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R&D IN U.S. NATIONAL ACCOUNTS

Barbara M. Fraumeni and Sumiye Okubo[1]

I. Introduction

The United States is a one of the leading performers of research and development (R&D) in the world. Its R&D expenditures are the highest of any OECD country and probably the highest in the world. Looking at R&D expenditures as a percent of gross domestic product (GDP), it ranks among the top ten countries.[2] Research and development R&D has long been of interest to researchers and policy makers because of its potential impact on economic growth. However, its impact is difficult to determine from the current measures in the national income and product accounts (NIPA's) and the standard growth accounting model. The NIPA's and the growth accounting model do not treat R&D as investment and thus underestimate R&D's contribution to national savings, the country's stock of knowledge, and the economy as a whole. In addition, the NIPA's do not attempt to measure the international impact of R&D as they focus on the domestic economy. However, data from the International Accounts Program of the Bureau of Economic Analysis (BEA) is an important input to any to attempt to include an international component in a U.S. R&D Satellite Account (R&DSA). This paper looks at a small

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[1]This paper represents views of the authors and is not an official position of the Bureau of Economic Analysis or the Department of Commerce.

[2] See National Science Board (2004). R&D expenditures from appendix table 4-43 for selected countries and total OECD are from 1981-2000. R&D shares of gross domestic product (GDP) for the top ten countries are from 1999, 2000, or 2001 and are in table 4-17.

subset of that data and lists other BEA or U.S. Census Bureau data that could be used as indicators of the impact of R&D.

This paper treats R&D as investment, rather than current expenditure. It is a continuation of previous work by Fraumeni and Okubo (2002, forthcoming) and by Carson, Grimm, and Moylan (1994). In addition to updating the R&DSA through 2002, it presents and discusses the R&D data collected by the International Account Program of BEA and poses a few research questions raised by R&D in an international context. The R&DSA is a partial satellite account as several components of the account need to be developed if possible in order to make it complete. These include international components, e.g., to incorporate cross-border flows and international spillovers from R&D, and industry components, e.g., industry specific expenditures and benefits. The R&DSA presented in this paper analyzes the impact of R&D on GDP, national saving, and other macroeconomic aggregates, and identifies the contribution of R&D to economic growth, using a sources of growth approach. In capitalizing R&D, the NIPA structure is modified by including R&D expenditures and benefits within the NIPA accounts. R&D expenditures are relatively easy to measure because data are available from the National Science Foundation (NSF). R&D benefits (returns to R&D capital) are much more difficult to measure; yet estimating them is critical to establishing a link between R&D, technical change, and growth in GDP.

II. International Considerations

A full analysis of the impact of R&D on the U.S. economy should include a consideration of the international scope and nature of activities directly and indirectly related to R&D.[3] Looking at R&D performed in the United States or abroad and cross-border trade in R&D provides only a partial picture of the potential impacts of R&D. Activities of multinationals, patenting, technology transfers, sales through affiliates, cross-border sales of advanced technology products, royalties, and licensing fees are all important indicators of the possible effect of R&D.[4] Estimating cross-border spillovers from R&D presents the most difficult challenge and most likely would involve the use of multiple indicators.

BEA collects a wide variety of information on multinationals, including a substantial amount of data relevant to a study of the impact of R&D. These multinationals include businesses operating in the United States, both U.S. multinationals and affiliates of foreign multinationals, as

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[3]The data used in this international considerations section are all from BEA. See for example Borga and Mann (2003), Bureau of Economic Analysis (BEA) (2001), BEA Foreign Direct Investment in the United States: Operations of U.S. Affiliates of Foreign Countries, (various years), BEA Foreign Direct Investment in the United States: Final Results from the 1997 Benchmark Survey, (and other benchmark survey titles), BEA U.S. Direct Investment Abroad: Operations of U.S. Parent Companies and Their Foreign Affiliates, (various years), and BEA U.S. Direct Investment Abroad: Final Results from the 1999 Benchmark Survey, (and other benchmark survey titles).

[4]BEA data on international private service transactions in royalties and license fees with unaffiliated businesses consist of "industrial processes" and "other" royalties and license fees. Industrial processes include "royalties, license fees, and other fees associated with the use of intangible assets, including patents, trade secrets, and other proprietary rights, that are used in connection with the production of goods." Other royalties and license fees include "royalties, license fees, and other fees associated with the use of copyrights, trademarks, franchises, rights to broadcast live events, software licensing fees, and other intangible property rights." See Abaroa and Sauers (2003) Table 3, footnotes 1 and 2, p. 57.

well as businesses operating abroad who are affiliates of U.S. multinationals.[5] These data on multinationals are clearly essential to obtaining a complete picture of the impact of R&D. U.S. multinationals perform the major share of business R&D in the United States. As well as their U.S. R&D, U.S. multinationals perform R&D abroad; this foreign spending is about one-fifth that in the United States. The U.S. affiliates of foreign multinationals perform substantial R&D in the United States, although their nominal dollar expenditures are significantly smaller than that of U.S. multinationals.[6] In addition, affiliated trade (between U.S. parents and their affiliates or between U.S. affiliates and their foreign parents) of R&D services accounted for about 80 percent of R&D services exports in 2001-2002.[7] During that period, the nominal dollar value of R&D services exports is two and a half to five times higher than R&D services imports, reflecting the high level of R&D activity in the United States. BEA also collects information on R&D services exports and imports by unaffiliated businesses, but the nominal dollar value of their R&D-related trade is much less than that of multinationals.

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[5]Affiliates of foreign multinationals operating in the United States are called U.S. affiliates and affiliates of U.S. multinationals operating abroad are called foreign affiliates in BEA publications. For example, see Borga and Mann (2003).

[6]Data on R&D by U.S. and foreign affiliates for recent years have been collected on a performing basis, except for the years covered by benchmark surveys, or censuses, when the data were collected on both a performing and a funding basis. Data for most earlier years were collected on a funding basis. For the years for which they are available both on a performing and a funding basis, the magnitude of R&D performed is larger than or almost as large as the magnitude of R&D funded by these affiliates.

[7]BEA recently revised their cross-border trade survey to allow for the tabulation of estimates of trade in R&D services by both affiliated and unaffiliated businesses.

