Measuring R&D in the National Economic Accounting System

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ECONOMISTS HAVE LONG recognized that research and development (R&D) products have the characteristics of fixed assets—their ownership rights are well defined, they are long lasting, they can be used repeatedly in the production of other goods and services, and their value depreciates over time. In the early 1990s, the Bureau of Economic Analysis (BEA) began researching how R&D expenditures should be treated in the core economic accounts. That research culminated when as part of the 2013 comprehensive revision of the national income and product accounts (NIPAs) and the 2014 comprehensive revision of the industry economic accounts (IEAs), BEA expanded the asset boundary to recognize business, academic, nonprofit, and government R&D expenditures as investment, not as a current expense. This new approach allows the accounts to better measure the effects of innovation and intangible assets on economic growth and productivity.

The enhanced treatment of R&D investment in the NIPAs and IEAs reflects the consensus view that R&D and other intellectual property products are critically important to the modern economy. Treating R&D as an investment allows economists to analyze its contribution to growth and productivity using the same framework as other capital goods.[1]

BEA's treatment is also consistent with the recommendations of international guidelines, notably the *System of National Accounts 2008,* which defines R&D as "creative work undertaken on a systematic basis to increase the stock of knowledge, and use of this stock of knowledge for the purpose of discovering or developing new products, including improved versions or qualities of existing products, or discovering or developing new or more efficient processes of production."[2]

This article describes the methodology underlying the measures of R&D investment and output in the NIPAs and the IEAs. The article discusses the following:

- Current-dollar R&D estimates and key issues, such as (1) the main source data, which are the National Science Foundations (NSF)'s R&D surveys, (2) how ownership of R&D is established, (3) how R&D developed for an entity's internal use is differentiated from R&D that is purchased, and (4) how BEA distinguishes between establishment and company R&D investment
- The development of depreciation rates and price indexes to derive R&D investment and output, including real measures
- The methodology for estimating R&D investment in the current quarterly estimates

In addition, a brief history of R&D economic accounting at BEA is discussed in the box "A Brief History of BEA's Capitalization of R&D."

Methodology: Current-Dollar Estimates

Overview

Estimating R&D investment requires valuing R&D expenditures when market prices are not available and identifying the owners of R&D investment.

BEA's standard approach for measuring output is to value it at market prices if possible. When market prices are not available—mainly when valuing output for own-account and nonmarket uses—the standard approach is to use the costs of production as a proxy.

BEA defines the owner (or investor) of R&D as the funder of the R&D. This decision was made largely because funders typically reserve some, if not all, rights to the outcome of the R&D and receive economic benefits from the R&D.

BEA estimates of R&D investment include (1) R&D that is funded by one entity but produced by another entity, which is considered "purchased" R&D, and (2)

1. For further analysis on the impact of R&D capital on multifactor productivity and value-added growth, see Steven Rosenthal, Matthew Russell, Jon D. Samuels, Erich H. Strassner, and Lisa Usher, "Integrated Industry-Level Production Account," Survey of Current Business 94 (August, 2014).

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2. European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, and World Bank, *System of National Accounts 2008* (New York: 2009): paragraph 6.207, 119.

R&D produced for an entity's own use, which is considered "own-account" R&D. Market prices are used to value purchased R&D, while the value of own-account R&D is estimated as the sum of production costs.

A Brief History of BEA's Capitalization of R&D

The Bureau of Economic Analysis' (BEA) effort to measure R&D investment and to examine the effects of R&D expenditures on the U.S. economy began with a set of satellite accounts. These accounts provided a means of exploring the effect of R&D activity on the economy and a framework through which various methodological and conceptual issues, such as how to measure changes in R&D prices, could be examined.

In 1994, BEA first published an R&D satellite account. In 2006, BEA introduced a revised satellite account and updated that account in 2007 and in 2010. This satellite account formed the general framework for how BEA would implement R&D into its core economic accounts.

However, the R&D estimates incorporated into BEA's core economic accounts differ from the satellite account estimates in two ways:

- **Source data differences.** To incorporate R&D as investment into the national income and product accounts (NIPAs) and into the industry economic accounts (IEAs), BEA uses additional data sources, such as the Census Bureau's economic census and information from publicly-traded companies.
- **Classification differences.** In the core accounts, R&D software remains in BEA's estimates of software investment. In the satellite account, BEA had removed R&D software from the software investment estimate, retaining it in R&D investment because the R&D satellite account was designed to focus on R&D as a capitalized asset.

The development of the R&D satellite account was funded by the National Center for Science and Engineering Statistics (NCSES) at the National Science Foundation (NSF). NSF data on R&D expenditures continue to serve as the primary data source for BEA's estimates. NSF and BEA are working together to collaborate on survey methodologies appropriate for BEA's R&D estimates.[1]

1. NCSES R&D statistics are collected from an expenditure, or current-cost perspective, following international guidelines in *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development* (Paris: Organisation for Economic Co-operation and Development, 2002). See also "R&D Recognized as Investment in U.S. Gross Domestic Product Statistics: GDP Increase Lowers R&D-to-GDP Ratio," *NSF InfoBrief (*forthcoming on the NSF's Web site).

Source data and adjustments

In producing estimates of R&D investment, BEA relies primarily on NSF's R&D surveys, which provide information on expenditures associated with the production of R&D. These surveys include the business research and development and innovation survey, higher education research and development survey, survey of federal funds for research and development, and survey of state government research and development. All are conducted annually except the survey of state government research and development, which is conducted every other year.[3] In general, the NSF surveys provide data beginning in 1953.

For years not covered by the surveys, BEA uses a variety of sources to estimate R&D investment. For example, for years before 1953, business R&D is estimated primarily by using employment data for scientists and engineers. For the details on the primary source data for all of BEA's R&D investment and output estimates, see table 1.

BEA adjusts the NSF expenditure data for coverage, for scope, and for alignment with the NIPA framework and concepts. The adjustments are as follows:

- BEA converts NSF R&D expenditures data on a fiscal year basis to a calendar year basis to align with the NIPAs.
- NSF surveys of business R&D collect some information on exports of R&D (including R&D performed domestically that is funded by sources outside of the United States). However, these data do not fully represent all of the R&D foreign trade flows recorded in BEA's economic accounts. BEA must also separately record imports of R&D, which are not captured in NSF's surveys of business R&D. As a result, instead of relying on the NSF data, BEA integrates its international transactions accounts (ITAs) data on imports and exports of R&D services when deriving measures of total R&D output and investment. This approach ensures consistency with BEA's methods for estimating imports and exports and with existing estimates of R&D services in the ITAs. To align the trade data with the definition of capitalized R&D services, a portion of the ITA-based imports and exports is removed because they represent non-R&D testing services.
- BEA's estimates of R&D investment exclude software R&D, which is already captured in BEA's estimates of software investment. To prevent double-counting, BEA removes the portion of software

3. The NSF surveys collect information on the sources of funds for R&D expenditures and for some sectors, the types and fields of research. For more information on the scope and design of each NSF survey, please see the information on the NSF Web site.

Table 1. Primary Source Data for BEA's Estimates of R&D Investment and Output

	1929–1941	1942–1946	1947–1952	1953–1954	1955	1956	1957–1959	1960	1961	1962–1963	1964	1965
Private business	A, B, C	A, B, C, D	A, B, C	E	F	G	H	I		J		
Academic institutions	A, N			O								
State and local government	R										S	
Nonprofit institutions	A, N			AC	F		AD	AE	F		AF	F
Federal government	A, N			AM, AN								
	1966	1967	1968–1969	1970	1971	1972	1973	1974–1976	1977	1978–1980	1981–1986	1987–1988
Private business	K										L	
Academic institutions	O					P						
State and local government	T		U	F		V		F	W	F		X
Nonprofit institutions	AG	F		AH	F		AI	F				
Federal government	AM, AN											
	1989–1994	1995	1996–1997	1998–2001	2002	2003–2005	2006	2007	2008	2009	2010–2012	
Private business	L								M			
Academic institutions	P										Q	
State and local government	F	Y	F				Z		F	AA	AB	
Nonprofit institutions	F		AJ	AK	AL	AK		AL	AK			
Federal government	AM, AN											

A Nestor Terleckyj, "Research and Development: Its Growth and Composition," *Studies in Business Economics* 82 (1963).

