2007 R&D Satellite Account Methodologies: Current-dollar GDP Estimates

Bureau of Economic Analysis/National Science Foundation R&D Satellite Account Background Paper

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Preface

This paper discusses the methodologies used in constructing current-dollar R&D investment in the 2007 R&D Satellite Account. It also provides an overview of the current treatment of R&D in the national economic accounts and discusses how R&D as investment would affect gross domestic product.

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The Bureau of Economic Analysis (BEA), in partnership with the National Science Foundation (NSF), has developed a research and development (R&D) satellite account that provides detailed statistics on R&D activity and its effect on economic growth. In particular, the satellite account shows the impact on such measures as gross domestic product (GDP), investment, and saving if R&D spending were treated as investment rather than as an expense. Currently, the national economic accounts do not treat R&D and many other intangibles as investment and thus cannot separately identify their contribution to U.S. economic growth. The R&D satellite account provides a framework to explore the treatment of R&D as investment and to explore new methodologies for this treatment prior to its incorporation into BEA's core national accounts around 2013.

This paper is part of a series of methodological papers released on the BEA web site documenting the 2007 R&D satellite account and the treatment of certain keys issues.[1] It is organized as follows. Section 1 provides an overview of the current treatment of R&D in the national economic accounts and discusses how changing the accounting treatment of R&D investment affects GDP. It also includes the methodology for avoiding a double-count in software investment. Section 2 addresses the nature of R&D as investment and discusses the funding vs. performance of R&D. Section 3 provides an overview of the adjustments to the source data that are needed to create an unduplicated measure of R&D investment consistent with the national income and product accounts (NIPAs). Section 4 provides an overview of the cost detail and prices used. Section 5 presents the methodologies used to prepare estimates of current-dollar output of R&D by performer. Conclusions are presented in section 6.

[1] Released on September 28, 2007. See <http://www.bea.gov/national/index.htm#researchanddevelopment>.

1 R&D in the national economic accounts.

1.1 Current treatment.

In the NIPAs, expenditures on R&D by business—whether actually purchased from others or carried out in-house—are treated as intermediate rather than final; they are considered a current expense of production and are not among the final expenditures added up in deriving GDP. Expenditures on R&D by government and by nonprofit institutions are treated as part of their current costs incurred in production and are reflected in current-period consumption expenditures. These expenditures are currently only partly identifiable in BEA's NIPAs. Federal purchases of R&D are identified and reflected in government consumption as an intermediate purchased service. Expenditures on in-house R&D performed by the Federal Government and state and local purchases of R&D are also reflected in government consumption, but are not separately identified. Spending on R&D by foundations and nonprofit institutions serving households are in personal consumption expenditures (PCE), but are not separately identified. In addition, BEA's estimates of international trade in services provide measures of exports and imports of R&D services. BEA separately estimates royalties and licensing fees, which include payments for the use of R&D protected by patents.

1.2 How treating R&D as investment affects GDP and GDI.

Treating research and development (R&D) as an investment rather than as an expense would result in important changes to the calculation of gross domestic product (GDP). These changes also need to be reflected in the calculation of gross domestic income (GDI), which is the alternative measure of and conceptually equal to GDP, that is calculated as the sum of income earned from production (see table A below).

1.2.1 Business sector.

Shifting business R&D expenditures out of expenses and into investment would lead to an increase in GDP equal to the value of R&D investment. Recognizing R&D as investment would have an equal effect on GDI that would be reflected in two components: Business income and depreciation (consumption of fixed capital). Because R&D would no longer be considered an expense, it would no longer be deducted from gross business income (corporate profits and proprietors' income). Therefore, business income would increase. Depreciation would also increase because R&D investment adds to the capital stock, which is subject to a decline in value over time. That increases business income by the amount of R&D investment less depreciation.

$$Bus\ Income_{R\&D\ adjusted} = Bus\ Income_{unadjusted} + (Investment_{R\&D} - Depreciation_{R\&D})$$

However, because the depreciation of capital stock is also a component of GDI, the depreciation of R&D investment would be added to the total measure of depreciation. Therefore, the net effect on GDI would be an increase equal to R&D investment, maintaining the accounting identity between GDP and GDI.

$$GDI_{R\&D\ adjusted} = GDI_{unadjusted} + (Bus\ Income_{R\&D} + Depreciation_{R\&D}) = Investment_{R\&D}$$

1.2.2 Nonprofits and general government.

In these two sectors, R&D would be reclassified from consumption to investment. Because consumption is already part of GDP, this shift alone would not change the measure of GDP.

However, recognizing R&D spending as investment by nonprofit institutions serving households (household sector) and governments would also require an estimate of the capital

services generated by R&D investment in order to capture the complete economic return. Capital services measure the value of a capital asset's use in production. Conceptually, that value is the amount a producer would be willing to pay to rent the asset for a given period. Because most capital assets are owned by the same entity that uses them with no observed transaction, capital services must be estimated indirectly.

In the R&D satellite account, capital services are measured as the sum of depreciation and the net returns on R&D investment. The inclusion in the R&D account of net returns to nonprofits and general government is a departure from the current calculation of GDI in the NIPAs, which includes only depreciation as a partial measure of capital services. The R&D satellite account, however, allows for exploratory approaches, and estimated returns on R&D investment are significant, suggesting that excluding these returns would substantially underestimate the actual impact of R&D investment. Therefore, estimates of R&D capital services are included. Accounting for net returns for nonprofit and government R&D is roughly parallel with the treatment in the business sector. In that sector, net returns are assumed to be included in business income, and similarly, net returns are included in nonprofits and in general government in the R&D satellite account.

Table A. Treating R&D as Investment: Effect on GDP and GDI

	Gross domestic product (GDP)			Gross domestic income (GDI)	
Sector	Current treatment in GDP	Adjusted GDP[1]	Change to GDP	Adjusted GDI[2]	Change to GDI
Business	Expenses	R&D spending reclassified to investment	Increase equals the value of R&D investment	1. Increase in business income equal to R&D investment less CFC 2. CFC boosted	Increases by value of R&D investment
Nonprofit institutions serving households (part of the household sector)	PCE	1. R&D spending reclassified to investment 2. PCE for services boosted	1. No change from reclassification 2. PCE services increase equal to capital services (CFC plus net returns)	1. Returns to R&D capital added[3] 2. CFC boosted	Increases by value of capital services (net returns plus depreciation)
General government	Government consumption	1. R&D spending reclassified to investment 2. Government spending on services boosted	1. No change from reclassification 2. Government spending on services increase equal to capital services (CFC plus net returns)	1. Returns to R&D capital added[3] 2. CFC boosted	Increases by value of capital services (net returns plus depreciation)

CFC Consumption of fixed capital
PCE Personal consumption expenditures
1. Adjusted GDP incorporates the impact of treating R&D as investment.
2. Adjusted GDI incorporates the impact of treating R&D as investment
3. Currently, GDI does not include a measure of returns on government or nonprofit investment.

