The Evolving Treatment of R&D in the U.S. National Economic Accounts

By Carol E. Moylan and Sumiye Okubo

Research and development (R&D) in the United States is sizable; by 2015, R&D expenditures totaled over $500 billion dollars. Total spending on R&D is now nearly the same size as private fixed investment in structures and about half the size of private fixed investment in equipment. (See table 1).

R&D has long been considered by economists as a driver of an economy's economic growth. Similar to expenditures on structures or capital equipment, expenditures on R&D may be viewed as generating future income and product. It provides benefits long into the future, especially with patent protections. It increases the stock of knowledge that in turn leads to new or improved products and processes. As such, R&D more closely resembles capital investment rather than intermediate inputs or current consumption. Yet, R&D is treated in business and tax accounting, and until 2013 in the U.S. economic accounts, as a current expense item for businesses, deducted from their sales along with other input costs of production.

This paper outlines changes in the treatment of R&D in the U.S. national economic accounts, from intermediate costs of production and current consumption to investment. It traces the development of a satellite account for R&D by the Bureau of Economic Analysis (BEA), from the initial examination published in 1994, followed by a 2002 paper that expanded the account. These advances were followed by the 2006 R&D Satellite Account,[1] additional improvements in 2007 and 2010, and finally incorporation of R&D as investment into the national economic accounts in 2013. Further improvements were introduced as part of the 2018 comprehensive update to the national accounts. Additional industry detail will be introduced as part of the 2020 annual update to the national accounts.

1. Sumiye Okubo, Carol A. Robbins, Carol E. Moylan, Brian K. Sliker, Laura I. Schultz, and Lisa S. Mataloni, "BEA's 2006 Research and Development Satellite Account: Preliminary Estimates of R&D for 1959-2002, Effect on GDP and Other Measures," *Survey of Current Business*, December 2006.

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The new treatment of R&D as capital represents a significant step toward producing a comprehensive and more accurate measure of investment and savings in the United States. It provides better estimates of capital stock and depreciation, the value of services from R&D and other fixed capital, and of net domestic product and, as a result, improved measures of economic output and growth. It provides an improved 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.

Table 1. Importance of Research and Development (R&D)
[Billions of dollars]

	1959	1997	2007	2012	2017
Gross domestic product	**521.7**	**8,577.6**	**14,451.9**	**16,197.0**	**19,519.4**
Research and development	**11.4**	**225.7**	**401.4**	**460.5**	**570.3**
Private	**4.4**	**148.1**	**268.0**	**313.4**	**422.0**
Business	4.2	139.9	254.5	291.9	395.8
Nonprofit institutions serving households	0.2	8.2	13.5	21.6	26.2
Government	**7.0**	**77.6**	**133.4**	**147.1**	**148.3**
Federal	6.8	70.7	119.3	131.4	128.8
Defense	5.7	33.6	62.5	61.5	55.0
Nondefense	1.1	37.1	56.8	69.9	73.8
State and local	0.2	6.9	14.1	15.7	19.5
Private nonresidential fixed investment					
Structures	18.1	250.3	510.3	479.4	586.8
Equipment	28.3	610.9	893.4	983.4	1,143.7
Addenda:					
R&D as a percentage of GDP	2.2	2.6	2.8	2.8	2.9
Nonresidential structures as a percentage of GDP	3.5	2.9	3.5	3.0	3.0
Nonresidential equipment as a percentage of GDP	5.4	7.1	6.2	6.1	5.9

For latest estimates, see the following NIPA tables:

Table 1.5.5. Gross domestic Product, Expanded Detail

Table 5.6.5. Private Fixed Investment in Intellectual Products by Type

Table 5.9.5. Gross Government Fixed Investment by Type

Background

R&D includes the sum of three types of activities: Basic research; applied research; and development. Basic research provides fundamental knowledge that leads to further advances in basic or applied research. Applied research uses both basic research and earlier applied research to make advances that can be used to produce new or improved products or processes. Development relies on both applied research and previous development efforts to provide new or improved products or processes. There are often lags in time before new knowledge from basic research is used to produce additional advances in basic research or in applied research, and in turn, to be used in development of new products and processes adopted or sold in the economy. Thus, expenditures on R&D may produce output and benefits long into the future, especially when such expenditures produce patent protections, and could be treated as investment—similar to business spending on structures and equipment—and included in a stock of intangible capital.

The System of National Accounts (SNA) is an internationally accepted set of guidelines developed under the direction of the United Nations Statistical Commission, with input from five major international organizations (European Commission, International Monetary Fund, OECD, United Nations, and World Bank), and from national statistics offices throughout the world that provides a framework for measuring national accounts. The 1968 revision of the SNA recommended the need for guidelines in national accounting for determining the boundary between current and capital expenditures for R&D.[2] Analysts, following this recommendation, proposed expanding the definitions of investment to include R&D and other types of intangible expenditures, as well as approaches to estimate the contribution of R&D to GDP.[3] These analysts led the effort to examine the role of R&D in the economy and how it influences future productivity and output. They began identifying items in the national accounts that are labelled R&D and other items that should be considered R&D. Their efforts started the process for producing a satellite account of R&D investment in the national accounts. As a result of these efforts, the 1993 update of the SNA encouraged countries to use a satellite account presentation in which to experiment with R&D as an investment. Finally, the 2008 revision of the SNA extended the asset boundary to include R&D as investment.

Satellite accounts provide a framework to expand the analytical capacity of the economic accounts without disturbing the core accounts. They provide detail that may not be seen in the standard accounts. These accounts usually focus on a specific activity, such as R&D, providing a flexible structure and expanding the existing detail. They also provide a “what if” scenario that allows national accounts offices such as BEA to experiment with new concepts before they are introduced into the core accounts. Satellite accounts are derived from the benchmark input-output accounts and are fully integrated with the national accounts.

The R&D satellite account served as a testing ground for a new concept (R&D as investment). It laid out possible methodologies for measuring R&D as an investment and the framework for including R&D investment that is consistent with measurement in the national accounts. It supplemented the official national accounts, providing greater detail and a basis for analyzing the impact of these investments on the U.S. economy. The results of these experimental estimates could then be discussed with others doing similar work in the international community in order to make additional improvements and to eventually derive new international standards.

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2. United Nations, *System of National Accounts, Revision*, (New York: United Nations, 1968).

3. See Nancy Ruggles and Richard Ruggles, *The Design of Economic Accounts* (New York: Columbia University Press, National Bureau of Economic Research, 1970); John Kendrick, *The Formation and Stocks of Total Capital* (New York: Columbia University Press, for the National Bureau of Economic Research, 1976); and Robert Eisner, *The Total Income System of Accounts* (Chicago, IL: University of Chicago Press, 1989).

1994 R&D Satellite Account

In 1992, BEA began taking a closer look at R&D, and how to change the treatment as a current expense, the treatment traditionally followed by business accountants. In 1994,[4] BEA initiated the development of a R&D Satellite Account. It laid out the foundations for the account, with the set of definitions of what is considered investment following the national income accounting rules, and a methodology for improving estimates of GDP that included spending on R&D as investment. The 1994 *Survey of Current Business* article systematically outlined the steps for changing the treatment of spending on R&D in the accounts. These steps were: (1) define and classify R&D spending by performers and funders; (2) design a methodology for creating a satellite account; and (3) estimate R&D expenditures, investment, capital stocks, and obtain data for these estimates.

In the national accounts, expenditures on R&D were treated as a current expense item for businesses, deducted from their sales along with other input costs of production. Business accountants treated R&D as a current expense, because the future benefits of individual projects are uncertain.[5] Expenditures on R&D by government and by nonprofit institutions and private universities were treated as expenditures on final goods and services. These expenditures were treated as current consumption for nonprofits and private universities, and as current spending by government entities (federal, state, and local). None were treated as investment. Spending by a U.S. resident for R&D performed abroad was treated as imports; and spending by a foreign resident performed in the United States, as exports.