B George Perazich and Philip M. Field, *Industrial Research and Changing Technology* (University of California: Work Projects Administration, 1940).

C *Science and Engineering in American Industry: Final Report on a 1953–1954 Survey* (Washington, DC: NSF).

D An adjustment for Manhattan Project R&D expenditures based on data from Richard Hewlett and Oscar Anderson, Jr., *The New World, 1939/1946: A History of the United States Atomic Energy Commission,* vol. I. (University Park, PA: Pennsylvania State University Press, 1962).

E *Science and Engineering in American Industry* (Washington, DC: NSF).

F Linking two NSF survey years using straight line interpolation, data from NSF surveys, or BEA NIPA data.

G *Science and Engineering in American Industry: Report on a 1956 Survey* (Washington, DC: NSF).

H *Funds for Research and Development in Industry* (Washington, DC: NSF).

I *Research and Development in Industry* (Washington, DC: NSF).

J *Basic Research, Applied Research, and Development in Industry* (Washington, DC: NSF).

K *Research and Development in Industry* (Washington, DC: NSF).

L *Survey of Industrial Research & Development* (Washington, DC: NSF).

M *Business Research and Development and Innovation Survey* (Washington, DC: NSF).

N John Kendrick, *The Formation and Stocks of Total Capital* (New York: National Bureau of Economic Research, 1976).

O "R&D Expenditures of Universities and Colleges by Source of Funds: Fiscal Years 1953–90" in *Selected Data on Academic Science and Engineering R&D Expenditures, FY 1990* (Washington, DC: NSF).

P *Survey of Research and Development Expenditures at Universities and Colleges* (Washington, DC: NSF).

Q *Higher Education Research and Development Survey* (Washington, DC: NSF).

R BEA data on gross investment for state and local governments.

S *R&D Activities in State Government Agencies Fiscal Years 1964 and 1965* (Washington, DC: NSF).

T *R&D Activities of Local Governments: Fiscal Years 1966 and 1967* (Washington, DC: NSF).

U *Research and Development in Local Governments: Fiscal Years 1968 and 1969* (Washington, DC: NSF).

V *Research and Development in State Government Agencies: Fiscal Years 1972 and 1973* (Washington, DC: NSF).

W *Research and Development in State and Local Governments Fiscal Year 1977* (Washington, DC: NSF).

X *Research and Development Expenditures of State Government Agencies: Fiscal Years 1987 and 1988* (Washington, DC: NSF).

Y *Survey of State Research and Development Expenditures: Fiscal Year 1995* (Washington, DC: NSF).

Z *State Agency Research and Development Expenditures* (Washington, DC: NSF).

AA *State Government Research and Development* (Washington, DC: NSF).

AB *Survey of State Government Research and Development* (Washington, DC: NSF).

AC *Research Expenditures of Foundations and Other Nonprofit Institutions, 1953–1954* (Washington, DC: NSF).

AD *Scientific Research and Development of Nonprofit Organizations: 1956 Expenditures and 1957 Manpower* (Washington, DC: NSF).

AE *Research and Other Activities of Private Foundations, 1960* (Washington, DC: NSF).

AF *Scientific Activities of Nonprofit Institutions: 1964 Expenditures and January 1965 Manpower* (Washington, DC: NSF).

AG *Scientific Activities of Nonprofit Institutions: 1966 Expenditures and January 1967 Manpower* (Washington, DC: NSF).

AH *Scientific Activities of Independent Nonprofit Institutions, 1970* (Washington, DC: NSF).

AI *R&D Activities of Independent Nonprofit Institutions, 1973* (Washington, DC: NSF).

AJ *Research and Development Funding and Performance by Nonprofit Organizations: Fiscal Years 1996 and 1997* (Washington, DC: NSF).

AK Census Bureau data on tax-exempt establishments in the scientific R&D services industry (NAICS 5417), data from NSF R&D surveys, and BEA data.

AL Census Bureau data from the Economic Census, 2002 and 2007

AM *Survey of Federal Funds for Research and Development* (Washington, DC: NSF).

AN *The Budget of the United States Government* for all fiscal years.

development R&D already embedded in its software estimates. Table 2 shows the amount of software R&D removed from the R&D estimates.

- BEA makes an adjustment to classify the enterprise data on an establishment basis in the IEAs. This approach assigns an establishment's activities to the industry most closely associated with that activity. In contrast, the NSF's industry classification assigns all of a multiunit company's R&D expenditures to one industry.

Tables 3–6 show in detail how BEA builds the R&D investment estimates from the NSF data. Table 3 shows total private business, table 4 shows the pharmaceutical and medicine manufacturing industry, table 5 shows the scientific R&D services industry, and table 6 shows federal government.

R&D ownership

BEA recognizes R&D investment by corporate and noncorporate business, nonprofit institutions serving households (NPISHs), academic institutions, federal government, and state and local governments. Because the accounting methods used by most businesses and governments do not capitalize R&D and because other data sources such as patent records do not provide comprehensive coverage of R&D assets, BEA must provide its own allocation of ownership to the corporate and noncorporate business sectors, NPISHs, and the general government sector. The allocation of ownership is important because it affects measures of net income such as corporate profits and personal income as well as measures of net saving because consumption of fixed capital is a charge against the income of the owner.[4]

NSF's surveys of R&D expenditures are conducted based on the *performer* of the R&D, but they also provide extensive information on the *funder* of R&D for each performer.

For the private sector, the allocation of R&D ownership to the funder is clear. However, the ownership of government-funded R&D may be less transparent. Government-funded R&D is supported through two primary mechanisms—purchases and grants. As an example, the federal government may directly purchase R&D from an academic institution, or the federal government may provide funding for R&D at an academic institution via a grant. The ownership of purchased R&D is straightforward, because the federal government normally retains ownership of the outcome of the purchased R&D activity. For grant-based R&D, however, the ultimate beneficiary is difficult to ascertain because both the federal government and the performer can benefit from the transaction. Historically, NSF surveys have not collected information on the allocation of purchased and grant-based R&D for the federal sector.[5] Because of this lack of direct information, federal purchases and grants of R&D are both treated as investment by the federal sector because the federal government is assumed to receive the primary economic benefit. The funders of R&D generally invest in R&D because they receive economic benefits; in the case of government funding, the economic benefits include the benefits that the government obtains on behalf of the general public.

For a perspective on how funding differs for each performer, see tables 7 and 8, which show the different funding sources for each R&D performer. The statistics are BEA-adjusted estimates based on NSF data.

Own-account versus purchased R&D

The NSF data used to derive R&D investment provide expenditures, or costs, for R&D performed by domestic entities regardless of whether it is produced for their own use (own-account) or produced for and funded by others.

4. In the context of the integrated macroeconomic accounts, the assignment of ownership affects the balance sheets of the owning sectors.

5. Since 2010, the NSF business and academic surveys have information on grant-based and purchased R&D for federally funded R&D. However, without historical data, BEA cannot properly account for grants and purchased R&D prior to 2010.

Table 2. Total Business R&D Including Software R&D

[Billions of dollars]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Software R&D in BEA's software investment	2	5	7	7	8	9	11	14	17	22	29	31
Business R&D investment excluding software R&D	83	90	92	92	94	105	116	126	134	146	160	161
Business R&D investment including software R&D	86	95	99	100	102	114	127	140	151	168	189	193

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Software R&D in BEA's software investment	31	35	35	38	43	47	50	51	51	61	62
Business R&D investment excluding software R&D	155	156	162	176	192	211	225	214	224	231	241
Business R&D investment including software R&D	186	191	197	214	235	258	275	265	275	293	303

R&D Research and development
NOTE. Estimates may not sum to totals because of rounding.