Estimating the extent or the location of spillovers requires more than an estimate of cross-border trade and R&D performed by multinationals. Knowledge can be transmitted and spillovers can occur without cross-border trade in R&D services, for example, through cross-border trade in goods and other services (Coe, Helpman, and Hoffmaister, 1995). [8] Coe, Helpman, and Hoffmaister conclude that developing countries can substantially boost their productivity by importing from developed countries a variety of intermediate products and capital equipment that embody advances from R&D. The magnitude of inward or outward foreign direct investment alone often does not suffice to estimate the extent of spillovers, even when R&D expenditures by parents and their affiliates is known. Researchers frequently use data on patents and patent citations (AlAzzawi, 2004) or data on royalties and license fees (Xu, 2000) to estimate knowledge flows and technology diffusion in combination with data on foreign direct investment (FDI). Fortunately BEA and the Census Bureau collect data on much of the information needed to supplement data on R&D services cross-border flows and R&D performed by multinationals, including data on other cross-border trade, inward and outward FDI, patent and license fees, and most of the other indicators mentioned at the beginning of this section. There is a large literature on international spillovers as well as a significant amount of relevant data, but the measurement and conceptual issues are complex. Accordingly, this section represents only a small first step towards quantifying the international dimension of the impact of R&D on U.S. economic growth.

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[8]This section has benefitted from discussions with Leo Sveikauskas on the literature on the international impact of R&D.

III. Changes in the NIPA's Arising from the Capitalization of R&D

Capitalizing R&D expands the scope of NIPA investment. Current NIPA measures of investment include plant, equipment, and inventories acquired by private businesses, nonprofit institutions, and government, and net foreign investment, and exclude household consumer durables, as well as most intangible capital, such as R&D, and, until the 1999 comprehensive NIPA revision, software. R&D expenditures are now treated as an intermediate input for businesses and current consumption for nonprofit institutions and general government.[9] However, changing the treatment of R&D in the NIPA's is more complicated than simply adding R&D expenditures to NIPA investment.

Capitalizing R&D produces several changes in the national accounts which are summarized in Table 1. The first change is to treat R&D expenditures by business as investment on the expenditure side, and not as an intermediate expense. Because R&D is no longer considered an expense, property-type income increases by an amount equal to the expenditure, reflecting changes in profits and depreciation of R&D capital.[10] The second change is to reclassify R&D expenditures by nonprofit institutions and general government from consumption

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[9]All R&D activities are allocated to the general government sector in the national accounts.

[10]Property-type income was defined before the December 2003 NIPA comprehensive revision as the sum of corporate profits, proprietors' income, net interest, capital consumption allowances, inventory valuation adjustments, rental income of persons, business transfer payments, and surplus of government enterprises, less subsidies. Alternatively, it is gross domestic income (GDI) less compensation of employees, indirect business tax and nontax liabilities, and the statistical discrepancy.

to investment.[11] Consumption of nonprofit institutions serving persons is part of personal consumption expenditures (PCE) in the accounts and general government consumption is part of government consumption.[12] Third, capitalizing R&D expenditures of nonprofit institutions and general government increases consumption by an amount equal to private returns to nonprofit institutions and general government R&D. Private returns are returns to the performer of R&D as contrasted with spillover returns, which are returns to beneficiaries of the R&D other than the performer. Private returns can also be called imputed services from the R&D capital consumed by nonprofit institutions and general government in the current period, a terminology that highlights the consumption nature of these returns.

In contrast to the returns to business R&D, the returns to nonprofit institutions and general government R&D are less likely to be included in the existing measure of GDP or gross domestic income (GDI), partly because of the way in which nonprofit institutions and general government are counted in GDP and partly because of the different nature of nonprofit institutions and general government R&D. First, because the output of nonprofit institutions and general government is for the most part not sold in markets, it is assumed to be equal to their input costs. And because no input cost is associated with R&D beyond the original investment period and the

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[11]The expenditures include those by Federally Funded Research and Development Corporations (FFRDCs). Government entities which perform R&D, such as public colleges and universities, are all classified as being part of general government.

[12]Some nonprofit institutions serve business, not persons, but this is a quite small percentage of nonprofit institutions economic activity. Nonprofit institutions serving business are treated as businesses in NIPA.

R&D output is not sold in markets, no direct value is put on the returns to the R&D of nonprofit institutions and general government, resulting in an understatement of their R&D. Second, because much of the output of nonprofit institutions and general government R&D is likely to be in nonmarket goods and services, such as reduced morbidity and mortality, it is less likely to be included in GDP, which is a measure of market goods and services.

It is assumed that spillover returns are already included in the national accounts. This is tantamount to assuming that spillovers accrue to business, not to nonprofit institutions and general government. The outcome of R&D will impact on business profits. If R&D is successful (a failure), business performers will earn higher (lower) profits, which are included and recorded in the NIPA's. Spillovers from the success or failure of R&D undertaken by others can impact on business profits as well.

On the income or GDI side of the accounts, the net effect of the changes must be identical in magnitude to the changes made on the expenditure side of the accounts as the NIPA's are a double-entry system. Depreciation and profits must be added in an amount equal to private returns to nonprofit institutions. In addition, depreciation and current surplus of general government must be added in an amount equal to private returns to general government R&D.[13] Spillover returns, regardless of their source, are assumed to be already included in GDP. Thus, on the income-side of the national accounts, all returns to R&D capital can be identified – private returns to nonprofit institutions and general government R&D can be added to spillover returns

[13]Current surplus for general government is the category comparable to profits for private entities.

that are already included in GDP; that is, spillover returns from nonprofit institutions and general government R&D and social returns to business capital.

Treating R&D expenditures as investment in the NIPAs would make these expenditures fully comparable to expenditures on other intangibles, such as software, that are already considered investments.[14] This treatment represents a step toward producing a comprehensive and more accurate measure of investment and savings in the United States. NIPA, as well as capital stock and depreciation, the value of services from R&D and other fixed capital and net domestic product and, as a result, improved measures of economic output and growth.[15] It provides a basis for addressing important macroeconomic, technology, and tax policy concerns and better informs policymakers about the true size of national saving and the nature of choices being made between current and future consumption.

Although this treatment provides conceptually improved estimates of output and growth, R&D is not treated as investment in the NIPA's for several reasons. First, R&D expenditures do not have an easily identifiable set of assets that can be measured or valued in a balance sheet.[16] Unlike plant and equipment and software, R&D capital is not generally sold for a market price. Thus, estimating services from R&D capital cannot be easily imputed from a representative set of

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[14] Software was capitalized beginning with the 1999 comprehensive NIPA revision. For a description of the methodology and quantitative impacts, see Bureau of Economic Analysis (2000).

[15] Eisner (1989), pp. 14-17.

