Concepts, Data, and Methods for Preparing Experimental National and State-Level R&D Production Statistics

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1. Introduction

The U.S. Bureau of Economic Analysis (BEA), in partnership with the U.S. National Science Foundation's (NSF's) National Center for Science and Engineering Statistics (NCSES), is developing an exploratory research and development (R&D) satellite account that measures the contribution of R&D activities to domestic production. The new R&D production measures in this account include value added, compensation, and employment associated with the R&D investment and exports in the National Income and Product Accounts (NIPAs). This document outlines relevant concepts, data, and methods used to prepare the experimental national and state-level statistics for this account.

BEA's satellite accounts are supplemental accounts that are linked to BEA's core accounts and expand on their analytical capability by exploring new concepts and methodologies. In addition, satellite accounts provide enhanced, complementary statistics on key sectors of the U.S. economy. They are particularly useful to measure economic activity like R&D that is spread across multiple industries as defined by the North American Industry Classification System (NAICS) used for BEA's official statistics. This satellite account includes not only the R&D performed by the scientific R&D services industry (NAICS 5417) but also by other industries in the business sector, including manufacturing, as well as by the nonprofit and government sectors.

The economic activity in the R&D satellite account is embedded in BEA's core statistics including national and regional data on gross domestic product (GDP), employment, and compensation. With this satellite account, using the latest data on R&D performance, BEA is exploring new methodologies within the GDP framework to identify and explicitly measure detailed components of R&D production at the national and state levels.

Among other insights, the experimental statistics can be used to show the contribution of the R&D sector to the national economy and to each state's economy. They can also be used to show the contribution of individual industries to R&D production or to directly compare the activity of the R&D sector to the economic activity of NAICS-defined sectors such as mining, construction, chemical manufacturing, accommodation, and food services. The contribution of the R&D sector is also measured in terms of the number of R&D jobs and the compensation for R&D work.

This new R&D satellite account builds on nearly two decades of collaborative work between BEA and NSF that laid out the foundation for BEA to expand its asset boundary within its core accounts by recognizing R&D expenditures as investment.[1] The work on R&D investment also began as a satellite account that served as a testing ground for R&D investment as a new concept and provided a means to explore the effect of this change and a framework to examine various methodological and conceptual issues. A detailed review and full references on BEA's prior collaborative work on R&D is provided in "The Evolving Treatment of R&D in the U.S. National Economic Accounts."[2]

[1] R&D expenditures were initially treated as a current expense and not included in GDP.
[2] A series of working papers on the first R&D satellite account are available on the BEA website.

2. Description of new statistics available in the R&D satellite account

The experimental R&D satellite account statistics are now available on the BEA website. There are four Excel files available for download—one each for value added, compensation, and employment as well as a bulk download file that contains all the statistics in a machine-readable format.

Each file contains statistics on R&D activity at the national level and for each of the 50 states and the District of Columbia from 2012–2023. For each geography, R&D activity is presented at the aggregate level and by producing sector—business, nonprofit institutions serving households (NPISHs), and government. The business statistics show the R&D produced by all for-profit enterprises. The nonprofit statistics show the R&D produced by private universities and colleges and nonacademic nonprofits. The government statistics show the R&D produced by federal and state and local governments including public universities and colleges. The R&D produced by federally funded research and development centers (FFRDCs) is attributed to the sector of the administrator of the FFRDC.

For value added, some industry detail is provided for R&D-intensive industries. For employment and compensation, statistics are published separately for the manufacturing sector and the nonmanufacturing sector. An addendum combines the R&D activity of private nonprofit universities and colleges (LineCode 14) and public universities and colleges under state and local government (LineCode 20).

In the state statistics, to ensure data quality standards, values below a certain threshold are suppressed and replaced with (L).

3. Definitions, concepts, and geography

This section provides definitions of key concepts relevant to the R&D satellite account. In addition, it discusses various aspects of R&D measurement including the relationship between R&D value added and R&D investment in BEA's economic accounts as well as the geography of R&D production.

3.1. Definitions

Research and (experimental) development comprises creative and systematic work undertaken to increase the stock of knowledge—including knowledge of humankind, culture, and society—and to devise new applications of available knowledge.[3]

Gross output is the broadest measure of economic activity. It includes both market-based economic activity and some nonmarket economic activity. The *market-based* economic activity is typically

[3] Organisation for Economic Co-operation and Development (OECD), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development* (Paris: OECD Publishing, 2015)

measured through sales/revenue generated from production and includes the value of goods and services purchased by industries for use in production (intermediate inputs) and the value of goods and services purchased by final users. *Nonmarket* activity refers to the production of goods and services that are either provided free of charge or for prices that do not significantly influence the amounts that producers supply or that purchasers demand. In the NIPAs, most of the production of nonprofit institutions and of government agencies is nonmarket production. The nonmarket economic activity is typically measured through expenses. Gross output double-counts some industry output because it includes output that is purchased by other industries for use as intermediate inputs.

