Framework for an Industry-based R&D Satellite Account

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Abstract

This paper introduces a proposed framework for estimating an Industry-based R&D Satellite Account (IRDSA). The IRDSA builds on the preliminary Research and Development Satellite Account (R&DSA) released in September 2006, and provides industry and commodity detail. It adapts the U.S. input-output (I-O) accounts to present a consistent and systematic framework to assess the role of R&D in the economy at both an industry and commodity level.

Inclusion of R&D in the industry accounts provides the framework for examining differences among industries' investments in R&D and the impact of these investments on GDP by industry. It shows the sources of R&D output, R&D industry value added (gross output minus intermediate inputs), and R&D final uses. It allows a detailed look at the composition of R&D funding and performance across industries and the development of improved R&D deflators. In the longer term, the framework can be used as a basis for incorporating R&D into the core national economic accounts.

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Introduction

This paper introduces a framework for incorporating R&D as investment into the input-output (I-O) accounts, and for producing an Industry-based R&D Satellite Account (IRDSA).[1] The framework provides a roadmap for including the industry component to the R&D Satellite Account (R&DSA) work at the Bureau of Economic Analysis (BEA). The IRDSA builds on the preliminary R&DSA released in September 2006, and adapts the U.S. input-output (I-O) accounts to present a consistent and systematic basis for assessing the role of R&D in the economy at both an industry and commodity level. Development of the IRDSA is a necessary first step in the process of incorporating R&D into the core U.S. national economic accounts, and is a continuation of the BEA efforts to improve measures of economic activities related to R&D.[2]

The IRDSA provides a more comprehensive measure of an economic activity by bringing together components of that activity wherever they occur throughout the economy, including for example, activities which are internal to the firm and for which there are no observable prices. It identifies R&D activities, and presents the data on both an industry and a commodity basis. It also includes information needed to estimate the impacts on productivity measures if R&D is treated as investment.

In addition, the paper discusses the methodological and data issues that must be addressed in estimating R&D investment and its impact on economic and productivity growth. It provides a summary of methodologies and data used to make the preliminary estimates of the industry component of the 2007 R&DSA.

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[1] An earlier version of this paper was prepared for presentation at the 16th International Input-Output Conference in Istanbul, Turkey, July 2 – 6, 2007.

[2] Carson, et al, 1994 was the first of several BEA papers on this topic.

Background

There are three approaches to measuring the impact of R&D on GDP: The expenditure approach; the income approach; and the production approach.[3] In September 2006, BEA released the preliminary Research and Development Satellite Account (R&DSA) for the period 1959-2002.[4] This preliminary R&DSA was based on the National Income and Product Account (NIPA) framework, and presents an expenditure-based set of estimates of R&D investment and gross domestic income of R&D for the total economy. It presented all business sector activity as one aggregate, rather than by detailed industry sector. The 2007 R&DSA extends the satellite account to provide preliminary industry detail and updates the period covered to 2004.[5]

The industry approach described in this paper provides the framework used for including R&D in the industry accounts in order to examine differences among industries' investment in R&D and the impact of these investments on GDP by industry. This framework is based on the I-O tables, which show the sources of R&D output, R&D industry value added (gross output minus intermediate inputs), and R&D final uses. It allows a detailed look at the composition of R&D funding and performance across industries. In the longer term, the framework can be used as a basis for incorporating R&D into the core national economic accounts.

[3] The production approach is equivalent to the industry I-O approach.
[4] Okubo, et al, 2006
[5] Robbins, et al, 2007.

Current measures of R&D activities in BEA's Accounts

The national economic accounts currently treat R&D expenditures as intermediate inputs. Consequently, for businesses, including government enterprises, R&D expenditures are not included in GDP. For nonprofit institutions serving households and general government, R&D expenditures constitute one of the costs that are used to indirectly measure output and consumption expenditures, and thus, they are already part of GDP.

Exports and imports of R&D services are included in estimates of international trade in services, and thus, affect GDP. Separate estimates of royalties and licensing fees, including transactions for the use of R&D protected by patents, are treated as intermediate costs, except when they represent international transactions.

