column 1. It shows that both imports and defense spending appear to have a positive effect on industry R&D spending and are highly significant (at the 1 percent level). The credit variable, identical to the one used in the time-series study, is positive but not statistically significant. In other regressions, omitting various variables, the credit coefficient remains largely unchanged and insignificant. According to this test, it does not appear that the credit had a strong effect on industry R&D spending.

Table 4 here.

An alternative to testing the effect of these variables for all industries is to test them individually for each industry. These tests were conducted for each industry with a ratio of R&D to shipments greater than or equal to 1 percent. The results, reported in Table 5, indicate that imports were apparently important in some industries while defense procurement was important in others. In only one industry, aircraft and missiles, did the credit appear to have a positive and significant effect. The results for this industry are obviously going to be influenced by the fact that it is the largest defense manufacturer. In 1987, this single industry accounted for 44 percent of all shipments to the federal government. The possibility of distinguishing between the effect of the credit and defense procurement is probably least likely for this industry.

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46 Annual DOD procurement was based on the figure reported in the *Statistical Abstract of the United States*, 1991, No. 542.

47 In this case, interpolation was based on the industry's share of R&D spending.

Table 5 here.

Another question which can be addressed using statistical analysis is whether or not the R&D boom accelerated after 1980 when the R&E credit was introduced. This question can be explored using company data obtained from the database, Compustat. With these data, it is possible to identify particular companies which are most likely to benefit from the R&E credit. Specifically, firms with positive net income or positive net income over the past three years are likely to benefit the most from the R&E credit. Unfortunately, data that describe the level of import competition or the magnitude of defense procurement are typically lacking at the company level, making it difficult to test a complete model of R&D behavior.

In order to test the possibility that the credit caused the R&D boom to accelerate, a model was estimated using a spline function. In this specification the credit variable essentially measures the change in R&D growth after 1980.[48] The model was tested for a sample of 221 firms from 1978 to 1985 with R&D spending of $25 million or more.

The results of this regression, again corrected for autocorrelation and including company dummy variables, are presented in Table 6. Results in the first column simply confirm that R&D intensity increased significantly during this period. The results in the second column show that R&D spending did accelerate after 1980 but that the magnitude of the acceleration was not significant at the 5 percent level. This is indicated by the positive coefficient (.091) on the credit variable. The second two regressions experimented with different specifications for the credit variable. In column 3, the acceleration was tested only for firms with current positive net income and in column 4, the effect was limited to firms

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[48] This is based on a spline function described in footnote 35.

with positive net income over the past three years.[49] By imposing these conditions, the effect of the credit is measured only for those firms with the strongest potential for benefiting from it. The result, is rather surprising since the coefficients on the revised credit variables are negative and even statistically significant. One interpretation is that firms with negative net income also experienced declining sales. If these firms did not reduce their R&D spending proportionately with sales, their R&D intensity would have increased. Once these firms are accounted for, R&D shows no sign of accelerating under the credit.

These results indicate that any acceleration in R&D spending after 1980 was most likely to occur among those firms with the least potential for benefiting from the credit--the ones with negative net income. There is little support here for believing that the R&E credit made much of a contribution to the R&D boom from 1978 to 1985.

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[49] In column 4 for example, the credit variable is equal to one only if the year is 1981 or later and the sum of current net profits and that of the previous three years are greater than zero.

References

Baily, Martin and Alok Chakrabarti (1988), *Innovation and the Productivity Crisis*, Washington, DC: The Brookings Institution.
Baily, Martin and Robert Lawrence (1985), "The Need for a Permanent Tax Credit for Industrial Research and Development," Hearing Before the Committee on Finance, U.S. Senate, 99th Congress, (June 20).
Cohen, Linda and Roger Noll (1992), "Research and Development," in Henry Aron and Charles Schultze, Eds., *Setting Domestic Priorities* (Washington, D.C.: The Brookings Institution).
Cohen, Wesley and Daniel Levinthal, (1989) "Innovation and Learning: The Two Faces of R&D," *The Economic Journal*, 99 (September): 569-596.
Economic Report of the President, various years, U.S. Government Printing Office.
Eisner, Robert, Steven Albert and Martin Sullivan (1984), "The New Incremental Tax Credit for R&D: Incentive or Disincentive?" *National Tax Journal*, 37 (June): 171-183.
Eisner, Robert (1985), "The R&D Tax Credit: A Flawed Tool," *Issues in Science and Technology* (Summer).
Hall, Bronwyn (1993), "R&D Policy During the 1980s: Success or Failure?" in James Poterba, ed., *Tax Policy and the Economy* (Cambridge Mass.: MIT Press): 1-35.
Kortum, Samuel (1993), "Equilibrium R&D and the Patent-R&D Ratio: U.S. Evidence," *American Economic Review, Papers and Proceedings*, 83 (May): 450-457.
Lall, Betty and John Marlin (1992) *Building a Peace Economy: Opportunities and Problems of Post-Cold War Defense Cuts* (Boulder: Westview Press).
Lerner, Joshua (1992), "The Mobility of Corporate Scientists and Engineers Between Civil and Defense Activities: Implications for Economic Competitiveness in the Post-Cold War Era," *Defence Economics*, 3 (August): 229-241.
Leydon, Dennis and Albert Link (1992), *Government's Role in Innovation* (Boston: Kluwer Academic Publishers).
Lichtenberg, Frank (1990), "U.S. Government Subsidies to Private Military R&D Investment: The Defense Department's Independent R&D Policy," *Defence Economics*, 1 (Feb.): 149-158.
Lichtenberg, Frank (1988), "The Private Investment Response to Federal Design and Technical Competitions," *American Economic Review*, 78 (June): 550-559.
Mansfield, Edwin (1986), "The R&D Tax Credit and Other Technological Policy Issues," *American Economic Review, Papers and Proceedings*, 76 (May): 190-194.
Mansfield, Edwin (1984), "How Effective Is the R&D Tax Credit?" *Challenge*, (November-December): 57-61.
Markusen, Ann and Joel Yudken (1992), *Dismantling the Cold War Economy* (New York: Basic Books).
National Science Foundation (1993) *Science and Engineering Indicators--1993*. Washington, DC: U.S. Government Printing Office (NSB 93-1).
National Science Foundation (1992) *Federal Funds for Research and Development: Fiscal Years 1990, 1991, and 1992*. Washington, DC: U.S. Government Printing Office (NSF 92-322).
National Science Foundation (1990) *Research and Development in Industry: 1989*. Washington, DC: U.S. Government Printing Office (NSF92-307).
National Science Foundation (1990) *National Patterns of R&D Resources: 1990*. Washington, DC: U.S. Government Printing Office.
Statistical Abstract of the United States, various years, U.S. Government Printing Office.