Value added is the difference between gross output and intermediate inputs and measures the contribution of an industry to GDP. Value added can also be measured as the sum of an industry's compensation of employees, taxes on production and imports less subsidies, and gross operating surplus. The sum of value added across all industries equals GDP.

R&D value added consists of the value that an industry generates as part of R&D production after it has accounted for its costs of energy, materials, and services used up in R&D production.

R&D employment consists of all full-time and part-time wage and salary jobs in which workers are engaged in the production of R&D. Self-employed individuals and temporary workers are not included. R&D workers include researchers and technicians. Included are also support staff that directly and indirectly support production of R&D.

R&D compensation consists of the pay to employees (including wages and salaries as well as supplements to wages and salaries, such as employer contributions to pension funds and health insurance) for their R&D work during a given year. Earnings of self-employed individuals and temporary workers are not included.

3.2. Relevant concepts

R&D value added and R&D investment in BEA's economic accounts

BEA publishes some measures of R&D production at the national level in detailed supply and use tables (SUTs). The principal measure of production in the SUTs is gross output. The SUTs show which industries produce R&D commodities as well as the intermediate and final uses of these commodities.[4] This framework highlights the interdependencies between R&D and the rest of the economy, as it allows for a detailed look at the composition of R&D production and use across industries.

With the 2013 comprehensive update of the NIPAs, BEA changed the treatment of R&D to investment,

[4] An example of an R&D commodity would be the R&D performed by private universities and funded by the federal government.

and adjusted all historical GDP data to reflect this new treatment, known as "capitalization" of R&D.[5] Prior to the capitalization of R&D, R&D expenditures were treated as intermediate inputs and not included in GDP.

There are conceptual differences between R&D production (R&D value added) and R&D investment. The relationship between total domestic R&D production in BEA's SUTs and total domestic R&D investment in BEA's NIPA investment tables is as follows:[6]

$$Total\ domestic\ R\&D\ supply\ =\ Total\ domestic\ R\&D\ investment \quad (1)$$

where total domestic R&D supply is computed from the SUTs as:

$$Total\ domestic\ R\&D\ supply = Total\ domestic\ R\&D\ gross\ output\ +\ R\&D\ imports\ -\ R\&D\ exports \quad (2)$$

Furthermore,

$$Total\ domestic\ R\&D\ gross\ output\ =\ R\&D\ value\ added\ +\ R\&D\ intermediate\ inputs \quad (3)$$

Thus,

$$R\&D\ value\ added = Total\ domestic\ R\&D\ investment - R\&D\ imports\ +\ R\&D\ exports - R\&D\ intermediate\ inputs \quad (4)$$

BEA currently publishes R&D production statistics (including value added and compensation) in the benchmark after-redefinitions use table. As in the R&D satellite account, statistics in the after-redefinitions use table include not only the R&D produced by NAICS 5417 but also the R&D produced by industries outside of NAICS 5417, which is assigned to NAICS 5417 in the redefinition process. The experimental statistics published in the R&D satellite account, however, differ in important ways. The first difference is that the after-redefinitions statistics have a broader scope, including non-R&D items as well as noncapitalized items, such as licensing of R&D. The second difference is that the after-redefinitions statistics rely mostly on existing BEA industry-level statistics as source data, whereas the satellite account measures rely on R&D survey data wherever possible.[7]

This satellite account provides an opportunity to test new measurements of underlying detail of R&D in

[5] See Stephanie H. McCulla, Alyssa E. Holdren, and Shelly Smith, "Improved Estimates of the National Income and Product Accounts Results of the 2013 Comprehensive Revision," *Survey of Current Business* 93 (September 2013): 14–45.

[6] Total R&D investment is the sum of private investment (NIPA table 5.6.5) and government investment (NIPA table 5.9.5).

[7] While R&D survey data from NSF are used as a foundation for the estimation of R&D gross output, the estimation of R&D value added and compensation in the after-redefinitions use table rely on the redefinition process. This process assumes the R&D inputs are similar to the inputs within the R&D industry (NAICS 5417), regardless of the industry in which the R&D is produced.

the NIPAs, which can improve the national statistics and, importantly, allow for the development of more accurate regional data.

Measurement of value added

Value added can be measured as the difference between gross output and intermediate inputs. It can also be measured using the income approach as the sum of factor incomes earned. The R&D satellite account uses the income approach to estimate value added. With this approach, value added is measured as:

$$Value\ added = Compensation\ of\ employees + Gross\ operating\ surplus + Taxes\ on\ production\ and\ imports\ less\ subsidies$$

Compensation of employees consists of the income accruing to employees as remuneration for their work for domestic production. It includes wages and salaries and supplements to wages and salaries. Gross operating surplus consists of the consumption of fixed capital (CFC)—the depreciation in the value of capital due to wear and tear, obsolescence, accidental damage, and aging—and profits.[8] Taxes on production and imports consist primarily of excise, sales, and property taxes. Subsidies are production-related monetary grants paid by government agencies to businesses.

