Tax Policy and Innovation

Edwin Mansfield

Summary. Tax policy should be formulated with recognition of its effects on research and development and innovation. Many changes in tax policy designed to stimulate innovation have been proposed in recent years. Some of these changes were embodied in the 1981 tax bill. Basic economic analysis and rudimentary statistics enable economists to make some useful statements about the effects of recent and proposed tax changes but, because practically no studies have been conducted in this area, there is little or no dependable information concerning the quantitative impact of particular changes of this sort on the rate of innovation.

In recent years, there has been considerable concern in the United States regarding the rate of innovation. On the basis of various kinds of data, it is widely believed that our technological lead over countries like Japan and the Federal Republic of Germany has narrowed, or no longer exists, and that a slowdown has occurred in the U.S. rate of innovation (*1*). In response to such signals, massive government studies have been carried out, and business groups and engineering and scientific organizations have performed their own analyses. In practically all the studies, attention has been devoted to the role of tax policy in stimulating industrial innovation. Without question, such attention is appropriate. It is important that tax policy be formulated with recognition of its effects on research and development (R & D) and other parts of the innovative process.

This article addresses the following questions: (i) What is known about the effects of the federal tax code on R & D and other innovative activities? (ii) To what extent can we estimate the effects of tax changes on R & D and other innovative activities? (iii) How adequate is existing information for policy purposes? (iv) What kinds of research are needed, both in the short term and in the longer run? At the outset, several points should be noted. First, my discussion of these questions must be both brief and selective. There is a large literature on this topic. Second, my purpose is not to comment on the desirability, or lack thereof, of particular tax provisions or proposals. Moreover, by pointing to gaps in existing knowledge, I do not mean to imply that, because of these gaps, the relevant tax provisions or proposals are ineffective or undesirable. Third, the research topics and methods suggested reflect my biases; others might suggest quite different topics.

The author is professor of economics at the University of Pennsylvania, Philadelphia 19104. This article is adapted from a paper presented at the National Science Foundation Colloquium on Tax Policy and Innovation in Washington, D.C., on 24 April 1981.

Tax Provisions Affecting R & D Expenditures

Before we turn to the specific provisions of the U.S. tax code that are often singled out as having a significant effect on R & D expenditures, it is important to recognize that they may be less important than the effects of tax policy on the nation's general macroeconomic climate. As is well known, economic policy-makers have relied heavily on tax changes in their attempts to manage the economy. Tax cuts have been used repeatedly to reduce unemployment; tax increases have been used (as in 1968) to fight inflation. From studies such as those of Schmookler (*2*), Mansfield (*3*), Grabowski (*4*), and Mueller (*5*), it appears that R & D expenditures (and the rate of invention, as measured by patent statistics) are affected significantly by the sales and profitability of firms, which in turn are influenced by the nation's general macroeconomic climate. To the extent that tax policy is formulated in a way that contributes to economic growth and price stability, it will encourage R & D, and more generally investment in all phases of innovative activity, both because of its effects on firms' sales and profits and because it will reduce the uncertainties involved in investment. High rates of inflation tend to discourage long-term investments in R & D because they make it difficult to forecast relative prices—and thus the profitability of investments in innovation—in the period when such investments come to fruition. High rates of unemployment discourage R & D expenditures because sales and profits tend to be low, and expectations concerning the future are adversely affected.

Before the 1981 tax bill was enacted, there were at least four provisions of the U.S. tax code that were generally regarded as having a significant effect on R & D expenditures. First, since 1954, firms have been given the option of fully deducting R & D expenditures in the year in which they occur. (Alternatively, they can capitalize R & D expenditures and amortize them over a period of at least 5 years, beginning with the month in which benefits first accrue from such expenditures.) For tax purposes, R & D expenditures are defined (*6*) as:

> . . . expenditures incurred in connection with the taxpayer's trade or business which represent research and development costs in the experimental or laboratory sense. The term includes generally all such costs incident to the development of an experimental or pilot model, a plant process, a product, a formula, an invention, or similar property, and the improvement of already existing property of the type mentioned. The term does not include expenditures such as those for the ordinary testing or inspection of materials or products for quality control or those for efficiency surveys, management studies, consumer surveys, advertising, or promotions. However, the term includes the costs of obtaining a patent, such as attorneys' fees expended in making and perfecting a patent application. On the other hand, the term does not include the costs of acquiring another's patent, model, production or process, nor does it include expenditures paid or incurred for research in connection with literary, historical, or similar projects.