Swenson, C.W. (1992), "Some Tests of the Incentive Effects of the Research and Experimentation Tax Credit," *Journal of Public Economics*, 49 (November): 203-218.

U.S. Dept. of Commerce (Various years), *Trade & Employment*, Washington, DC: U.S. Government Printing Office (TM-4-87).

U.S. Dept. of Commerce (Various years), *U.S. Imports of Merchandise for Consumption and General Imports of Merchandise*, Washington, DC: U.S. Government Printing Office.

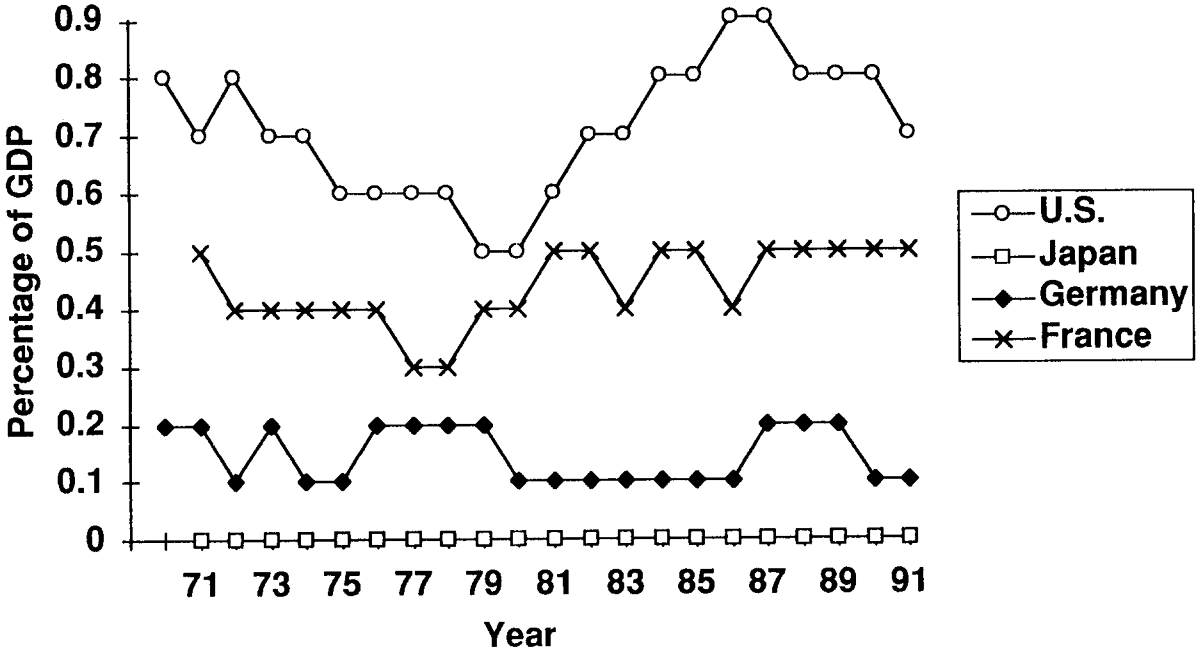
U.S. Dept. of Commerce (Various years), "Shipments to Federal Government Agencies," *Current Industrial Reports*, Washington, DC: U.S. Government Printing Office (MA-175).

U.S. Dept. of Commerce (1987), "Manufacturer's Shipments to the Federal Government." *1987 Census of Manufactures*, Washington, DC: U.S. Government Printing Office (MC87-S-7).

U.S. Dept. of Commerce (Various years) "Value of Product Shipments," *Annual Survey of Manufactures*, Washington, DC: U.S. Government Printing Office (M88(AS)-2).