To calculate total business own-account R&D, BEA starts with total NSF R&D costs plus a profit markup on the amount of R&D sold,[6] and subtracts R&D sales by businesses reported by the Census Bureau's economic surveys.[7] The Census Bureau data are based on receipts and already embed a profit markup. To calculate total business R&D investment, BEA subtracts from its estimate of NSF-based total business R&D expenditures, which includes the profit markup, the following: R&D sold to other sectors, such as

6. Because the NSF data are based on production costs, the market price of the purchased R&D is not captured. To estimate the market value of R&D, BEA applies a profit markup. BEA calculates this profit markup based on the net operating surplus of the miscellaneous professional, scientific, and technical services industry. This is an industry category from BEA's GDP-by-industry data that contains scientific R&D services within it as a subindustry. Net operating surplus is estimated as gross operating surplus less consumption of fixed capital, and thus reflects a residual profit-like measure for the industry.

7. The Census Bureau economic surveys used to estimate R&D sales include the economic census, the service annual survey, and the annual survey of manufactures.

Table 3. BEA's R&D Investment Reconciled to NSF R&D Expenditures for Total Private Business

[Millions of dollars]

Line		Description	2007	2008	2009
1	**R&D investment by private business**	Calculated as the sum of own-account R&D (line 2) and purchased R&D (line 8) and equals line 7 in NIPA table 5.6.5.	**210,801**	**224,522**	**213,951**
2	**Own-account R&D investment**		**115,615**	**114,427**	**97,130**
3	NSF R&D expenditures for all industries	Funds for industrial R&D performed in the United States, excludes FFRDCs. For 2007, values come from NSF's SIRD. For 2008 and 2009, values come from NSF's BRDIS.	269,267	290,680	282,393
4	*Plus:* SIRD to BRDIS time series adjustment	An adjustment based on the NSF's survey of federal funds for research and development to bridge survey differences between the SIRD and BRDIS for R&D funded by the federal government.	9,167	0	–3,816
5	*Plus:* Adjustment to account for the full cost of production	A capital consumption adjustment to convert business depreciation to economic depreciation.	–101	–77	–418
6	*Less:* Software R&D	The removal of software R&D that is in BEA's software estimates to avoid double-counting.	47,655	51,036	52,618
7	*Less:* Census Bureau sales of R&D converted to expenses	R&D sales, which include exports and R&D paid for by the government, NPISHs, and other businesses, from BEA's annual input-output (I-O) R&D services estimates, converted to a cost-basis. BEA's I-O estimates are based on the Census Bureau's economic census, SAS, and annual survey of manufactures data. FFRDCs are removed from the Census Bureau data to be consistent with the NSF data.	115,063	125,141	128,411
8	**Total purchased R&D**		**95,186**	**110,096**	**116,821**
9	Imports of R&D	Imports are based on BEA International Transaction Accounts data for research, development, and testing services.	10,843	13,580	13,845
10	*Plus:* R&D purchased from academic institutions	Industry-funded R&D performed by academic institutions from unpublished detail from BEA's academic R&D estimates that are based on data from NSF's survey of research and development expenditures at universities and colleges.	2,924	3,148	3,195
11	*Plus:* R&D purchased from NPISHs	Industry-funded R&D performed by nonprofit organizations from unpublished detail from BEA's NPISH R&D estimates that are based on Census Bureau data for tax-exempt scientific R&D establishments.	5,605	7,122	9,789
12	*Plus:* R&D purchased from state and local governments	Industry-funded R&D performed by state and local government from unpublished detail from BEA's state and local government R&D estimates that are based on data from NSF's state government research and development survey.	2	3	3
13	*Plus:* R&D purchased from FFRDCs	Industry-funded R&D performed by FFRDCs from unpublished detail from BEA's estimates of FFRDC R&D that are based on data from NSF's R&D expenditures at federally funded R&D centers survey.	86	94	94
14	*Plus:* Purchases of R&D in the social sciences and humanities from for-profit R&D services establishments (NAICS 54172)	R&D in the social sciences and humanities from BEA's annual I-O estimates that are based on the Census Bureau's economic census and SAS data.	1,618	1,735	1,754
15	*Plus:* Cost of R&D performed in company headquarters (NAICS 551) and R&D services subsidiary and auxiliary establishments (NAICS 5417)	R&D transferred from company headquarters and R&D services establishments to the primary industry of the company, which shows up as purchased R&D rather than as own-account R&D. The estimates are from a reconciliation of NSF SIRD data (for 2007) and BRDIS data (for 2008–2009) with BEA's annual I-O R&D estimates that are based on the Census Bureau's economic census and SAS data and a special tabulation of auxiliary establishments.	64,562	71,803	76,323
16	*Plus:* R&D purchased from other businesses, specifically R&D services establishments	Purchases from BEA's annual I-O R&D estimates after subtracting sales to other sectors, exports, and the cost of R&D that is transferred to other establishments within the company. BEA's annual I-O estimates are based on the Census Bureau's economic census and SAS data.	9,546	12,611	11,817

BRDIS Business research and development and innovation survey
FFRDCs Federally funded research and development centers
NAICS North American Industry Classification System
NPISHs Nonprofit institutions serving households
NSF National Science Foundation
R&D Research and development
SAS Service annual survey
SIRD Survey of industrial research and development
NOTE. Estimates may not sum to totals because of rounding.

governments and NPISHs and exports of R&D. The R&D sold to government and NPISHs is classified as R&D investment for those sectors. BEA then adds the following: business purchases of R&D from government and NPISHs and imports of R&D. Table 3 provides a walkthrough of the steps BEA uses to calculate business R&D investment from the NSF expenditure data. Investment of all funders of R&D is estimated using a similar methodology.

Establishment versus company

NSF's industry classification is company based, which assigns all of a multiunit company's R&D expenditures to one industry. For a given company, expenditures

Table 4. BEA's R&D Investment Reconciled to NSF R&D Expenditures for the Pharmaceutical and Medicine Manufacturing Industry (NAICS 3254)

[Millions of dollars]