The option to expense is not applicable to expenditure on R & D buildings, equipment, or other capital assets. Because expenditures for R & D are an investment in know-how that is expected to yield benefits in the future, the option to expense them has been considered to be a tax incentive for R & D (*7*).

Second, individuals (since 1917) and corporations (since 1936) have been allowed deductions for contributions to educational and scientific institutions. The institution must be nonprofit, and its activities must be "carried on in furtherance of a scientific purpose," "in the public interest," and not "of a type ordinarily carried on as an incident to

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commercial or industrial operations." The income of such a scientific institution is exempt from federal income tax. (However, the income from "unrelated" business activities is taxable.) The deductions and exemptions clearly encourage the allocation of resources to science.

Third, since 1954, the income that an individual inventor receives from the sale of a patent is treated as a capital gain, not as ordinary income. This is the case even if the person is a "professional" inventor who might be regarded as selling patents "in the regular course of business." This treatment is available only if the holder of the patent is the inventor or someone who bought his interest before the invention is put to practical use, not an employer or relative of the inventor. Also, it is available only if "all substantial rights" in the patent (or an undivided interest in all such rights) are transferred. Without question, this relatively generous tax treatment of the sale of a patent raises the prospective returns from, and thus encourages, invention.

Fourth, since 1977, Treasury regulation 1.861-8 has required U.S. multinational firms to allocate some of their domestic R & D expenditures against income from foreign sources. The argument for such an allocation has been that, if a U.S. firm spends money for R & D in the United States and the products and processes are sold abroad, then a portion of these R & D costs should be allocated against foreign sales. To understand the effects of this regulation, one must know something about the foreign tax credit. The principles underlying the credit are that (i) profits will be taxed fully in the nation in which they are earned, and (ii) the nation in which the owner of these profits resides will either not tax the profits at all or grant the owner a credit for taxes paid to the nation where they are earned. But the foreign tax credit is not allowed to exceed the U.S. tax that would be levied on this same income if it were earned domestically. Thus, if the income as defined by U.S. tax law is less than it is for purposes of tax liability in the nation where earned, part of the foreign tax credit may be denied. Besides increasing the effective tax rate on foreign income, this regulation may encourage multinational firms to move some of their R & D overseas. However, it is important to recognize that many exceptions and limitations are contained in regulation 1.861-8. For example, R & D carried out to meet health, environmental, or other U.S. requirements can be allocated solely to U.S. income, and the fact that R & D results are used abroad with a time lag can be taken into account (*8*). Nonetheless, many observers argue that Treasury regulation 1.861-8 has been an incentive for firms to move their R & D overseas (*9*).

Tax Provisions Affecting Investment in Plant and Equipment

Besides affecting R & D expenditures, tax policy influences the rate of innovation indirectly through its effects on the level and composition of investment in plant and equipment. Schmookler (*2*) and others have provided evidence that the rate of technological change depends on the rate of investment in plant and equipment. In part, this is due to the fact that R & D by itself is generally of little value to a firm, because it is usually only one stage of a long process leading to a successful innovation. A major, and often the most expensive, stage of the process involves the construction of a new plant, new equipment, or both. Because of this complementarity between R & D, on the one hand, and new plant and equipment, on the other, increases in the rate of investment in plant and equipment tend to raise the profitability of many R & D projects, whose findings could not be used effectively, or perhaps at all, if the rate of investment in plant and equipment were lower.

The rate of investment in plant and equipment also affects the rate at which new technology is introduced and diffused. Many types of new technology cannot be applied unless they are embodied in new plant or equipment. For example, consider the case of numerically controlled machine tools. In order to obtain the benefits from many advances in the relevant technology, firms must invest in new machine tools. Some improvements can be made by modifying existing equipment, but often it simply is not feasible or economical to do so. Thus, the rate of diffusion of many innovations depends on the rate of investment in plant and equipment. If the investment rate is high, the number of pieces of equipment that incorporate the innovation will increase at a relatively fast rate. If the investment rate is low, this number will increase relatively slowly.

Tax policy can influence the rate of investment in plant and equipment in several different ways. To begin with, both corporate and individual tax rates help determine the level and rate of growth of gross national product, as well as the rate of inflation. Both high rates of inflation and high rates of unemployment tend to discourage investment in plant and equipment, for much the same reasons that they tend to discourage relatively long-term R & D projects. Tax policy can be used to help promote relatively high employment and relatively stable prices. Needless to say, tax policy cannot be viewed in isolation from the government's expenditure, monetary, and international economic policies, which influence the general macroeconomic climate. Nor should it be assumed that we know how to formulate tax policy and integrate it with other aspects of economic policy in such a way that full employment with stable prices is assured. But economists are in agreement that tax policy is one of the major factors influencing the general macroeconomic climate, which in turn affects investment in plant and equipment.