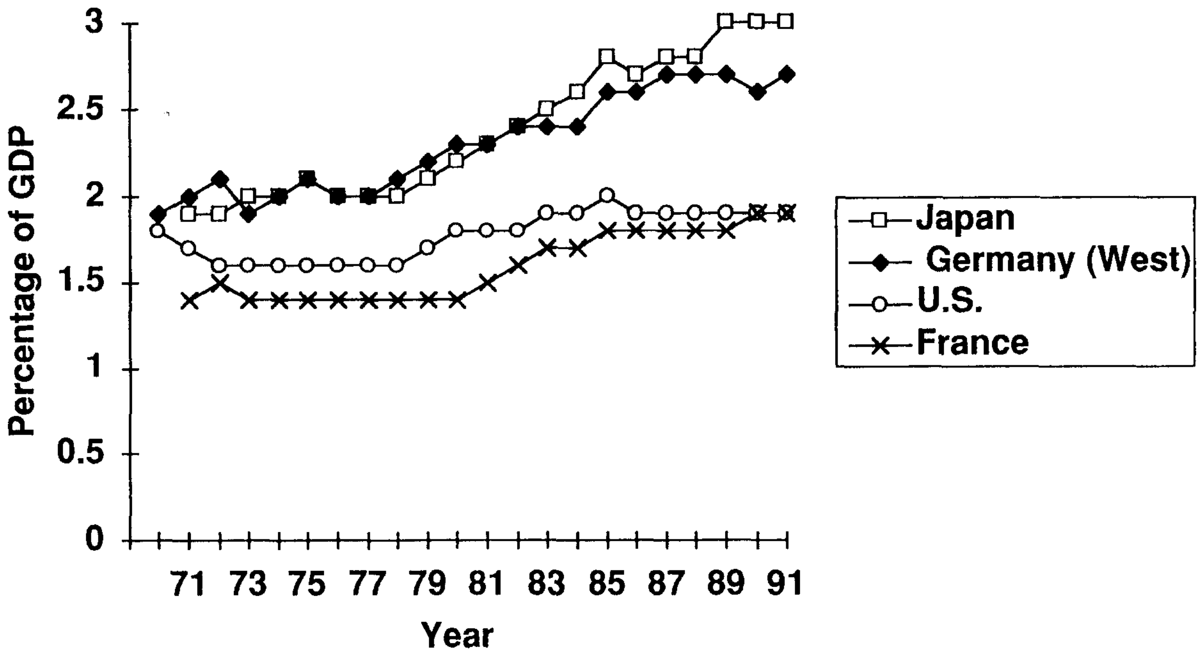
U.S. General Accounting Office (1993), "DOD Budget: Department of Defense Support for Domestic Civil Activities," Washington, DC: U.S. Government Printing Office (GAO/NSIAD-94-41).

Figure 1
Defense R&D Spending as Percentage of GDP



Source: NSF, "Science & Engineering Indicators," 1993.

Figure 2
Nondefense R&D Spending as Percentage of GDP



Source: NSF, "Science & Engineering Indicators," 1993.