Line		Description	2007	2008	2009
1	**R&D investment by the pharmaceutical and medicine manufacturing industry**	Calculated as the sum of own-account R&D (line 2) and purchased R&D (line 9) and equals line 9 in NIPA table 5.6.5.	**56,756**	**61,235**	**56,903**
2	**Own-account R&D investment**		**27,780**	**27,363**	**21,888**
3	NSF expenditures for R&D for the pharmaceutical and medicine manufacturing industry (NAICS 3254)	Funds for industrial R&D performed in the United States, excludes FFRDCs and funds from the federal government. For 2007, values come from NSF's SIRD. For 2008 and 2009, values come from NSF's BRDIS.	47,624	47,994	44,823
4	*Plus:* SIRD to BRDIS time series adjustment	An adjustment, based on R&D expenses reported on publicly-traded companies' annual financial statements, is made to bridge survey differences between the SIRD and BRDIS.	0	519	0
5	*Plus:* Adjustment to account for the full cost of production	A capital consumption adjustment is made to convert business depreciation to economic depreciation.	–653	–382	–642
6	*Less:* Software R&D	The removal of software R&D that is counted in BEA's software estimates to avoid double-counting.	D	D	D
7	*Less:* The cost of R&D performed in company headquarters (NAICS 551) and R&D services subsidiary and auxiliary establishments (NAICS 5417)	Based on BEA's company to establishment adjustment, which is from a reconciliation of NSF SIRD (for 2007) and BRDIS (for 2008–2009) data and BEA's annual input-output (I-O) R&D estimates. BEA's I-O estimates are based on the Census Bureau's economic census and SAS data and a special tabulation of auxiliary establishments.	16,273	18,037	18,751
8	*Less:* Exports of R&D	The cost of exports is based on BEA International Transaction Accounts data for research, development, and testing services.	D	D	D
9	**Total purchased R&D**		**28,977**	**33,872**	**35,015**
10	Imports of R&D	Imports are based on BEA International Transaction Accounts data for research, development, and testing services.	D	D	D
11	*Plus:* R&D purchased from academic institutions	Total for all industry-funded R&D performed by academic institutions from unpublished detail from BEA's academic R&D estimates that are based on data from NSF's survey of research and development expenditures at universities and colleges. Information on industry shares comes from SIRD data (for 2007) and BRDIS data (for 2008–2009) on company-funded R&D performed by universities and colleges.	1,824	2,012	1,572
12	*Plus:* R&D purchased from NPISHs	Total for all industry-funded R&D performed by nonprofit organizations from unpublished detail from BEA's NPISH R&D estimates. BEA's NPISH estimates are based on Census Bureau data for tax-exempt scientific R&D establishments. Information on industry shares comes from SIRD data on company-funded R&D performed by nonprofit organizations (other than universities and colleges).	2,701	2,847	3,913
13	*Plus:* R&D purchased from state and local governments	Total for all industry-funded R&D performed by state and local government from unpublished detail from BEA's state and local government R&D estimates that are based on data from NSF's state government research and development survey. Industry share is proxied with SIRD data on company-funded R&D performed by academic institutions and nonprofit organizations.	1	2	2
14	*Plus:* R&D purchased from FFRDCs	Total for all industry-funded R&D performed by FFRDCs comes from unpublished detail from BEA's estimates of FFRDC R&D that are based on data from NSF's R&D expenditures at federally funded R&D centers survey. Industry share is proxied with SIRD data on company-funded R&D performed by academic institutions and nonprofit organizations.	D	D	D
15	*Plus:* The cost of R&D performed in company headquarters (NAICS 551) and R&D services subsidiary and auxiliary establishments	R&D costs transferred from company headquarters and R&D services establishments to the pharmaceutical and medicine manufacturing industry, described in line 7.	16,273	18,037	18,751
16	*Plus:* R&D purchased from other businesses, specifically R&D services establishments	Total for all industries' purchases from BEA's annual I-O R&D estimates after subtracting sales to other sectors, exports, and R&D that is transferred to other establishments within the company. The residual is assumed to equal R&D sold to other businesses. BEA's annual I-O estimates are based on the Census Bureau's economic census and SAS data. Industry shares are estimated based on SIRD data (for 2007) and BRDIS data (2008–2009) on business purchases of R&D from other domestic for-profit companies.	4,760	7,142	6,555

BRDIS Business research and development and innovation survey
D Data suppressed to avoid the disclosure of data from individual companies.
FFRDCs Federally funded research and development centers
NAICS North American Industry Classification System
NPISH Nonprofit institutions serving households
NSF National Science Foundation
R&D Research and development
SAS Service annual survey
SIRD Survey of industrial research and development
NOTE. Estimates may not sum to totals because of rounding.

can be made in several different types of establishments, including manufacturing plants or services-producing facilities, company headquarters, a free-standing R&D laboratory that provides all its output to the rest of the company (auxiliary establishment), or an independent establishment that sells its R&D output. Since the NSF surveys do not link R&D expenditures to establishments, using the NSF industry classification would imply that *all* pharmaceutical and medicine manufacturing R&D activity was conducted in manufacturing plants when more realistically, it was conducted in R&D laboratories, company headquarters facilities, manufacturing plants, and other types of establishments.

BEA's industry input-output accounts are classified based on establishments. According to this establishment-based approach, for example, a multiunit company with one establishment whose main activity is manufacturing and another establishment whose main activity is R&D services will have the output of the manufacturing establishment assigned to the manufacturing sector (the primary industry) and the output of its R&D services establishment assigned to the services sector. To incorporate R&D as investment in BEA's input-output accounts, the NSF data are converted to an establishment basis. BEA applies a

Table 5. BEA's R&D Investment Reconciled to NSF R&D Expenditures for the Scientific R&D Services Industry (NAICS 5417)

[Millions of dollars]

Line		Description	2007	2008	2009
1	**R&D investment by the scientific R&D services industry**	Calculated as the sum of own-account R&D (line 2) and purchased R&D (line 8) and equals line 17 in NIPA table 5.6.5.	**7,256**	**9,200**	**9,068**
2	**Own-account R&D investment**		**5,633**	**6,936**	**6,326**
3	NSF expenditures for R&D for the scientific research and development services industry (NAICS 5417)	Funds for industrial R&D performed in the United States, excludes FFRDCs and funds from the federal government. For 2007, values come from NSF's SIRD. For 2008 and 2009, values come from NSF's BRDIS.	12,017	14,798	13,613
4	*Plus:* Adjustment to account for the full cost of production	A capital consumption adjustment to convert business depreciation to economic depreciation.	45	22	–15
5	*Less:* Software R&D	The removal of software R&D that is already counted in BEA's software estimates to avoid double-counting.	795	948	945
6	*Equals:* NSF R&D expenditures with BEA adjustments		11,267	13,872	12,653
7	Divide by 2	Assuming that R&D expenditures for own-account use are 50 percent of R&D expenditures, then R&D that is sold is the remaining 50 percent.	5,633	6,936	6,326
8	**Total purchased R&D**		**1,622**	**2,264**	**2,742**
9	Imports of R&D	Imports are based on BEA International Transaction Accounts data for research, development, and testing services.	D	D	D
10	*Plus:* R&D purchased from academic institutions	Total for all industry-funded R&D performed by academic institutions from unpublished detail from BEA's academic R&D estimates that are based on data from NSF's survey of research and development expenditures at universities and colleges. Information on industry shares comes from SIRD data (for 2007) and BRDIS data (for 2008–2009) data on company-funded R&D performed by universities and colleges.	7	187	455
11	*Plus:* R&D purchased from NPISHs	Total for all industry-funded R&D performed by NPISHs from unpublished detail from BEA's estimates based on Census Bureau data for tax-exempt scientific R&D establishments. Information on industry shares from SIRD data on company-funded R&D performed by nonprofit organizations (other than universities and colleges).	159	441	607
12	*Plus:* R&D purchased from state and local governments	Total for all industry-funded R&D performed by state and local government from unpublished detail from BEA's state and local government R&D estimates that are based on data from NSF's state government research and development survey. Industry share is proxied with SIRD data on company-funded R&D performed by academic institutions and nonprofit organizations.	0	0	0
13	*Plus:* R&D purchased from FFRDCs	Total for all industry-funded R&D performed by FFRDCs from unpublished detail from BEA's estimates of FFRDC R&D that are based on data from NSF's R&D expenditures at federally funded R&D centers survey. Industry share is proxied with SIRD data on company-funded R&D performed by academic institutions and nonprofit organizations.	D	D	D
14	*Plus:* Cost of R&D performed in company headquarters (NAICS 551) for use in scientific R&D services establishments	The costs incurred in NAICS 551 establishments are transferred as the sum of production costs.	1	1	1
15	*Plus:* R&D purchased from other businesses, specifically R&D services establishments	Total for all industries' purchases from BEA's annual input-output (I-O) R&D estimates after subtracting sales to other sectors, exports, and R&D that is transferred to other establishments within the company. The residual is assumed to equal R&D sold to other businesses. BEA's annual I-O estimates are based on the Census Bureau's economic census and SAS data. Industry shares are estimated based on SIRD data (for 2007) and BRDIS data (for 2008–2009) on business purchases of R&D from other domestic for-profit companies.	807	774	718

BRDIS Business research and development and innovation survey
D Data suppressed to avoid the disclosure of data from individual companies.
FFRDCs Federally funded research and development centers
NAICS North American Industry Classification System
NPISH Nonprofit institutions serving households
NSF National Science Foundation
R&D Research and development
SAS Service annual survey
SIRD Survey of industrial research and development
NOTE. Estimates may not sum to totals because of rounding.

company-to-establishment adjustment based on a reconciliation of Census Bureau-based data from the scientific R&D services industry (establishment-based) with the NSF's company-based data. See the box "BEA's Company-to-Establishment Adjustment for the Scientific R&D Services Industry" for more information.