Domestic R&D was only partly identifiable in the national accounts. The R&D satellite account provided a more complete picture of R&D activity within the GDP framework. It also provided an approach for valuing R&D as investment and the impact of this investment in the United States. R&D was measured by summing its production costs; there are few market transactions selling and buying R&D, and thus, no direct measures of output. The total of these costs was referred to as R&D expenditures. BEA used survey data from the National Science Foundation (NSF)—the Federal agency that is responsible for producing R&D-related statistics for the United States—to estimate R&D expenditures. These data were adjusted to be statistically and conceptually consistent with the national accounts. For example, the national accounts are measured in calendar years, rather than in the fiscal years that are collected by the NSF.

Methodology

The two major organizational groups in the satellite account were private and public. Private included business or industry; private universities and colleges; private hospitals, charitable foundations, and other nonprofit institutions serving households; and most federally-funded research and development centers

4. See Carol Carson, Carol Moylan, and Bruce Grimm. "A Satellite Account for Research and Development," *Survey of Current Business*, November 1994.

5. The national accounts did include another intangible asset—mineral exploration and development—within its estimates of nonresidential structures, even though businesses expensed some of these expenditures (e.g., dry holes).

(FFRDCs). Public (government) included Federal government, State and local governments, public universities and colleges, and FFRDCs administered by state and local governments.

Current-dollar expenditures. Capitalizing R&D expanded the scope and rearranged the national accounts. R&D expenditures funded by business were reclassified from a current business expense to business investment. These expenditures were added to business gross output as an imputation, causing business income to rise. R&D expenditures funded by nonprofit institutions and general government were reclassified from consumption to investment. Because consumption expenditures were already part of GDP, this shift alone did not change the measure of GDP. However, recognizing these expenditures as investment increased the services of R&D capital for nonprofit institutions and general government by their consumption of fixed capital (depreciation). This raised GDP because depreciation is treated as an expense for nonprofits and government.

For analytical purposes, the satellite account divided R&D expenditures into three groups: By performer with industry detail; by source of funding; and by type. Significantly more detail was shown for expenditures by performer than by source of funding. Information on performer by industry corresponded to the R&D performing company's primary industry or sector of origin in production.

Existing R&D survey data were not sufficient to completely identify ownership of R&D. An allocation by funder would be closer to an ownership basis than an allocation by performer. The funder of R&D was considered the owner, largely because the funder is usually the direct economic beneficiary of R&D; the performer is often not the major financial supporter. However, constant-dollar estimates by source of funding and by type, needed in the preparation of the capital stock, required additional work. Different types of R&D – basic, applied, and development – impact the economy in different ways and with different time lags.

Constant-dollar expenditures. To estimate constant-dollar R&D expenditures, BEA deflated the costs of R&D inputs by performer using weighted indexes of input prices.[6] The costs of inputs and input prices were used because R&D output and output price measures are not available. The R&D surveys from the NSF were used to derive the input costs at the finest level of detail possible with the limited cost information available. The cost components were matched as closely as possible to "proxy" prices (prices of inputs that closely match the components as possible).[7] The constant-dollar expenditures by performer were derived by summing the individual constant-cost components. This approach provided constant-dollar estimates that took into account the changing mix of R&D performers over time.

Deriving constant-dollar expenditures by funder and by type of R&D is more difficult. Most performers have multiple sources of funding, and conduct more than one type of R&D. As a result, additional detail was needed

6. In 1994, BEA had not yet moved to using a Fisher-chained weighted formula for estimating "real" or inflation-adjusted measures.

7. These "proxy" prices were used because data collected by the NSF do not always match coverage of data used by BEA. NSF data are collected by firm, i.e., a firm may produce turbines, household appliances, plastics, but its classification is based on the largest portion of sales. For national accounts, BEA divides up this production of products by industry. To use the aggregate classification would not show the kinds of information about industry output or value added.

on the cost components by funder and by type. While it was possible to derive constant-dollar estimates by funder when the performer and funder do not coincide, BEA was unable to derive estimates by type of R&D

Stocks of R&D capital

BEA produced estimates of R&D capital stock that were consistent with its approach to estimate tangible capital. Three elements were used to derive the R&D capital stock estimates: Performer breakdown currently available for constant-dollar R&D investment; current methodology used by BEA for fixed tangible capital stocks; and uniform service lives for R&D capital.

Scope of R&D capital. The estimates included all types of R&D in all fields, and provided estimates consistent with the view that R&D was a new form of wealth. The satellite account could not, however, provide the same level of detailed information by categories of R&D. In addition, these estimates included both successful and unsuccessful R&D, on the assumption that returns from successes are sufficient to pay for failures. This treatment was consistent with the national account treatment of mineral exploration expenditures that include both successes and failures.

Allocation of R&D capital and consumption of fixed capital (CFC). The satellite account provided the total R&D capital stock and the CFC on the basis of performer for private and government components, rather than by funder. Although an allocation by funder would be closer to an ownership basis than an allocation by performer, additional work was needed to provide constant-dollar estimates of R&D expenditures by funder in the satellite account.

Timing. The satellite account took into consideration the lags between the time an R&D project begins and the time the results are found in new products and processes. Two types of lags were identified: Gestation lags and application lags. Gestation lags are the time needed to complete an R&D project, and application lags refer to the time between R&D project completion and introduction of the results into commercial use. The sum of the two lags is the time it takes for R&D investments to produce new knowledge that is used commercially. These lags were found to vary from 1 to 2 years for gestation, and from 1 year to more than 2 years for application; these lags also varied by type of research (basic, applied, and development).

Only the gestation lag needed to be considered for the satellite account. It was assumed to be one year. But, because the national accounts include capital and labor used in the production process in the current period, another type of output had to be introduced with the gestation lag: R&D inventories, similar to work-in-progress for tangible capital goods that need more than a year to produce. At the end of the gestation period, R&D inventories must be added to stocks of intangible fixed capital.

Depreciation patterns and rates. R&D capital loses value over time because of obsolescence; new innovations, declines in effectiveness in the production process; leakage of technical knowledge to competitors; and expiration of intellectual property protection.

A depreciation pattern for R&D stocks was assumed. Without R&D capital markets, little information exists to put a value on "used" R&D capital. A European review of patent renewal rates found no definitive patterns, but it did find that patterns of depreciation could range from geometric to a straight line with a bell-shaped retirement distribution.[8]

The 1994 R&D satellite account used the same methodology that was used at the time for BEA's estimates of fixed tangible capital to construct the stock of R&D capital. It used the perpetual inventory method, with uniform average service lives, straight-line depreciation, and a bell-shaped distribution within each vintage of capital to determine discards. Replacement cost was used to measure the current-dollar stock of R&D, rather than historical cost.[9]

Highlights

The 1994 R&D Satellite Account provided a number of important results:

- Industry had performed two-thirds or more of R&D for the last 40 years.
- The Federal Government funded a large, but declining, share of R&D. The decline was steep after 1987.
- By 1992, basic research was 17 percent of all R&D, almost double its 1960 share. The offsetting decline was in development, which accounted for 59 percent of all R&D in 1992. The share of applied research was little changed.
- R&D funded by government and nonprofit institutions was equal to 1.2 percent of GDP in 1992, and R&D funded by industry was equal to 1.7 percent. Since 1960, the sum of the two ranged from 2.2 percent in 1978 to 2.9 percent in 1985 and in 1992.
- Constant-dollar expenditures increased at an average annual rate of over 7 percent from 1953 to 1968. Constant-dollar expenditures then leveled off for nearly a decade before resuming an uptrend, but at a more moderate rate.
- With lags and growing more smoothly, the constant-cost R&D net fixed capital stock mirrored the pattern of constant-dollar expenditures. In 1992, R&D capital would have added almost 9 percent to the net wealth of government and business.
- The average age of the constant-cost R&D gross fixed stock, a rough indicator of the age of the knowledge embodied in the stock, increased from about 6.5 years in 1960 to a high of 8.9 years in 1980. It then decreased to 8.2 years in 1992.[10]

8. For the review of patent renewal rates, see Ariel Pakes and Mark Schankerman, "The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return of Research Resources," in *R&D, Patents, and Productivity*, edited by Zvi Griliches, pp. 78-88, (Chicago: Un. of Chicago Press for the National Bureau of Economic Research, 1984).