Figure 3
Effective R&E Tax Credit and Discount Rates

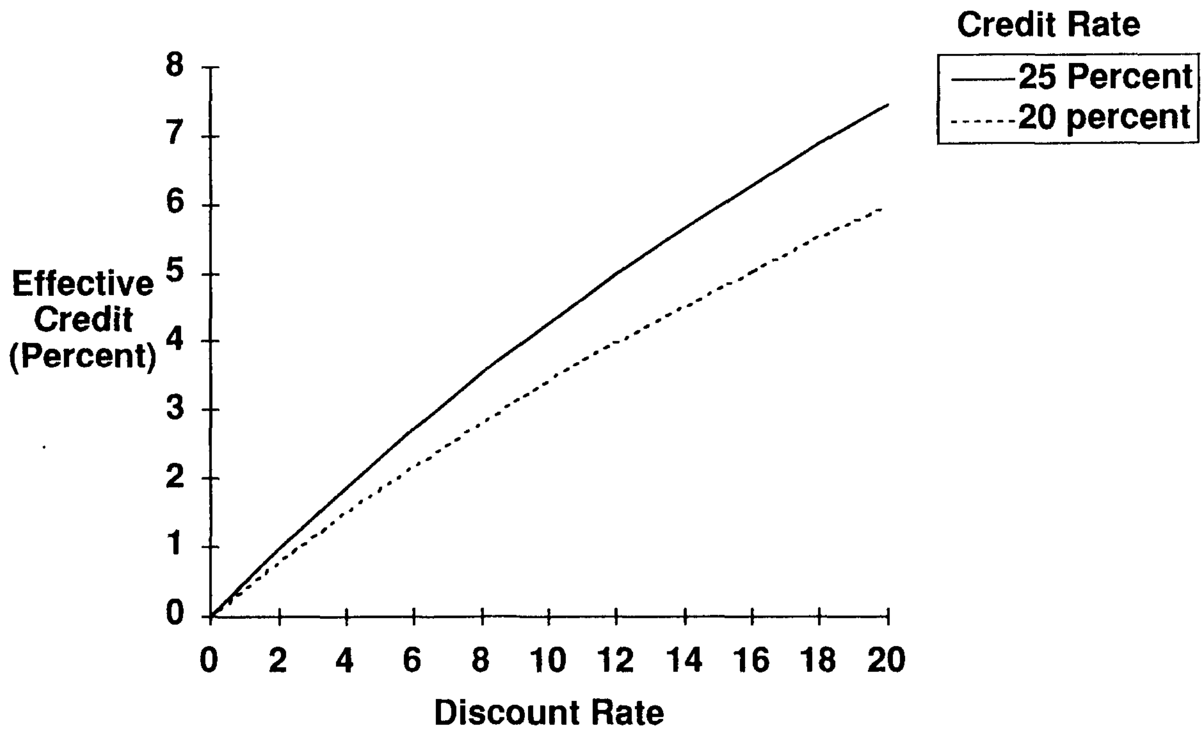
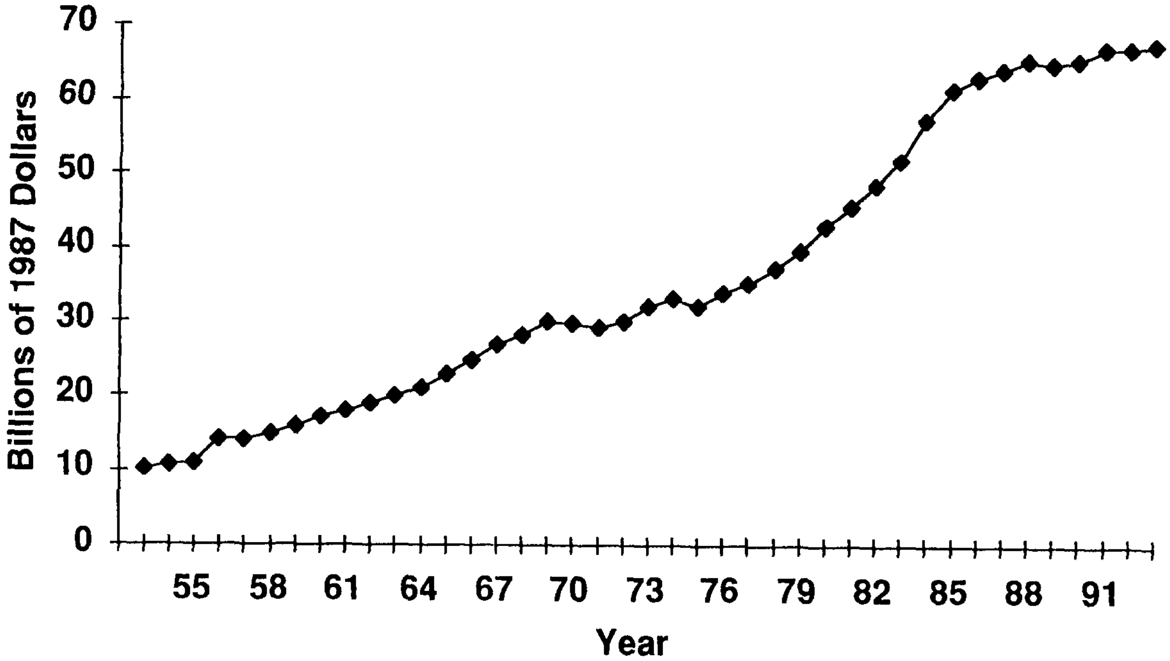
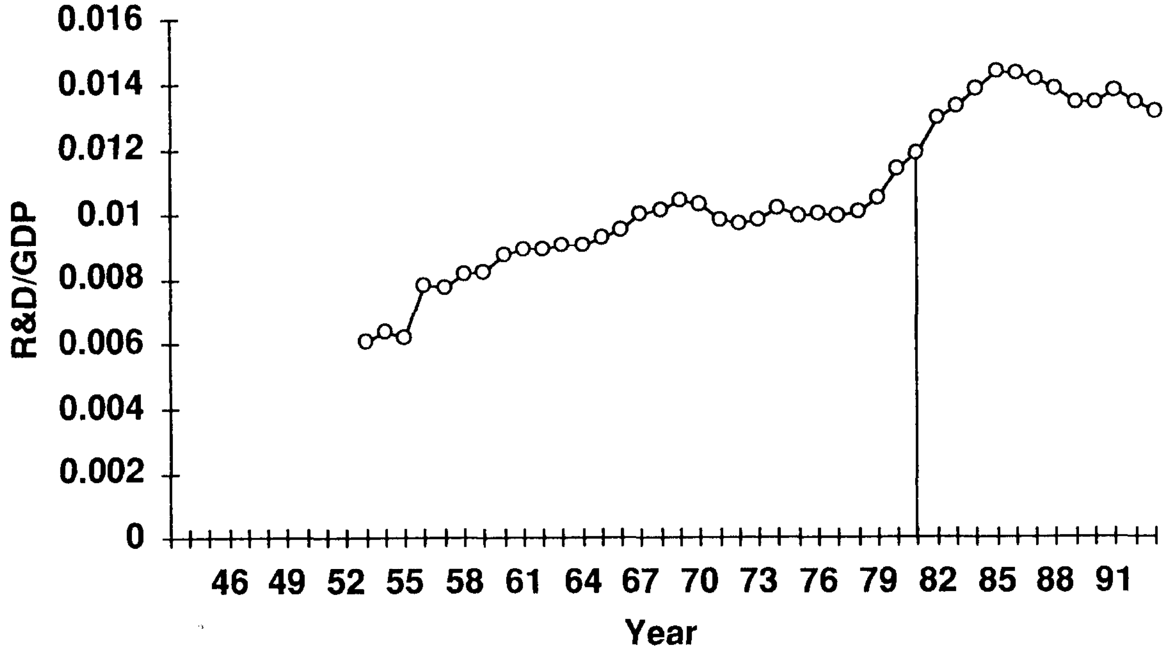


Figure 4
Industry R&D Spending
[1987 Dollars]