[16] See System of National Accounts 1993, for discussion of treatment of R&D in the national accounts, pp. 9-10, para. 1.51.

market values as can be done, for example, with imputed rents from owner-occupied housing. It is usually measured on a cost basis, and does not represent a final demand value. Second, the rate of return to business R&D is included in the returns to all fixed capital -- plant, equipment, and R&D; separating out the returns to R&D is as thorny a problem as estimating services of R&D capital. A third and related problem is one of appropriability; other private producers may also benefit from the R&D, either as imitators or as buyers of the new product incorporating the new technology. Also difficult to determine are spillover benefits from nonprofit institutions and government R&D investments, and those spillovers, such as pollution reduction R&D, from which society as a whole benefits and for which no market exists. Other problems in measuring R&D capital and R&D services include the choice of deflators, service lives, depreciation, the rates of return, and the lag structure, or the length of time before the benefits from R&D are realized.

These problems create uncertainty with estimates of R&D capital and its rate of return, but can be addressed by using a supplemental or satellite account. Satellite accounts provide a means of experimenting with methods of estimating R&D capital and alternative scenarios of R&D returns to get a picture of the order of magnitude of the size and impact of R&D capital on GDP, without reducing the usefulness of the main accounts. Fraumeni and Okubo (2002, forthcoming) test the sensitivity of the estimates using alternative assumptions about the R&D

deflator, depreciation rates, and the lag structure; in this paper only three alternative scenarios are presented.[17]

IV. Assumptions

The spillover assumption and other assumptions made in constructing the R&DSA are listed in Table 2.

A number of researchers have estimated the private and social rates of return to private R&D capital. In general, these returns are gross returns, including both the net return to capital and depreciation.[18] Private rates of return average from 20 to 30 percent. These private rates of return reflect the returns received by the innovator. Social rates of return, which include the spillover benefits, are much higher, ranging from an average lower bound of about 30 percent to an average upper bound of 80 percent.[19] Although researchers have in various ways attempted to include nonmarket benefits, for the most part they reflect spillovers that we assume are already included in GDP.

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[17]Fraumeni and Okubo also includes and extended discussion of what current NIPA includes and excludes, largely based on Mansfield, et. al. (1977) and presents equations which show how the NIPA estimates are modified if R&D is capitalized.

[18]Bureau of Labor Statistics (1989), p. 39.

[19]See Council of Economic Advisers (CEA) (1995), p. 5. The CEA table is adapted from Griliches (1992) and Nadiri (1993). Leo Sveikauskas has pointed out in conversations that the rates of return shown in the CEA table represent different types of returns. For example, what is called a private return may be a return not only to the R&D performer, but also to all other firms within the industry. However, his conclusion is that the rates of return used by Fraumeni and Okubo are reasonable rates of return, if anything perhaps somewhat too low.

The private rates of return to R&D based on these studies are considerably higher than the average returns to other types of investments. It can be argued that R&D investments would require a higher rate of return than other investments because of the risk and uncertainty attached to R&D. There are more failures than successes associated with R&D investments – the rule of thumb often used is that for every successful project, ten projects fail. In addition, businesses investing in the R&D must take into account the likelihood of imitation by competitors, and also the uncertainty in the timing of commercialization of the R&D project, especially for basic and applied research. Because of the wide range of estimated rates of return, the assumption made is that the average private rate of return is 25 percent and the average social rate of return, which includes spillovers, is 50 percent.[20]

Because nonprofit institutions and general government tend to focus their R&D on nonmarket benefits and do not have to pass the market test that private firms do, their rate of return on R&D is arbitrarily assumed to be one-third smaller than the return to private R&D; that is, the private rate of return for nonprofit institutions and general government is assumed to be 16.7 percent, and the social rate of return, 33.4 percent.

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[20]A Joint Economic Committee Staff Report (U.S. Congress, (1999), p. 12) concluded that it is reasonable to assume that the private rate of return is about 25 percent and that the social rate of return is about twice as high as the private rate. The Economic Report of the President concludes that the social return to R&D averages about 50 percent (Economic Report of the President (1995), Box 3-5, p. 122). A recent study of patenting by R&D laboratories of a manufacturing firm conducting R&D estimated the average private rate of return to product R&D to be about 21 percent (Arora, Ceccagnoli, and Cohen (2002)).

A simplified capital service flow equation is used in this paper to estimate returns to R&D capital; all tax terms are ignored:

(1) Return = net return + depreciation, or

(2) $Return_t$ = net rate of return * capital $stock_{t-1}$ + depreciation rate * capital $stock_{t-1}$,

where the rate of return is held constant for each scenario over all years, but varies depending upon whether a private, spillover, or social rate of return is employed. Ignoring the tax terms (such as those which would reflect the expensing of many R&D costs and the taxation of profits from R&D) on average tends to underestimate business returns to R&D. Tax terms are not an issue for nonprofit institutions and general government. Thus, since only nonprofit institutions and general government private returns to R&D capital are a return net addition to GDP (see Table 8), equation 2 provides a good approximation of additions to GDP due to R&D capitalization. Ideally, the equation should be revised to include taxes to adjust the estimates of the return to business R&D capital and the contribution of that capital to GDP growth.

R&D is deflated by the private fixed nonresidential investment chain-type price index from the pre-December 2003 NIPA comprehensive revision NIPA Table 7.6.[21]

The geometric depreciation rate is 11 percent, which is the same rate used in the 1994 BEA study. In the earlier BEA project, straight-line depreciation was combined with a Winfrey

[21]Pre-December 2003 NIPA comprehensive revision data is used throughout this paper as the gross domestic income components from BEA's GDP by industry program were not available when the R&D estimates were constructed.

(bell-shaped) retirement distribution to construct the BEA R&D capital stocks because this methodology was used at the time to construct BEA estimates of fixed tangible capital stocks. The R&D service life was adjusted to mimic a target 11-percent geometric rate of depreciation since this rate was approximately the midpoint of then available estimates of R&D depreciation rates. The previous project compared estimates using the straight-line/Winfrey methodology and an 11-percent geometric rate, and found that the differences were "modest".[22]

The lag is a one-year lag which is the same lag length used in the 1994 BEA estimates of R&D capital. Past studies have identified two types of lags: Gestation lags and application lags. Gestation lags refer to the time needed to complete an R&D project, and application lags, to the time between completion of the R&D and its initial commercialization. Past research has found that the gestation lags range between 1 to 2 years and that application lags range from less than 1 year to 2 years.[23] A one-year lag assumption takes into account only the gestation period. In subsequent research a longer lag may be employed; the alternative scenarios discussed later use up to a 7 year lag.

With a one-year lag, expenditure in one year becomes investment of the following year, and there is an entry for change in R&D-in-progress.

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[22]See Carson, Grimm, and Moylan (1994), p. 45 and box, p. 48, for a comparison for selected years.

[23]Carson, Grimm, and Moylan (1994), p. 44. See also Bureau of Labor Statistics (1989), pp. 6-7, 19-21, for a discussion of studies that look at the lag between research and profits and productivity growth.