9. See Carson, et.al., p. 44.

10. Ibid., pp. 45-46.

2002 R&D Satellite Account

The 2002 R&D Satellite Account[11] (R&DSA) extended the work presented in the 1994 R&D Satellite Account. It adjusted BEA's national accounts structure to include R&D investment and benefits, and it modified the expenditure and income sides of the accounts. It provided rough estimates of the impact of treating R&D as investment on GDP, gross domestic income (GDI), and savings. It updated information from 1992 to 2002, and provided an approach to assess the impact of R&D on the economy and growth. It was a partial R&DSA, providing a preliminary and exploratory examination of R&D in the U.S. economy, without fully developing other components, such as international, regional, and industry components.

The R&DSA used the sources of economic growth approach, based on growth-accounting models, to analyze the relationship between output and inputs in production and to determine the contribution of inputs, including R&D.

Background: Changing Treatment of R&D

The R&DSA: (1) capitalized R&D expenditures; (2) imputed a return to R&D capital, both private and social; (3) estimated the impact of R&D investment on GDP growth; and (4) provided estimates of investment, capital stock and wealth, saving, and returns to fixed capital, for all assets adjusted to exclude R&D. It tested the sensitivity of the estimates using alternative assumptions about the R&D deflator, depreciation rates, and the lag structure. It used a growth accounting model to estimate the returns to R&D capital.

Treating R&D expenditures as investment in the national accounts would make these expenditures comparable to expenditures on another intangible—software—that was already treated as capital.[12] This treatment represented a step toward producing a comprehensive and more accurate measure of investment and savings in the United States.

Similar to the 1994 account, R&D investment was shown by R&D performance (as opposed to funding) by business, government, and nonprofit institutions. The methodology assumed constant returns to scale and assumed that factors, including R&D capital, were chosen to minimize costs and hired until the marginal revenue products of these factors were equal to their purchase price.[13]

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11. See Barbara M. Fraumeni and Sumiye Okubo, "Using national accounts to assess the role of R&D in the U.S. economy," in *R&D and the knowledge-based society: Linking the production, dissemination, and application of research*, edited by Mu Rongping and W.A. Blanpied, (Beijing: Science Press, 2000), pp. 154-67; Fraumeni and Okubo, "R&D satellite accounts and the returns to private R&D," paper presented at the Allied Social Science Association Meetings, New Orleans, LA, January 7, 2001; Fraumeni and Okubo, "R&D in the national income and product accounts: A first look at its effect on GDP," paper presented at the National Bureau of Economic Research conference, Washington, DC, April 27-27. 2002; Fraumeni and Okubo, "R&D in the National Income and Product Accounts: A First Look at Its Effect on GDP," in *Measuring Capital in the New Economy*, National Bureau of Economic Research, Studies in Income and Wealth, V. 65, edited by Carol Corrado, John Haltiwanger, and Daniel Sichel (Chicago: Un. of Chicago Press, 2005), pp. 275-322.

12. Beginning with the 1999 benchmark update of the national accounts, expenditures on computer software were capitalized in the core accounts.

13. The methodology assumes that factor input markets are competitive, and that the firm takes factor prices as given and adjusts quantities of factor inputs to minimize costs. Each factor is hired until the marginal revenues it generates equals its price (e.g., for labor, the wage rate).

Changes in the national accounts

Capitalizing R&D expanded the scope of investment and produced several other changes in the composition of the national accounts on both the expenditure and income sides, and in the level of GDP. (see Table 2.)

Expenditures side. The R&DSA identified three categories of R&D performers: Businesses, nonprofit institutions, and general government.

As in the 1994 account, the current-dollar measure of GDP increased by the reclassification of business R&D expenditures from intermediate expense to investment. R&D expenditures of nonprofit institutions and general government were reclassified from consumption to investment. Consumption increased by an amount equal to the returns to nonprofit institutions and to general government R&D. These returns can also be called the imputed services from the R&D capital consumed by nonprofit institutions and general government – highlighting the consumption nature of these returns.

These reclassifications of R&D expenditures and imputations of returns to R&D capital changed the composition of GDP. The national accounts tables were revised to incorporate the changes and expanded detail for R&D. Capitalizing R&D had a significant effect on measures of consumption, investment, and wealth. It raised the estimate of investment and, therefore, the estimate of national savings, as well as capital stock.[14] R&D investment and R&D fixed capital stock, an important component of wealth, were large relative to current measures of investment and stock. Business performers accounted for more than two-thirds of R&D investment and capital stock. Notable period-by-period differences in the growth rate of R&D investment by performing sector may have had, and may continue to have, an effect on economic growth.

The returns did not include spillover returns; that is, returns to beneficiaries of the R&D other than the performer. The spillover returns were assumed to have been already included in the national accounts. These spillovers were assumed to accrue to business, not to nonprofit institutions or to general government. The outcome of R&D would affect business profits. If R&D were successful (a failure), business performers would earn higher (lower) profits, which were included and recorded in the national accounts. Spillovers from the success or failure of R&D undertaken by others can affect business profits as well.

14. The national savings rate is equal to gross investment (the sum of gross private domestic, gross government, and net foreign investment), less the statistical discrepancy, divided by gross national product.

Table 2. Capitalization of R&D

R&D Imputations, R&D Performed By:	GDP			GDI	
	Original Treatment in GDP	GDP: When R&D Capitalized	Change in GDP Measure	GDI: When R&D Capitalized	Change in GDI Measure
Business	Business expense	R&D spending reallocated to investment	Increase = R&D investment	Increase in profits & depreciation	Increase by the value of R&D investment
Nonprofit Institutions serving households	Consumption (PCE)	1) R&D spending reallocated to investment 2) Increase in PCE for services = private R&D returns; spillover returns already in GDP	1) No change 2) Increase = capital services (CFC plus net returns)	Increase in profits & depreciation = increase in private returns to R&D capital; spillover returns already in GDI	Increase by the value of capital services (net returns plus depreciation)
General government	Government consumption	1) R&D spending reallocated to investment 2) Increase in government spending on services = R&D returns; spillover returns already in GDP	1) No change 2) Increase = capital services	Increase in current surplus & depreciation = increase in returns to R&D capital; spillover returns already in GDI	Increase by the value of capital services (depreciation)

Income side. In a double-entry system like the national accounts, the net effect of the changes on the income or GDI side of the accounts must be identical in magnitude to the changes on the expenditure side of the accounts. GDI rises by the same amount as GDP, as capitalizing R&D increases gross operating surplus. Because R&D is no longer considered an expense, gross operating surplus increases by an amount equal to the expenditure, and reflects changes in profits and depreciation of R&D capital. Adjustments were made for the increase in profits and depreciation for business. Unlike business R&D capital where the return is already included in gross operating surplus, depreciation and profits (equal to private returns) on nonprofits' R&D capital must be added. Depreciation and current surplus of general government must also be added in an amount equal to the returns to general government R&D. The returns to R&D capital were separated out from other types of capital, and its share of gross operating surplus was identified. The share of returns to R&D in adjusted gross operating surplus was significant, averaging 20 percent over the period examined. Spillover returns, regardless of their source, were assumed to be already included in GDP.