For government and NPISHs, CFC serves as a measure of the value of the current service of the capital (fixed assets) owned and used by these entities. Thus, the value added in the government and nonprofit sectors consists only of compensation of employees and CFC.

R&D performance and funding

As mentioned above, there is an important conceptual distinction between R&D value added and R&D investment. Beyond the conceptual distinction, R&D production and R&D investment are attributed differently to sectors of the economy. For R&D production, BEA attributes the activity to the sector that performed the R&D. For R&D investment, BEA attributes the activity to the sector that funded the R&D.[9] For example, the R&D performed by businesses but funded by the federal government would be attributed to the private sector on a production (or performance) basis but to the federal government on an investment (or funding) basis.

To measure R&D production, only federal intramural R&D and state and local intramural R&D—the R&D performed in facilities owned and operated by the federal government or state and local governments—are attributed to the government sector. The R&D performed at a federally funded research and development center (FFRDC) is attributed to the sector that administers the FFRDC. FFRDCs are research

[8] Profits include proprietors' income, corporate profits, and business current transfer payments (net).
[9] To measure R&D investment, BEA assigns ownership to the R&D funder. For a more detailed discussion of R&D ownership, see Marissa J. Crawford, Jennifer Lee, John E. Jankowski, and Francisco A. Moris, "Measuring R&D in the National Economic Accounting System," *Survey* 94 (November 2014).

institutions that are funded by the federal government but administered by businesses, universities, and other nonprofit organizations. For example, the R&D performed by business-administered FFRDCs is assigned to the business sector, whereas the R&D performed by FFRDCs administered by private nonprofit higher education institutions is assigned to the nonprofit sector. This is to ensure consistency with other production measures.

For R&D investment, BEA attributes the R&D funded by the federal government to the federal government regardless of the performer and the funding mechanism (contracts or grants).[10] BEA also treats the R&D performed at FFRDCs as investment by the federal government. This treatment captures the outsized role of the federal government in funding R&D, where the economic benefits to the federal government include the benefits that the government obtains on behalf of the general public.

Lastly, for both R&D production and R&D investment measures, the R&D performed and/or funded by higher education institutions in BEA's data is split between the three R&D-producing sectors: business, NPISHs, and government. Private for-profit academic institutions are included in the business sector, private nonprofit academic institutions are included in the NPISH sector, and public universities and colleges are included in state and local government.

The results of the conceptual and sectoral differences between R&D value added and R&D investment are shown in table 1. The experimental statistics show R&D value added was $701.8 billion in 2023. This compares with $1,003.0 billion in R&D investment. This difference is explained by the conceptual differences outlined in equation (4) above as well as differences in source data and methodologies between the two measures. The approximate $300 billion difference is mostly accounted for by intermediate inputs in the production of R&D. Smaller portions of the difference are due to net exports of R&D. The business sector is the predominant sector in both R&D production ($578.8 billion in R&D value added) and R&D investment ($727.0 billion). The table also shows the outsized role of the federal government in funding R&D ($211.0 billion in R&D investment) and its much smaller role in R&D performance ($24.4 billion in R&D value added). The R&D value added for NPISHs and state and local government sectors is larger than the R&D investment by these sectors, indicating the external R&D funding these sectors receive, in particular from the federal government.

[10] With a contract, the federal government usually retains ownership of the outcome of the purchased R&D activity. With a grant, the ownership typically transfers to the grantee; however, both the federal government and the grantee can benefit from the outcome of the R&D activity. BEA treats both R&D federal contracts and grants as R&D investment by the federal sector because the federal government is assumed to receive the primary economic benefit of this investment. Most of the R&D that is funded by the federal government, regardless of the funding mechanism, is performed in support of the missions of the individual funding agencies.

Table 1. R&D Value Added and R&D Investment, 2023

[Millions of current dollars]

Sector	R&D value added (RDSA)	R&D investment (NIPA)
Research and development (R&D)	701,833	1,003,000
Private	640,083	765,446
Business	578,807	726,967
Nonprofit institutions serving households	52,276	38,478
Government	61,750	237,475
Federal	24,378	211,033
State and local	37,372	26,442

NIPA National income and product accounts
RDSA Research and development satellite account
U.S. Bureau of Economic Analysis

Own-account R&D versus for-sale R&D

Own-account production is production performed by an entity (e.g., business or government) for its own use. This is in contrast to production that is performed by the entity but funded by another entity (known as "for-sale"). This distinction is important in the context of R&D because these need to be measured differently. Own-account R&D is nonmarket activity, and it is estimated as the sum of production costs, whereas for-sale R&D is measured through receipts.

While detailed estimates are generated for own-account R&D separately from for-sale R&D given their measurement differences, the R&D satellite account statistics aggregate the two.