The investment equation is as follows:

(3) GDP total investment$_t$ = expenditures$_{t-1}$ + change in R&D-in-progress$_t$ = expenditures$_t$,

where by definition:

(4) Change in R&D-in-progress$_t$ = expenditures$_t$ - expenditures$_{t-1}$, and

(5) Completed R&D$_t$ = expenditures$_{t-1}$

The original BEA investment and capital stock estimates were updated through 2002 for this paper based on NSF expenditure data.[24] All calculations are done on a performer basis, rather than a funder basis.[25] The NSF nominal dollar expenditure data from 1992 are adjusted for differences in the levels and composition of BEA and NSF R&D expenditures using a regression approach. One basic difference between the BEA and NSF R&D data is the allocation of R&D expenditures by public colleges and universities. BEA allocates these expenditures to government while NSF allocates these expenditure to nonprofit institutions. The NSF data only identify R&D expenditures by the Federal government, not by State and Local governments. To adjust for these differences, for the three performer categories: business, general government, and nonprofit institutions, simple linear regressions of the BEA categories against a constant time trend and nearest comparable NSF category are fit for 1953-1992. A time trend

[24]See National Science Foundation (2001A, 2003).

[25]Using a performer basis begs the question of whether it is the performer or the funder, if different from the performer, who receives the private return.

times NSF data interaction term is included in the general government performer equation as the associated coefficient is significant. In all cases, the adjusted R-squared is above .9 and all coefficients are highly significant. The results from the fitted equation are used to forecast what BEA values would have been for 1993-2002. This is a simplified approach; in the earlier project a number of specific adjustments were made to the NSF data.[26]

The same deflator is used to deflate R&D investment, stock, and returns to R&D. Additive aggregation is used when creating R&D totals as there are no differences in the underlying deflator.

A chain index number formula is used to aggregate across estimates, say consumption and investment, with different underlying deflators, unless a component is negative. For example, if GDP is equal to the sum of investment (I) and consumption (C), the rate of growth of aggregate 1996 dollar adjusted GDP is calculated as

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[26]In the earlier project, statistical adjustments made included those for timing and geographic coverage and to fill in missing data for some industries for some years (see Carson, Grimm, and Moylan,(1994), p. 42. These adjustments raised the nominal dollar level of R&D expenditures in most years above those reported by the National Science Foundation (NSF), by at most 3 percent. In a few years, 1961-64, the nominal dollar expenditures are very slightly lower than those reported by NSF, at most by .4 percent. The level of the estimated nominal1993-2002 R&D data is always above the level of the NSF data, again by at most 3 percent.

(7) .5*(nominal dollar I_{t-1}/nominal dollar adjusted GDP_{t-1}

+ nominal dollar I_t/nominal dollar adjusted GDP_t)

* (real I_t/real I_{t-1}-1)

+ .5*(nominal dollar C_{t-1}/nominal dollar adjusted GDP_{t-1}

+ nominal dollar C_t/nominal dollar adjusted GDP_t)

* (real C_t/real C_{t-1}-1),

a methodology parallel to that used to estimate contributions of R&D to growth (see footnote 40). The growth rates are then used to extend the real adjusted GDP series before and after 1996, the base year.

Additive aggregation is used when a component is negative.

V. Effects of the Proposed Changes in Estimates

Capitalizing R&D increases the level of real and nominal GDP and affects the components of the accounts. It has a very small effect on the rate of growth of real GDP, but a significant effect on the composition of GDP and on our understanding of the sources of economic growth. Capitalizing R&D also raises investment and therefore savings, and GDP. Specifically, over the 1961-2002 period.

--- The rate of growth of real GDP is increased by less than 0.1 percentage point and the nominal level of GDP is increased by 2 percentage points.

--- The distribution of consumption and investment in the economy is changed and the national savings rate is raised by 2 percentage points, from 19 to 21 percent.

--- Regardless of the alternative assumptions made about R&D service lives, depreciation, lag in benefits, or deflators, R&D is a significant contributor to economic growth, with the contribution of returns to R&D capital ranging from 4 to 15 percent of GDP growth.[27]

A. NIPA Tables with Adjusted Measures

Changing the treatment of R&D in the national accounts changes the measures of PCE, investment, and profits and other property-type income in the accounts. Tables 3 and 4 show the changes to the national accounts by providing a numerical link between current measure GDP and adjusted GDP for selected years: 1961, 1966, 1973, 1995, 2000, and 2002. Table 3 focuses on expenditure components (GDP); Table 4 focuses on income components (GDI). The difference between GDP and GDI is the statistical discrepancy, which is unaffected by the innovations in the R&D Satellite Account.

Table 3 shows GDP by expenditure categories. It highlights significant changes to the accounts by capitalizing R&D. The biggest addition is business fixed investment. Reclassifying R&D by nonprofit institutions and general government from consumption to investment does not change GDP except through private returns (returns to these performers). The share of business R&D in total R&D varies from 68 percent to 75 percent for the years shown, with the shares for

[27] Rates of growth are computed throughout this paper from endpoint to endpoint. For example, the 1961-2002 rate of growth of adjusted GDP is calculated as [(1996 dollar adjusted GDP_{2002}/1996 dollar adjusted GDP_{1961}) raised to the power (1/(2002-1961))-1] all times 100.

1966, 1973, and 1995 on the lower end of the range. The share of nonprofit institutions R&D is total R&D is relatively constant, varying from 7 percent to 9 percent of total R&D. During the 3 middle years shown: 1966, 1973, and 1995, it is the share of government R&D investment in total R&D investment that increases when the share of business R&D investment in total R&D decreases. Private R&D investment is 11 to 12 percent of gross private domestic investment (GPDI) except in 1973 when it is only 9 percent of GPDI and in 2002 when it is 14 percent of GPDI. Private returns to R&D capital of nonprofit institutions and general government has a small impact on GDP. They amount to less than 1 percent of current measure GDP. Depreciation, one component of private returns to R&D capital, is commonly larger than the net return, the other component. The net return is to the performer only (excludes spillovers), but depreciation is on the total R&D capital stock. The magnitudes for private R&D investment are larger than those for private returns to R&D performed by nonprofit institutions and general government.

The addenda to Table 3 shows how current measure GDP changes when R&D is capitalized, and shows separately a R&D component and a net return component in the adjusted GDP. First, R&D investment is listed as an addition, but a significant portion of R&D expenditures is subtracted because it is included in current measure GDP. This portion includes R&D expenditures of most nonprofit institutions and of general government.[28] The largest

[28]Some government R&D investment is already capitalized in the current national accounts measures. Adjustments are made to deduct what can be specifically identified: R&D software defense expenditures, from the estimates of other than R&D investment, capital stock, and depreciation.

component of R&D expenditures excluded from current measure GDP is expenditures for R&D performed and funded by business.[29] The subtractions are a substantially smaller part of R&D fixed investment in 2002 than they are in 1961, and reflect the larger share of R&D performed and funded by business in all R&D in 2002. Of total returns to R&D, only returns to the performer are a net addition to GDP for the reasons outlined previously.