1.3 Avoiding the double-counting of software.

For the 2007 R&D satellite account, the cost of developing software that is to be marketed outside the company as an R&D activity was subtracted from GDP to avoid a double count because the NSF source data also include these costs. Those costs were double-counted in

the 2006 R&D satellite account, once in R&D investment and once in software investment. For 2007, the double-counted R&D software was removed from the software estimate and retained in R&D investment because the R&D satellite account is designed to treat all R&D as a capitalized asset. This adjustment lowered GDP and business investment by the amount of the double-count.

Beginning with 2002, the estimates of software R&D are taken from the NSF industry survey on the amount of total R&D performed for "software development" technologies. For 1990-2001, these estimates are implicitly included the NSF data on R&D, but not separately identified. For those years, software R&D was derived using the more-inclusive NIPA own-account software and the available NSF data. To create a consistent time series, an estimate of R&D software was derived and added to the estimate for R&D for the years 1978 to 1989. Prior to 1978, the values were considered negligible, so no adjustment is made.

The double-count had become significant in recent years. While for most of the 1980s and 1990s, the double-count is estimated to be about 5 to 6 percent of business funding of R&D, by 2004, this double-current grows to 17 percent of business funding of R&D and to 43 percent of total own-account software.

2 Nature of R&D investment

The treatment of R&D investment in the R&D satellite account is similar to treatment of investment in tangible capital goods in the NIPAs. Investment in R&D reflects purchases of R&D by business and by governments and their expenditures on own-account R&D that will be used to generate future product and income streams for its owners. Conceptually, the investment should be recorded for the sector that owns the R&D asset.

The satellite account provides estimates of R&D investment that are derived from NSF data and measured by source of funding. Ownership of the R&D output is needed to properly assign income flows to the various economic sectors in the NIPAs. The existing R&D survey data do not completely identify ownership. Consequently, the funder of R&D activity is treated as the owner of the R&D output. This means that currently the satellite account treats R&D funding of a grant for the performance of R&D the same way that it treats a contract for the purchase of R&D. In this satellite account, the owner is assumed to be the sole entity with the direct economic benefit from the R&D activity. Spillovers are recognized to exist and conceptually are already reflected in existing measures of GDP and GDI. However, the R&D satellite account does not separately identify these impacts for R&D.

The satellite account provides two major disaggregations of R&D expenditures: 1) R&D output by performer and source of funding and 2) R&D investment by type of funder. Although R&D investment is based on source of funding, R&D output by performer is also an analytically useful measure that allows users to see each sector's contribution to the performance of R&D. In addition, performer-based R&D activity is the foundation for estimating current-dollar R&D investment because these estimates are based on the most detailed source data available.

To derive R&D investment, the detailed performance-based R&D output by major sources of funding were re-aggregated to a funding basis, and then imports were added and exports were subtracted. In the R&D satellite account, five sources of funding are distinguished: Federal Government, state and local governments, business, universities and colleges, and other nonprofit institutions serving households.

Performer-based data from NSF were used wherever possible in preparing estimates of R&D output. This approach attempts to avoid at lease two problems. First, the data reported by funders would have to be adjusted to convert them from a time-of-payment-to-the-performer basis to a time-of-expenditure-by-the-performer basis in order to be consistent with the timing with which purchases of goods and services are generally recorded in the NIPAs. Second, the data reported by funders would have to be adjusted to avoid double-counting. Otherwise, R&D that is subcontracted would be counted twice—once by the primary source of funding and once by the secondary source of funded that subcontracted the R&D. When insufficient performer data were available, the estimates of R&D output were derived using funder-reported data. After compiling the NSF reported R&D expenditures, any missing data were estimated and the data were adjusted to be conceptually and statistically consistent with the NIPAs. The R&D investment flows then were cumulated into an R&D capital stock with an annual depreciation rate using methods that are also consistent with the NIPAs.

3 Adjustments to the Source Data.

A number of adjustments were made to the NSF survey-based spending data on R&D to make them statistically and conceptually consistent with the NIPAs. The adjustments required to incorporate R&D investment into the NIPA framework are shown in Table B. By adjusting the performer-based expenditure data, an unduplicated output measure is created. Not all of these

adjustments have been incorporated into the 2007 R&D satellite account. Also, since the survey coverage varies from performer to performer, not all sectors require the same adjustments. A blank cell indicates an adjustment that is considered necessary, but has not yet been made. The steps shown in table B are described below:

Step 1. The performer-based survey data were adjusted to match the scope of capitalized R&D. The satellite account uses the definition of R&D outlined in the OECD Frascati Manual 2002 that includes R&D activity in the social sciences and humanities, but excludes activities that are solely for commercialization and marketing.[2] This manual presents an internationally accepted classification system and guidelines for internationally comparable data on R&D activity.

Because the sum of current-period R&D production costs are used to develop current-period investment, expenditures for materials not used in the current period should also be subtracted from the output measure and included in inventories. In order to avoid double-counting, R&D that is purchased to be used for further R&D production should be reflected as an intermediate purchase and excluded. However, payments for the use of R&D in the form of technology or patent licensing fees should be treated as a cost of production and included.

Step 2. The R&D survey data were adjusted to make them consistent with the accounting conventions of the NIPAs. Data were converted to a calendar year basis when necessary and foreign performed R&D activity that was separately identified was excluded.

Step 3. Conceptually, capital expenditures on physical plant should not be included in the measure of R&D investment. When capital expenditures were included in the source data or

[2] Organization for Economic Co-operation and Development (OECD), (2002a). *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development;* Paris, France, OECD Publications.

easily estimated, they were subtracted and treated separately as part of the stock of fixed capital used to create R&D. Similarly, as described in section 1.3, an adjustment for software R&D was made to NIPA software investment to avoid the double-counting of this investment in the business sector. Lastly, R&D funds passed through from one institution to another R&D performer were removed; these funds were already reported as expenses by the sector performing the R&D.

Step 4. A conceptual adjustment was made to put depreciation of structures and equipment and software used in producing R&D on a basis that reflects the valuation and consistency appropriate for the NIPAs. Accounting for the full value of investment, includes the costs associated with the use of the stock of fixed capital used to create R&D. These costs include the economic depreciation on the structures, equipment (and, conceptually, software) used in production measured by a consumption of fixed capital (CFC) estimate. The full cost of production would also include an adjustment for taxes and subsidies on production. The satellite account used two basic approaches to obtain a NIPA-consistent estimate for the consumption of fixed tangible R&D capital. When data for R&D capital expenditures were available or easily estimated, they were removed from the reported total if included in the source data; economic consumption of this capital was estimated using a perpetual inventory methodology and added back into the remaining R&D expenditures. When expenditure data on the investment in physical R&D capital was not available, an implied economic depreciation was calculated based on historical-cost depreciation for this physical R&D tangible capital.