3.3. Geography of R&D

One important and unique feature of the R&D satellite account is that it includes R&D production statistics (R&D value added and corresponding R&D employment and compensation) for each state and the District of Columbia. These R&D production by state statistics are based on the state in which the R&D is performed. For example, the R&D activity of a multiunit pharmaceutical company that is headquartered in New Jersey but has R&D facilities in Pennsylvania is attributed to Pennsylvania. R&D performed in U.S. territories is not included.

4. Source data

Two types of data are used to prepare the experimental national and regional statistics for this satellite account: (1) data that are collected on an enterprise basis and (2) data that are collected on an

establishment basis.[11] This distinction is relevant because BEA's industry statistics are prepared on an establishment basis. Thus, the enterprise data need to be converted to an establishment basis to ensure comparability. The methodology for this conversion is described in some detail in the methodology section.

Enterprise basis. The enterprise data consists of NSF annual surveys of R&D expenditures covering all major R&D performing and funding sectors in the United States. These include the Business Enterprise Research and Development Survey (BERD), the Annual Business Survey (ABS), the Higher Education Research and Development Survey (HERD), the Survey of Federal Funds for Research and Development, the FFRDCs Research and Development Survey, the Nonprofit Research Activities Survey (NPRA), and the Survey of State Government Research and Development. The NSF surveys are also a principal source for BEA's estimates of national R&D investment.

The BERD survey collects data on industry R&D expenditures and R&D employment, wages and salaries, and benefits for for-profit nonfarm businesses with 10 or more employees. Data on R&D activities of microbusinesses—businesses with less than 10 employees—are collected in the ABS. The HERD survey collects data from U.S. colleges and universities that spent at least $150,000 in separately accounted for R&D in the fiscal year. The three government surveys—federal funds for R&D, state government R&D, and FFRDCs R&D survey—collect data on R&D activity performed and funded by federal agencies; by departments and agencies in each state, the District of Columbia, and Puerto Rico; and by FFRDCs, respectively. The NPRA survey collects information on R&D performed by 501(c) nonprofit organizations.

Establishment basis. The establishment data includes the U.S. Census Bureau's Economic Census (EC), the U.S. Bureau of Labor Statistics' (BLS') Quarterly Census of Employment and Wages (QCEW) and Occupational Employment and Wage Statistics (OEWS), and BEA's SUTs and regional data on output, compensation, and employment. The BEA data reflect the results of the 2023 comprehensive update and the 2024 annual update of the National Economic Accounts and Regional Economic Accounts. The EC collects and publishes data on the scientific R&D services industry (NAICS 5417) and aggregate R&D expenditures for the R&D performed by the corporate, subsidiary, and regional managing offices industry (NAICS 55114).

The main source data are summarized in table 2 by R&D producing sector.

[11] An establishment is an economic unit—business or industrial—at a single geographic location where business is conducted or where services or industrial operations are performed. An establishment is not necessarily identical to an enterprise or company, which may consist of one or more establishments.

Table 2. Summary of Source Data

R&D producing sector	Source data
Business	R&D performed by businesses (including for-profit private universities and colleges): BERD, ABS, state-level special tabulations of BERD data R&D performed by FFRDCs administered by businesses: FFRDC R&D survey Supplemental sources: QCEW, OEWS, BEA SUTs
Nonprofit institutions serving households	R&D performed by private nonprofit universities and colleges: HERD R&D performed by nonacademic nonprofits: QCEW, BEA SUTs, NPRA R&D performed by FFRDCs administered by nonprofits: FFRDC R&D survey Supplemental sources: EC, QCEW, BEA SUTs
Government	Federal intramural R&D: Federal funds for R&D survey State and local intramural R&D: State government R&D survey, HERD For-sale R&D performed by public universities and colleges: HERD Supplemental sources: BEA SUTs

ABS Annual Business Survey
BERD Business Enterprise Research and Development Survey
EC Economic Census
FFRDCs Federally funded R&D centers
HERD Higher Education Research and Development Survey
NIPA National income and product accounts
NPRA Nonprofit Research Activities Survey
OEWS Occupational Wage and Employment Statistics
QCEW Quarterly Census of Employment and Wages
R&D Research and development
SUTs Supply and use tables
U.S. Bureau of Economic Analysis

5. Methodology

The general methodology for the experimental statistics in the R&D satellite account consists of three main steps.

The first step is to determine the scope of the account and identify national and state-level source data on R&D. Determining the scope of the account involves identifying the domestic R&D activity within BEA's SUTs that is capitalized and accounts for R&D investment or R&D exports in GDP.

The second step is to prepare national statistics on R&D value added, employment, and compensation by industry. These estimates are prepared by R&D performing sector as reported in each of the NSF R&D surveys. The R&D survey data are adjusted and supplemented with internal BEA data and data from other sources.