Conceptual Overview

The preliminary R&DSA released in September 2006 was based on the NIPA framework and provides an aggregate measure of R&D investment and its impact on the total economy. The IRDSA, used to produce the first industry estimates in 2007, is an extension of the preliminary 2006 R&DSA. It uses the I-O account to focus on R&D activities by industry. Its primary purpose is to provide a systematic and consistent structure and data set for examining the role of R&D in the economy on both an industry and commodity basis.

The industry component of the 2007 R&DSA provides partial presentation of the supply of R&D commodities. In the 2007 R&DSA, this presentation is limited to thirteen R&D-intensive industries plus an "all-other" aggregated category, rather than the full set

of industries described in this framework paper. The addition to gross output due to own-account R&D investment is shown directly for these industries.[6] The R&D satellite account estimates of investment by R&D-intensive industries also provide a partial presentation of the capital flow component of the industry framework provided here. For these R&D-intensive industries, investment in both own-account R&D commodities and for-sale R&D commodities are provided in the industry component of the 2007 R&D satellite account.

Relationship to the I-O accounts

The I-O accounts show the relationships between all the industries in the economy and all the commodities that these industries produce and use. The accounts provide an analytical framework with detailed linkages among industries and between industries and final demand. The estimates of purchases of commodities are shown in producers' prices. The I-O accounts consist of the make table, use table, direct requirements table, total requirements tables, and a capital flow table.

The IRDSA is based on the I-O accounts. It brings together components of R&D activities that occur throughout the economy. It identifies and aggregates R&D activities whether they are purchased from other firms or performed by units in the same firm for internal use (own account) and without observable prices. It presents the data on an industry and commodity basis. This framework facilitates the estimates of the interdependencies between R&D output and the rest of the economy. The IRDSA includes additional information needed to estimate the impacts on productivity measures

[6] The for-sale R&D component of gross output can be derived residually, as the change in gross output less own-account R&D.

when R&D is treated as investment; specifically, R&D capital stocks and R&D employment tables. The IRDSA represents a model to be used as BEA moves forward in including R&D into the core national economic accounts by 2013.

What Is the Same?

The IRDSA uses the overall industry and commodity classification system and the special definitions and conventions of the I-O accounts. BEA produces a standard set of make and use I-O tables. These standard tables measure NAICS-industry output as the total of all goods and services that each industry produces. It does not distinguish between primary and secondary goods and services that an industry produces.[7] These tables are consistent with other economic accounts and industry statistics.[8] The IRDSA provides a similar set of make and use tables as the standard I-O accounts.

Data on industries are classified on an establishment basis in the I-O accounts, and most of the source data are establishment-based.[9] They currently identify a portion of establishments' spending on domestic R&D, based on Census Bureau data on establishments classified in two main R&D industries: Scientific Research and Development Services (NAICS 5417),[10] and Management of Companies and Enterprises

[7] In BEA's I-O accounts, a second set of supplemental tables is also prepared. These tables reassign products that are not the primary output of an industry to those industries in which they are primary. These supplemental tables are consistent with the I-O theory and convention that follow the principle of homogeneity. The homogeneity principle groups establishments by similarity of production processes, so that each industry is comprised of establishments that have similar production functions, producing outputs with a similar set of inputs. For example, hotels produce both accommodations services and restaurant meals; the primary output of hotels is accommodations services, and their secondary output is restaurant meals. Industry output, after redefinition, is used in the calculation of total requirements tables, and are generally not comparable to other economic accounts statistics.

[8] These tables became the standard or "featured" tables beginning with the 1997 Benchmark I-O accounts.

[9] As do the GDP-by-industry account and fixed assets tables.

[10] This industry is included in a broader sector: Miscellaneous professional, scientific, and technical services, in the GDP-by-industry accounts.

(NAICS 551).[11] The IRDSA does not change this treatment of these industries and commodities.

What is Different?

The IRDSA makes several changes to the standard I-O accounts. First, like the preliminary R&DSA, the IRDSA changes the treatment of R&D purchases by businesses from intermediate consumption to investment. The IRDSA recognizes R&D as an investment whose benefit extends beyond the current production period. Therefore, the current treatment of R&D as intermediate consumption in the I-O accounts must be changed to capture the role of R&D in the production process. Second, the IRDSA defines a second set of commodities under R&D, those produced for the establishment's own use, or own account. Both R&D produced for sale and R&D for own account are treated as investment. Own account R&D can be considered to be "purchased" by its creator as investment, but this imputed purchase does not have a market and price associated with it.[12] Third, the IRDSA also reclassifies R&D expenditures of nonprofits and of general government as investment; however, the increment to output and consumption expenditures is based on consumption of fixed capital for R&D assets rather than on R&D expenditures.