Step 5. Domestic investment includes R&D imports, which consist of R&D output performed abroad and used in the U.S. For business investment, an adjustment to the performer-based R&D estimates was made to add the payments for imports of research, development and

testing services (RTD) used in BEA's international transaction accounts (ITAs).[3] For Federal investment, an estimate of foreign performed R&D based on Federal R&D obligations data was added.

Step 6. Domestic investment excludes R&D exports, which consist of R&D output performed in the U.S. and used abroad. For business investment, an adjustment was made to the performer-based estimates to subtract the cost of exports of RDT services. It was assumed that there were no exports of government-funded R&D output.

For 2004, the derived investment that includes the adjustments described above is approximately $17 billion higher than the R&D expenditures reported by NSF.[4]

[3] See the U.S. International Transactions Accounts data on >http://www.bea.gov/international/>. Although these data are not a perfect match for the scope of R&D activity considered investment in the satellite account, the RDT series is a close proxy. The scope of R&D activity considered investment in the R&D satellite account is that of the *Frascati Manual*, which would include testing prototypes, but not routine testing. Thus, the RDT services data may include non-R&D transactions of unknown, but likely small, magnitude.

[4] Total NSF-based R&D expenditures may be found in Table 1. U.S. Research and Development Expenditures, by Performing Sector and Source of Funds: 1953-2006. National Science Foundation, Division of Science Resources Statistics, 2007. *National Patterns of R&D Resources: 2006 Data Update.* NSF-07-331.

Table B. Adjustments to Transform NSF Survey Data to Current-Dollar R&D Investment in the 2007 R&D Satellite Account

Adjustments		Explanation/method	Private performers			Government performers					
			Business	Private colleges and universities	Private nonprofit institutions	Public colleges and universities	Federal Government	State and local government	FFRDC business	FFRDC nonprofit	FFRDC colleges and universities
1. Align with Frascati defined R&D											
Plus or minus expenditures to align the survey data with Frascati-defined R&D	+	R&D in social sciences	Partial adjustment	X		X	NAN	NAN			
	+	R&D in the humanities		X		X	NAN	NAN			
	-	Expenditures for commercialization.	NAN	NAN	NAN	NAN	NAN	X	NAN	NAN	NAN
Plus payments for the use of R&D purchased as an intermediate input to production of R&D in the sector	+	Surveyed expenditures are reported either by performer or by funder and exclude intermediate consumption to avoid double-counting. Gross output includes intermediate consumption, including the payment for the use of R&D	X								
2. Adjust for NIPA consistency	+/-	These adjustments align the survey data to NIPA conventions	X								
Adjust from fiscal to calendar year			NAN	X	NAN	X	X	X	X	X	X
Subtract expenditures for foreign performers	-	This is a survey data adjustment, Frascati data should be domestic performance only.	NAN	X		X	NAN				
3. Adjust for double-counting of capital and other R&D funds											
Subtract capital expenditures for purchase of structures and equipment	-	Capital expenditures embedded in the current expenditure survey data should be removed from the gross output measure.	NAN	X	X	X	X	X	X	X	X
Subtract capital expenditures for purchase of software	-	Software expenditures embedded in the current expenditure survey data should be removed from the gross output measure.	X								
Subtract R&D funds which are passed though to others to perform R&D	-	R&D funds should only be reported once and are already done so by the performing sector	NAN	X		X					
4. Adjust to move from expenditures to full value of output											
Plus consumption of fixed capital on structures, equipment, and software owned by R&D producers and used to perform R&D performed in the US.	+	Consumption of fixed capital is part of the cost of production; Frascati-based expenditures do not include depreciation or CFC measures. Where source data include depreciation already, BEA adjusts to align reported depreciation to a NIPA-consistent measure.	X	X	X	X	X	X	X	X	X
Plus other taxes on production less subsidies	+/-	These taxes and subsidies are production related, none identified									
5. Adjust for Imports of R&D	+	Domestic investment includes imported capital	X		X		X				
6. Adjust for Exports of R&D	-	Domestic investment excludes exported capital	X		X						

Notes: FFRDC Federally funded research and development centers. "X" indicates that the adjustment was made. "NAN" indicates that no adjustment is necessary. Blanks indicate a future adjustment may be made.

4 Cost detail and prices.

R&D investment is difficult to measure largely because most R&D is not bought and sold in markets. Conceptually, the value of R&D to a company is equal to the discounted present value of the future benefits that the company will derive from the R&D. However, this value is embedded in the value of the goods and services the company sells, and there is no direct measure of either the contribution of R&D to sales or the market price underlying R&D assets. Companies can normally report on the cost of performing R&D, but not the market price of R&D. Therefore, the only available current-dollar value is the cost of its production. The issue then becomes how to deflate this current-dollar value to produce an estimate of real investment.

Ideally, measures of real R&D investment would be calculated using market prices for R&D output. Without these market prices, four scenarios for approximating R&D output prices were developed. These scenarios are discussed in detail in a separate R&D satellite account price methodology paper. [5] One scenario deflates the current-dollar R&D investment expenditures based on input-cost prices for each sector. Three other scenarios use price indexes that are applied to all R&D investment in aggregate regardless of the underlying cost detail. They differ from the input-price approach in that their assumptions reflect output prices at both the aggregate business and expanded industry levels and include certain characteristics to reflect the inherent risk of R&D investments: higher depreciation rates, profit residual prices, and higher

[5] For a detailed discussion of BEA's methodologies for R&D prices, see Adam M. Copeland, Gabriel W. Medeiros, and Carol A. Robbins, "Estimating Prices for R&D Investment in the 2007 R&D Satellite Account, (December 2007). <http://www.bea.gov/national/index.htm#researchanddevelopment.

rates of return. A Fisher chaining methodology was followed to develop real R&D expenditures in all price scenarios.[6]

An obvious drawback to the input-cost approach is that it necessarily implies zero productivity growth because real output, by definition, grows at the same rate as real inputs. Thus, this approach seems particularly inappropriate for measuring a dynamic sector like R&D. However, the input-cost index is the most straightforward way to estimate real R&D and this method is currently used in the NIPAs to measure the value of real investment that companies create for their own use. Thus, it represents a lower bound for real R&D growth.

Deflating R&D investment using the input-cost approach required that the estimates first be prepared by detailed cost component for each performing sector and then be adjusted to derive funder-based R&D investment. This method takes into account variations in the composition of inputs for different R&D performers.

Estimates of performer-based output are the foundation for calculating real R&D using the input-cost approach since only two of the funding price indexes exist: Total Federal purchases of R&D (defense and non-defense) and the Federal intramural R&D price deflator calculated as part of the performer-based calculations.

In order to derive funder-based estimates of real investment, it was necessary to first derive a chain-type price index for real performer-based R&D output using the detailed cost components by performer. Next, a chain-type price index for nonfederal funding of R&D was created by adding the two Federal sources of funding—intramural and extramural—as negative components to the detailed component structure for R&D output by performer. This index then

[6] For a detailed discussion of BEA's chain-type methodologies, see Landefeld, J. Steven, Moulton, Brent R., and Cindy M.Vojtech. 2003. "Chained-dollar Indexes: Issues, Tips on Their Use, and Upcoming Changes." Survey of Current Business (November): 8-16.

was used in the calculation of real R&D investment by funding: All nonfederal funding components, including imports, were deflated by this price index. While this methodology is less than ideal, it is the best methodology available using the currently available prices.