The third step is to build state-level estimates when source data used for the national estimates have regional detail or develop allocator series to distribute the national values of R&D value added,

employment, and compensation by R&D industry to states when the source data lacks the same regional detail. This step requires closely aligning the detail in the national statistics with the detail available in the state source data that is used for the allocator series.

The national and state-level estimates are aggregated to the publication level described in section 2. The publication statistics show three major R&D producing sectors reported in BEA's statistics: (1) business, (2) NPISHs, and (3) government. These three sectors also include R&D by higher education institutions: private for-profit academic institutions are included in the business sector, private nonprofit academic institutions are included in the NPISHs sector, and public universities and colleges are included in state and local government.

The rest of this section discusses in some detail the methodology used to prepare the experimental national and state statistics. The methodology discussion is organized by R&D performing sector as reported in the NSF R&D surveys.

5.1. Business sector

The business sector survey data cover R&D activity performed by for-profit enterprises, excluding business-administered FFRDCs.

5.1.1. Employment and compensation

At the national level, total R&D employment for the business sector is estimated using R&D employment headcounts, while total R&D compensation is estimated as the sum of wages, salaries, and fringe benefits and stock-based compensation from BERD and ABS. Because these headcounts and compensation include only employees whose primary responsibility is R&D, the BERD data is augmented with an estimate of incidental employment—a measure of employment for employees indirectly related to the production of R&D—to align with BEA's measure of employment and compensation, which is broader in scope. BEA's estimates of R&D employment do not include temporary employees, as those under contract and from temporary agencies are captured as purchases of intermediate services in national accounting.

Incidental employment is calculated as a share of nonincidental employment using OEWS data on occupations in the scientific R&D services industry (NAICS 5417). Incidental employment is calculated based on a selection of non-R&D occupations (such as cafeteria workers and cleaning staff) that are employed by NAICS 5417 establishments. Based on this data, in the establishments that perform for-sale R&D, incidental employment was 4.8 percent of total non-incidental employment. For establishments that perform own-account and auxiliary R&D, incidental employment was 2.8 percent of total non-incidental employment. This translates to roughly a 3.5 percent increase on average over BERD employment to account for incidental employment and compensation.

Total R&D employment and compensation are broken down by industry. Because the survey data are on an enterprise basis and all BEA statistics are reported on an establishment basis, a company-to-establishment adjustment is made to the survey data. This process is described in detail in section 5.1.3.

At the state level, the estimates of business R&D employment and compensation are also based on data from the BERD and ABS surveys. The data from these surveys, however, are more limited compared to the national level. Therefore, the state methodology is shaped by the availability of the state-specific data.

R&D employment and compensation in the business sector are estimated using special tabulations of R&D employment and compensation by state and industry from the BERD survey. The employment data are only available for 5 years, 2018–2022. The R&D employment series is extended back to 2012 by applying an average employment-to-compensation ratio for the period that employment is available to the estimated total business R&D compensation for 2012–2017.

Two adjustments are made to these estimates. First, an adjustment for incidental employment is also made to state employment using the same adjustment factor used at the national level. Second, an adjustment for microbusiness R&D is also added. R&D expenditures from the ABS are available by state for own-account R&D and for-sale R&D for the 2017–2022 period. These data, however, are not available by industry. The state-level industry breakdown of the ABS data is based on the industry breakdown of the ABS data at the national level.

Lastly, the state R&D employment and compensation estimates are adjusted to reflect R&D activity on an establishment basis. The methodology for the company-to-establishment adjustment is described in section 5.1.3. All state R&D employment and compensation estimates are then used to allocate the corresponding national R&D employment and compensation estimates to states.

5.1.2. Value added

For both national and state estimates, value added is measured additively from its components—compensation, gross operating surplus (GOS), and taxes on production and imports less subsidies (TOPI-S). At the national level, GOS and TOPI-S are estimated separately and then added to the compensation estimate to derive value added. At the state level, allocators are developed for the non-compensation portion of value added, which is then added to compensation to estimate value added.

At the national level, to compute GOS, the first step is estimating the CFC used in R&D production. To compute CFC, data from the BERD survey on depreciation of property, plant, equipment, and intangible assets is combined with a capital consumption allowance adjustment (CCAdj). The CCAdj converts a tax concept of depreciation to a national accounts concept.

GOS is computed in one of two ways depending on whether the R&D produced is for sale or whether it

is own-account or auxiliary R&D. Production of for-sale R&D is measured through receipts, while production of own-account or auxiliary R&D is measured through expenses, and GOS measures need to reflect this. In addition to CFC, receipt-based measures of GOS conceptually include a host of subcomponents, like profits from the sale of R&D, while expense-based measures of GOS conceptually only include a capital services measure.[12] Capital services measure the services capital provides, similar to the way compensation measures the services labor provides.

To estimate GOS for for-sale R&D, a GOS-to-compensation ratio from BEA's SUTs is applied to the previously estimated compensation for this component. For own-account or auxiliary R&D, GOS is equal to a capital services measure. This measure is imputed based on a ratio of capital services to CFC and the CFC estimates based on the BERD survey. This ratio is based on internal BEA research that was used to estimate capital services for the 2018 comprehensive revision of the NIPAs.