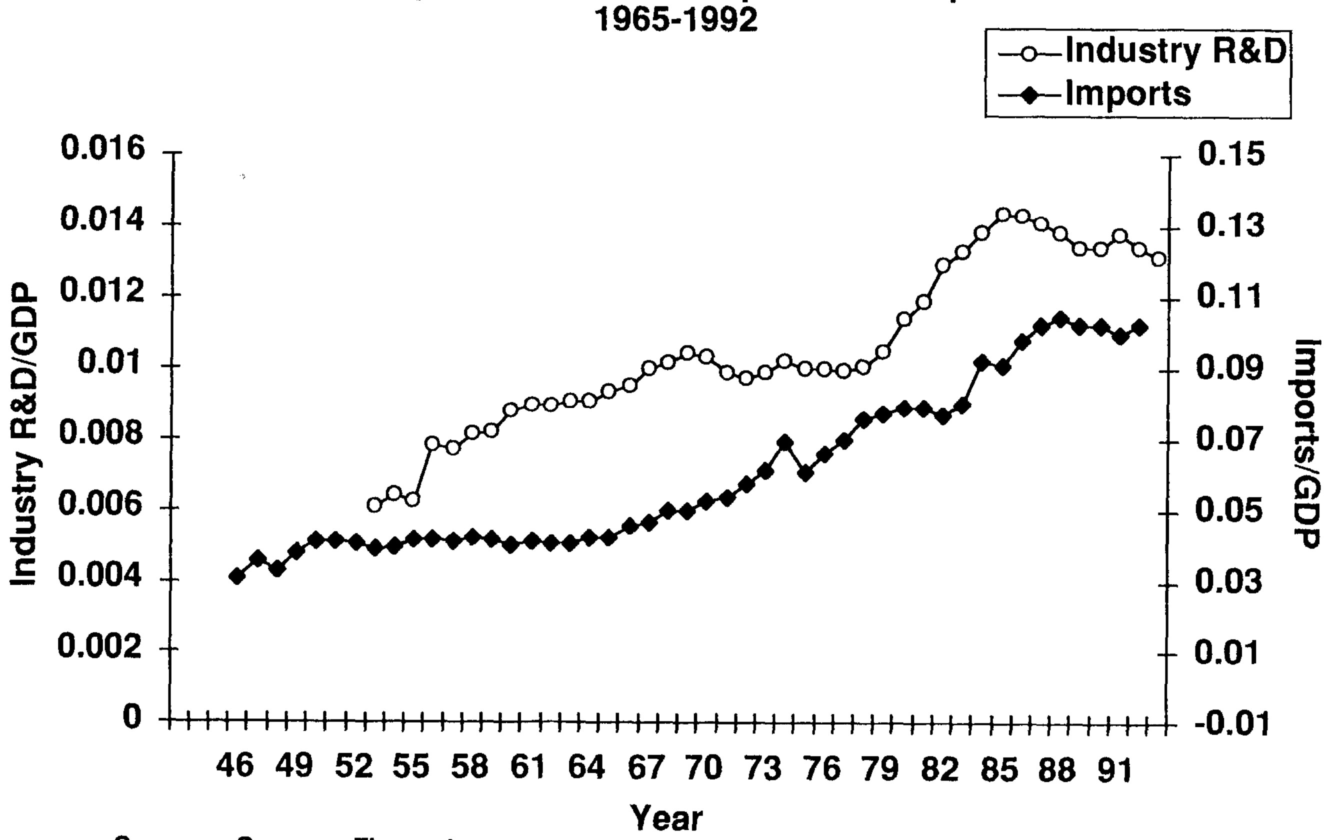
Sources: NSR, "National Patterns of R&D Resources,1990," NSF "Science & Engineering Indicators, 1993," and Economic Report to the President, 1994.

Figure 5
Ratio of Industry R&D to GDP:
1953-1993



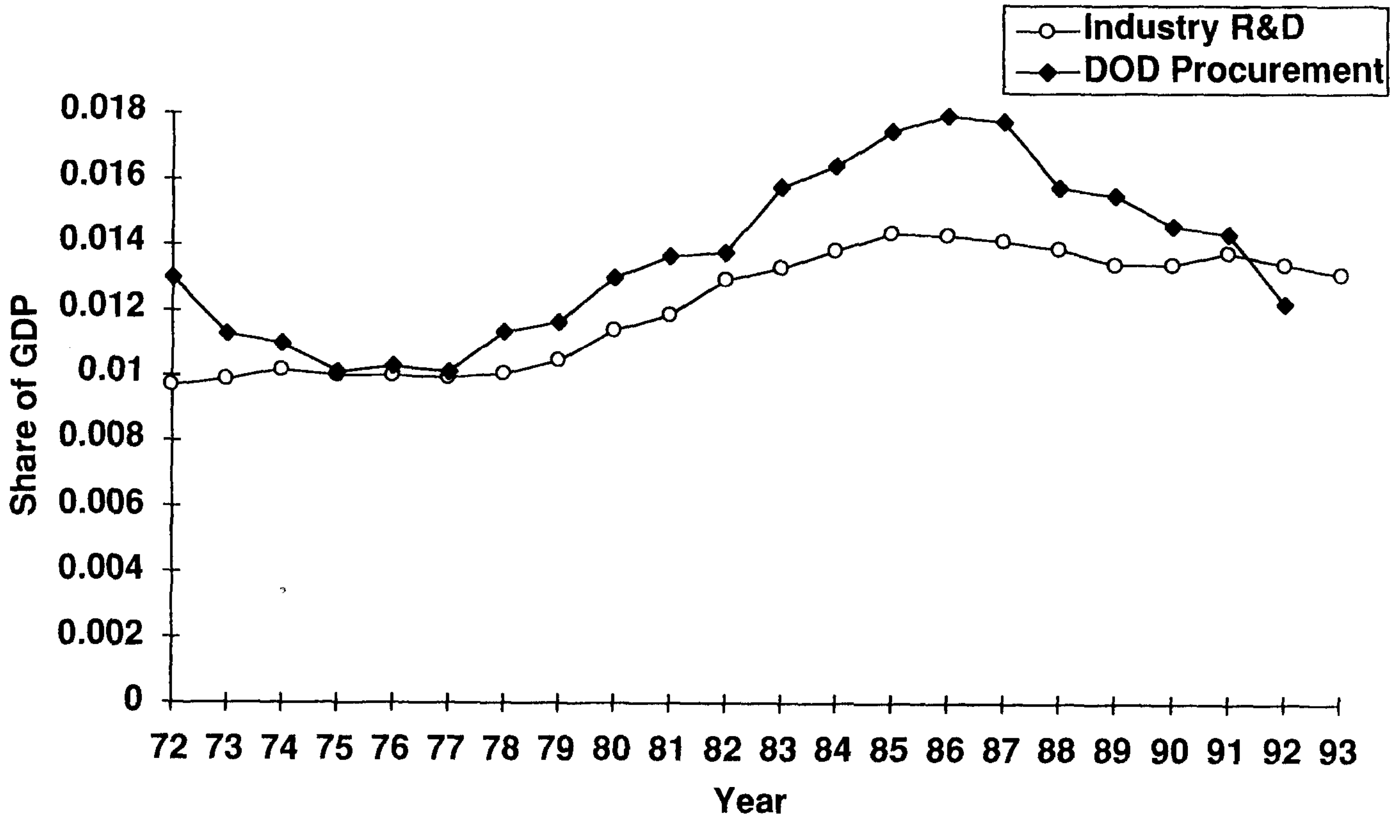
Sources: Same as Figure 4.