Defining the cost components was largely based on the source data detail and the availability of appropriate prices to deflate each component. Current-dollar R&D investment estimates for some sectors were based on input cost components such as compensation, material and supplies, and overhead. Components for others sectors were based on the sources of R&D funding when input cost detail was not available or easily estimated.

The remainder of this paper describes the methodologies used for current-dollar R&D output by performer, for R&D investment by funder, and the steps needed for incorporation into the NIPAs.

5 Methodologies—R&D Output by Performer.

A summary of the data sources, assumptions and estimation techniques is presented for each R&D performing sector. As it does with other estimates, BEA modified available source data to tailor them to the statistical and conceptual requirements of the NIPAs. For the business sector, current-dollar estimates for certain key industries were prepared to examine the impact of R&D investment on GDP by industry. Methodologies for the detailed industry–based estimates are presented in a separate report.[7]

5.1 Business Performers.

Source data for current-dollar R&D expenditures by industry originate from NSF's *Survey of Industrial Research and Development (SIRD),* an annual company-based survey that

[7] Carol A. Robbins, Felicia V. Candela, Mahnaz Fahim-Nader, and Gabriel W. Medeiros, "Methodology for the Industry Estimates in the 2007 R&D Satellite Account", December 2007. < http://www.bea.gov/national/index.htm#researchanddevelopment>

covers R&D performed by all for-profit R&D-performing companies. This survey provides total costs for research and development performance by industry, and for each industry, it provides a distribution of the share of these costs by type of cost. The survey includes depreciation expenses on R&D capital and excludes R&D capital expenditures. Respondents are asked to exclude the cost of R&D contracted to outside organizations to avoid any double-counting of R&D costs. Beginning with 1998, the data are reported on a North American Industry Classification System (NAICS) basis. Prior years are on a Standard Industrial Classification (SIC) basis and there is an overlap of some data on both classification systems for 1997 and 1998.

Estimates were prepared at a detailed industry level and aggregated to derive total expenditures on R&D performed by business. Beginning with 1987, current-dollar estimates were prepared for 13 R&D intensive industries and an "all other" industry on a NAICS basis. Estimates for 1987 to 1997 were converted from an SIC basis to a NAICS basis to provide a time series long enough for analytical use. For 1959 to 1987, industry-level estimates were prepared on a Standard Industrial Classification (SIC) basis.

5.1.1 Estimate missing data.

The NSF suppressed total and federally funded R&D cost data for certain years and industries in order to avoid the disclosure of confidential survey data. In these cases, judgmental estimates of the undisclosed federally funded costs were made for the satellite account. These cost estimates were then combined with the reported "company and other-funded" R&D costs to estimate total R&D costs in these industries.

The judgmental estimates for federally funded R&D were prepared using a two stage

approach. First, preliminary estimates of federal funding for missing industries were derived using the industry's federal R&D funds reported for nearby years. In this case, an annual growth rate was often calculated and used to fill in the missing data. This "vertical" approach ensured that the estimates were of the correct order of magnitude. Next, the preliminary estimates were adjusted using the next higher industry aggregate and reported funds for other industries within the same industry group. This "horizontal" approach ensured that the estimates fit with data reported at the larger industry group level. After the judgmental estimates were complete, a final check was performed to ensure that the annual expenditures at the all-industry, manufacturing and nonmanufacturing levels matched those reported by NSF.

5.1.2 Remove R&D of Federally funded research and development centers FFRDCs

Prior to 2001, NSF included the funding of industry-administered FFRDCs as part of the industry estimates, although they were not separately identified by industry. Because total industry-administered FFRDCs are presented as a separate performer in the R&D satellite account, it was necessary to remove these funds from the appropriate industries. Total NSF reported industry-administered FFRDC R&D expenditures were split by individual FFRDC based on the Federal obligations to the individual FFRDCs. To determine from which industries the FFRDC R&D expenses should be removed, the operations of the individual FFRDCs and the primary industry served were examined.

5.1.3 Valuation adjustment for purchased R&D.

The NSF values business R&D performance on a cost basis. While the value of own-account output was estimated as the sum of costs, the value of purchased R&D should include

the R&D seller's margin between receipts and costs.[8] In order to include this margin, it was necessary to distinguish between the types of industry R&D output: Purchases of R&D and own-account investment. The satellite account used a multi-step process to first make the split between own-account and purchased R&D and then to add a profit margin when no additional data were available to measure R&D purchases based on receipts rather than costs.[9] The steps to derive business own-account R&D were as follows:

- Federal Government funding, which is on a cost basis, was subtracted from total business R&D costs by industry.
- Next, the BEA-derived estimate for state and local funding of business less an estimated profit markup was subtracted from the non-Federal R&D costs.[10] These estimates were distributed to industries based on the industry R&D share of total non-federally funded business R&D.
- Next, the cost of producing business R&D exports used in BEA's international transaction accounts was subtracted. These costs were estimated using the markup described above. Industry classifications were based on unpublished BEA data on international services transactions.
- Prior to 2004, an estimate of the overestimation of R&D costs in the wholesale trade sector was subtracted. In 2004, the NSF provided a revised industry classification structure that reassigns much of wholesale trade-classified R&D and moves it to the

[8] Own-account R&D investment by business refers to the R&D output that businesses develop for their own use rather than for sale to others. Purchased R&D refers to R&D that is purchased from others instead of being developed internally.
[9] For a more detailed explanation, see "Methodology for the Industry Estimates in the 2007 R&D Satellite Account," December 2007.
[10] This margin was estimated using the ratio of net operating surplus to gross output for miscellaneous professional, scientific, and technical services (5412OP) from BEA's GDP-by-industry data. The margin methodology was used for both business purchases from other businesses and business purchases by government.

manufacturing sector, primarily to the pharmaceutical and medicine manufacturing, semiconductor and other electronic component manufacturing, computers and peripheral equipment manufacturing, and communications equipment manufacturing industries. This adjustment realigns R&D costs more closely to the source of industry receipts and it creates a consistent time series for these industries.[11]

- Next, the cost of R&D performed in NAICS industry 5417 (scientific research and development services) establishments that were reported in other industries on the NSF enterprise-based survey was subtracted. The NSF industry classification system assigns all multiunit company's R&D costs to one industry. This would include a free-standing R&D lab that sells its output to other firms as well as to other divisions of the company and that should be classified on an establishment basis in NAICS industry 5417. This adjustment was derived using a special tabulation for the year 2004 linking employment and payroll data for establishments from the Business Register to the NSF's industry categories for multiunit companies in the SIRD sample frame to adjust the company data to establishments.
- Lastly, the cost of R&D sold to other domestic business was subtracted. This adjustment used total domestic sales from NSF data, less an estimated markup. Insufficient data were available to completely assign these R&D sales to the industries that received payments for the sale of R&D. After estimating the magnitude of R&D sales from NAICS industry 5417, it was assumed that industries other than 5417 sold R&D output in proportion to their performance of R&D.