Table 4 focuses on components of GDI. The rates of growth of the 1996 dollar estimates for returns to R&D capital are inputs to the contribution calculations, along with current dollar shares. The share of all returns to R&D in adjusted GDP doubled between 1961 and 2002, rising from less than 4 percent to 8 percent. Returns to business R&D consistently represent the largest component of R&D, averaging close to 80 percent of total returns to R&D in all years shown.

The addenda to Table 4 presents a similar comparison for GDI as that shown in the addenda to Table 3 for GDP. The total of all returns to R&D capital is shown in the first block of entries after the entry for current measure GDP. The main body of the table separates these returns by sector, that is, private or government, and breaks them out into net return and depreciation. All (social) returns to business R&D and spillover returns to nonprofit institutions

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[29]General government funds R&D performed by business and nonprofit institutions, business funds R&D performed by nonprofit institutions and general government, and nonprofit institutions fund R&D performed by general government. Of these five cross-funding categories, only general government funding represents more than 1 percent of total R&D expenditures. According to our estimates, from 1961-2002 general government funding of business represented on average 34 percent of total R&D expenditures, while general government funding of nonprofit institutions represented 7 percent. The treatment of all cross-funding, except in the case of general government funding business, depends on whether the funding is a transfer or a contract.

and general government are subtracted because they are included in current measure GDP. As is required by a double-entry national accounts system such as the NIPA's, GDP from the expenditure- (product) side is exactly equal to GDP from the income-side.[30]

B. Effects on GDP, GDI, and National Savings

Capitalizing R&D affects both the product (GDP) and income (GDI) sides of the national accounts in a double-entry system. It affects estimates of savings, investment, and the returns to R&D and property-type income.

Savings and Investment

Capitalizing R&D has a significant effect on measures of savings and investment. It raises the estimate of investment and, therefore, the estimate of national savings. R&D investment is large relative to the current measure of investment, representing on average 13 percent of current measure investment (Table 5).[31] Table 6 shows that capitalizing R&D raises the national savings rate around 2 percentage points. As defined in NIPA Table 5.1, the national savings rate is equal

[30]The statistical discrepancy, which is the difference between GDP on the expenditure- (product) side and GDI on the income-side, is not shown as it is unchanged and has no impact on the estimates or the analysis.

[31]When growth rates are calculated, the periods are: 1953-60, 1961-66, 1966-73, 1973-95, 1995-2000 and 2000-2002; when shares or contributions are calculated, the periods are: 1953-60, 1961-66, 1967-73, 1974-95, 1996-2000, and 2001-2002.

to gross investment (the sum of gross private domestic, gross government, and net foreign investment) less the statistical discrepancy, divided by GNP.[32]

Tables 5 and 7 show that historically there is substantial variation in the rates of growth of R&D investment. In 1953-61, the rate of growth of both business and nonprofit institutions R&D expenditures are very high, but in 1961-66 and 2000-2002 it is the rates of growth for nonprofit institutions and general government that stand out. R&D expenditures by business performers accelerated notably in the second half of the nineties, during the so-called "new economy" period. The annual rates of growth for total real R&D shown in Table 7 range from a low of -4 percent in 1970 to a high of 24 percent in 1956.

The variation in the adjusted national savings rate measure by period shown in Table 6 primarily arises from variations in the current measure national savings rate, which ranges from a low of 15.7 percent in 2001-2002, to a high of 21.3 percent in 1961-66. The downward trend in the current measure national savings rate is due in part to the trends in net foreign investment. Net foreign investment is positive until the early seventies when it turns negative, but it is still positive for the majority of the decade. From 1983 onwards it is negative except for in 1991. The 2001 recession and the statistical discrepancy impacts on the national savings rate in 2001-2002. From 2000-2002 the decline in nominal gross private domestic investment exceeds the increase

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[32]As GNP is the market value of goods and services produced by labor and property supplied by U.S. residents, regardless of where they are located, GNP is equal to GDP plus net income from the rest of the world.

in nominal government investment, at the same time the statistical discrepancy (a subtraction) is positive.

R&D is a much smaller percentage of current measure investment in the first period, 1953-61, then in all subsequent periods. During that first time period, current measure nominal investment declined in several years.[33] On the other hand, R&D investment experienced a high rate of growth in all years from 1953-1961.

Although business performers have consistently accounted for at least two-thirds of R&D investment, the type of R&D performed and the funding of R&D has changed over time. Although the share of basic research in total R&D has doubled over the period from 1953 to 2002, from 9 percent in 1953 to 18 percent in 2002, the share of total basic research performed by business decreased from one-third to about one-sixth. However, from 1986 to 1997 the share rose substantially, with businesses performing about one-fourth of total basic research. Looking at the three categories of R&D, businesses performed the largest share of development R&D: the business share ranging from three-quarters to nine-tenths of total development R&D during the period 1953-2002.[34] The share of total basic R&D performed by the Federal

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[33]See pre-comprehensive BEA fixed asset table 7.5 and NIPA Table 1.1 for real government investment and real gross private domestic investment, respectively.

[34]The three categories of R&D are "basic research, " work undertaken to acquire new knowledge without any particular application in mind, "applied research," aimed at gaining the knowledge to meet a specific recognized need, and "development," which is the systematic use of the knowledge gained from research directed toward the production of useful materials, devices, systems, or methods. See National Science Board (1998), pp. 4-9.

government declined from 22 percent in 1961 to 9 percent by 2002.[35] The share of total basic R&D performed by nonprofit institutions, primarily universities and colleges, rose by about 30 percent, although not monotonically, from 45 percent in 1953 to about 75 percent in 2002.[36] In the 1960s and early 1970s, general government on net funded the bulk of total R&D, especially for defense and the space race.[37] The Federal government funding share of total R&D has declined steadily from a peak of around two-thirds in the first half of the sixties to approaching one-quarter by 2002.

Returns to R&D and Property-type Income

This section describes the effect of capitalizing R&D on the income side of the accounts.

GDI rises by the same amount as the increase in GDP (see Table 8), as capitalizing R&D increases property-type income. The returns to R&D capital can be separated out from other types of capital, and its share of property-type income can be identified.