Assumptions

R&D is not generally sold for a market price and is not easily identified. As a result, estimates of the value of services from R&D capital could not be easily imputed from other market values of similar types of capital.

Measures of R&D capital and services would require several assumptions for deflators, depreciation, service lives, rates of return, and lag structure (length of time before the benefits from R&D are realized).

The major sets of assumptions used to construct the partial R&DSA are outlined below: Returns to R&D and other parameters, including the deflator, depreciation, lags in service lives, and spillovers (see table 3).

Returns to 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. The social rate of return includes the private rate of return plus spillover returns.

Based on past studies, the private rates of return to R&D to business R&D capital could be assumed to be considerably higher than the average returns to other types of investments. It could be argued that R&D investments by businesses would require a higher rate of return than other investments because of the risk and uncertainty attached to R&D. Past studies found a wide range of rates of return, with private rates of return averaging 20 to 30 percent and social rates of return averaging 30 to 80 percent. In the partial R&DSA, it was assumed that the average private rate of return was 25 percent, the average spillover return was 25 percent, and the average social rate of return (the sum of the two) was 50 percent.[15]

Nonprofit institutions and general government tend to focus their R&D on nonmarket benefits and do not have to pass the market test like private firms. Their private rate of return on R&D was arbitrarily assumed to be one-third smaller than the return to private R&D. The assumed rates of return for nonprofit institutions and general government were: Private rate of return of 16.7 percent; spillover return of 16.7 percent; social return of 33.4 percent.

For the return to business R&D capital, social benefits were assumed to be included in current measures as well as adjusted measures. For the return to R&D capital for nonprofit institutions and general government, only spillover returns were assumed to be included in current measures; for the adjusted measures, private and spillover returns were both assumed to be included.

15. See Council of Economic Advisors (CEA), *Supporting R&D to Promote Economic Growth, 1995*. http//www.whitehouse.gov/WH/EOP/CEA/econ/html/econ-rpt.html; Zvi Griliches, "Research Expenditures and Growth Accounting," in *Science and Technology in Economic Growth*, ed. B.R. Williams (New York: Halstead Press, 1973), pp. 59-94; M. Ishaq Nadiri, "Innovations and Technological Spillovers," NBER Working Paper no. 4423 (Cambridge: National Bureau of Economic Research, 1993), http://papers.nber.org/papers/W4423.

Table 3. Assumptions for 2002 R&DSA

<table>
<tr><th colspan="4">Benefits</th></tr>
<tr><th></th><th>Current Measures</th><th colspan="2">Adjusted Measures (percent)</th></tr>
<tr><td>Return to business R&D capital</td><td>Social benefits included</td><td colspan="2">No change: Social benefits included</td></tr>
<tr><td>Return to nonprofit institutions and general government R&D capital</td><td>Spillover benefits included</td><td colspan="2">Private and spillover benefits included</td></tr>
<tr><td>Net return to other than R&D general government capital</td><td>n.a.</td><td colspan="2">3.5</td></tr>
<tr><th colspan="4">Gross Rates of Return</th></tr>
<tr><th>Rates of Return on:</th><th>Private Return (percent)</th><th>Spillover Return (percent)</th><th>Social Return (percent)</th></tr>
<tr><td>Private R&D</td><td>25</td><td>25</td><td>50</td></tr>
<tr><td>Nonprofit institutions and general government R&D (2/3rds of the above rates)</td><td>16.7</td><td>16.7</td><td>33.4</td></tr>
<tr><th colspan="4">Other</th></tr>
<tr><th colspan="2">Deflator</th><th>Depreciation Rate</th><th>Lag</th></tr>
<tr><td colspan="2">Private nonresidential fixed investment</td><td>11%</td><td>One year</td></tr>
</table>

Other Assumptions: Deflators, depreciation, lags in service lives

Deflators: The private nonresidential fixed investment chain-type price index from the pre-December 2003 national accounts comprehensive update[16] was used to deflate R&D.

Depreciation: The depreciation rate, a geometric rate of 11 percent, was the same rate used in the 1994 BEA study. The methodology was the same as that used to construct the BEA estimates of fixed tangible capital stocks. The R&D service life was adjusted to mimic a target 11-percent geometric rate of depreciation, which was approximately the midpoint of the available estimates of R&D depreciation rates at the time.

Lags in Service Lives: The lag structure was the same as that used in the 1994 BEA study. Under this assumption, it takes one year to complete an R&D project (gestation lag, the time to complete an R&D project.

16. Pre-December 2003 national accounts comprehensive update data were used because the gross domestic income components from BEA's GDP by industry program were not available when the R&D estimates were made. See national accounts Table 7.6, national accounts comprehensive update.

Effects on variables used in growth analysis: Gross operating surplus and gross returns to capital

A growth accounting model provided the basis for estimating the returns to R&D capital and the contribution of R&D to economic growth based on GDI. Distinguishing the return to R&D capital from returns to other types of capital provided 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 equation used in the basic growth accounting model showed the rate of growth of real output as a function of real capital input, real labor input, and the rate of productivity change.

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

Where: ROG = rate of growth

Q = real output

K = real capital input

L = real labor input

$\alpha_{R\&D}$ = current-dollar gross operating surplus from R&D share

α_O = current-dollar gross operating surplus from other-than-R&D share

α_L = current-dollar labor income share

λ = rate of multifactor productivity change

O = all non R&D capital

The gross return to capital is defined as gross operating surplus divided by the fixed capital stock. Distinguishing R&D fixed capital stock from fixed capital stock other than R&D stock allowed for the estimation of gross rates of return from R&D capital, as distinct from all other capital.[17]

Contributions of R&D to growth were estimated based on GDI components, using 3 scenarios.

- Scenario 1 (lowest contribution) assumed the 1994 BEA GDP deflator, a depreciation rate of 20 percent for business and 8.3 percent for nonprofits and general government, a 7-year lag, spillover gross rate of return of 12.5 percent for business, 8.3 percent for nonprofits and general government.
- Scenario 2, the **base** case, used the private nonresidential fixed investment deflator, and assumed a 11 percent depreciation rate, a 1-year Lag, spillover gross rate of return of 25 percent for business and 16.7 percent for nonprofits and general government.

17. Approximate annual contributions were calculated as a weighted growth rate, where the weights were 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 0.5*(nominal dollar return to R&D (t-1)/nominal dollar adjusted GDP(t-1)) + 0.5*(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.

- Scenario 3 (highest contribution) assumed the information processing equipment and software deflator, a 11 percent depreciation rate, a 1-year lag, spillover gross rate of return of 25 percent for business, and a rate of return of 16.7 percent for nonprofits and general government.

Effects of the proposed changes in estimates

Capitalizing R&D increased the levels of both nominal and real GDP and affected the components of the accounts. It had 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 raised investment, and therefore savings and GDP.

Over the 1961–2000 period:

- Capitalizing R&D increases the rate of real GDP growth by 0.1 percentage point.
- The distribution of consumption and investment in the economy changed, and the national savings rate rose by 2 percentage points, from 19 to 21 percent.
- The analysis showed R&D to be a significant contributor to economic and productivity growth. In the **base** case scenario, the contribution of R&D investment accounted for 3 percent of overall GDP growth and the contribution of returns to R&D capital accounted for 1 percent of GDP growth.
- R&D investment was on average 13 percent of current fixed investment; R&D fixed capital stock added 6 percent to current fixed capital stock.
- Returns to R&D capital represented 20 percent of property-type income.
- Regardless of the alternative assumptions made about R&D service lives, depreciation, lag in benefits, or deflators, R&D was a significant contributor to economic growth, with the contribution of R&D investment ranging from 2 to 7 percent of GDP growth and the contribution of returns to R&D capital ranging from 5 to 14 percent of GDP growth.