Quarterly estimates

BEA prepares quarterly estimates of current-dollar R&D investment back to 1947. However, the most complete and accurate source data are the NSF surveys of R&D expenditures, which provide only annual data. BEA thus relies on a number of methods and data sources to interpolate annual estimates of R&D investment into quarterly estimates. These methods and sources vary depending on the period.

For NPISHs, academic institutions, federal government, and state and local governments, little information on quarterly trends in R&D activity is available. Therefore, quarterly estimates are interpolated from annual estimates assuming no quarterly pattern. For business R&D, the quarterly interpolation methods are split into three periods, each with a different interpolation method: 1947–1990, 1991–2007, and 2008 forward.

For 1947–1990, the quarterly estimates are interpolated assuming no quarterly patterns.

For 1991–2007, current-dollar business R&D is interpolated using a seasonally adjusted composite series from the quarterly census of employment and wages (QCEW) from the Bureau of Labor Statistics (BLS).

Table 6. BEA's R&D Investment Reconciled to NSF R&D Expenditures for Federal Government

[Millions of dollars]

Line		Description	2007	2008	2009
1	**R&D investment by the federal government**	Calculated as the sum of own-account R&D (line 2) and purchased R&D (line 12) and equals line 16 in NIPA table 3.9.5.	**122,531**	**127,210**	**129,287**
2	**Own-account R&D investment**	Calculated as the BEA-adjusted NSF data (line 9) less small equipment costs (line 10) plus adjustment to account for the full cost of production (line 11).	**28,062**	**28,923**	**29,655**
3	NSF R&D total obligations	Survey of federal funds for R&D.	127,263	127,106	141,090
4	NSF R&D intramural obligations	Survey of federal funds for R&D.	29,932	29,637	31,543
5	Convert NSF R&D obligations to R&D outlays	Uses a 3-year weighted moving average in which the most recent year (time period t) receives 50 percent of the weight, t–1 receives 30 percent of the weight, and t–2 receives 20 percent of the weight.			
5a	Adjust the NSF R&D total obligations	Uses the calculation in line 5 to convert the NSF R&D total obligations data (line 3) to outlays data.	123,920	126,078	134,129
5b	Adjust the NSF R&D intramural obligations	Uses the calculation in line 5 to convert the NSF R&D intramural obligations data (line 4) to outlays data.	28,443	29,333	30,649
6	Create own-account ratio	Equals line 5b divided by line 5a.	0.23	0.23	0.23
7	NSF R&D total outlays	BEA uses NSF obligations data by performer from NSF's Survey of federal funds to allocate the federal outlays data into performers because NSF outlays data is not split between performer.	121,875	123,059	126,854
8	Calculate own-account outlays	Applies the own-account obligations ratio (line 6) to the total R&D outlays data (line 7) to derive the own-account outlays.	28,085	28,495	29,290
9	Convert fiscal year (FY) data to calendar year (CY) data	CY(t) = 0.75*FY(t) + 0.25*FY(t–1).	27,577	28,393	29,092
10	*Less:* Small equipment costs	Removes small equipment costs included in NSF's R&D expenditure data in the Survey of federal funds.	1,136	1,209	1,245
11	*Plus:* Adjustment to account for the full cost of production	A capital consumption adjustment is made to convert business depreciation to economic depreciation.	1,621	1,740	1,809
12	**Total purchased R&D**		**94,469**	**98,287**	**99,632**
13	R&D purchased from industry	Total for all federally-funded R&D performed by private business from unpublished detail from BEA's private business R&D estimates that are based on data from NSF's SIRD (2007) and BRDIS (2008 and 2009).	44,234	46,424	44,350
14	*Plus:* R&D purchased from academic institutions	Total for all federally-funded R&D performed by academic institutions from unpublished detail from BEA's academic R&D estimates that are based on data from NSF's Survey of research and development expenditures at universities and colleges.	28,704	29,570	31,578
15	*Plus:* R&D purchased from FFRDCs	Total for all federally-funded R&D performed by FFRDCs from unpublished detail from BEA's estimates of FFRDC R&D that are based on data from NSF's R&D expenditures at federally funded R&D centers survey.	13,789	14,540	15,337
16	*Plus:* R&D purchased from NPISHs	Total for all federally-funded R&D performed by nonprofit organizations from unpublished detail from BEA's NPISHs R&D estimates that are based on Census Bureau data for tax-exempt scientific R&D establishments. Federal funding of nonprofit R&D performance is proxied using NSF's Survey of federal funds data.	7,577	7,578	8,185
17	*Plus:* R&D purchased from state and local governments	Total for all federally-funded R&D performed by state and local government from unpublished detail from BEA's state and local government R&D estimates that are based on data from NSF's state government research and development survey.	164	176	182

BRDIS Business research and development and innovation survey
FFRDCs Federally funded research and development centers
NAICS North American Industry Classification System
NPISH Nonprofit institutions serving households
NSF National Science Foundation
R&D Research and development
SIRD Survey of industrial research and development
NOTE. Estimates may not sum to totals because of rounding.

Table 7. Funding of R&D by Performer, 2007

[Millions of dollars]

Funder	NIPA investment sector	Performer						Total investment/ funding
		Federal government	State and local government	Private business [1]	Nonprofit institutions [2]	Public academic institutions [3]	Private academic institutions [4]	
Federal government	Federal government	28,230	160	48,930	10,795	19,487	14,929	122,531
State and local government	State and local government		273	251	1,445	3,097	368	5,434
Private business [1]	Private fixed investment		2	202,273	5,605	1,982	942	210,804
Nonprofit institutions [2]	Private fixed investment		18	677	5,717	2,577	1,445	10,434
Public academic institutions [3]	State and local government				123	8,546		8,669
Private academic institutions [4]	Private fixed investment				123		1,960	2,083
Total output/performance		**28,230**	**454**	**252,131**	**23,809**	**35,688**	**19,645**	**359,955**

NAICS North American Industry Classification System
NIPAs National income and product accounts
R&D Research and development
1. Includes industry-administered federally funded research and development centers.
2. Includes nonprofit-administered federally funded research and development centers.
3. Includes public academic-administered federally funded research and development centers.
4. Includes private academic-administered federally funded research and development centers.
NOTE. Estimates may not sum to totals because of rounding.

BEA's Company-to-Establishment Adjustment for the Scientific R&D Services Industry

The National Science Foundation (NSF) publishes statistics for the costs incurred in the production of research and development (R&D) performed by the scientific R&D services industry. These statistics are collected on a *company basis* rather than on an *establishment basis*. As a result, they exclude production costs for R&D establishments that are part of a multiunit company but that are classified in another industry, such as the pharmaceutical and medicine manufacturing industry.

For the Bureau of Economic Analysis (BEA) to produce R&D investment estimates, it must convert the NSF company basis data on the scientific R&D services industry to an establishment basis in keeping with the BEA industry accounts. The conversion yields an estimate of R&D costs that includes expenditures on a company basis within the scientific R&D services industry plus expenditures for scientific R&D performed by establishments that are part of multiunit companies outside of the industry.[1]

NSF cost data include (1) expenditures for R&D paid for by the company, which are treated as own-account R&D, and (2) expenditures for R&D paid for by others, which are treated as R&D sales. For most of the time series, NSF does not differentiate between these two categories. Beginning with the publication of the business research and development and innovation survey (BRDIS) in 2008, however, NSF started reporting data that can be used to approximate costs for own-account R&D, which was approximately 50 percent of total expenditures in 2008 and 2009. Based on the first couple of years of BRDIS results, BEA makes the assumption that half of the NSF scientific R&D services industry expenditures are associated with the production of own-account R&D. The other half of the expenditures are associated with R&D produced for sale.