Figure 6
Industry R&D and U.S. NonpetroleumImports:
1965-1992



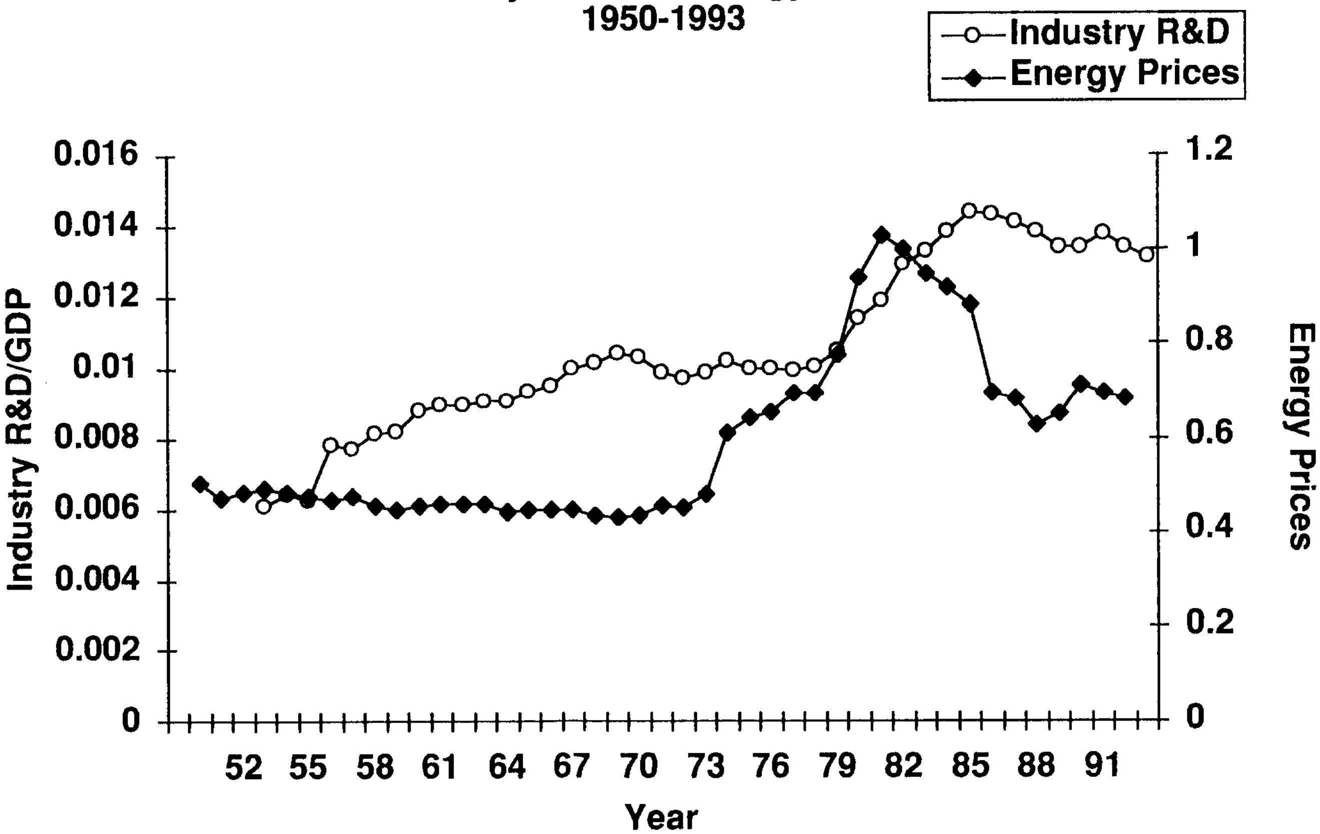
Sources: Same as Figure 4.