2006 R&D Satellite Account

The 2006 R&DSA extended previous efforts to assess the impact of R&D by looking at alternative scenarios that take into account the most important characteristics of R&D and developing a more complete national accounts framework to estimate R&D activity.[18] The account built on the earlier work at BEA on developing R&D satellite accounts by Carson, Moylan, and Grimm (1994) and Fraumeni and Okubo (2002).

BEA's 2006 satellite account introduced the presentation of the investment flows, the resulting stocks of R&D assets, and the income generated within the accounts for GDP and the national accounts sectors. For the first

18. For details, see Sumiye Okubo, Carol A Robbins, Carol Moylan, Brian K. Sliker, Laura I. Schultz, and Lisa S. Mataloni, "BEA's 2006 Research and Development Satellite Account: Preliminary Estimates of R&D for 1959-2002 Effect on GDP and Other Measures," *Survey of Current Business*, 86 (December 2006): 14-25.

time, BEA used the funder perspective to represent ownership and link the owner/funder to the direct economic benefits. Earlier versions of BEA's R&D satellite accounts were based on the performer of the R&D. Unlike the 1994 and 2002 versions, BEA no longer assumed a gestation lag.

The R&D satellite account was developed in partnership with the NSF. The NSF provided the funding for the project and their staff reviewed the methodologies and results.

Measuring R&D as investment

As stated in earlier sections, for most of the R&D conducted in the United States, there is neither an observable market price nor a product that can be used to measure output. BEA's standard approach to estimating nonmarket activity—such as the output of general government and nonprofit institutions as well as goods that businesses create for their own use—has been to measure the activity as the sum of input costs. For R&D, the detailed, 50-year time-series data collected by the NSF allowed this approach to be used.

However, the conventional use of the input-cost approach as a proxy measure of R&D output did not take into account the dynamism of R&D activity. The standard approach applied input price indexes to produce a measure of real output. Deflation using input prices assumed that the output prices were changing at exactly the same rate as input costs, precluding productivity gains that stemmed from R&D.

Products that embody a high level of R&D, such as computers and communications equipment, tend to have relatively short life cycles, paced by the rapid introduction of new, R&D-driven technologies. This relatively fast obsolescence means that the time period during which the costs of R&D must be recovered is short. In order to earn high rates of return, companies in R&D-intensive industries must raise the productivity of new products by lowering costs and increasing sales.

To take these market dynamics into account, the 2006 R&D satellite account explored the effect of R&D activity on the economy using four R&D scenarios—scenarios A, B, C, and D.

Four scenarios

Scenarios A, B, C, and D attempted to capture specific characteristics of R&D activity, such as relatively high productivity, rapid depreciation, and high rates of return (see table 4). The scenarios differed in regard to assumptions in four areas: Price indexes, depreciation, rates of return to business, and rates of return to government and nonprofit institutions serving households.

Price indexes. Because most R&D is not bought and sold on the market, its value to a company is embedded in the value of all the goods and services that it sells; there is no direct measure of the contribution of R&D to the sales or the market price underlying the R&D assets. Companies can report on all the costs of conducting R&D, but not the market price of R&D. Firms know the market price of other assets, like computers and communications equipment, the share of sales, share of profits (difference between sales price and cost of production), and therefore, estimates of the real (inflation-adjusted) value of these assets is straightforward. The real value of these assets can be estimated by dividing the current-dollar value of these assets by a price index based on their sales. This is not true for R&D.

Four different scenarios were used to estimate the value of real R&D investment:

- In Scenario A, real R&D was based on the measure of input costs, deflated by a price index created from information on the cost components for R&D. This approach implies zero productivity growth because real output, by definition, grows at the same rate as real inputs, and therefore, is not a good measure for a dynamic sector like R&D.
- In Scenario B, real R&D output was assumed to be higher than the value of real R&D input by the amount of productivity growth recorded in higher productivity industries. The price index used to calculate real output was calculated by subtracting average multifactor productivity (MFP) growth for a group of manufacturing industries with the highest MFP growth from the increase in the price indexes used in scenario A. This adjustment provided a cost-based index that reflects the high productivity growth of R&D.
- Scenario C assumed that the value of real R&D output was proportional to the output prices of the most productive industries. Real R&D output was estimated using a weighted average of BEA's GDP-by industry value-added price indexes for key high-productivity service industries: Air transportation, broadcasting and telecommunications, securities and commodity brokers, and information-processing and data-processing industries.
- Scenario D assumed that the value of real R&D output was proportional to the output prices of R&D-intensive products. The prices of these products were assumed to be the best proxies for the value of R&D embodied in these products. This index was calculated from price indexes for the largest R&D-performing manufacturing industries: Chemicals, computer and electronic products, machinery, and aerospace and defense.

Table 4. 2006 R&DSA, Assumptions for the Different Scenarios

Parameter	A	B	C	D
Depreciation of R&D	15 percent	before 1987: change in private fixed investment in nonresidential equipment and software depreciation after 1987: information processing equipment depreciation	Same as B	Same as B
Price index	Input cost-component based	cost-based price index adjusted to proxy high-productivity growth in manufacturing	composite price index based on value added of five high-productivity service industries	composite price index based on the value added of the four industries that perform the most R&D
Net return to business R&D (capital services)	Same as other fixed assets	average net rate of 15 percent	Same as B	Same as B
Net return to general government and nonprofit R&D (capital services)	none	estimated net return based on long-term average in the real 10- year treasury rate, plus a higher premium for R&D investment	Same as B	Same as B

Depreciation. BEA used ranges of average annual depreciation rates estimated in past economic studies.[19] For business R&D, the range was between 12 and 25 percent. For government and nonprofit institutions, the depreciation was expected to be lower because R&D is closer to basic research and would be likely to obsolesce more slowly.

The assumed depreciation rate for Scenario A was 15 percent a year. Scenarios B, C, and D used a methodology based on previous academic studies.[20] It took into account changes in the pace of technology change in recent years and, therefore, an accelerating rate of depreciation. The depreciation rate before 1987 was

19. See Ariel Pakes and Mark A. Schankerman, "The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources," in *R&D, Patents, and Productivity* (Chicago: University of Chicago Press, 1984); M. Ishaq Nadiri and I. R. Prucha, "Estimation of the Depreciation Rate of Physical and R&D Capital in the U.S. Total Manufacturing Sector." *Economic Inquiry*, 34 (January 1996): 43–56; Baruch Lev and Theodore Sougiannis, "The Capitalization, Amortization, and Value Relevance of R&D," *Journal of Accounting and Economics*, 21, 107-138; Jeffrey Bernstein and Theofanis P. Mamuneas, "Depreciation Estimation, R&D Capital Stock, and North American Manufacturing Productivity Growth," Paper presented at the Bureau of Economic Analysis, Washington, DC, November 4, 2004.

20. See Ricardo J. Caballero and Adam B. Jaffe, "How High are the Giant's Shoulders: An Empirical Assessment of Knowledge Spillovers and Creative Destruction in a Model of Economic Growth," in *NBER Macroeconomics Annual 1993*, edited by Olivier Blanchard and Stanley Fischer (Cambridge MA: The MIT Press, 1993).

assumed to be equal to the rate of overall investment in equipment and software. After 1987, the rate was assumed to be equal to the depreciation rate for information-processing equipment and software. The resulting depreciation rates were about 16 percent in 1959 and reached 23 percent in 2002.

Business rates of return. Past studies found the range of rates of return for R&D was high relative to other investments. Total returns that include spillovers were even higher—about twice the corresponding private returns to the originators of R&D.[21] More recently, higher returns (than those determined in earlier studies in 1970s and 1980s), were necessary to offset the increasing rates of technical obsolescence, faster depreciation, volatility, and risk that have occurred for products that embody R&D, such as computers, software, and other information-communications- technology products.