[11] For more information on this realignment, see the National Science Foundation, Science Resources Statistics, Infobrief 07-313, "*Revised Industry Classification Better Reflects Structure of Business R&D in the United States*," Brandon Shackelford (February 2007)

After estimates of business own-account R&D costs by industry were completed, costs of R&D purchases from business were calculated as a residual. Then, a profit margin was added to derive the value of purchased R&D.

5.1.4 Conceptual adjustment for depreciation.

A capital consumption adjustment was performed to place the R&D satellite account depreciation on an economic basis consistent with the NIPAs. Industry R&D expenditures reported to NSF include tax-based depreciation, or capital consumption allowances (CCA), for R&D buildings, property and equipment. This is a historical-cost measure based on the prices in the period in which the R&D assets were purchased. NSF began separately reporting this depreciation rate beginning in 1998. No data are available on investment in physical R&D capital. An estimate of the implied historical-cost depreciation was removed from the total R&D expenditures and replaced with an estimate of current-cost depreciation, or consumption of fixed capital (CFC), valued at replacement cost. This adjustment was performed at the total industry level.

For 2002 to 2004, the total NSF-reported depreciation cost shares were applied to the total R&D expenditures to develop annual historical-cost depreciation. For 1987 to 2001, the estimates of the historical cost depreciation were derived by applying the NSF reported total industry depreciation share in 2001 (3.6 percent) to the total industry R&D expenditures for each year. The rate from 2001 was used because, based on BEA research on industry depreciation

rates, the NSF reported depreciation rates for 1998 to 2000 were considered too low.[12] Historical-cost depreciation estimates from the 1994 satellite account were used for 1959 to 1986.[13,14] These costs were then removed from the total R&D expenditures for all years.

The historical-cost depreciation was replaced with an estimate of current-cost depreciation. For 1959 to 1987, estimates of current-cost depreciation from the 1994 R&D satellite account were used. In the 1994 R&D satellite account methodology, estimated historical cost depreciation was scaled to a current-cost basis using the ratio of current-cost to historical cost depreciation calculated for estimated R&D physical capital investment by private universities and colleges. Data from this sector were deemed to be a good proxy for the business sector because they were based on a more detailed reporting of investment in R&D capital upon which it was possible to directly calculate historical and current-cost depreciation. Beginning with 1988, current-cost depreciation was estimated by extrapolating forward the 1987 value using the annual growth rate in corporate CFC estimates from NIPA Table 7.13 "Relation of Consumption of Fixed Capital in the National Income and Product Accounts to Depreciation and Amortization as Published by the Internal Revenue Service."

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[12] One explanation for the low depreciation estimates may be that the survey question was new. For more information , see Ian Mead, "R&D Depreciation Rates in the 2007 R&D Satellite Account", (December 2007). < http://www.bea.gov/national/index.htm#researchanddevelopment>

[13] See Carson, Grimm, and Moylan (1994).

[14] A different methodology was used to derive historical-cost depreciation in the 1994 R&D satellite account based on the limited data available at the time. For 1958, BEA estimated these expenses by multiplying together industry depreciation rates obtained from NSF and total industry R&D expenditures. BEA derived depreciation expenses for 1982 by calculating the ratio of depreciation to payroll expenses for R&D auxiliaries and applying the result to the industry R&D compensation costs derived from the source data. Depreciation and payroll expenses for 1982 were obtained from the Bureau of the Census (1982 Enterprise Statistics Auxiliary Establishments Report, US DOC, Bureau of the Census, Table 6. Gross Depreciable Assets by Primary Function of Auxiliaries: 1982 and Table 1. Employees by Type of Work Performed: 1982). BEA interpolated the years between 1958 and 1982 based on a simple annual rate of change between the two data points. The depreciation rate calculated in 1982 was held constant and applied to the total R&D expenditures from 1983 to 1987 to estimate historical-cost depreciation expenses for those years.

5.1.5 Source of funding.

In the NSF industry source data, only two sources of funding are distinguished for R&D performed by industry: Federal funds and "company and other funds." State and local funding was estimated using data from surveys of state and local R&D. It was assumed that the funding of business R&D from universities and colleges and from other nonprofit institutions was negligible and foreign funding was small enough so that the remainder of business R&D funding could be labeled "from business."

5.1.6 Deflation categories.

To deflate using the input-cost approach, it was necessary to disaggregate the output of R&D performed by type of cost. For this disaggregation, the NSF reported distribution of industry R&D costs by cost type was used:

- Compensation for R&D personnel
- Materials and supplies
- Depreciation
- Other costs (overhead)

Additionally, the expenses for compensation of R&D personnel were split into two parts in order to deflate these components separately: wages for scientists and engineers, and wages for support personnel.[15]

Table C below summarizes the major elements of the business sector R&D investment methodology.

[15] BEA used data from a 1990 working paper by John Jankowski of the NSF, *Construction of a price index for Industrial R&D Inputs*, August 1, 1990. In this paper, Jankowski used unpublished NSF data on R&D expenditures by type of input to estimate through 1987 the split of R&D wages into scientist and engineer wages and support personnel wages for selected industries. BEA used the 1987 split of wage costs held constant beginning with 1987.

Table C. Methodology Summary for the Business R&D Estimates	
Source Data/NSF Survey	*Survey of Industrial Research and Development*
Scope of source data	Excludes funds for: • Social sciences • The humanities • Commercialization Reflects R&D performed in the U.S. only Reflects historical cost depreciation on assets used to perform R&D
Detail used	Sources of funding: • Company and other • Federal Distribution of costs for: • Compensation of R&D personnel • Materials and supplies • Overhead and other • Depreciation
Additional data used	Split of compensation into: 1) scientists and engineers and 2) support personnel based on 1987 data from NSF working paper (Jankowski 1990).
Expenditures excluded by BEA	Industry-administered FFRDCs (for years prior to 2001)
Adjustments	Estimation of missing data Depreciation on a current cost basis (CFC) Seller's margin on purchased R&D
Cost categories deflated using the input-cost price indexes	Compensation of R&D scientists & engineers Compensation of R&D support personnel Materials and supplies Overhead and other CFC

5.2 Academic Performers.

Source data for R&D expenditures by academic institutions come from NSF's *Survey of R&D Expenditures at Universities and Colleges*, which collects the separately budgeted R&D expenditures in science and engineering fields reported by universities and colleges. This annual survey, which is close to a universe survey, provides fiscal-year R&D expenditures by academic

institution, by source of funding. The survey does not include a separate measure of physical capital spending, but it includes depreciation as an unidentifiable part of overhead costs.