From a more microeconomic view, tax policy has an important impact on the rate of investment in particular industries. The field of energy production is an example. To take a recent illustration, consider the case of gasohol. To encourage the production of gasohol, the federal government exempted it from the federal gasoline tax, worth 40 cents on the 10 percent ethanol content of gasohol. And many states exempted it from their motor fuel taxes, worth another 40 cents to $1 per gallon of ethanol. To the extent that these tax exemptions more than offset the cost advantage of regular gasoline over ethanol made from corn, investment in gasohol production facilities was encouraged. Also, certain types of R & D projects (that would otherwise be unprofitable) may have been carried out because of these tax exemptions.

In addition, the government has established specific tax incentives to encourage investment in plant and equipment. One is the so-called investment tax credit, first instituted in 1962. A credit has been allowed for 10 percent of the cost of qualified property that is either constructed or purchased. Qualified property generally has included tangible personal property (but not air-conditioning and heating units), tangible property (other than a building and its structural components) used in manufacturing, transportation, communication, research, or storage, agricultural and horticultural structures, new elevators and escalators, and qualified expenditures connected with the rehabilitation of certain kinds of buildings (*6*).

A firm is allowed to deduct this credit from its income tax bill. Clearly, the effect of this credit is to reduce the cost

to the firm of buying a new piece of equipment. For example, suppose that a firm buys a machine tool for $100,000. If it can deduct $10,000 (that is 10 percent of the $100,000) from its income tax bill, it obviously is paying less than $100,000 for the machine tool. By the same token, increases in the size of the investment tax credit tend to encourage such investment. For example, if the credit were increased from 10 to 12 percent, the firm would pay even less for the machine tool.

In addition to the investment tax credit, another specific tax incentive to encourage investment in plant and equipment has been accelerated depreciation. To determine its profits, a firm must include some measure of the cost of the services of its capital assets. One way to calculate depreciation is to spread the cost of plant and equipment (less their scrap value) evenly over their life. For example, if a firm buys a piece of equipment for $20,000 and if it is expected to last 10 years (its scrap value being zero), it would charge depreciation of $2000 per year for this machine for 10 years after its purchase. This way of calculating depreciation is only one of the methods in common use. The firm would prefer to depreciate a piece of equipment as rapidly as possible. Regardless of the fact that the piece of equipment may have a useful life of 10 years, the firm would prefer to depreciate it in 5, rather than 10, years because the firm's taxes will be shifted to the future (less being paid in the first 5 years, more in the second 5 years). Thus, the present value of the firm's tax payments is reduced (*10*).

At various times, the government has allowed an acceleration in the rate at which firms depreciate plant and equipment. Since this has reduced the present value of the firm's tax payments, it has reduced the after-tax costs of plant and equipment and increased their profitability, thus encouraging investment in plant and equipment. Also, accelerated depreciation (like the investment tax credit) has increased a firm's cash flow—that is, its sum of depreciation allowances and after-tax profit. Since investment in plant and equipment is often regarded as being directly related to cash flow, this too has encouraged investment in plant and equipment.

In recent years, it has been suggested that the effects of both accelerated depreciation and the investment tax credit have been reduced by inflation (*10*). Accounting techniques tend to exaggerate true net income during inflationary periods. Since depreciation is based on the historical cost of assets, not their replacement cost, depreciation costs tend to be understated, with the result that profits tend to be exaggerated. Of course, inflation also affects other items in a firm's accounting statements, and not all effects are in the same direction. But studies (*10*) indicate that on balance inflation tends to exaggerate profits, with the result that firms' tax payments are increased. As pointed out above, this tends to reduce the effects of both accelerated depreciation and the investment tax credit.

Tax Provisions Affecting Investment in New Technology-Based Firms

There is evidence that major innovations often are introduced by new firms [for example, see (*11*)]. Thus, the provisions of the tax code affecting investment in new technology-based firms are of interest. At least four tax provisions have favored the establishment and health of such small businesses. First, tax advantages are granted to regulated investment companies. A regulated investment company is a domestic corporation that derives at least 90 percent of its gross income from dividends, interest, and gains from the sale or disposition of stocks and securities and that meets other requirements of the tax code. A venture capital company is a regulated investment company that provides capital for firms chiefly involved in developing new products or processes. To qualify as a venture capital company, the Securities and Exchange Commission must certify that the firm is primarily engaged in providing capital to other firms that are primarily engaged in developing and exploiting new or improved products, processes, and technology. If it meets this and other legal requirements, a venture capital company is not taxed on the amounts that it distributes to its stockholders. In contrast to ordinary firms, which have their dividends taxed twice (once as part of corporate income and once as part of the individual stockholder's income), a venture capital company can distribute all of its income without paying a corporate tax. This tax provision is regarded as encouraging investment in new technology-based firms.