TOPI-S is estimated using BEA SUTs data. A ratio of TOPI-S to compensation is derived and applied to the previously computed compensation estimate to derive an estimate of TOPI-S.

At the state level, state R&D expenditures from the BERD survey are used to allocate the non-compensation portion (GOS and TOPI-S) of value added to states. These estimates are then added to the state compensation estimates described above to generate R&D value added.

5.1.3. Company-to-establishment adjustment

In addition to the adjustments to the NSF enterprise data for coverage, scope, and alignment with the NIPA framework and concepts described above, an important adjustment involves reclassifying the enterprise R&D data to an establishment basis.

With an enterprise approach, all of a company's R&D activity is assigned to the company's primary industry. With an establishment-based approach, the R&D activities performed at different establishments within a company are assigned separately. For example, a pharmaceutical company might perform R&D in an establishment with manufacturing (the company's primary industry) as its main activity and in another establishment with R&D services as its main activity. With the establishment-based approach, the R&D activity of this company would be split between the manufacturing industry and the R&D services industry. In contrast, the NSF source data assign all of the example company's R&D activity to the manufacturing industry.

[12] The inclusion of capital services in own-account measures was introduced in the *System of National Accounts 2008*: "A3.41 The 2008 SNA recommends that when estimating the value of the output of goods and services produced by households and corporations for own final use, it is appropriate to include a return to capital as part of the sum of costs when this approach is used for estimating output in the absence of comparable market prices. However, no return to capital should be included when production for own final use is undertaken by non-market producers."

For the national R&D investment estimates, BEA adjusts the NSF data based on a reconciliation of the EC establishment-based data for the scientific R&D services industry (NAICS 5417) with the NSF's enterprise-based data.[13] This reconciliation results in an estimate of the R&D expenditures for the NAICS 5417 industry that include the expenditures on a company basis as reported by NSF and the expenditures for scientific R&D services by multiunit companies outside of the NAICS 5417 industry.[14]

To make this adjustment, BEA assumes half of the NSF NAICS 5417 industry R&D expenditures are associated with the production of own-account R&D and the other half with the R&D produced for sale. Furthermore, BEA assumes NSF NAICS 5417 sales, estimated as half of its R&D expenditures, are included in the EC.[15] Subtracting the NSF sales from the EC sales results in an estimate of R&D sales for establishments that are part of multiunit companies. This amount is taken out proportionally from the primary industries (for example, the pharmaceutical manufacturing industry) in the enterprise data and moved to the NAICS 5417 industry. Note that this adjustment results in an adjustment ratio that does not vary by industry. An adjustment is also made for the state estimates of R&D investment in GDP by state, but the ratio is assumed to be the same as the national ratio.

A similar broad company-to-establishment adjustment is also made to the experimental R&D production statistics in this satellite account. However, the reconciliation is made with the QCEW for NAICS 5417. Note the important assumption here that the entirety of the economic activity in NAICS 5417 is in scope—in other words, the business-sector employment captured in the QCEW for NAICS 5417 is also captured in the BERD survey (likely just in a different industry). This adjustment is important for comparability of the R&D production data to other BEA industry data.

The first step is to adjust the QCEW employment and wages to align with the employment and compensation that is in scope for the BERD survey. A national wage-to-compensation ratio based on BEA compensation data is applied to the national and state-level NAICS 5417 QCEW wages to account for supplements that are included in compensation but excluded from wages. The second adjustment is motivated by the fact that QCEW data for NAICS 5417 include for-profit (5417P), nonprofit (5417N), and auxiliary (5417A) establishments, while BERD data exclude nonprofit activity. Hence, an estimate of employment and compensation for 5417N establishments anchored in experimental QCEW data on nonprofits is subtracted from the NAICS 5417 QCEW data, conceptually leaving only for-profit and auxiliary establishments within NAICS 5417. A third adjustment is made to remove the FFRDC activity

[13] For noneconomic census years, data from the Service Annual Survey (SAS) are used to interpolate between economic census years. For more information on the estimating methods and source data underlying BEA's R&D investment statistics, including the company-to-establishment adjustment for these statistics, see Marissa J. Crawford, Jennifer Lee, John E. Jankowski, and Francisco A. Moris, "Measuring R&D in the National Economic Accounting System," *Survey* 94 (November 2014).

[14] All establishments of a scientific R&D services company are assumed to be scientific R&D services establishments.