Separate estimates of R&D expenditures for public and for private academic institutions were prepared by source of funding. Several adjustments were made to the expenditure data to make them conceptually consistent with the NIPAs and with the Frascati definition of R&D.

5.2.1 Statistical adjustments.

Several statistical adjustments were made: For timing, for geographic coverage, to avoid double-counting, and to add non-scientific R&D expenditures. The NSF convention of a July to June academic fiscal year was used to convert the academic year data to a calendar year basis. Expenditures for R&D performed in geographic areas outside the United States, such as U.S. territories and possessions that are not included in the NIPAs, were excluded. Expenditures for federally funded R&D performed at Federal schools were removed since these expenses are already reflected in the estimates of Federal Intramural R&D reported by NSF in its *Survey of Federal Funds for Research and Development.* Because academic surveys tabulate expenditures by individual school, expenditures on R&D performed outside of the United States or at Federal schools could be removed. Funds that academic institutions reported were passed through to other R&D performing entities were also excluded. This adjustment began in 1997, the first year pass-through funds are available from NSF, and avoided a double-counting of those funds in total investment because they were already reported by the actual performer of the R&D. Lastly, expenditures by academic institutions for non-science and engineering R&D were added to better align the R&D satellite account estimates with the Frascati definition of R&D.

5.2.2 Conceptual adjustment for depreciation.

Similar to the business expenditures, the valuation of academic depreciation of structures and equipment used in producing R&D needed to be adjusted to put it on an economic valuation basis. An estimate of the implied historical-cost depreciation on R&D large equipment and structures (not separately identified in total R&D expenditures) that was embedded in the reported total R&D expenditures was removed. Expenditures were also removed for R&D "research" equipment purchased from current fund accounts. These expenses were separately identified in total R&D expenditures.[16] BEA treats the funding on "research" equipment as R&D physical capital investment for small R&D equipment.

The CFC for structures and small and large equipment that is consistent with the NIPAs, was estimated using a perpetual inventory methodology and added next. Since the academic survey does not include a separate measure of physical R&D capital spending on large equipment and structures, these expenditures were estimated using data from a variety of sources, including both the academic and federal surveys and data on the capital expenditures for educational structures in the NIPAs. Estimates for capital expenditures, historical-cost depreciation, and CFC were derived as follows:

The first step was to estimate science and engineering (S&E) capital expenditures by source of funding. Although NSF academic surveys do not presently provide an estimate of R&D capital expenditures, they do report the more aggregated total and federally funded expenditures for S&E capital through 1989, which includes R&D capital. Beginning with 1990, Total S&E capital expenditures were extrapolated using NIPA data on private and government

[16] Research equipment is purchased by the academic institution from current fund accounts.

fixed investment in educational structures.[17] Next, Federally funded S&E capital expenditures were extrapolated using obligations for R&D plant by Federal agency to academic institutions. These data are collected through the NSF's *Federal Science and Engineering Support Survey*.

The second step was to estimate expenditures on R&D structures and large equipment. R&D capital expenditures were estimated to be approximately 40 percent of the estimated total S&E capital. This percentage was based on the amount of S&E research space (total assigned square feet) relative to total science and engineering space reported in various NSF *Science and Engineering Research Facilities at Universities and Colleges* survey reports.[18] Next, it was assumed that 15 percent of the estimated R&D capital investment was for large equipment. This split was chosen judgmentally and was based on information from the financial surveys from the early 1990's and the 1988 and 1990 NSF facilities surveys that suggested a plausible range of 5% to 20%. The remaining R&D capital investment (85 percent of the total estimated) was for structures.

Next, the implied historical-cost depreciation of structures and equipment was calculated using the depreciation patterns and service lives prescribed for NSF reporting purposes. For small research equipment, a 7 year service life was assumed with a declining balance rate of 1.65. For large equipment, a 16 year service life was assumed with a declining balance rate of 1.65. For structures, a 48 year service life was assumed with a declining balance rate of 0.948. The implied depreciation for structures and large equipment was subtracted from reported R&D expenditures and replaced with a CFC for structures and equipment (both large and small research equipment) using a geometric depreciation rate.

[17] Tables 5.4.5A&B. Private Fixed Investment in Structures by Type and Tables 5.8.5A&B. Gross Government Fixed Investment by Type, in the NIPA interactive tables, www.bea.gov.
[18] *Science and Engineering Facilities at Universities and Colleges, 1994, v.I.* National Science Foundation.

NIPA investment prices were used to calculate depreciation. For private equipment, the price index for private fixed investment in equipment and software by educational services industry (NAICS 61) was used. For private structures, the price index for private fixed investment in nonresidential structures by educational services industry (NAICS 61) was used. For public equipment, an unpublished NIPA price index for state and local government fixed investment in equipment and software was used. For public structures, an unpublished NIPA price index for state and local government fixed investment in educational buildings was used. These prices were also used to deflate the CFC cost components for structures and equipment in the input-cost scenario.

5.2.3 Source of funding.

In the NSF academic source data, five sources of funding are distinguished for R&D performed by universities and colleges: Federal, business, state and local governments, universities and colleges, and "other." Foreign funding was assumed to be small enough so "other" could be labeled "from other nonprofit institutions serving households."

5.2.4 Deflation categories.

Detailed information about how the academic R&D expenditures are allocated for the various types of input costs such as labor or intermediate inputs are not collected in the academic survey data or otherwise readily available. Prices at that level of detail are also not readily available. However, BEA develops prices on the overall costs for biomedical research and development for the National Institutes of Health. For these reasons, two source of funding categories were developed to deflate the non-CFC portion of academic R&D investment: Department of Health

and Human Services (HHS) and non-HHS funded.[19] Total current-dollar academic R&D investment expenditures were split into the following four cost categories:

- Non-HHS funded R&D expenditures less CFC
- HHS funded R&D expenditures less CFC
- CFC for equipment used to perform R&D
- CFC for structures used to perform R&D

Table D below summarizes the methodology used to estimate current-dollar output of R&D performed in the academic sector.

[19] Using source of funding data from the academic survey and data on Federal agency R&D obligations to the academic sector from the NSF *Survey of Federal Funds for Research and Development*, BEA estimated that the National Institutes of Health of the HHS funds 37 percent of total current dollar academic R&D investment in 2004.