To estimate R&D costs incurred by establishments outside of companies classified in the scientific R&D services industry, BEA uses data from the Census Bureau's economic census and service annual survey (SAS). These data are already on an establishment basis and are based on receipts, or sales, of R&D.[2] Economic censuses, conducted every 5 years, provide detailed receipts of R&D services produced by the scientific R&D services industry. For noneconomic census years, SAS data are used to interpolate between the economic census years. Because the economic census data and the SAS data are based on receipts, they do not cover own-account R&D expenses. BEA assumes that NSF scientific R&D services company-based sales, estimated as half of published NSF R&D expenditures, are included in the Census Bureau-based data.

So from the Census Bureau-based data, an estimate of total establishment-based R&D sales is calculated. And from the NSF data, an estimate of sales by establishments that are part of a scientific R&D services company is calculated. Subtracting the NSF sales from the Census Bureau-based sales produces an estimate of R&D sales for an R&D establishment that is part of a multiunit company. This amount is moved from the primary industry (for example, the pharmaceutical or computer manufacturing industries) as reported by the NSF company-based data to the scientific R&D services industry.

1. BEA assumes that all establishments that are part of a scientific R&D services company are also scientific R&D services establishments.

2. The Census Bureau provides a special tabulation during economic census years for auxiliary establishments. The primary function of an auxiliary establishment is to manage, administer, service, or support the activities of the other establishments of the company. There are no market transactions because all of the output is provided to the rest of the company and expenses instead of receipts are collected for these establishments.

Table 8. Funding of R&D by Performer, 2012

[Millions of dollars]

Funder	NIPA investment sector	Performer						Total investment/ funding
		Federal government	State and local government	Private business [1]	Nonprofit institutions [2]	Public academic institutions [3]	Private academic institutions [4]	
Federal government	Federal government	35,566	279	45,624	13,959	23,020	18,130	136,579
State and local government	State and local government		294	317	2,944	3,240	399	7,193
Private business [1]	Private fixed investment		4	227,047	10,899	2,073	1,165	241,188
Nonprofit institutions [2]	Private fixed investment		28	1,162	10,422	3,192	1,822	16,627
Public academic institutions [3]	State and local government				232	10,164		10,396
Private academic institutions [4]	Private fixed investment				225		3,081	3,306
Total output/performance		**35,566**	**605**	**274,149**	**38,681**	**41,689**	**24,598**	**415,289**

NAICS North American Industry Classification System
NIPAs National income and product accounts
R&D Research and development
1. Includes industry-administered federally funded research and development centers.
2. Includes nonprofit-administered federally funded research and development centers.
3. Includes public academic-administered federally funded research and development centers.
4. Includes private academic-administered federally funded research and development centers.
NOTE. Estimates may not sum to totals because of rounding.

The composite quarterly indicator is constructed by weighting three-quarter moving averages of industry-specific QCEW wage data. The composite QCEW series is constructed using a weight of 60 percent for the scientific R&D services industry's wage growth. The remaining 40 percent weight of the series is allocated to the other private industries using the annual distribution of R&D investment.

For 2008 forward, quarterly business R&D is interpolated using seasonally adjusted R&D expenses reported on publicly traded companies' quarterly financial statements as an indicator. See table 9 for information on the specific quarterly interpolation methods for private business, nonprofits, and government sectors.

Methodology: R&D Depreciation

The depreciation rates used by BEA to estimate business R&D depreciation are based on the concept that unlike tangible assets, which depreciate because of obsolescence that causes physical decay or wear and tear, R&D capital depreciates because its contribution to a firm's profit declines over time.[8] BEA developed a forward-looking profit model and used its annual industry output and R&D investment for 1987–2007 to estimate industry-specific R&D depreciation rates. Table 10 shows the R&D depreciation rates for 10 R&D-intensive industries. As described in Li's working paper (2012), the results are consistent with expert opinions and conclusions from empirical analysis that R&D depreciation rates should be higher than the traditional assumption, 15 percent, and should vary across industries. Details of the model and estimation results are described in Li (2012).

Industries not specifically identified use the depreciation rate for the scientific R&D services industry of 16 percent. This rate is also used for NPISHs and academic institutions.

For general government R&D, a contribution to profits is not estimated, but like business R&D, depreciation reflects obsolescence over time. Based on this concept, BEA observed that R&D investments

Table 9. Indicators for Quarterly Interpolation of R&D Investment

	1947–1990	1991–2007	2008 forward
Business	No quarterly pattern	QCEW-based composite wage indicator	Seasonally adjusted R&D expenses reported on quarterly financial statements
Academic institutions	No quarterly pattern		
NPISHs	No quarterly pattern		
State and local government	No quarterly pattern		
Federal government	No quarterly pattern		

NPISHs Nonprofit institutions serving households
QCEW Quarterly census of employment and wages
R&D Research and development

Table 10. Business R&D Depreciation Rates

NAICS code	Industry	Depreciation rate (percent)
3254	Pharmaceutical and medicine manufacturing	10
3341	Computers and peripheral equipment manufacturing	40
3342	Communications equipment manufacturing	27
3344	Semiconductor and other electronic component manufacturing	25
3345	Navigational, measuring, electromedical, and control instruments manufacturing	29
3361–3363	Motor vehicles, bodies and trailers, and parts manufacturing	31
3364	Aerospace products and parts manufacturing	22
5112	Software publishers	22
5415	Computer system design and related services	36
5417	Scientific research and development services	16

NAICS North American Industry Classification System
R&D Research and development

8. For more details on R&D business depreciation rates, see Wendy C.Y. Li, "Depreciation of Business R&D Capital," Bureau of Economic Analysis/National Science Foundation Paper (Washington, DC: BEA, 2012).

were associated with the production of other products that eventually became obsolete; for example, investments in stealth technology were associated with the development of particular military aircraft. As innovations give way to newer technologies, the original R&D becomes less valuable or obsolete, thus bringing an end to the effective service life of the R&D.

BEA derived service lives for four federal government functions: defense, health, space, and energy. To estimate service lives for these government R&D asset types, BEA selected a sample of representative projects. The service life for an R&D project spans the time from prototype design through the end of production of the physical tangible asset. An average for all sample projects for a particular R&D asset type, such as defense R&D, was used to calculate the overall life for the R&D asset (table 11).

For nondefense transportation and other R&D and for all state and local government R&D assets, BEA adopted the same rate (16 percent) used for the private scientific R&D services industry.

Table 11. Government R&D Depreciation Rates

	Depreciation rate (percent)
Federal government	
Defense	
Purchased R&D	20
Own-account R&D	16
Nondefense	
Aerospace R&D	7
Health R&D	9
Energy R&D	9
Transportation R&D	16
Other R&D	16
State and local government	
Own-account R&D	16

R&D Research and development

Methodology: Price Measures

Price deflators for R&D are used to develop quantity measures for R&D investment, stocks, and depreciation. Unfortunately, these prices are generally unobservable, given that much R&D is produced for own-account use and that R&D projects are heterogeneous in nature (so that similar outputs are not available for observation). Consequently, it is generally accepted that measures of own-account R&D investment are derived as the sum of the costs of their inputs, such as compensation, materials and supplies, and capital services. In the absence of direct price measures for R&D output, this input cost approach is the preferred method for constructing R&D price indexes.[9] However, by using an input cost index as a proxy for the output price change, the impact of productivity change on the value of real R&D output or on investment is not captured. Considering the widely held view that R&D expenditures are an important source of increases in productivity, BEA uses the economy-wide measure of multifactor productivity produced by BLS as the estimate of unobserved R&D productivity. This productivity adjustment is made by subtracting the growth rate of private nonfarm business sector multifactor productivity from the growth rate of the R&D input cost index.