[11] The Census Bureau form for NAICS 5417 collects information for firms that produce scientific research and development services, and provides a separate section for auxiliaries of firms that conduct R&D. If the R&D production is at a different establishment than the establishment where the headquarters is located, then it should be treated as Auxiliary Scientific Research and Development Services, which is industry 54170A in the standard tables. Other R&D activities that are reported under Management of Companies and Corporations are re-defined in the I-O accounts and are included in NAICS 5417 in the supplemental tables.

[12] The supplemental (after redefinitions) table separates out the primary and secondary output of industries, and re-defines the R&D output of industries, as a secondary output with a different production process from their primary products. In the supplemental table, R&D commodity output (for sale and for own-account) is re-defined as output of the scientific R&D services industry (NAICS 5417).

Proposed Framework for the IRDSA

The framework for the IRDSA proposed here represents a model or tool that can be used to examine differences in the R&D output of establishments in R&D-intensive industries and differences in impact of R&D investment in these industries. The proposed IRDSA has five tables: The Make Table (table 1); the Use Table (table 2); the Capital Flow Table (table 3); the Capital Stock Table (table 4); and the Employment and Compensation Table (table 5). The availability of data and methodologies to estimate a full set of tables would determine the feasibility of producing a full IRDSA.[13]

In the 2007 R&DSA, the industry component is a partial presentation of the supply of R&D commodities, limited to thirteen R&D-intensive industries and one "all-other" aggregate industry. A full set of industries described in this framework paper is not included in the 2007 R&DSA. The 2007 R&DSA provides estimates of gross output of own-account R&D investment for these industries and investment in both own-account R&D and for sale R&D commodities, plus a partial presentation of the capital flow component.

The Make Table

The Make Table (Table 1) accounts for domestic and international production. The table highlights the industry defined as R&D services under NAICS 54 (professional business services). Besides R&D commodities for sale, it also identifies a new commodity under R&D services (5417); that is, R&D services for internal use or own account. The make table shows the details of R&D-related services produced by industries, presenting the details of the R&D commodities produced by an industry, either

[13] Availability of funding would determine how rapidly BEA can achieve production of the IRDSA.

for sale or for own account. For example, the computer manufacturing industry produces computers as its primary product, and produces a secondary product, computer-related R&D services, for its own use in the computer industry. R&D-related services produced by other industries are treated similarly.

The Make Table follows the change in the treatment of government as producer, a change introduced in the 2003 Comprehensive Revision of the NIPA. This change explicitly recognizes that general government is engaged in the production of services (valued as the expense of providing those services), and treats the purchase of goods and services by general government as intermediate inputs. Services that are directly purchased from government (for example, college education) are treated as secondary products of the government industry, and the remaining services are treated as consumption expenditures of government. The IRDSA incorporates this change by including a row for government R&D services in the subset of R&D commodities under 5417 in the Make Table. Treatment of all non-R&D commodities and industries does not change from that in the I-O accounts.

The Use Table

The Use Table (Table 2) shows the consumption of commodities by each industry or final user. The total output of each commodity is equal to the sum of all intermediate uses of the commodity by industry and all sales to final users, or the sum of the row entries. The column entries show the dollar value of each commodity used by each industry and the value-added component of that industry. The total output of each

Table 1. Make Table

		Industries							Total commodity output at basic prices	Imports	c.i.f adjustment	Total supply at basic prices	Trade and transport margins	Taxes less subsidies including import duties	Total supply at purchasers' prices
		Agriculture, forestry, and fishing	Manufactured products	Information services	Lessors of nonfinancial intangible assets	NAICS 54 - Professional and business services		Government	Other						
						Non-R&D	R&D Services								
Commodities	NAICS 11 - Agriculture, forestry, and fishing														
	NAICS 31-33 Manufactured products														
	NAICS 51 - Information services														
	NAICS 533 - Lessors of nonfinancial intangible assets														
	NAICS 54 - Professional and business services														
	NAICS 5417 - R&D services														
	For sale														
	Own-account[1]														
	NAICS 54 excl 5417 - Non-R&D professional and business services														
	Government														
	Other														
Total industry output at basic prices															

1. The own-account R&D commodity can be split into a number of sub-commodities reflective of those industries producing own-account R&D, such as own-account pharmaceutical R&D, own-account other chemicals R&D, own-account semiconductor manufacturing R&D, etc.