Figure 7
Industry R&D and Defense Procurement:
1972 to 1993



Sources: Same as Figure 4 and *Statistical Abstract of the U.S.*, various years.

Figure 8
Industry R&D and Energy Prices: 1950-1993



Sources: Same as Figure 4 and *Statistical Abstract of the U.S.*, various years.

Figure 9
Expected Effect of the R&E Credit on Industry R&D

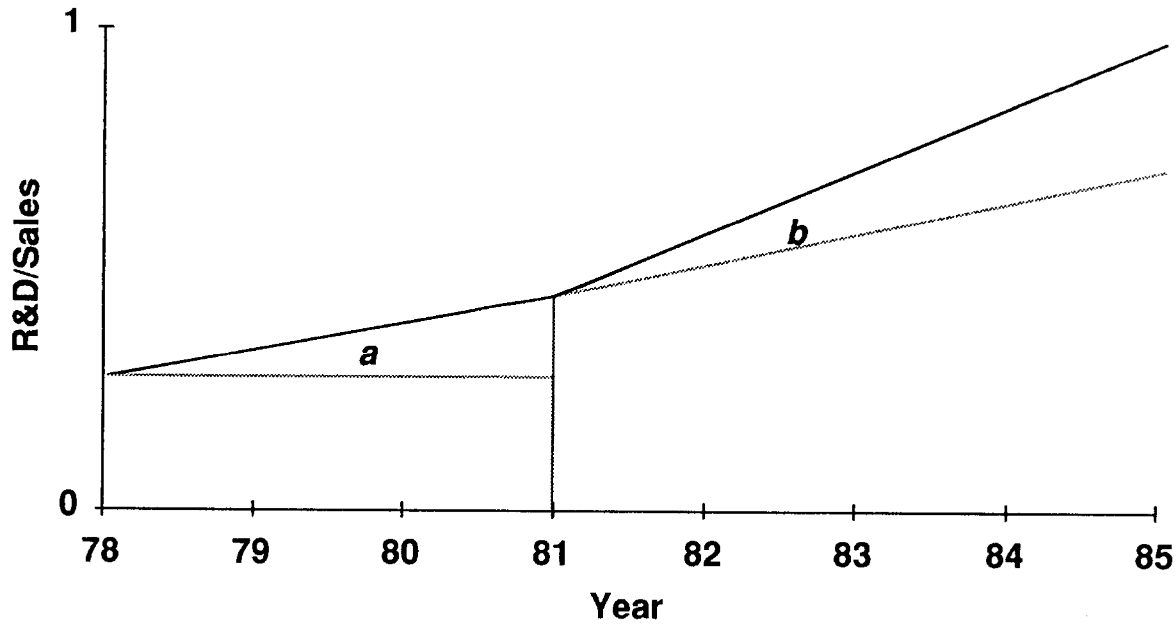
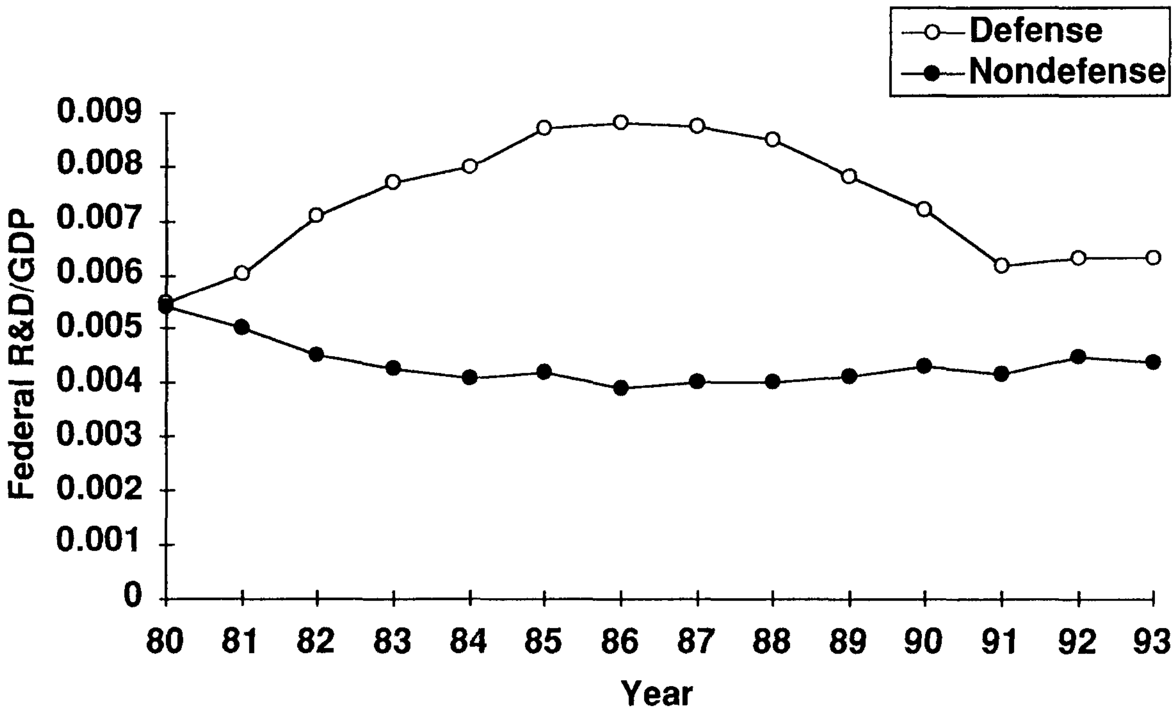


Figure 10
Federal R&D Spending for
Defense and Nondefense



Sources: NSF, "Science & Engineering Indicators, 1993," and *Economic Report to the President*, various years.