Second, tax advantages are granted to small business investment companies. A small business investment company, licensed and operated under the Small Business Investment Act of 1958, provides equity capital to small businesses by buying their convertible debentures. Each small business investment company must have paid-in capital and surplus of at least $150,000; the Small Business Administration can lend the company additional funds. A small business investment company has at least three kinds of tax advantages. (i) A loss on the sale, exchange, or worthlessness of the stock can be treated by stockholders as an ordinary loss; it does not have to be offset against gains from sales of stock; and it can be regarded as a business loss for net operating loss deduction purposes. (ii) A loss on the sale, exchange, or worthlessness of convertible debentures purchased from small businesses (or stock gotten through conversion) can be treated by the company as an ordinary loss. (iii) Rather than the normal 85 percent deduction for dividends received from domestic corporations, the company gets a 100 percent dividends received deduction. According to Charles River Associates (*12*), small business investment companies devote about 60 percent of their investment funds to technology-based firms. Thus, these tax advantages for small business investment companies are widely regarded as encouraging investment in new technology-based firms.

Third, certain corporations with no more than 15 stockholders have been allowed to elect treatment according to subchapter S of the tax code. The corporation must be domestic, must have all individual stockholders, must get no more than 20 percent of its gross receipts from passive investment income, and must meet other requirements. If the stockholders elect to be treated in this way, they report their share of the corporate profits whether distributed or not. Some advantages of such an election are that limited liability can be retained while the corporation has the tax benefits of an unincorporated entity, certain fringe benefits unavailable to partnerships and individuals exist, income may be split among children and other relatives, and certain types of tax deferral can occur. These tax advantages are often regarded as encouraging investment in new technology-based firms.

Fourth, a loss on the sale, exchange, or worthlessness of "small business stock" may be treated as an ordinary loss, not a capital loss, if the aggregate amount of money and other property received by the corporation for stock, as a contribution to capital and as paid-in surplus, is $1 million or less. The maximum loss that can be treated in this way is $50,000 or $100,000 on a joint return. This treatment is available only to the original owners of the stock. The advantage of this treatment is that the tax reduction is larger if a given loss is treated as an ordinary, not a capital loss.

Thus, the riskiness of investing in such stock is reduced somewhat. This is often regarded as encouraging investment in new technology-based firms.

Although these four provisions of the tax code are often cited as incentives for investment in new technology-based firms, there are other provisions that may discriminate against small, new firms. In particular, loss offsets, depreciation allowances, and investment tax credits are of limited, if any, immediate use to small, new firms because, since their profits are small, or nonexistent, their corporate tax liability is likely to be negligible. The extent of the discrimination against small, new firms depends on the carry-forward and carry-back provisions pertaining to unused operating losses. More will be said about the adequacy of these provisions below.

Finally, it should be noted that, to a considerable extent, the tax advantages just described have been granted to all small firms, not just to new or small technology-based firms. A loss on the sale of small business stock may be treated as an ordinary loss, whether or not the firm is technology-based. A corporation with 15 or fewer stockholders has been able to elect subchapter S treatment, whether or not it is technology-based. Regulated investment companies and small business investment companies do not invest only in technology-based firms. To repeat, many of these tax advantages, while valuable to new technology-based firms, are available to all small firms (*13*).

Proposed Changes in Tax Provisions Affecting the Rate of Innovation

In recent years, four major reports (*10*, *14–17*) have discussed ways in which tax policy might be used to stimulate technological innovation in the United States. In each report, tax policy was only one instrument of public policy that was considered, and, as would be expected, there was some disagreement about the specific measures proposed and the relative importance of various kinds of proposals. However, none of the reports questioned the fact that tax policy can play a major role in stimulating the rate of innovation. I describe briefly five of the major proposals that were made in these reports.

1) The Industry Advisory Subcommittee of the Domestic Policy Review (*14*) proposed that tax credits be granted for R & D. Perhaps the most important advantages of such tax credits are that they involve less direct government control than many alternative devices to stimulate additional R & D and that in some respects they are relatively easy to administer. Their most important disadvantages are that they do not help firms that have no profits, and that they are likely to encourage the same kind of R & D that is already being done—rather than the more radical and risky kind of work where the shortfall, if it exists, is likely to be greatest. Also, any program of tax credits may run into problems in making sure that a reasonable definition of R & D is observed by firms which, of course, have an incentive to use as wide a definition as possible. In my view, tax credits for increases in R & D spending are preferable to a tax credit for R & D spending, although the problem of defining R & D remains.