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[35]This paragraph depends almost exclusively on R&D data from NSF. The government and nonprofit institutions sectoring used by NSF differ from those in the rest of this paper. The relevant NSF categories are Federal government, universities and colleges, and other nonprofit institutions. In this paper, following Carson, Grimm, and Moylan (1994), R&D expenditures by public universities and colleges are allocated to general government. In this paragraph when the term "Federal government" is used, BEA 1994 definitions are being employed; when the term "general government" is used, NSF definitions are being employed.

[36]National Science Board (2004) Chapter 4 and the Appendix tables to Chapter 4.

[37]Funding of general government R&D by others is subtracted from general government R&D expenditures, including funding of others, to arrive at net funding by general government.

The share of property-type income in GDI increases on average by 1 percentage point per year, (see Table 9), due to capitalizing R&D. The share of returns to R&D in adjusted property-type income is significant, averaging 20 percent (see Table 9). Except for 1961-66, when the share of property-type income in GDI is relatively high, there is little variation in the share of R&D returns in property-type income.

C. Effects on Variables Used in Growth Analysis: Property-type Income and Gross Returns to Capital

The growth accounting model provides the basis for estimating the returns to R&D capital and the contribution of R&D to economic growth on the income-side. By typically excluding R&D capital, past analyses of sources of economic growth have attributed property-type income to fixed assets other than R&D capital. Accordingly, the rate of return to fixed assets and the contribution of those assets to GDP growth on the income-side have been overstated. Distinguishing the return to R&D capital, from returns to other types of capital provides a means of determining its size relative to other types of traditionally measured returns to capital and, therefore, R&D's relative contribution to economic growth.

The basic growth accounting model equation is:

(6) ROG of Q = α_K* ROG of K + α_L* ROG of L + λ, where

α_K = nominal dollar property-type income share = rS/p_QQ,

α_L = nominal dollar labor income share = wH/p_QQ, ROG is the abbreviation for rate of growth, Q is real output, K is real capital input, L is real labor input, $p_Q Q$ is nominal dollar output, and λ is the rate of productivity change.

Equation 6 is revised to include R&D capital as follows:

(7) $$\text{ROG of } Q = \alpha_{R\&D} * \text{ ROG of } K_{R\&D} + \alpha_O * \text{ ROG of } K_O + \alpha_L * \text{ ROG of } L + \lambda,$$

where the subscript R&D refers to R&D capital and O refers to all other capital. The contribution of R&D to economic growth on the income-side is equal to $\alpha_{R\&D}$* ROG of $K_{R\&D}$/ROG of Q; the contribution of other assets is α_O* ROG of K_O/ROG of Q.

Equation 7 of this paper shows the revisions needed in the basic growth accounting model to allow for incorporation of R&D capital. Gross return to capital is defined as property-type income divided by fixed capital stock. Distinguishing R&D fixed capital stock and property-type income from fixed capital stock, other than R&D, and the related property-type income allows for the estimation of gross rates of return for R&D capital, as distinct from all other capital. Property-type income is the same as what would be used in the construction of the alphas, the income shares, in equations 6 and 7.

In the current NIPA's, rates of return on capital tend to be overstated as R&D stock is not included in the capital stock denominator, yet most of the return to R&D capital is included in the property-type income numerator. The returns to R&D additions to GDP amount to 1 percent of current measure GDP, yet R&D fixed capital stock averages 6 percent of current measure fixed capital stock.[38] However, the effect on the gross return to total fixed capital stock is small as the changes are a relatively small percent of the current measure totals.[39]

D. Sources of Growth Analysis: Contributions of R&D to Growth

Contributions of R&D to growth are estimated on the income-side.[40] Table 10 shows the contributions for a base case, for the alternative scenario which results in the lowest estimate of the contribution of R&D to GDP growth, and for the alternative scenario which results in the highest estimate of the contribution of R&D to GDP growth. For 1961-2002, the contribution of return on R&D capital to growth in adjusted GDP averages 11 percent.[41] Since much is unknown about R&D, such as the appropriate deflators, depreciation rates, lengths of gestation and application lags, and spillover gross rates of return, a number of alternative scenarios are analyzed in Fraumeni and Okubo (forthcoming) using different assumptions about the deflators,

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[38]See Fraumeni and Okubo (2002, forthcoming).

[39]If inventories and land (including subsoil minerals) were included in the estimate of capital stock, both the current and adjusted measure of the gross rate of return would be lower.

[40]Annual approximate contributions are calculated in this paper as a weighted growth rate, where the weights are the average share in the preceding period and the current period. For example, the contribution of R&D investment to growth in adjusted GDP is calculated as .5*(nominal dollar return to $R\&D_{t-1}$/nominal dollar adjusted GDP_{t-1} + nominal dollar return to $R\&D_t$/nominal dollar adjusted GDP_t)* ((real return to $R\&D_t$/real return to $R\&D_{t-1}$)-1)*100. An average of the annual contributions is then calculated and reported in Table 10.

[41]Griliches (1973) p. 78, estimates the product-side contribution of R&D to GDP growth to be .34 percent as of 1966, probably considerably less. Our estimate of this contribution is .22 for the 1961-66 period (see Table 10).

depreciation rates, lag structure, and the spillover gross rates of returns.[42] All of these scenarios are updated through 2002 for this paper, but only two scenarios are shown in the table as they provide a range for the possible contribution of R&D to GDP growth. The contribution estimates range from a low of 4 percent to a high of 15 percent. A higher depreciation rate is the main factor which lowers the contribution from the base case; however, lowering the spillover gross rate of return is also a factor. Other variations in assumptions are less important. Using the information processing equipment and software deflator alone accounts for the 4 percentage point increase of the contribution from the base case to the highest contribution case. The alternative scenarios that R&D is an important source of GDP growth regardless of the assumptions adopted.

For the base case and for the alternative scenario which results in the highest estimate of the contribution of R&D to GDP growth the contribution of R&D to GDP growth is very high. This is because GDP growth is very low for 2001-2002: 1 percent (see Table 5), because returns to R&D enter with a one-year lag, and the rate of growth of spending on R&D is very high from 1995-2000: 9 percent (see Table 5). In the alternative scenario which results in the lowest estimate of the contribution of R&D to GDP growth, the lag is seven years, so there is only a small impact of the high rate of growth of spending on R&D during the second half of the nineties. This result begs the question of whether R&D lags vary depending upon the business

[42]The BEA 1994 deflator is extended through 2002 using the GDP growth rate.

cycle. For example, do businesses defer bringing new products (created at least in part through their R&D efforts) to market during recessions or slowdowns?