Table 1
Research and Experimentation Credit:
Allowable Credit

Year	Allowable R&E Credit (Millions)
1981	873
1982	1,641
1983	2,165
1984	2,638
1985	2,780
1986	1,309
1987	1,053
1988	1,276
1989	1,391
1990	1,547
1991	1,656

Source: *Corporation Income Tax Returns*, Internal Revenue Service (IRS) and unpublished IRS data.

Table 2
Regressions on R&D Intensity
Annual Data

Independent Variable: Industry R&D/GDP

Independent Variable	1953-1992		1970-1992	
	1	2	3	4
Credit	.062	.066*	.32**	.12**
	(.048)	(.053)	(.03)	(.04)
Imports/Shipments		5.42**		5.12**
		(1.56)		(.92)
Defense/Shipments		-1.72		10.77**
		(2.55)		(2.89)
Energy Prices		.18		.141*
		(.15)		(.081)
Constant	.99**	.59**	1.02**	.46**
	(.13)	(.15)	(.02)	(.10)
Adjusted R^2	.95	.95	.90	.95
Durbin-Watson	1.15	1.40	1.88	2.08

Note: Standard errors are in parentheses. All estimates are multiplied by 100.
* Significantly different from zero at the 5 percent level.
** Significantly different from zero at the 1 percent level.

Table 3
Industry Data

Variable	Mean	Standard Deviation	Description
R&D/Shipments	.028	.034	Ratio of company funds spent on industrial R&D to industry shipments. Source: NSF, "Research and Development in Industry," 1989, 1979. Missing observations (primarily in the early years) were estimated by interpolation.
Imports/Shipments	.112	.151	Ratio of imports for consumption to industry shipments. Source: U.S. Dept. of Commerce, *Trade & Employment* and "U.S. Imports of Merchandise for Consumption and General Imports of Merchandise."
Defense/Shipments	.059	.130	Industry shipments to the U.S. Dept. of Defense divided by total industry shipments. Source: U.S. Dept. of Commerce, "Shipments to Federal Government Agencies," and "Manufacturer's Shipments to the Federal Government." Missing observations were estimated using defense procurement to estimate annual levels of Dept. of Defense shipments and then interpolated to determine individual industry shipments.
Credit	.429	.495	Variable equal to 1 when R&E tax credit was in place, equal to 0 otherwise.
Shipments			Total industry shipments. Source: U.S. Dept. of Commerce, "Shipments to Federal Government Agencies," and "Annual Survey of Manufacturers."

Table 4
Regressions on R&D Intensity
All Industries, 1969-1989

Independent Variable	Independent Variable: R&D/Shipments 1	2	3	4
Imports/Shipments	.016**	.016**		
	(.005)	(.005)		
Defense/Shipments	.039**		.039**	
	(.009)		(.009)	
Credit	.0009	.0011	.0006	.0012
	(.0008)	(.0008)	(.0008)	(.0008)
Industry Variables	x	x	x	x
Adjusted R^2	.99	.99	.99	.99
Durbin-Watson	1.62	1.64	1.80	1.46

Note: Standard errors are in parentheses.
* Significantly different from zero at the 5 percent level.
** Significantly different from zero at the 1 percent level.

Table 5
Regressions on R&D Intensity
Descriptive Results for Specific Industries
1969-1989

Industries for which imports had a significant positive effect on R&D intensity.	Mean R&D/Shipments	Standard Industrial Classification
Drugs and other Medicines	.094	283
Other Chemicals	.015	284,285, 287-89
Office, Computing and Accounting Machines	.132	357
Electronic Components	.044	367
Motor Vehicles and Equipment	.031	371
Optical, Surgical, Photographic, and other Instruments	.059	383-87
Industries for which defense spending had a significant positive effect on R&D intensity.		
Rubber Products	.010	300
Other Machinery, except Electrical	.013	351-56, 358,359
Electrical Components	.044	367
Aircraft and Missiles	.052	372, 376
Scientific and Mechanical Measuring Equipment	.051	381,382
Industries for which the R&E tax credit had a significant positive effect on R&D intensity.		
Aircraft and Missiles	.052	372, 376
Other industries with high R&D intensity. (R&D/shipments greater than .01)		
Industrial Chemicals	.029	281-82, 286
Petroleum Refining	.012	290
Stone, Clay and Glass Products	.010	320
Radio and TV Receiving Equipment	.018	365
Communication Equipment	.079	366
Other Electrical Equipment	.021	361-64, 369

Table 6
Regressions on R&D Intensity
Company Data: 1978-1985

Independent Variable: Company R&D/Sales

Independent Variable	1	2	3	4
Time Trend	.190**	.119**	.296**	.196**
	(.011)	(.045)	(.019)	(.027)
Credit				
All Firms		.091		
		(.057)		
$[\pi_t>0]$			-.164**	
			(.025)	
$[\pi_t,\pi_{t-1},\pi_{t-2}>0]$				-.008**
				(.035)
Imports/Shipments				
Defense/Shipments				
Company Dummy Var.	x	x	x	x
Adjusted R^2	.94	.94	.94	.94
Durbin-Watson	1.95	1.96	1.95	1.94

Note: Standard errors are in parentheses. All estimates are multiplied by 100.
* Significantly different from zero at the 5 percent level.
** Significantly different from zero at the 1 percent level.