[15] The EC data and SAS data are based on receipts and do not cover own-account R&D expenditures. The EC data, however, are augmented with expenses of NAICS 5417 auxiliary establishments. Because the primary role of the auxiliary establishments is to support activities of other establishments within the company, these establishments have no sales, thus expenses rather than receipts are collected for these establishments.

embedded in the QCEW NAICS 5417 for for-profit establishments because these are not in scope for the BERD survey. This adjustment is based on QCEW data and public information for privately administered FFRDCs. These adjustments effectively set the levels of R&D employment and compensation for NAICS 5417. Note there are additional adjustments made to the BERD data to align it with national accounting concepts; these adjustments were discussed earlier in this section.

The second step is to compute the difference between the adjusted NAICS 5417 QCEW employment and compensation from the respective BERD-based measures for this industry. These are the amounts of R&D employment and R&D compensation that need to be moved from the primary industries (manufacturing and other non-5417 services industries) to NAICS 5417.

Lastly, adjustment factors are computed by expressing the difference between the adjusted NAICS 5417 QCEW employment and compensation from the respective BERD-based measures as a share of total BERD-based R&D employment and compensation *less* the BERD-based employment and compensation in NAICS 5417. Hence, these adjustment factors vary by state and year but not by non-5417 industry within a state. Applying these factors to the BERD-based R&D employment and compensation for each non-5417 industry ensures amounts are taken out proportionally from each industry and moved to NAICS 5417.

To illustrate the company-to-establishment adjustment consider a numerical example (table 3). Suppose total R&D employment based on the BERD survey for a given economy (national or state) is 1,000. In addition, the BERD-based NAICS 5417 R&D employment for the same economy is 200, whereas the NAICS 5417 QCEW-based employment is 600 (after removing the nonprofit and the FFRDC employment). The difference between the QCEW-based employment measure and the BERD-based measure is 400 (or 600 minus 200). This is the employment that needs to be moved from other industries to NAICS 5417. The adjustment factor is 0.50 computed as 400/(1000 minus 200).

Suppose there are two additional industries in this economy besides NAICS 5417 with BERD-based employment of 500 and 300, respectively. Applying the adjustment factor to the employment of the two industries reduces their employment by 50 percent to 250 and 150, respectively. In turn, employment in NAICS 5417 increases by 400 to 600 so total R&D employment in the economy remains 1,000.

Table 3. A Numerical Illustration of the Company-to-Establishment Adjustment

	BERD-based R&D employment (company basis)	QCEW-based employ-ment	Difference	Adjustment factor	BERD-based R&D employment (establishment basis)
Industry 1	500				500 × 0.50 = 250
Industry 2	300				300 × 0.50 = 150
NAICS 5417	200	600	600 – 200 = 400	400 / (1,000–200) = **0.50**	200 + 400 = 600
Total	**1,000**				**1,000**

BERD Business Enterprise Research and Development Survey
NAICS North American Industry Classification System
QCEW Quarterly Census of Employment and Wages
R&D Research and development
U.S. Bureau of Economic Analysis

Ongoing research focused on linking establishment data from the Census Bureau's Business Register to the enterprise data from the BERD survey aims to provide state and national company-to-establishment adjustments that vary by industry, to refine the reallocation of the company R&D activity to the establishments that are more likely to perform R&D. These include corporate offices, R&D labs, and manufacturing plants. The refinement of the company-to-establishment adjustment will ensure assignment of the company R&D performance to the correct state and industry.

5.2. Higher education sector

The higher education survey data cover both public and private higher-education institutions.

At the national level, R&D employment for this sector is estimated based on headcounts and full-time equivalent (FTE) employment as well as HERD compensation (salaries, wages, and fringe benefits) from the HERD survey public use microdata. The R&D employment headcounts in the HERD survey are available for all years except 2020 and 2021. For these years with missing employment data, employment was estimated using HERD compensation data. The employment headcounts including the extrapolated 2020 and 2021 values are then converted to an FTE basis using the average FTE-to-headcount ratios in the 2022 and 2023 period, for which FTE employment data are available. The conversion of the headcount series to an FTE basis reflects an adjustment for students in the HERD employment headcounts.

Value added for this sector is estimated by adding an estimate of CFC to the compensation estimate. The CFC estimate is derived from the CFC estimate that BEA prepares for its academic R&D output.

At the state level, the higher education sector estimates are also based on the HERD survey public use

microdata. The HERD microdata provide detailed information on R&D expenditures, compensation (salaries, wages, and fringe benefits), and employment by higher education institution. These data are used to estimate state and national estimates of R&D compensation and employment. For value added, the non-compensation component of value added (CFC) is allocated to states based on HERD R&D expenditures and added to the state compensation estimates.

In the HERD microdata, data are reported separately for private universities and public universities. Two adjustments are made to the data. The first adjustment is to remove passthrough expenditures for R&D that is funded by the federal government. A second adjustment is made to convert the R&D data from a fiscal year basis to a calendar year basis.

Once all the components related to R&D produced by higher education institutions are estimated, the estimates are then aggregated into two separate groups following BEA conventions: (1) R&D produced by private universities and colleges (assigned to the nonprofit sector) and (2) R&D produced by public universities and colleges (assigned to state and local government).