In periods that productivity increases, the price of R&D is adjusted downward because of the underlying assumption that more R&D can be produced per unit of input; conversely, the price of R&D is adjusted upward when productivity declines because less R&D can be produced per unit of input.

Three R&D price indexes are used in the NIPAs and IEAs: a business R&D price index, an academic R&D price index, and a federal own-account R&D price index. All three price indexes are based on an input cost approach. The academic and federal price indexes are used for R&D performed by academic institutions and the federal government, respectively. (All of R&D performed by the federal government is own-account). The business price index is used for all other R&D performers; that is, private business, NPISHs (excluding academic institutions), and state and local government because they are assumed to have similar R&D cost structures.

Measures of real or inflation-adjusted R&D output and investment are derived by deflating each current-dollar R&D estimate with the corresponding R&D price index.

Business R&D price index

The annual business R&D price index is a weighted average of the cost components of the scientific R&D services industry (60 percent) and an "all private industries" aggregate (40 percent). Beginning with 1997, prices for compensation, material inputs, depreciation, and other costs are separately constructed for the scientific R&D services industry and the all private industry group. These prices are then aggregated using a Fisher formula to derive a single business R&D price

9. In preparing the satellite account, BEA experimented with several R&D price indexes. The featured price index was an aggregate output price index, which was a weighted average of the output prices of the products produced by R&D-intensive industries. This price index exhibited average annual decreases. The business price index used for implementation, based on an input cost approach, into the core accounts increases at about 2 percent per year.

index. For 1929–1996, prices are constructed for compensation and other costs for the scientific R&D services industry and the all private industries group. These prices are also aggregated using a Fisher formula to derive a single business R&D price index. The price index for each cost component is derived using source data that vary over time because of availability. Table 12 provides a full description of each cost component price.

Weights for each cost component are from NSF surveys of business R&D expenditures. Table 13 presents the weights for each cost component for selected years.

Annual prices are interpolated to derive quarterly prices using quarterly indicator data. For periods prior to 1975, quarterly indicator data are not used, and the

Table 12. Business R&D Price Index, Cost Components, and Source Data

Cost component	1929–1946	1947–1960	1961–1974	1975
Scientific R&D services (NAICS 5417)				
Wages and salaries	Wage and salary accruals per FTE for all private industries		Average wages for chemists and engineers	
All other costs [1]	Wage and salary accruals per FTE for all private industries	Average PPI for intermediate materials, supplies, and components		Average PPI for intermediate materials and supplies, excluding food and energy
Materials and supplies [1]	Not applicable			
Depreciation [1]	Not applicable			
Other costs [1]	Not applicable			
All other private industries				
Wages and salaries	Wage and salary accruals per FTE for all private industries		Wage and salary accruals per FTE for manufacturing	QCEW average wages for all private industries
All other costs [1]	Wage and salary accruals per FTE for all private industries	Average PPI for intermediate materials, supplies, and components		Average PPI for intermediate materials and supplies, excluding food and energy
Materials and supplies [1]	Not applicable			
Depreciation [1]	Not applicable			
Other costs [1]	Not applicable			

Cost component	1976–1977	1978–1987	1988–1996	1997 forward
Scientific R&D services (NAICS 5417)				
Wages and salaries	ECI for wages and salaries of professional, specialty, and technical occupations	QCEW average wages for R&D laboratories (SIC 7391)	QCEW average wages for commercial physical research (SIC 8731)	QCEW average wages for scientific R&D services (NAICS 5417)
All other costs [1]	Average PPI for intermediate materials and supplies, excluding food and energy			Not applicable
Materials and supplies [1]	Not applicable			KLEMS price for materials inputs by industry for miscellaneous professional, scientific, and technical services
Depreciation [1]	Not applicable			CFC price for business services
Other costs [1]	Not applicable			Fisher-weighted price for energy and services inputs by industry for miscellaneous professional, scientific, and technical services. Weights for the Fisher aggregation from KLEMS.
All other private industries				
Wages and salaries	QCEW average wages for all private industries			
All other costs [1]	Average PPI for intermediate materials and supplies excluding food and energy			Not applicable
Materials and supplies [1]	Not applicable			KLEMS price for materials inputs by industry for total private
Depreciation [1]	Not applicable			CFC price for business services
Other costs [1]	Not applicable			Fisher-weighted price for energy and services inputs by industry for total private; weights for Fisher aggregation from KLEMS.

CFC Consumption of fixed capital
ECI Employment cost index
FTE Full-time employee
KLEMS K-capital, L-labor, E-energy, M-materials, and S-purchased services
NAICS North American Industry Classification System
PPI Producer price index
QCEW Quarterly census of employment and wages
R&D Research and development
SIC Standard Industrial Classification

1. Before 1997, all other costs was an aggregate measure. Beginning in 1997, it was disaggregated into materials and supplies, depreciation, and other costs.

Table 13. Business R&D Price Index, Weights for Cost Components

[Percent]

Cost component	1929	1963	1975	1987	1997	2002	2007	2012
Scientific R&D services								
Wages and salaries	58	58	60	52	58	54	58	61
All other costs [1]	43	42	41	48	.....	.....	.....	.....
Materials and supplies [1]	.....	.....	.....	.....	13	12	11	9
Depreciation [1]	.....	.....	.....	.....	1	3	4	4
Other costs [1]	.....	.....	.....	.....	27	31	27	26
All other private industries								
Wages and salaries	58	58	60	52	59	56	59	62
All other costs [1]	43	42	41	48	.....	.....	.....	.....
Materials and supplies [1]	.....	.....	.....	.....	13	11	11	9
Depreciation [1]	.....	.....	.....	.....	2	4	4	4
Other costs [1]	.....	.....	.....	.....	27	30	25	25

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1. Before 1997, all other costs was an aggregate measure. Beginning in 1997, it was disaggregated into materials and supplies, depreciation, and other costs.

NOTE. Estimates may not sum to totals because of rounding.

annual prices are interpolated without a pattern.

Beginning with 1976, the business R&D price index is interpolated using a quarterly pattern series based on average wages derived from QCEW data. The indicator series for 1976–1990 is based on a three-quarter moving average of seasonally adjusted average wages for all private industries. For 1991 forward, the QCEW-based pattern series is constructed using seasonally adjusted wage and employment data to derive an average wage for the scientific R&D services industry and for all other industries. The growth rate in the average wages for each industry set are then weighted (60 percent for the R&D services industry and 40 percent for all other private industries), and a three-quarter moving average is applied to construct the final indicator series.

Academic R&D price index

Because the characteristics and cost structure of academic institutions differ greatly from other types of for-profit and nonprofit institutions, an academic-specific R&D deflator enhances the accuracy of the estimates of real R&D produced by academic institutions. The academic R&D price index is adapted from an approach outlined in *Inflation Measures for Schools, Colleges, and Libraries: 2001 Update,* which is a data volume that reports price trends for educational institutions.[10]

The academic R&D price index comprises the following input cost components: R&D personnel wages and salaries, overhead/materials and supplies/purchased services, and economic depreciation. The source of the price data for each cost component varies over time, depending on availability. Table 14 provides the composition of the academic R&D price index for each period.

Two primary sources are used to develop weights for the academic R&D price index: *Inflation Measures* and NSF's higher education research and development (HERD) surveys.[11] In addition to data from *Inflation Measures* and the HERD surveys, estimates of current-cost depreciation of equipment and structures used in the production of R&D were used as the weights for the measure of capital services for R&D production.

The weights from each source are used to create an annual time series of weights for each cost component; these are presented in table 15 for selected years. The price index weights and input costs are combined to create the Fisher-weighted academic R&D price index.