2) The Committee for Economic Development (*15*) and the Industry Advisory Subcommittee of the Domestic Policy Review (*14*) proposed that firms be allowed to expense their expenditures for R & D plant and equipment. If adopted, this proposal would have more effect on firms and industries where R & D is capital-intensive than on those where it is relatively labor-intensive, and to some extent, it might result in an increase in the capital-labor ratio in R & D. One problem with this proposal, as well as with tax credits, is that R & D does not account for the lion's share of the costs of carrying out an innovation. On the basis of data for about 40 innovations in the chemicals, machinery, and electronics industries, my students and I (*18*) found that R & D accounted for less than 50 percent of the total costs. Other groups have put the percentage even lower (*18*). In industries where R & D constitutes only a small share of total innovation costs, some observers question whether allowing firms to expense expenditures can have a major impact on the rate of innovation.

3) The Committee for Economic Development (*15*) and the Industry Advisory Subcommittee of the Domestic Policy Review (*14*) suggested that Treasury regulation 1.861-8 be altered or repealed. The Industry Advisory Subcommittee recommended its repeal. The Committee for Economic Development recommended that the regulation be limited to the part of a firm's R & D expenses that is directly related to, and traceable to, its foreign earnings.

4) The Committee for Economic Development (*15*) proposed that further accelerated depreciation be allowed in order to encourage investment in plant and equipment. It supported "the intent of current legislative proposals to shorten the capital recovery period for tax purposes, rather than to hold to the traditional concept that requires depreciation to be spread over the entire useful life of an asset. In order to overcome some of the investment disincentives caused by inflation, investors should be permitted capital write-offs that approximate the rising costs of replacing their plant and equipment" (*15*, p. 7). Of course, one problem with many methods of accelerated depreciation is that they entail large revenue losses to the Treasury. It has also been suggested that depreciation allowances be indexed to adjust for changes in prices. This is a more direct way of dealing with many of the distortions caused by inflation, but it is generally viewed as more burdensome from an administrative point of view. Like further accelerated depreciation, this proposal would result in substantial revenue losses. The effect of these measures depends in part on whether, and to what extent, these revenue losses would be offset by increases in other kinds of revenues or by reductions in expenditures.

5) Both the Domestic Policy Review (*14*) and Committee for Economic Development (*15*) reports proposed that the qualifications for subchapter S treatment be liberalized. The former report advocated that the liberalization be limited to small firms that spend more than a certain percentage of sales on R & D. The latter report would increase the subchapter S limit on stockholders from 15 to 100, but no mention was made of limiting this liberalization to R & D–intensive firms. In addition, the Commerce Technical Advisory Board (*16*) proposed that the carry-forward provision for unused operating losses be extended so that these losses could be carried forward for a longer period of time. This would benefit new technology-based firms that often have losses before they get on their feet. Further, several of the reports proposed that investors be enabled to defer capital gains taxes on sales of stock in small firms, if such sales are "rolled over" to acquire securities of other small firms. This is meant to reduce the "lock-in" effect of the capital gains tax. Investors have an incentive to postpone sales of assets because capital gains are taxed only when realized and in many cases can be turned over to heirs essentially tax-free. This lock-in effect may discourage investors from allocating capital efficiently in response to emerging investment opportunities.

The Economic Recovery Tax Act of 1981

In August 1981, the Congress passed a major tax bill that incorporated some of the proposals discussed above. At least five provisions of the bill are relevant here (*19*).

1) The law provides a 25 percent tax credit for R & D expenditures in excess of the average amount of R & D expenditures in a base period (generally the previous three taxable years). Expenditures qualifying for the new incremental R & D tax credit are "in house" expenditures for R & D wages and supplies, 65 percent of the amount paid for contract research, and 65 percent of corporate grants to universities and certain scientific research organizations for basic research. The credit applies to expenditures made after 30 June 1981 and before 1986.

2) Firms are allowed to depreciate assets much more quickly than in the past. The cost of assets can be recovered over 3, 5, 10, or 15 years. The recovery period for automobiles, light-duty trucks, and R & D equipment is 3 years. For most other equipment, except long-lived public utility property, it is 5 years. Certain utility property, railroad tank cars, and mobile homes have a recovery period of 10 years. For other types of utility property, it is 15 years.