5.3. Government sector

For federal R&D, the experimental statistics use data on federal intramural R&D (paid for and performed by the federal government) and intramural personnel costs. BEA breaks down federal R&D activity into defense and nondefense in the experimental statistics. The source data for state and local government cover public institutions excluding public universities and colleges. The experimental BEA statistics for state and local government also include public universities and colleges as described in section 5.2. Both federal and state and local source data from the NSF surveys are adjusted to convert the data from a fiscal year basis to a calendar year basis.

At the national level, federal R&D employment is derived from personnel costs by agency for federal intramural activity from the Survey of Federal Funds for Research and Development using employment-to-compensation ratios from BEA industry data since the federal funds survey does not have employment information. The agency data are aggregated to reflect the R&D activity by function (defense and nondefense). Federal R&D compensation reflects the personnel costs for federal intramural activity from the federal funds survey.

For state and local government, R&D employment is derived from 2021–2023 data for state intramural employment headcounts from the Survey of State Government Research and Development. The 2021 estimates are extrapolated back to 2012 using inflation-adjusted state intramural expenses. R&D compensation is derived from the state employment estimates and an employment-to-compensation ratio derived from BEA industry data.

Value added is estimated by adding CFC to the compensation estimate. CFC for both federal and state and local government is estimated using CFC-to-compensation ratios from BEA industry data.

At the state level, estimates for the government sector are based on R&D obligations data by federal agency and state from the Survey of Federal Funds Survey and R&D expenditures data from the Survey of State Government R&D. The Survey of State Government Research and Development provides data on the R&D performed by public institutions excluding public universities (primarily hospitals). Only the information on intramural R&D from the federal and state surveys is used.

State R&D compensation estimates for the federal government are generated using an allocator based on federal obligations for R&D. The employment estimates use the same allocator adjusted using wage rates from the experimental QCEW nonprofit 5417 data. The non-compensation portion of value added is estimated using an allocator based on federal obligations for both R&D and R&D plant.

R&D employment and compensation estimates for the state and local government are generated using an allocator based on employment data from the state R&D survey. The employment allocators are available for 2021–2023 and were extrapolated to 2012 using state intramural R&D expenditures. The non-compensation portion of value added is estimated using an allocator based on R&D expenditures.

5.4. Nonprofit sector (excluding higher education)

The source data for the nonprofit sector cover nonacademic nonprofit institutions.

In addition to the private academic R&D described in section 5.2, the experimental BEA statistics for the nonprofit sector consist of estimates for R&D facilities and hospitals.

At the national level, R&D activity of nonprofit R&D facilities are estimated separately from nonprofit hospitals. R&D facilities employment and wages are estimated using experimental QCEW nonprofit data. Supplements are computed based on supplements-to-wage ratios from BEA industry data and added to wages to compute compensation. CFC is also computed using CFC-to-wage ratios from BEA industry data and added to compensation to generate value added.

For nonprofit hospitals, R&D employment and wages are estimated using underlying BEA data on nonprofit hospitals R&D activity. Like with R&D facilities, supplements are computed based on supplements-to-wage ratios from BEA industry data and added to wages to compute compensation. CFC is also computed using CFC-to-wage ratios from BEA industry data and added it to compensation to generate value added.

At the state level, the employment and compensation allocators for both the nonprofit R&D facilities and hospitals are based on experimental QCEW data on nonprofits. For value added, allocators for the non-compensation portion of value added are developed using QCEW nonprofit data adjusted with compensation-to-value added ratios from either the HERD-based estimates or state and local government estimates for the R&D facilities and hospitals, respectively.

5.5. Federally funded research and development centers

The FFRDC survey data are a census of all FFRDCs and are reported by the sector of the administrator of the FFRDC. These data are adjusted to convert the data from a fiscal year basis to a calendar year basis.

Based on the survey data, estimates are generated separately for FFRDCs administered by universities, private businesses (attributed to NAICS 5417P), and nonprofits (attributed to NAICS 5417N). These are then added to their respective sectors to generate publication-level statistics.

All FFRDC estimates are largely based on expenditure data collected by the FFRDCs R&D survey. At the national level, R&D employment is derived using FFRDC costs and employment-to-cost ratios from other sources: HERD for FFRDCs administered by higher education institutions, R&D nonprofit estimates for FFRDCs administered by nonacademic nonprofit institutions, and business R&D estimates as well as data from QCEW and public information for the business-administered FFRDCs. R&D compensation and value added was derived similarly using compensation-to-cost and value added-to-cost ratios from each of the respective sources.

At the state level, separate estimates are also generated for the FFRDCs administered by businesses, nonprofits, and higher education institutions. For the academic- and nonprofit-administered FFRDCs, state-level R&D FFRDC expenditures are used as allocators for employment, compensation, and value added. For business-administered FFRDCs, state estimates are generated using the state detail in the national source data and similar ratios used for the national estimates.