Federal own-account R&D price index

Federal own-account R&D prices are based on a weighted average of the prices of various components of federal nondefense consumption expenditures and gross investment, including compensation of general government employees, selected intermediate goods and services, structures, and equipment. Prices for federal own-account R&D are developed by first decomposing current-dollar estimates into the following cost components:

- Compensation of federal employees performing R&D
- Intermediate inputs and overhead
- Consumption of fixed capital (CFC) for structures used in the production of own-account R&D
- CFC for equipment used in the production of own-account R&D

These cost components are then deflated using a variety of BEA price indexes. Compensation of federal employees performing R&D is deflated using the price indexes for federal nondefense compensation of employees, which are based on an indicator derived from BLS employment data. Intermediate inputs and overhead are deflated using an aggregate price built up from prices used to deflate selected components of nondefense intermediate goods and services (excluding the consumption of fixed capital and petroleum), which are largely based on various BLS producer price indexes (PPIs), consumer price indexes, and employment cost indexes. Prices for the CFC for the structures and equipment used in the production of own-account R&D are based on the prices for federal nondefense structures and equipment investment, which are based

10. Research Associates of Washington, *Inflation Measures for Schools, Colleges and Libraries: 2001 Update* (Washington, DC: Research Associates of Washington, 2001).

11. Beginning in 2010, the NSF HERD surveys collect information on R&D expenditures by universities and colleges. The HERD survey is a newly redesigned higher education survey, which collects additional information, compared with its predecessor, the survey of research and development expenditures at universities and colleges. The HERD survey collects information on R&D expenditures by type of cost, including compensation costs, other direct costs, and indirect costs.

Table 14. Academic R&D Price Index, Cost Components, and Source Data

Cost component	1929–1946	1947–1959	1960–1974	1975–1977
Compensation				
R&D university faculty	Wage and salary accruals per FTE for educational services from the NIPAs		AAUP average salary for all faculty	
Research associates	Wage and salary accruals per FTE for educational services from the NIPAs			QCEW average wages for colleges, universities, and professional schools (SIC 822)
Fringe benefits	Wage and salary accruals per FTE for educational services from the NIPAs		AAUP average benefits for all faculty	
Overhead/purchased services/ materials and supplies	Gross domestic purchases price index	PPI for SOP intermediate supplies, materials, and components		
Depreciation				
Private equipment	IPD (chain) for investment in equipment by education services industry			
Private structures	IPD (chain) for investment in structures by education services industry			
Public equipment	IPD (chain) for investment in equipment by education services industry			
Public structures	State and local government price index for educational structures			

Cost component	1978–1989	1990–1996	1997–1998	1999 forward
Compensation				
R&D university faculty	AAUP average salary for all faculty			
Research associates	QCEW average wages for colleges, universities, and professional schools (SIC 8221)	QCEW average wages for colleges, universities, and professional schools (NAICS 6113)		OES data for life, physical, and social scientists in colleges, universities, and professional schools (NAICS 6113)
Fringe benefits	AAUP average benefits for all faculty			
Overhead/purchased services/ materials and supplies	PPI for SOP intermediate supplies, materials, and components		Fisher-weighted price for energy, materials, and services by industry from KLEMS for educational services (NAICS 61)	
Depreciation				
Private equipment	IPD (chain) for investment in equipment by education services industry			
Private structures	IPD (chain) for investment in structures by education services industry			
Public equipment	IPD (chain) for investment in equipment by education services industry			
Public structures	State and local government price index for educational structures			

AAUP American Association of University Professors
FTE Full-time employee
IPD Implicit price deflator
KLEMS K-capital, L-labor, E-energy, M-materials, and S-purchased services
NAICS North American Industry Classification System
NIPAs National income and product accounts
OES Occupation employment statistics
PPI Producer price index
QCEW Quarterly census of employment and wages
R&D Research and development
SIC Standard Industrial Classification
SOP Stage of processing

Table 15. Academic R&D Price Index, Weights for Cost Components

[Percent]

	1929	1962	1974	1986	1997	2002	2007	2012
Compensation	**54**	**56**	**55**	**55**	**51**	**50**	**49**	**52**
R&D university faculty	23	24	23	23	22	21	21	22
Research associates	20	21	20	20	19	19	18	19
Fringe benefits	11	11	11	11	10	10	10	10
Overhead/purchased services/materials and supplies	**36**	**37**	**36**	**38**	**42**	**44**	**45**	**42**
Depreciation	**10**	**7**	**10**	**8**	**7**	**6**	**7**	**6**
Private equipment	3	2	3	2	2	1	1	1
Private structures	1	1	1	1	1	1	1	1
Public equipment	4	3	4	4	3	3	3	3
Public structures	2	1	2	1	1	1	2	2

R&D Research and development
NOTE. Estimates may not sum to totals because of rounding.

on a variety of PPIs and BEA price indexes.

Federal nondefense prices are used to deflate both nondefense and defense own-account R&D because they better reflect the mix of input materials and employees used in the R&D process than prices including defense inputs and personnel.

Methodology: Current Quarterly Estimates

BEA's current quarterly estimates of R&D are less detailed than its annual estimates. BEA produces separate estimates for R&D investment of total private business, nonprofit institutions (including private academic institutions), federal government, and state and local

government (including public academic institutions). The source data available, and thus the estimation methods used, vary for the advance, second, and third estimate vintages. Real measures are derived by deflating the current-dollar measures by the appropriate price index. Table 16 summarizes the source data used for each R&D investment category and each vintage of estimate.

Private business R&D investment

For the advance estimate vintage, current-dollar business R&D is extrapolated forward from the previous quarter with the growth rate of seasonally adjusted aggregate wages for all private industries derived from average earnings, hours, and employment data from the BLS Current Employment Statistics (CES).[12]

For the second and third vintages, BEA constructs an indicator based on reported R&D expenses from a matched sample of publicly traded companies' quarterly financial statements.

The business R&D price index for the current quarterly estimate is derived as the growth rate in a three quarter moving average of a composite average wage index based on data from the BLS CES in which average wages of the scientific R&D services industry receives a 60 percent weight, and the average wages of all private industries receives a 40 percent weight.[13]

Nonprofit and state and local government R&D investment

The methodology for measuring current-dollar R&D investment of private nonprofit institutions and state and local government is consistent for all three estimate vintages. BEA's estimates of private nonprofit R&D include private academic institutions' R&D, while its estimates of state and local government R&D include public academic institutions' R&D. Both nonprofits and state and local government use an indicator based on the growth rate in an aggregate wage series constructed using BLS CES data for the education and health services industry. The price index for R&D performed by academic institutions is calculated by deriving an average wage for the education and health services industry using CES data.

Federal R&D investment

During the preparation of current quarterly estimates, estimates of federal R&D investment are derived by extrapolating NSF survey data using growth rates based on figures from *The Budget of the United State Government*. The price index for federal own-account R&D is calculated by using the same source data as the annual price index.

12. Aggregate wages are the product of the number of employees, weekly hours, and hourly earnings.

13. Average wages are the product of weekly hours and hourly earnings divided by the number of employees.

Table 16. Indicators for Current Quarterly Estimates of R&D Investment and Prices

Component	Advance estimate	Second and third estimates
Business R&D investment, current dollars	Aggregate wages from BLS CES for all private industries.	R&D expenses as reported on publicly-traded companies' quarterly financial statements.
NPISH R&D investment, current dollars	Aggregate wages from BLS CES for education and health services.	
State and local R&D investment, current dollars	Aggregate wages from BLS CES for education and health services.	
Federal R&D investment, current dollars	*The Budget of the United States*	
Business, NPISH, and state and local government performer price index	Composite average wages from BLS CES using 60 percent scientific R&D services and 40 percent all private.	
Academic performer price index	Average wage from BLS CES for education and health services.	
Federal own-account price index	Various BEA price indexes	

BLS Bureau of Labor Statistics
CES Current Employment Statistics
NAICS North American Industry Classification System
NPISH Nonprofit institutions serving households
R&D Research and development