3) The law provides for a 2-year suspension of Treasury regulation 1.861-8. In the two taxable years after the passage of the act, all R & D expenditures in the United States will be allocated to sources within the country. The Secretary of the Treasury is asked to conduct a study of the impact of regulation 1.861-8 on R & D activities in the United States and on the availability of the foreign tax credit. Within 6 months of the enactment of the law, the secretary must submit a report of the study's findings to the Congress.

4) Firms are allowed a larger tax deduction than in the past for contributions of newly manufactured equipment to universities for research. In the past, the amount of the deduction was equal to the amount of the taxpayer's basis in the property. Now it equals the taxpayer's basis plus 50 percent of any appreciation, but not to exceed twice the basis.

5) The law contains provisions directed at small business. In particular, it increases the maximum number of shareholders for a subchapter S corporation from 15 to 25 and allows certain trusts to be qualified shareholders.

Estimating the Effects of Tax Policy: The Case of the Investment Tax Credit

How much effect will the 1981 tax changes have? What would have been the effects of the measures that were proposed but not adopted? As an example, consider R & D tax credits. Given a credit of a particular size and type, we would like to estimate the size of the revenue loss and how, and to what extent, this loss will be offset. We would also like to estimate how much additional R & D will result from the tax credit, and the kinds of R & D that will be augmented. Further, we would like to estimate the extent to which the tax credit will stimulate additional investment in post–R & D phases of the innovation process—investment in plant and equipment, manufacturing start-up, and marketing start-up. And we would like to estimate the effects of the additional R & D on the diffusion of innovations since R & D promotes the diffusion, as well as the development, of innovations (*20*).

In part because economists have neglected the study of technological change until relatively recently, and in part because of the inherent difficulty of estimating the effects of tax policies on R & D expenditures and other forms of investment in innovation, relatively little is known about the effects of various tax measures. However, this does not mean that nothing is known. In particular, the effects of the investment tax credit and accelerated depreciation on the rate of investment in plant and equipment have been studied. It is instructive to survey the results of the studies, both because they are of interest and because they illustrate the problems encountered in studies of this sort.

In the late 1960's, Hall and Jorgenson (*21*) studied the effects of tax policy on investment behavior. They adopted a neoclassical type of model that assumes that the production function is of Cobb-Douglas form, that the economic depreciation rate of plant and equipment is a constant, that profit is maximized over the long run, and that perfect rationality and perfect competition exist. They recognized that these assumptions are only approximations to reality, but they felt that the results would nonetheless be useful guides for economists and policymakers. From their model, Hall and Jorgensen concluded, "Tax policy can be highly effective in changing the level and timing of investment expenditures" (*21*, p. 59). This conclusion is based on their estimates of the quantitative effects of the investment tax credit and accelerated depreciation on investment in plant and equipment from 1962 to 1970. According to their results, the investment tax credit increased investment by about $3 billion (1965 dollars) per year and accelerated depreciation increased it by about $1 billion (1965 dollars) per year.

Building on Hall and Jorgenson's results, Bischoff (*22*) constructed a model in which input proportions are variable only before capital goods are put into place (a so-called putty-clay model), where the Cobb-Douglas production function is replaced by the less restrictive CES (constant elasticity of substitution) production function, and where expected output and expected relative prices are assumed to be generated by distributed lag mechanisms. According to Bischoff's results, the investment tax credit increased equipment expenditures by about $2 to $3 billion (1958 dollars) per year in 1964 and 1965, and accelerated depreciation increased them by about $0.7 billion (1958 dollars) per year in the 1960's.

In 1971, two other studies reported on the effects of tax incentives on investment in plant and equipment. Coen (*23*) used a model that assumes that firms adjust their capital stocks to desired levels at rates that are dependent on the adequacy of cash flows to finance desired capital expenditures. From this model, which is quite different from that of Hall and Jorgenson, Coen estimated that the effects of the investment tax credit and accelerated depreciation, together with some other tax incentives, were smaller than indicated by Hall and Jorgenson or Bischoff. Specifically, Coen concluded, "Policies that produced an estimated $5.1 billion (constant 1954 dollars) in tax savings in manufacturing from 1954 through mid-1962 increased manufacturing capital expenditures by only $2.0 billion during the same period; and policies that produced an estimated $8.6 billion in tax savings from mid-1962 through the third quarter of 1966 increased expenditures by only $2.8 billion" (*23*, p. 179). (Note that these figures are totals, not annual amounts.)