The rate of return to business R&D investment for Scenario A was assumed to be an average rate of 11 percent in 1959–2002, the same rate as other private fixed investments. For scenarios B, C, and D, a higher average rate of return of 15 percent was assumed.

Returns to government and nonprofit institutions. Net returns to fixed assets owned by government and nonprofit institutions were not included in the national accounts in 2006. The accounts treated depreciation (CFC) of these assets as a partial measure of the services they provide; the net return was zero.

Scenario A adopted the 2006 national accounts treatment; it did not account for any net returns to R&D investment by government and nonprofit institutions serving households. Scenarios B, C, and D assumed a net rate of return to R&D investment equal to the average real rate on ten-year Treasury securities, adjusted to reflect a higher return to R&D relative to other investments. These returns were deflated by a price index created for Scenario B based on the high-productivity services-sector industries.

Impact on key national accounts measures

Scenario D was used as the featured measure for the estimates for the 2006 R&DSA. These results were approximately mid-range of the three high-productivity options.[22]

Scenario comparison. Scenario A produced the smallest impact on GDP of the four alternatives. It assumed no productivity growth. In 1959–2002, R&D boosted current-dollar GDP level by an annual average of 2.3 percent, and the average contribution of R&D to real GDP growth was 2.2 percent.

The high-productivity-growth scenarios, B, C, and D, showed an average increase in the level of current-dollar GDP of 2.6 percent. Differences in contributions to growth of real GDP among the scenarios were very small (from 4.3 to 4.9 percent). Scenario B, which used the high MFP index, had the largest contribution to

21. *Op. cit.*, pp. 22-23. Spillovers are not explicitly identified and included in the national accounting framework. The accounts value assets at their private value, the value to the owner. Effects are implicitly reflected in the market prices, but not estimated.

22. Detailed tables, along with an overview of the terms and methodology used in the construction of the tables can are found at https://www.bea.gov/newsreleases/general/rd/2006/pdf/rdreport_append.pdf .

growth (4.9 percent) in 1959–2002. Scenario C used the composite price index from high-productivity services industries, and showed an average contribution to growth of GDP of 4.3 percent in 1959–2002 and 6.3 percent 1995–2002. Scenario D, which used a composite price index for R&D performing industries, had similar results, with 4.7 percent in 1959–2002 and 6.7 percent in 1995–2002.

Highlights

The 2006 account made clear that treating R&D as an investment would have a substantial impact on GDP and other measures. Highlights from the 2006 satellite account included the following:

- Current-dollar investment in R&D totaled $276.5 billion in 2002.
- Recognizing R&D as investment would increase the level of current-dollar GDP by an average 2.5 percent per year in 1959–2002.
- R&D investment and the income flows arising from accumulated R&D capital would account for about 4.5 percent of real GDP growth in 1959–2002. In 1995–2002, R&D investment would account for about 6.5 percent of growth.[23]
- R&D investment would increase current-dollar gross private domestic investment in 2002 by more than 11 percent, or $178 billion. The national saving rate in 2002 would be 16 percent, instead of 14 percent.
- Business investment in R&D as a percentage of GDP surpassed government investment as a percentage of GDP in 1981.
- Business investment accounted for just under 2 percent of current-dollar GDP in 2000, compared with just over 1 percent in 1960.

2007 Update of R&DSA

The 2007 R&DSA updated and extended the estimates of the effect of R&D on economic growth that were published in the 2006 R&DSA.[24] Because the R&DSA was a prelude to bringing a new treatment of R&D into BEA's core accounts scheduled for 2013, BEA begin experimenting not just with an alternative treatment in GDP, but also with the industry, regional, and international aspects of a new treatment of R&D.[25]

Thus, the account was completely re-estimated beginning with 1959 to incorporate several enhancements to the 2006 R&DSA:

- Several enhancements were made to estimation methods.

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23. Results based on estimates that value real (inflation adjusted) R&D at prices of products produced by R&D-intensive industries.

24. For additional information, see Carol A. Robbins and Carol E. Moylan, "Research and Development Satellite Account Update: Estimates for 1959-2004, New Estimates for Industry, Regional, and International Accounts," *Survey of Current Business* 87 (October 2007): 49-92.

25. Because the focus of this article is on national and industry estimates of R&D, this paper will not be discussing the regional and international aspects of the satellite account.

- For the first time, BEA provided industry-specific estimates of R&D investment, gross output, and value added.
- Two years of data (2003–2004) were added to the estimates and previous years were revised.

Estimation enhancements

The 2007 update of the R&D satellite account made several enhancements to estimation methods:

- **Eliminating double-counting.** A double-count embedded in the R&D investment and software investment estimates was eliminated. With the release of the 1999 comprehensive update of GDP, BEA began treating three types of computer software spending—prepackaged software, custom software, and own-account software—as investment, and thus, they were included in GDP.[26] Within the NSF source data, the cost of developing software that is marketed outside the company is treated as an R&D activity. These costs were double counted in the 2006 R&DSA, once in R&D investment and once in software investment. BEA removed the amount from the software investment estimate, retaining it in R&D investment because the satellite account was designed to focus on R&D as a capitalized asset.
- **International transactions adjustment.** Estimates of R&D investment were adjusted to account for international transactions (R&D output performed in the U.S. and used abroad and R&D output performed abroad and used in the U.S.).
- **Profit margin adjustment.** The valuation of business purchases of R&D was improved. The 2007 update distinguished between two types of industry investment in R&D output: Business purchases of R&D and own-account investment. Own-account R&D is the R&D output that businesses develop in-house for their own use, instead of for sale to others. The NSF values business R&D performance on a cost basis. Because BEA estimates the value of own-account investment as the sum of costs, no adjustment was needed for own-account R&D investment. For businesses purchases of R&D, BEA wanted the value that the buyers of the R&D spent, not the cost to the sellers of the R&D. So, BEA added an adjustment to the NSF-based value to include the R&D seller's margin between receipts and costs. This adjustment was used for both business purchases from other businesses and for business purchases by the Federal government.
- **Price indexes for R&D output.** The updated R&D account presented new estimates of real R&D investment based on two price indexes instead of the four shown in the 2006 satellite account. A new featured aggregate output price index was chosen that better reflected the value of R&D investment to the industries that purchase or create R&D for investment purposes. This price index was a Fisher-weighted average of the output prices of 13 R&D-intensive industries; the index was weighted according to each industry's share of annual business R&D investment. It assumed that there are common factors in R&D production processes across industries and the new index tended to average out the extreme effects of rapidly falling or rising output prices for particular products.

26. Own-account software includes all in-house software development, whether it is for software to be used exclusively for internal company operations or for software to be marketed outside the company, such as a firm developing a software program for widespread distribution.

The previous 2006 R&DSA featured a price index (from scenario D) created with a combination of value-added prices and output prices for the four industries that performed the most R&D. The new index used gross output prices derived mainly from Bureau of Labor Statistics (BLS) producer price indexes. The new index also included all 13 R&D-intensive industries rather than a subset and incorporated a finer adjustment for industry weighting and updating. The estimates that result from the new price index were similar to the previous estimates