VI. Conclusions and Future Research

Construction of the partial R&D Satellite Account within a NIPA framework allows for the estimation of the impact of R&D on GDP and other macroeconomic aggregates as well as the estimation of the contribution of R&D to economic growth using a sources of economic growth approach. The sources of economic growth approach is based on growth accounting models, which have been used to analyze the relationship between output and inputs in production and to determine the contribution of inputs, including R&D.[43] They are part of a rich tradition examining the sources of economic growth, including productivity growth, as epitomized by the work of Edward F. Denison, John W. Kendrick, Dale W. Jorgenson and his co-authors, and others such as Stephen D. Oliner and Daniel E. Sichel.[44] R&D expenditures have been listed as a possible cause of productivity growth in the attempts to identify the factors behind the so-called Solow residual.[45]

Substantial additional work is needed to determine the effect of R&D on GDP. A new focus of this paper is the global impact of R&D. Little is known about R&D cross-border

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[43]See op. cit., Solow (1957); and OECD (2001), Annex 3.

[44]See Denison (1985); Kendrick (1973); Jorgenson, Gollop, and Fraumeni (1987); Jorgenson and Stiroh (2000); Oliner and Sichel (2000); and Jorgenson (2001).

[45]See Denison (1979), pp. 122-127; and Kendrick and Grossman (1980), pp. 10, 16-18, and Chapter 6, pp. 100-111.

spillovers although a number of researchers have investigated this issue. There is no attempt in this paper to quantify these spillovers. The reasonableness of these assumptions made about the rates of return, depreciation rates, service lives, deflators, gestation and application lags still needs to be assessed. Each of these factors may have varied over time as the composition of R&D expenditures by performers has changed and the nature of technical change itself has changed. Also, the business cycle may affect timing, particularly lags. Also, further work is needed to determine whether or not the pattern of returns to R&D, both private and spillover, has varied over time or has remained constant. The pattern of returns may vary over the lifetime of a specific asset, may certainly vary from one investment to another, and may vary over time, for different vintages of R&D investment, because of the impact of economic slowdowns or other factors. Without a means of gauging these kinds of changes, assessing the effect of R&D on GDP is difficult. In addition, rates of return that may be appropriate for private R&D may not be appropriate for government R&D.

This paper is a another step in improving our understanding of the contribution of R&D to growth. It shows how a national income accounting methodology can be used to examine the role of R&D and how capitalization of R&D expenditures might affect GDP and raises the question of the international impact of R&D and which data might be of use in estimating that impact. BEA is currently undertaking a significant research project funded by NSF to examine the assumptions made, look at the possibility of constructing an industry level R&DSA, begin to quantify if possible the international dimension, and to produce annual BEA/NSF R&DSA's starting in 2006. BEA is looking forward to the challenges that such an undertaking represents.

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Table 1 Changes to the National Accounts					
R&D Imputations, R&D Performed By:	**GDP**			**GDI**	
	Treatment in Current Measure GDP	**Adjusted GDP**	**Change in Current Measure GDP**	**Adjusted GDI**	**Capitalizing R&D Change in Current Measure GDI**
Business	Intermediate input	Reallocate to investment	Increase	Increase in profits & depreciation	Increase
Nonprofit Institutions	Consumption (PCE)	1) Reallocate to investment 2) Increase in consumption = private R&D returns; spillover returns already in GDP	1) No change 2) Increase	Increase in profits & depreciation = increase in private returns to R&D capital; spillover returns already in GDI	Increase
General Government	Government consumption	1) Reallocate to investment 2) Increase in consumption = private R&D returns; spillover returns already in GDP	1) No change 2) Increase	Increase in current surplus & depreciation = increase in private returns to R&D capital; spillover returns already in GDI	Increase

Table 2
Assumptions

Benefits			
	Current Measures	Adjusted Measures (percent)	
Return to business R&D capital	Social benefits included	No change: Social benefits included	
Return to nonprofit institutions and general government R&D capital	Spillover benefits included	Private and spillover benefits included	
Gross Rates of Return			
Rates of Return on:	Private Return (percent)	Spillover Return (percent)	Social Return (percent)
Private R&D	25	25	50
Nonprofit institutions and general government R&D (2/3rds of the above rates)	16.7	16.7	33.4
Other			
Deflator		Depreciation Rate	Lag
Private fixed nonresidential investment		11%	One year

Table 3
Estimated Components for Adjusted Gross Domestic Product
(in billions of 1996 dollars)
(***Bolded italics*** titles show R&D components.)

Year	1961	1966	1973	1995	2000	2002
Adjusted gross domestic product*	**2,446**	**3,254**	**4,169**	**7,705**	**9,446**	**9,716**
Personal consumption expenditures	1,541	2,008	2,681	5,087	6,237	6,591
Nonprofit institutions						
Services						
Private returns to R&D capital*	**2**	**4**	**7**	**17**	**22**	**25**
Net return	1	1	2	6	7	9
Depreciation	1	2	5	11	14	17
Gross private domestic investment	304	483	652	1,286	1,993	1,843
Business fixed investment						
Completed R&D**	***33***	***43***	***47***	***121***	***195***	***224***
Change in R&D-in-progress**	***1***	***4***	***2***	***12***	***19***	***6***
Nonprofit institutions fixed investment						
Completed R&D**	***3***	***5***	***6***	***16***	***21***	***26***
Change in R&D-in-progress**	***1***	***0***	***0***	***1***	***2***	***2***
Net exports of goods and services	(18)	(40)	(62)	(78)	(399)	(489)
Government consumption expenditures and gross investment	673	834	901	1,411	1,596	1,724
Consumption expenditures						
Services						
Private returns to R&D capital*	**7**	**10**	**17**	**39**	**49**	**55**
Net return	2	4	6	13	17	19
Depreciation	5	7	11	26	32	36
Fixed investment						
Completed R&D**	***7***	***13***	***16***	***35***	***46***	***51***
Change in R&D-in-progress**	***1***	***1***	***1***	***2***	***1***	***7***

* Bolded numbers appear as listed in the addenda to the table below.
** The sum of the bolded italics numbers for completed R&D and change in R&D-in-progress appear in the addenda to the table below.

Table 4
Estimated Adjusted Components for Components of Gross Domestic Product by Industry Group
(in billions of 1996 dollars)
(***Bolded*** italics titles show R&D components.)