Klein and Taubman (*24*) used still another type of model to estimate the effects during the 1960's of the investment tax credit and accelerated depreciation. Using equations taken from the then current version of the Wharton model, Klein and Taubman entered tax changes as shifts in interest rate terms in the equations for investment and translated them into effects on the rate of return in these equations. In contrast to the other

studies, the effects of these tax incentives were estimated in the context of a reasonably complete multiequation model of the national economy. The results, which Klein and Taubman emphasize are tentative, indicate that the effects of these tax incentives were smaller than those estimated by Hall and Jorgenson.

As investigators such as Eisner (*25*), Fisher (*26*), and Harberger (*27*) have pointed out, each of the studies had particular limitations. In many cases, the authors themselves took pains to point out that their results were provisional and tentative. Thus, it is not surprising that there are differences among the findings of the studies.

In more recent years, a great deal of additional work has been carried out, but Chirinko and Eisner (*28*) suggested that there still is considerable disagreement over the effects of increases in the investment tax credit on total business fixed investment. They investigated the effect of an increase of 10 percentage points in the tax credit, as estimated by various models—the Bureau of Economic Analysis, Chase Econometrics, Data Resources, Inc., Michigan, MPS, and Wharton. The estimates apparently vary widely. Thus, recent work has not dispelled the disagreements and uncertainties.

How Adequate Is Existing Information for Policy Purposes?

In evaluating various actual and proposed changes in tax policy, policy-makers must estimate the effects. Economists have many analytical tools that can be used to make such estimates. At the simplest and most informal level, basic economic theory and rudimentary statistics can be useful. In addition, econometric models have been devised and estimated to help explain and predict the levels of R & D spending and of investment in plant and equipment. Studies based on interviews with business executives can be helpful. Without question, many of the advances made in economics in recent decades have resulted in tools that are relevant to the problems discussed here.

However, the fact that economists have a variety of potentially useful tools does not mean that they have achieved a consensus with regard to the effects of the changes in tax policy. Even with respect to the effects of the investment tax credit, which has received more attention from economists than the changes in the other tax provisions, there have been wide differences of opinion among leading economists. Existing information on the changes in tax provisions discussed above is largely qualitative. On the basis of general economic theory, it seems likely that many of these changes will increase the rate of innovation, at least to some extent. But there is little or no evidence concerning the extent of the increase. In part, this is due to the fact that the rate of innovation is very difficult to measure. But even if we are willing to work with other variables that are more readily measured, such as R & D expenditures, patent statistics, or rates of productivity increase, little or nothing is known about the quantitative effects of the tax changes on these variables. Basically, the reason for this lack of information is not that the proposed changes are impervious to economic analysis but that practically no work has been devoted to this topic by economists.

Perhaps the only quantitative economic research dealing with the effects of such tax changes was done by Brimmer (*29*), in cooperation with Data Resources, Inc. This study was described briefly by Shepherd (*30*) of Texas Instruments, which financed the study. According to Shepherd, "the enactment in 1966 of a continuing 25 percent tax credit on industrial R & D expenditures would have added 0.2 percentage points to annual productivity gains during 1966–77, 0.3 percentage points per year in 1978–87, and 0.4 percentage points per year in 1988–97. . . . This 25 percent tax credit would, moreover, generate, for comparable time periods, average annual gains (in 1972 dollars) of about $2 billion, $5 billion, and $11 billion in R & D expenditures; and approximately $4 billion, $36 billion, and $102 billion in GNP. Finally, we estimated that the tax cost of this program would average a net loss of $2.3 billion annually for the first ten years." (Note that this tax credit, unlike the one passed in 1981, was not an incremental tax credit.)

Since the analysis on which these conclusions are based was not published, it is difficult to know how much confidence the authors of the study have in the results. Because it is difficult to obtain solid information concerning the effects of such a tax credit on the size and composition of R & D expenditures, and because our knowledge is limited concerning the effects of R & D expenditures on productivity growth, it seems likely that the results are rough. As in any analysis of this sort, it is important to know the specific assumptions that are being made and the sensitivity of the results to the values of parameters that cannot be estimated accurately. Without such knowledge, it is difficult to comment further on the results.

The innovation process can be broken down into various stages: applied research; preparation of project requirements and basic specifications; prototype or pilot-plant design, construction, and testing; production planning, tooling, construction, and installation of manufacturing facilities; manufacturing start-up; and marketing start-up. Clearly, some of the actual and proposed tax changes have a more direct impact on some stages than on others. R & D tax credits stress the earlier stages; investment tax credits and accelerated depreciation emphasize the later stages. But because of complementarities among the various stages, any tax change is bound to have some effect on all stages. Unfortunately, there is no quantitative evidence concerning the effects of each such change on the amount of resources devoted to each stage.