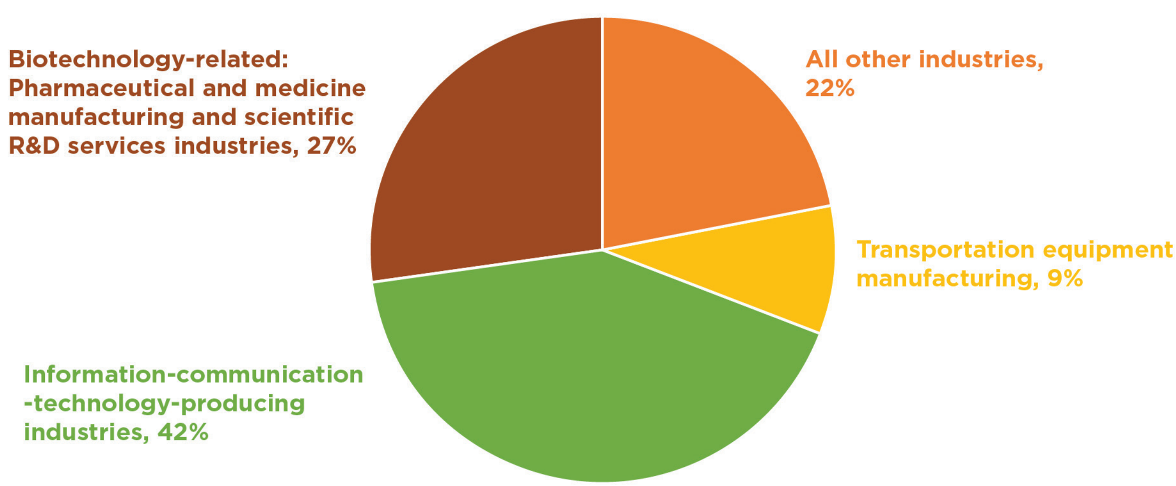
The input price index for R&D investment continued to be based on an aggregation of detailed price indexes for the inputs used to create R&D output.

R&D by industry

The 2007 R&D satellite account estimates provided a first look at the impact of recognizing R&D as investment on private industry gross output (GO) and on value added.[27]

The industry satellite account provided detail for a set of 13 R&D-intensive industries that accounted for more than two-thirds of business R&D investment in 2004 and that had the highest ratios of R&D investment to industry receipts. These industries included pharmaceutical and medicine manufacturing, computer and peripheral equipment manufacturing, semiconductor manufacturing, software publishing, computer systems design and services, and six other detailed industries. The new statistics showed (chart 1) that the "information, communication, and technology (ICT) and biotechnology-related industries would have accounted for two-thirds of the business sector's R&D contribution to GDP growth between 1995 and 2004.

Chart 1. Sources of Business R&D's Contribution to Real GDP Growth, 1995–2004



Source: U.S Bureau of Economic Analysis[28]

27. For more information on gross output and on value added, see appendix at the end of this paper.

28. See page 58 of Carol A. Robbins and Carol E. Moylan, "Research and Development Satellite Account Update: Estimates for 1959-2004, New Estimates for Industry, Regional, and International Accounts," *Survey of Current Business* 87 (October 2007)

GO and value added. As stated above, the 2007 update distinguished between two types of industry investment in R&D output: Business purchases of R&D and own-account investment. Treating own-account R&D as investment would add an equal amount to both GO and value added. The value of intermediate inputs would not change. Business purchases of R&D would not affect industry GO, but they would change intermediate inputs because these purchases would be reclassified as investment. The value of intermediate inputs would fall by the value of the R&D investment, and value added would increase by the same amount.

Establishment-based approach. Estimates of R&D investment by industry were prepared using an establishment-based approach. This is consistent with the framework used for BEA's GDP by industry accounts, and it provides for a better understanding of the industry behavior of R&D activity.

In an establishment-based approach, the R&D activity, performed at different establishments within a company, are assigned to the industries where the establishments are located. In contrast, the NSF source data assign all of a company's R&D activity to the company's primary industry. BEA adjusted the NSF data to assign R&D activity across all of company's establishments to the appropriate industries. Unpublished data from the Census Bureau were used to approximate the portion of each company's R&D expenditures performed in R&D laboratories and in company headquarters.

Valuation adjustment for purchased R&D. The NSF values business R&D performance on a cost basis. As stated earlier, the value of purchased R&D should include the R&D seller's margin between receipts and costs. BEA used a multi-step process to first make the split between own-account and purchased R&D and to then add a profit margin.[29]

From R&D performance to investment. The R&D account featured industry R&D investment, not performance. To adjust from a performance measure to a funding (or investment) measure, BEA:

- Subtracted the cost of R&D funded by the federal government, by state and local governments, and by nonprofit institutions serving households; the cost of R&D sold to other domestic businesses; and that which was exported.
- Adjusted for an undercount of software R&D in the NSF data.
- Added purchases of nonscientific R&D from for-profit R&D services establishments.
- Added industry-funded R&D performed by academic institutions, non-profit institutions serving households, by federally funded research and development centers, and by state and local governments.
- Added domestic purchases of R&D from other for-profit companies and imports of R&D.

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29. For a more detailed explanation, please see the BEA paper by Carol A. Robbins, Felicia V. Candela, Mahnaz Fahim-Nader, and Gabriel W. Medeiros, "*Methodology for the Industry Estimate*, December 2007" (This paper is part of a series of methodological papers released on the BEA web site documenting the 2007 R&D satellite account and its treatment of key issues, December 2007), www.bea.gov/papers/pdf/industrymethods.pdf.

Comparison of the 2007 and 2006 R&DSA estimates

The picture of the economy presented in the revised estimates was similar to that shown by the estimates published in 2006. However, in the 2007 vintage estimates, current-dollar investment in R&D was higher for all years. Similarly, for the period 1959-1999, current-dollar GDP was higher; it was lower beginning with 1999 due to the increasing impact of the software adjustment.

Highlights

- R&D as investment would have accounted for a 7-percent share of the average GDP growth rate from 1995 to 2004.
- Current-dollar private fixed investment for 2004 would have been 8.8 percent, or $166.3 billion, higher than published private fixed investment. This measure removed the double-counting of R&D expenditures in software investment.
- For the first time, BEA provided R&D statistics for R&D-intensive industries. The largest contribution from an R&D intensive industry to average real GDP growth from 1995 to 2004 would have been from the pharmaceutical and medicine manufacturing industry. The second largest contribution would have been from the software publishing industry.

2010 Update

By extending the estimates through 2007, the 2010 update of the R&DSA now included coverage of the business cycle expansion that ended in December 2007. The estimation methodologies used for this update were consistent with the methodologies used for the 2007 update. Most of the improvements were made to the estimates of R&D investment by industry.

Estimation improvements

The 2010 update made several improvements to estimation methods:

- **Incorporation of comprehensive update for GDP.** The updated estimates of R&D investment by industry incorporated the results of the 2009 comprehensive update of the national accounts and the 2010 comprehensive update of the annual industry accounts. These updates did not change the overall picture presented in the 2007 update.
- **Introduction of new R&D industry.** BEA began separately identifying the finance, insurance, real estate, rental and industry. In the 2007 update, this industry had been included in the "all other for-profit industries." As a result, the number of detailed R&D industries increased from 13 to 14.
- **Expanding the scope of the industry account.** The R&DSA by industry was expanded to include R&D investment by non-profit industries and by government to show a more complete picture of R&D investment in the GDP by industry accounts.

Highlights

- Growth in R&D investment from 1995 to 2007 continued to track with business cycles.
- Between 1998 and 2007, GDP would have been, on average, 2.7 percent, or $301.5 billion higher if R&D spending was treated as investment.
- R&D as investment would have accounted for a 7.1 percent share of the average GDP growth rate from 2002 to 2007.
- Recognizing R&D as investment changed the relative importance of the 14 R&D intensive industries as contributors to economic growth. The pharmaceutical and medicine manufacturing industry's share of growth in real private industry value added would be almost four times larger (1.9 percent compared with the unadjusted estimate of 0.5 percent).
- At 29 percent of the business sector's R&D investment, the 2007 biotechnology-related industries' share had more than doubled from 1998.

2013/2014 New Treatment of R&D in the Core Accounts

As part of the 2013 comprehensive update of the national accounts and the 2014 comprehensive update of the industry accounts, BEA expanded its asset boundary within its core accounts to recognize R&D expenditures as investment, not as a current expense.[30] This change in the treatment of R&D occurred almost 20 years after BEA first introduced the concept of an R&D satellite account. Over that time period, international guidelines—in particular, the *System of National Accounts 2008*—changed to recommend that R&D be treated as an investment.[31] Also, the methodologies used by both BEA and the international community to measure that R&D investment and its stocks of capital evolved and improved significantly.