Year	1961	1966	1973	1995	2000	2002
Adjusted gross domestic product*	**2,446**	**3,254**	**4,169**	**7,705**	**9,446**	**9,716**
Private industries						
Property-type Income						
Returns to business capital						
Returns to R&D capital*	**73**	**120**	**178**	**438**	**568**	**663**
Net return	57	94	139	341	443	517
Depreciation	16	26	39	96	125	146
Returns to nonprofit institutions capital						
Returns to R&D capital*	**3**	**7**	**14**	**34**	**44**	**50**
Net return	2	5	9	23	29	34
Depreciation	1	2	5	11	14	17
Government						
Property-type income						
Returns to general government capital						
Returns to R&D capital*	**14**	**21**	**35**	**78**	**98**	**110**
Net return	9	14	23	52	66	74
Depreciation	5	7	11	26	32	36

* Bolded numbers appear in the addenda to the table below.

addenda:

	1961	1966	1973	1995	2000	2002
Current measure gross domestic product	2,432	3,228	4,123	7,544	9,191	9,440
Returns to R&D capital**	91	148	226	549	710	823
Returns to business capital	73	120	178	438	568	663
Returns to nonprofit institutions capital	3	7	14	34	44	50
Returns to general government capital	14	21	35	78	98	110
Less returns to R&D capital included in current measure GDP	82	134	202	493	639	743
All returns to business capital	73	120	178	438	568	663
Spillover returns to nonprofits institutions capital	2	4	7	17	22	25
Spillover returns to general government capital	7	10	17	39	49	55
Net increase in R&D expenditures in GDP	14	22	30	106	186	199
R&D fixed investment (Table 3)	45	67	73	187	284	317
Less R&D expenditures in current measure GDP (Table 3)	30	45	42	81	98	117
Adjusted gross domestic product	2,446	3,254	4,169	7,705	9,446	9,716

** Returns to R&D capital listed here include all returns to R&D capital, e.g., both private and spillover returns.
Note: The value of some entries is affected by rounding.

Table 5
Rates of Growth of Real R&D Investment
and Current Measure Real Gross Domestic Product (GDP),
& R&D Investment Share of Existing Measure
(percent)

Periods	Real R&D Investment				Current Measure Real GDP	Periods	Share R&D Fixed Investment is of Current Measure Investment*
	Total	Business	Nonprofit Institutions	General Government			
1953-61	11	12	16	6	3	1953-60	10
1961-66	8	7	14	12	6	1961-66	14
1966-73	1	1	1	3	4	1967-73	13
1973-95	4	5	4	4	3	1974-95	13
1995-2000	9	10	7	5	4	1996-2000	13
2000-2002	6	4	10	12	1	2001-2002	15
1961-2002	5	5	5	5	3	1961-2002	13
1953-2002	6	6	7	5	3	1953-2003	13

* Shares are average nominal dollar shares.

Table 6
National Savings Rate
(percent)

Periods	Adjusted Measure	Impact of Capitalizing R&D	Current Measure
1961-66	23.7	2.4	21.3
1967-73	21.9	2.2	19.7
1974-95	20.2	2.0	18.1
1996-2000	20.3	2.1	18.2
2001-2002	18.1	2.3	15.7
1961-2002	20.9	2.1	18.7

Note: Totals may be off by +/- .1 because of rounding.

Table 7
Real R&D Investment, Levels and Growth Rates
(in millions of 1996 dollars)

Year	Level	Rates of Growth	Year	Level	Rates of Growth	Year	Level	Rates of Growth
1953	19,285		**1974**	71,466	-2			
1954	20,878	8	**1975**	67,450	-6			
1955	22,814	9	**1976**	70,528	5			
1956	28,201	24	**1977**	72,330	3			
1957	31,536	12	**1978**	75,935	5			
1958	34,213	8	**1979**	80,500	6			
1959	38,585	13	**1980**	84,229	5			
1960	42,145	9	**1981**	87,703	4			
			1982	92,378	5			
1961	44,820	6	**1983**	102,978	11			
1962	48,081	7	**1984**	116,624	13			
1963	53,805	12	**1985**	128,877	11			
1964	58,521	9	**1986**	132,965	3			
1965	61,664	5	**1987**	138,452	4			
1966	66,584	8	**1988**	143,230	3			
			1989	148,425	4	**1996**	202,750	9
1967	68,839	3	**1990**	156,213	5	**1997**	220,665	9
1968	70,638	3	**1991**	163,144	4	**1998**	240,920	9
1969	71,459	1	**1992**	170,519	5	**1999**	262,470	9
1970	68,946	-4	**1993**	169,695	0	**2000**	283,782	8
1971	67,558	-2	**1994**	172,123	1	**2001**	301,233	6
1972	69,641	3	**1995**	186,737	8	**2002**	316,900	5
1973	72,594	4						

Table 8
Net Additions to GDP and R&D Totals
(as a percent of current dollar, current measure GDP)

Periods	Net Additions to Current Measure GDP			R&D Totals	
	Total	R&D Funded and Performed by Business	Private Returns to NP&GG from R&D Performed by NP&GG*	R&D Investment	Returns to R&D
1961-66	1	1	1	3	6
1967-73	2	1	1	3	7
1974-95	2	1	1	2	7
1996-2000	2	2	1	3	7
2001-2002	3	2	1	3	7
1961-2002	2	1	1	3	7

* Shares are average current dollar shares.
Note: Totals may be off by +/- 1 because of rounding.

Table 9
Share of Property-type Income in Gross Domestic Income (GDI)
& Share of Returns to R&D in Property-type Income
(percent)

Periods	Share of Property-type Income In Adjusted GDI	Difference Adjusted and Current Measure GDI	Share of Property-type Income In Current Measure GDI	Share of Returns to R&D in Adjusted Property-type Income
1961-66	36	1	35	16
1967-73	34	1	32	21
1974-95	35	1	34	20
1996-2000	37	1	35	19
2001-2002	36	2	35	20
1961-2002	35	1	34	20

* NP&GG is an abbreviation for nonprofit institutions and general government.
Note: Totals may be off by +/- 1 because of rounding.

Table 10
Contribution of Return to R&D Capital to Growth in Adjusted GDP
Alternative Scenarios: Lowest Contribution, Base Case, & Highest Contribution
(as a percent of GDP growth rate)

Scenario Variations	Lowest	Base case	Highest
Deflator	1994 BEA/GDP Deflator	Gross Private Fixed Nonresidential Investment Deflator	Information Processing Equipment and Software Deflator
Depreciation	Constant 20% Depreciation Rate for Business, 11% for NP&GG*	11% Depreciation Rate	11% Depreciation Rate
Lag	7 Year	1 Year	1 Year
Spillover Gross Rate of Return	Constant at 12.5% for Business, 8.3% for NP&GG*	Constant at 25% for Business, 16.7% for NP&GG*	Constant at 25% for Business, 16.7% for NP&GG*
Periods			
1961-66	4	11	12
1967-73	6	12	14
1974-95	4	10	17
1996-2000	3	9	12
2001-2002	5	38	46
1961-2002	4	11	15

* NP&GG is an abbreviation for nonprofit institutions and general government.