In evaluating the effects of the actual and proposed tax changes, it also would be useful to know how each change would affect firms of various sizes and firms in various market settings. Although we lack any quantitative evidence, certain points on this score seem rather obvious. Liberalization of the qualifications for subchapter S treatment, extension of the carry-forward provision for losses, and the proposed tax-free roll-over of equity investment all tend to benefit small firms, not large ones. On the other hand, the repeal or alteration of Treasury regulation 1.861-8 tends to benefit large firms, not small ones. A tax credit for R & D tends to benefit R & D–intensive industries, whereas further accelerated depreciation tends to benefit capital-intensive industries. The expensing of R & D expenditures for R & D plant and equipment benefits firms whose R & D is relatively capital-intensive and whose R & D is growing at a sufficiently rapid rate to prompt the expansion of their R & D plant and equipment.

Despite the fact that some of the recent and proposed tax changes have been under consideration (at least sporadically) for over a decade, there seem to be few published estimates of the revenue losses that many of them would produce. About a decade ago, Secretary of Commerce Peter Peterson estimated that a 25 percent tax credit for R & D would create a revenue loss of $2 billion to $3 billion annually, which (although it pertains to a much earlier period) is close to the estimate of Brimmer quoted above. According to estimates made by

the Joint Committee on Taxation, the incremental R & D tax credit exacted in 1981 will result in an annual revenue loss of $400 million to $900 million, and the suspension of Treasury regulation 1.861-8 will result in about a $100 million annual revenue loss. But these losses are small when compared to those resulting from the accelerated depreciation under the 1981 bill. By the committee's estimate, accelerated depreciation will cost the Treasury about $10 billion in 1982, $26 billion in 1984, and $53 billion in 1986.

Conclusions

Ideally, economists and policy analysts would like to subject an actual or proposed change in public policy to some form of benefit-cost analysis. Although basic economic analysis and rudimentary statistics enable us to make some useful statements about the effects of the recent and proposed tax changes, these statements are far too fuzzy, incomplete, and subject to error to permit a reasonably sophisticated or convincing benefit-cost analysis to be carried out. Without question, our nation's tax policies have a major impact on the rate of innovation. But because practically no studies have been conducted to estimate the effects of various past or proposed tax changes, we have little or no dependable information concerning the quantitative impact of particular changes of this sort on the rate of innovation.

Studies of the effects of tax changes on the rate of innovation face important problems. Because there is no adequate measure of the rate of innovation, it is necessary to use crude measures like R & D expenditures, patent statistics, and rates of productivity growth. It is also difficult to isolate and gauge the effects of a change in tax policy on any of these measures, because other factors do not remain constant. In addition, because some of the proposed tax changes have not been put into effect before, at least in the United States, U.S. historical data may be of limited use in estimating the effects.

Despite these difficulties, I think that at least six types of research would be worthwhile (*31*). (i) Econometric models should be constructed from U.S. data to try to estimate the effects of the recently enacted 25 percent incremental R & D tax credit on R & D expenditures. Also, studies should be made of the effects of the 1981 accelerated depreciation on R & D expenditures. (ii) A carefully designed study might be carried out to determine what U.S. general managers and R & D executives estimate to be the effects of each of the recent tax changes and proposals discussed above (*32*). (iii) The authors of the 1981 tax bill were wise to call for a study of the effects of Treasury regulation 1.861-8. However, it may be difficult to carry out a detailed empirical study in the time frame required by the bill. (iv) It should be possible to analyze data from foreign countries to estimate the effects of changes in the tax policies that they have adopted. Many of the tax changes proposed or enacted in the United States have been tried elsewhere. (v) Studies might be carried out to determine what a carefully designed sample of foreign managers and government officials believe to have been the effects of these tax policies. (vi) An investigation might be conducted to determine what problems, if any, occurred in other countries with regard to the administration of R & D tax credits and other proposed devices.

Because of the limitations of existing theory and methods, it seems doubtful that studies of this kind will yield more than a fraction of what policy-makers would like to know. But if the investment in such studies is limited to an appropriately modest sum, it seems likely, at least to me, that their value to policy-makers would substantially exceed their costs. Without such studies, policy discussions in this area will continue to be severely hampered by the lack of rudimentary facts and systematic analysis.

References and Notes

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31. For a more complete description of these studies, see the paper by E. Mansfield presented at the National Science Foundation's Colloquium on Tax Policy and Innovation, Washington, D.C., 24 April 1981.
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