Table D. Methodology Summary for the Academic R&D Estimates	
Source Data/ NSF Survey	NSF *Survey of R&D Expenditures at Universities and Colleges.* NSF *Survey of Federal Funds for Research and Development*
Scope of source data	Excludes funds for: • Social sciences • The humanities • Commercialization Reflects R&D performed at all domestic and nondomestic institutions Reflects historical cost depreciation on assets used to perform R&D Treats small equipment R&D purchases as a current fund expense
Detail used	Sources of Funding: Federal State and Local Business Institutional (own funding) Other Public and Private Institutional Control Geographical location
Expenditures excluded by BEA	Non-domestic R&D performed Federal Schools Current-fund spending on small research equipment Funds passed through to other R&D performers
Expenditures added by BEA	Non-science and engineering R&D performed (Frascati R&D)
Adjustments	Academic to calendar year basis Depreciation to a current-cost basis
Cost categories for input-cost deflation	HHS-funded R&D less CFC Non-HHS funded R&D less CFC CFC equipment CFC structures

5.3 Federal Government performers.

The NSF *Survey of Federal Funds for Research and Development* measures annual data on Federal Government R&D reported by outlays (actual current expenditures) and by obligations (commitments to make outlays in the future). R&D outlays are available by spending agency. R&D obligations are available by agency and by R&D performer, with separate detail for Federal intramural R&D personnel and non-personnel costs. The costs for Federal intramural performers encompass R&D performed at government operated labs and exclude FFRDCs administered by non-government entities. Obligations data are also available over a longer time period than outlays. Detail on R&D plant obligations and outlays are reported separately. Depreciation of R&D plant is excluded. Outlay and obligation data together were used to prepare estimates of outlays by performer.

5.3.1 Statistical adjustments.

Several statistical adjustments were made to estimate investment: Two timing adjustments and an adjustment to convert Federal intramural obligations to outlays. Data are reported on a fiscal-year basis; these data were converted to a calendar-year basis by using a weighted average of adjacent years. Prior to calendar year 1976, the federal fiscal year was July to June; in 1976, the fiscal year was September to August; and beginning in 1977, the fiscal year is October to September. A second timing adjustment was also required because not all obligated funds are spent in the year they are obligated. Obligations were converted to outlays using a two-stage process. First, a three-year moving average formula was applied to approximate the disbursements of the R&D and R&D plant obligations over time. Obligations were assumed to be used over three years with 50, 30 and 20 percent used in the first, second and

third years, respectively. The adjusted agency obligations by performer were then controlled to the agency R&D and R&D plant outlays. This procedure provided an imputation for Federal intramural outlays split by non-personnel and personnel costs.

5.3.2 Treatment of the International Space Station.

Beginning in FY 2000, the National Aeronautic and Space Administration (NASA) reclassified the International Space Station (ISS) from R&D expenditures to R&D plant and began reporting to NSF as such. To eliminate the discontinuity in the NASA obligations and outlays data, the ISS project expenditures were reclassified to R&D plant for the earlier years of the project as well (1995-1999). Using the reported annual expenditures for the ISS from the budget of the United States government, both R&D obligations and outlays data were adjusted. The data were reclassified only to the Federal intramural and industry performers as these were the primary sectors affected.[20]

5.3.3 Estimate CFC.

Estimates of CFC for R&D structures and equipment were derived using the obligations converted to outlays data on R&D plant. First, the amount of investment in R&D capital by type was estimated. For R&D large equipment and structures, it was assumed that 15 percent of R&D plant outlays were for large R&D equipment and 85 percent are for R&D structures. These splits are similar to those assumed for academic R&D. In addition, 6 percent of the non-personnel R&D costs were assumed to be for small equipment capital and this was subtracted from the non-personnel costs. The remaining non-personnel costs were considered solely for R&D

[20] See NSF Infobrief 02-309 (February 2002) for supporting information about the NASA reporting change.

materials and supplies. The CFC was estimated using a perpetual inventory methodology and was treated in the cost estimates as a separate R&D expense.

5.3.4 Deflation categories.

The estimated outlays for Federal intramural R&D personnel costs were the basis for the current-dollar compensation estimates. The remaining non-personnel costs were for materials, supplies, and the CFC on equipment and structures. Therefore, the following cost components were estimated for Federal intramural R&D performance:

- Compensation of R&D personnel
- Materials and supplies
- CFC for R&D equipment
- CFC for R&D structures.

5.3.5 Price indexes.

- Because of the availability of numerous federal price deflators closely related to these costs components, the R&D expenditures were split into four additional categories based on federal agency funding for each cost component listed above:
- Department of Defense (DOD)
- Department of Energy (DOE)
- HHS
- NASA and other

Table E below summarizes the major elements of the Federal intramural sector R&D investment methodology.

Table E. Methodology Summary for the Federal Intramural R&D Estimates	
Source Data/NSF Survey	Survey of Federal Funds for Research and Development
Scope of source data	Excludes funds for: • The humanities • Commercialization Reflects R&D performed in the U.S. only Does not include historical cost depreciation on assets used to perform R&D
Detail used	Federal intramural obligations by agency are controlled to outlays. R&D plant separately identified. Distribution of costs for: • Compensation (personnel) • Nonpersonnel
Additional data used	U.S. Budget data for the costs of NASA International Space Station, which is moved to R&D plant.
Expenditures excluded by BEA	Estimate of small R&D equipment expenses
Adjustments	Addition of current-cost CFC
Cost categories deflated using the input cost price indexes	Compensation of R&D personnel Materials, supplies, overhead and other CFC on small and large equipment CFC on structures
Further decomposition of costs by agency	DOD DOE HHS NASA and other

5.4 State and local government performers.

Survey data from the NSF on state and local R&D activities are available for only a selected number of years. For state governments, data on R&D activities are available for 1964, 1965, 1972, 1973, 1977, 1987, 1988, and 1995. For local governments, data on R&D activities are available for 1966-1969 and 1977. While the NSF surveys varied in level of detail regarding state and local data, most surveys included both non-plant and plant expenditures on R&D; they did not include a depreciation expense as part of their reported R&D expenditures.

5.4.1 Estimate missing data.

BEA relied heavily on various estimation techniques to fill in the missing data for this sector. Preliminary estimates of R&D performance by state and local governments by source of funding and of state and local funding of R&D performance were prepared by state and by local governments and then combined to an aggregated total. NSF source data were used where they existed and interpolated and extrapolated the estimates using indicator series to fill in missing years. For R&D performance, the following indicator series were used for sources of funding:

- Federal funding: Federal R&D outlays to state and local governments from the Federal R&D estimates.
- State and local funding: State and local expenditures on "Other Economic Affairs" from NIPA estimates of state and local government consumption expenditures and gross investment by function.[21]

[21] See NIPA table 3.15.5, line 94.

- Non-government funding: total "company and other non-federal" funds spent for industrial R&D performance from NSF's *Survey of Industrial Research and Development*.

For state and local funding of universities and colleges, funding data derived as part of the academic R&D performer estimates were used. For state and local funding of other performers, the following indicator series were used:

- Business performance: total "company and other non-federal" funds expended for industrial R&D performance from NSF's *Survey of Industrial Research and Development*.
- Nonprofit organizations performance: State and local funding of other nonprofit organization R&D performance was used from the R&D estimate for other nonprofit organizations.

Similarly, an indicator series was used to fill in missing years for state and local expenditures on R&D plant using the Census Bureau's "State and Local Construction Spending" for medical buildings beginning with 1993. For prior years, R&D plant expenditures were extrapolated back using the NIPA state and local investment series for "Hospitals."

5.4.2 Statistical adjustments.

State and local fiscal-year R&D expenditures were converted to a calendar-year basis assuming that most states followed a July to June fiscal year.