New treatment

BEA now recognized expenditures for both purchased and own-account R&D by businesses, nonprofit institutions serving households, and general governments as fixed investment and the depreciation of those assets in consumption of fixed capital (CFC). The funder of the R&D, as reported in the NSF surveys, is classified as the owner of the R&D. BEA continued to rely primarily on NSF's R&D surveys to estimate R&D investment. As with the satellite account, BEA adjusted the NSF data for coverage, scope, and to align with the framework and concepts of the national accounts.

One difference in focus from the satellite account and the introduction of R&D into the core accounts was the treatment of R&D software. BEA now excluded R&D software from the estimates of R&D as they were

30. For a more detailed explanation, see Marissa J. Crawford, Jennifer Lee, John e. Jankowski, and Francisco A. Moris, "Measuring R&D in the National Accounting System," *Survey of Current Business* (November 2014): 1-15.

31. European Commission, International Monetary Fund, Organization for Economic Co-operation and Development, United Nations, and World Bank, *System of National Accounts 2008* (New York:2009).

already included in BEA's estimates of software investment. In the satellite account, BEA had removed the double-count of R&D software from software investment and retained it in R&D investment because the emphasis of the account was on R&D.

In addition to the reclassification of government R&D spending from consumption to investment, the new treatment of R&D also changed the classification of government spending between the federal government and state and local governments. The federal government is a major funder of R&D through research grants, while state and local governments are major producers of R&D at public universities and hospitals. Because ownership of the R&D asset is assigned to the funder of the R&D, federally funded R&D performed at public universities and hospitals was now recorded as federal gross investment in R&D.

Price deflators for R&D were needed to develop inflation-adjusted measures for investment, stocks, and depreciation. Unfortunately, as mentioned earlier in this paper, prices for R&D are generally unobservable, given that much of R&D is produced for own use and that R&D projects are generally heterogeneous. The satellite account experimented over time with several possible choices for price deflators, including input cost and output price indexes. In bringing the new treatment into the core accounts, BEA decided on an input cost approach with a productivity adjustment.

For the business depreciation of R&D, BEA significantly improved upon earlier methodologies used in the satellite account. BEA now used a forward-looking profits model that derived R&D depreciation rates for certain R&D intensive industries.[32]

Effects on GDP

The impact on GDP of recognizing R&D as investment was significant. The 2013 definitional change that had the largest impact on the level of GDP was the capitalization of R&D—accounting for over half of the upward revision for all years from 1959 forward. For 2012, total R&D investment was $396.7 billion or 2.4 percent of revised GDP.

2013 Comprehensive Revision of GDP
[Billions of dollars]

	1959	1997	2002	2007	2012
Gross domestic product	522.5	8,608.5	10,977.5	14,606.8	16,497.4
			Revision in Level		
Gross domestic product	15.9	276.1	337.9	480.7	559.8
From capitalization of R&D	8.7	207.0	244.4	330.9	396.7

32. Wendy C.Y. Li and Bronwyn H. Hall, "Depreciation of Business R&D Capital," Bureau of Economic Analysis R&D Satellite Account Paper (August 2016); https://www.bea.gov/research/papers/2016/depreciation-business-rd-capital.

One tradeoff with the recognition of R&D as investment was the loss of a satellite account dedicated to R&D. Some detail is no longer provided. For example, BEA no longer publishes estimates of R&D output by performer and no longer breaks down the industry investment into own account and purchased R&D. Unlike the satellite accounts, BEA does now provide some quarterly detail; estimates of total private fixed investment in R&D and of government investment in R&D may now be found quarterly on BEA's national accounts website. Annually, BEA does provide some detail for business and for nonprofit institutions serving households.

Intellectual property products.

As part of the 2013 comprehensive update, BEA also recognized entertainment, literary, and artistic originals as investment. As a result, BEA created a new category of fixed investment: Intellectual property products (IPPs). This category consists of private fixed investment in software, in R&D, and in entertainment, literary, and artistic originals. Private investment in software was previously included in the "equipment and software" category. Annually, BEA produces tables for private fixed investment in IPPs that includes industry detail for the most R&D intensive industries. Table 5, taken from BEA's website, shows the level of detail available for annual estimates of private fixed investment in intellectual property products.

Table 5. Detail for BEA's family of tables 5.5.x, Private Fixed Investment in Intellectual Property Products by Type

Line	
1	**Private fixed investment in intellectual property products**
2	**Software**
3	Prepackaged
4	Custom
5	Own account
6	**Research and development**
7	Business
8	Manufacturing
9	Pharmaceutical and medicine manufacturing
10	Chemical manufacturing, excluding pharmaceutical and medicine
11	Semiconductor and other electronic component manufacturing
12	Other computer and electronic product manufacturing
13	Motor vehicles, bodies and trailers, and parts manufacturing
14	Aerospace products and parts manufacturing
15	Other manufacturing
16	Nonmanufacturing
17	Scientific research and development services
18	All other nonmanufacturing
19	Nonprofit institutions serving households
20	Universities and colleges
21	Other nonprofit institutions
22	**Entertainment, literary, and artistic originals**
23	Theatrical movies
24	Long-lived television programs
25	Books
26	Music
27	Other

2018 Enhancements in the Core Accounts

In the continuing evolution of the treatment of R&D in the U.S. economic accounts, BEA made two enhancements to R&D as part of its 2018 comprehensive update of the national economic accounts: A reclassification of software R&D and an introduction of capital services into own-account investment.

Reclassification of software. In 2013, when BEA expanded its asset boundary within its core accounts to recognize R&D expenditures as investment, BEA excluded R&D software from the estimates of R&D as they were already in BEA's estimates of software investment. This treatment created an inconsistency in the classification of software R&D between the national economic accounts and the estimates produced by the NSF, the primary provided of the R&D data used by BEA. It also created an inconsistency between the core accounts and BEA's previously published R&D satellite accounts. As part of the 2018 comprehensive update, BEA reclassified R&D for own-account software originals from software to R&D. This reclassification removes these inconsistencies.

Introduction of capital services into own-account investment. As mentioned earlier in this paper, BEA's approach for measuring own-account R&D as investment has been the sum of production costs. These costs included the reported charges for depreciation of fixed assets used in the production of this own-account investment, but, with the exception of the 2002 R&DSA, it excluded the value of the return to capital. As part of the 2018 comprehensive update, BEA replaced their depreciation measure with a BEA-derived measure of capital services that reflects both the depreciation and the return to capital. These capital services measures are based on BLS external rates of return and on BEA data on prices, depreciation, and capital stocks to estimate capital services.

Effects on GDP

The reclassification of own-account software originals from software to R&D decreased software investment and increased R&D by equal amounts; GDP was not impacted. The introduction of capital services into own-account investment of R&D increased R&D and GDP by equal amounts, beginning with 2008. The largest impact was $14.4 billion in 2017.

2020 Expansion of Industry Detail

In the continuing evolution of the treatment of R&D in the U.S. economic accounts, BEA plans to expand the NIPA tables 5.6.x to provide a greater level of detail for the "all other nonmanufacturing" R&D industry. This industry will now be split into four separate industries: Software publishers, financial and real estate services, computer systems design and related services, and other nonmanufacturing, NEC. The publication of the new industry detail will be particularly useful for users who have wanted to be able to identify software R&D. This expanded detail allows them the ability to view a measure of software investment that includes software R&D.

Conclusion

Over the last 25 years, BEA has made great strides in improving the treatment of R&D in the U.S. national economic accounts. BEA will continue to improve on the measurement of this important intangible asset. In particular, more research is still needed to improve the estimates for deflation and returns to R&D.

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