5.4.3 Estimate CFC.

Estimates of CFC for R&D structures and equipment were derived using estimates of R&D plant investment. Similar to the estimation methods for other performers, it was assumed that 15 percent of R&D plant outlays were for large R&D equipment and 85 percent were for R&D structures. An additional 6 percent of the total R&D expenditures was assumed to be for small equipment capital and was subtracted from total R&D expenditures. The remaining expenditures were assumed to be for R&D materials and supplies. The CFC was estimated using a perpetual inventory methodology and was treated in the cost estimates as a separate R&D expense.

5.4.4 Deflation categories.

The NSF provided no cost breakdowns for state and local R&D expenditures. For the input-cost scenario, state and local R&D output was deflated using the following splits:

- R&D excluding CFC
- CFC for R&D small and large equipment
- CFC for R&D structures.

5.5 Other nonprofit institutions serving households.

Survey data for other nonprofit institutions are available only for selected years, and the data available for those years is limited in its detail. For the estimate of current-dollar nonprofit R&D expenditures, data from several older NSF surveys were compiled: *Research and Development Funding and Performance by Non-Profit Institutions, Fiscal Years 1996 and 1997,* R*&D Activities of Independent Non-Profit Institutions, 1973,* and *Scientific Activities of*

Independent Non-Profit, 1970. While the NSF surveys varied in level of detail regarding nonprofit data, most surveys included only non-plant performance expenditures on R&D.

5.5.1 Estimate missing data.

Because of limited source data and the limited number of data years available, BEA's estimates for the R&D performed by these institutions are relatively simple. NSF source data were used where they existed and the estimates were interpolated and extrapolated using indicator series to fill in missing years. For R&D performance, the following indicator series were used for sources of funding:

- Federal funding: Estimated Federal R&D outlays to other nonprofit institutions which were prepared as part of the Federal sector estimates.
- Non-federal funding: Tax-exempt expenses from NAICS industry 5417 were used beginning with 1992. For earlier years, the NAICS series was extrapolated by "Foundations and nonprofit research" from the NIPA PCE estimates by type of product.

5.5.2 Other adjustments.

Because the definition of the fiscal year is unknown for the various nonprofit institutions, no timing adjustment to the source data was made. Also no adjustment for CFC was made for this performer.

5.6 Federally funded research and development centers

Federally funded research and development centers (FFRDCs) are research and development organizations financed almost exclusively by the Federal Government, but administered under contract by universities and colleges, consortia of universities and colleges, industrial firms, or nonprofit organizations. The Federal Government initiated FFRDCs during World War II to help in the R&D of the war effort, most notably to help on the Manhattan project. There are currently 37 FFRDCs.

The NSF provides estimates of FFRDCs split into three sectors: FFRDCs administered by industrial organizations, FFRDCs administered by universities and colleges, and FFRDCs administered by other nonprofit organizations. Beginning with 1972, the NSF has reported expenditures on R&D for FFRDCs administrated by universities and colleges as part of its *Survey of R&D Expenditures at Universities and Colleges*. The NSF also provided total R&D expenditures of academic FFRDCs for a few selected years prior to 1972 (1958, 1964, and 1968). Beginning with 2001, NSF began providing in this survey the expenditures for FFRDCs administered by industrial organizations and by other nonprofit organizations. Prior to 2001, industry-administered FFRDCs were reported by the industries which administered them in the NSF *Survey of Industrial Research and Development,* although not separately identified; total costs for these FFRDCs were identified for most years. The NSF reported expenditures of FFRDCs administered by nonprofit organizations for the years 1964, 1966, 1969, and 1973 as part of its survey of nonprofit organizations. Federal obligations for all three types of FFRDC are also available as part of Federal funding of R&D.

5.6.1 Administered by industry.

For years prior to 2001, it was assumed that the funding for industry-administered FFRDCs was all federal. While the NSF Industry survey provided total costs for most years, it provided no split between federal and nonfederal funding. Two adjustments were made to the NSF data. The first was to fill in any missing data using the derived Federal outlays to FFRDCs administered by industrial organizations. The second was to derive an estimate of CFC using the same methodology that was used for the federal intramural sector.

5.6.2 FFRDCs administered by nonprofit institutions serving households.

For years when NSF did not report R&D expenditures, estimates were derived by interpolation using estimated Federal outlays to FFRDCs administered by nonprofit organizations. To derive an estimate of CFC, the same methodology that was used for the federal intramural sector was used.

5.6.3 Administered by universities and colleges.

Separate estimates of R&D expenditures for public and for private FFRDCs by source of funding were prepared. FFRDCs administered by consortia of both public and private schools in the private sector were included.

Missing expenditures for earlier years were interpolated using derived Federal outlays to academic FFRDCs. Two statistical adjustments were made: For timing and for geographic coverage. The NSF convention of a July to June academic fiscal year was followed to convert the academic year data to a calendar year basis. Two FFRDCs located outside the United States were removed: The National Astronomy and Ionosphere Center, located in Puerto Rico and the

Cerro Tololo Inter-American Observatory, located in Chile. To derive an estimate of CFC, the same methodology that was used for the academic sector was used.

5.6.4 Deflation categories.

Detailed information about how the R&D expenditures of FFRDCs are allocated for the various types of input costs such as labor or intermediate inputs is not available. Because almost all funding of these centers comes from federal funding, the R&D expenditures were split into the following categories for deflation purposes:

- R&D investment funded by the DOD and NASA
- Non-CFC R&D investment funded by the DOE and all other agencies.
- CFC for small equipment
- CFC for large equipment and structures

5.7 Backward extensions of the survey data.

In order to develop the necessary statistical foundation to construct capital stock estimates using the perpetual inventory method, estimates of R&D investment were prepared for years prior to 1953 which is when the NSF surveys began. Using various data sources, the R&D expenditure estimates were extended back to 1920. Estimates of R&D expenditures were not made for years before 1920, because little information is available; it was assumed that R&D expenditures before 1920 were quite small. The development of these estimates was described in detail in the technical note for the 1994 R&D satellite account.[22]

[22] See Carson, Grimm, and Moylan (1994), page 54.

6 Conclusions

Presenting the R&D investment estimates in a satellite account of the GDP accounts allows BEA to refine estimates and provide additional methodological improvements prior to fully incorporating R&D as investment in the accounts. While the estimates of R&D investment were prepared using the best source data available, the NSF data were not collected with the intent of providing an economic measurement of R&D for the U.S. national economic accounts. As a result, current methodologies for developing R&D as investment rely heavily on adjusting the source data and require a number of assumptions.

BEA continues to further refine and expand the scope of these estimates. More detailed information will be needed: For example, on R&D transactions, ownership and asset boundaries, and prices. The requirements of quarterly indicator series and source data timeliness must be addressed. As the development of the accounting framework for treating R&D as investment progresses, each improvement advances the attempt to measure the effect on the U.S. economy of investment in R&D.

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