Table 2. Use Table

		Industries							Final Uses				Total commodity output
		Agriculture, forestry, and fishing	Manufactured products	Information services	Lessors of nonfinancial intangible assets	NAICS 54 - Professional and business services: Non-R&D	NAICS 54 - Professional and business services: R&D Services	Government	Other	Personal consumption expenditure	Private fixed investment	Net export of goods and services	Government consumption expenditures and gross investment	
Commodities	NAICS 11 - Agriculture, forestry, and fishing												
	NAICS 31-33 Manufactured products												
	NAICS 51 - Information services												
	NAICS 533 - Lessors of nonfinancial intangible assets												
	NAICS 54 - Professional and business services												
	NAICS 5417 - R&D services	Intermediate purchases of R&D commodities[2]								Final purchases of R&D commodities				R&D commodity output
	For sale													
	Own-account[1]													
	NAICS 54 excl 5417 - Non-R&D professional and business services												
	Government												
	Other												
Value added	Compensation of employees												
	Taxes on production and imports less subsidies												
	Gross operating surplus												
Total Industry Output													

1. The own-account R&D commodity can be split into a number of sub-commodities reflective of those industries producing own-account R&D, such as own-account pharmaceutical R&D, own-account other chemicals R&D, own-account semiconductor manufacturing R&D, etc.

2. In practice, intermediate purchases of R&D are zero. However, were R&D output used only once to create more R&D output, it would be considered an intermediate purchase, rather than as investment.

industry is equal to the sum of all intermediate uses of commodities and value added, or the sum of the column entries.

The Use Table provides a detailed industry and commodity picture of the change in treatment of R&D from intermediate inputs for businesses to investment and from consumption to investment for non-profits and general government. The R&D activities that used to be intermediate inputs of businesses are reclassified as R&D commodities that are "purchased" or transferred as investment in final uses, regardless of whether it is produced for own use or for sale. These changes increase the estimate of GDP by the value of the R&D output. Reclassifying non-profit R&D and government R&D expenditures from consumption to investment does not change GDP, but the addition of a return (net return plus consumption of fixed capital) to non-profits and government from their R&D investments increases GDP. This return represents the flow of services from the R&D asset that would not exist if R&D is treated as a consumption item. Total R&D investment by business and private non-profits is included in private fixed investment, and R&D investment by government is included in government investment. Estimates of the consumption of fixed capital (CFC) component of the returns to R&D capital for non-profits and government are included in their respective consumption measures, consistent with the current treatment in the national economic accounts in which CFC is a partial measure of the services that these assets provide.[14] The output of non-profits is divided between investment in R&D (R&D purchases) and PCE. The PCE of non-profits falls by the purchases of R&D now treated as investment, and increases by the addition of CFC of R&D capital. Other categories of final uses do not change; that is, household PCE, non-

[14] Net returns to assets of non-profits institutions and government are not included in the U.S. national economic accounts.

R&D investment, government expenditures, and net exports do not change from the standard treatment in the I-O accounts.

The Use Table also provides estimates of income (Gross Domestic Income) or Value Added. The Use Table of the IRDSA highlights the value added of R&D-producing and non-R&D-producing industries. The value added portion of the table shows three subcategories of detail: Compensation of employees; gross operating surplus, and taxes on production and imports less subsidies to the primary and secondary outputs of industries. The gross operating surplus includes the net returns to and depreciation of R&D capital for businesses, and depreciation for non-profits and government. The R&D expenditures that are treated in the current industry accounts as intermediate inputs are now included in the business income components of gross operating surplus of industries; gross operating surplus also includes the services of fixed capital used to create the R&D output.

The net returns to non-profits and government R&D capital and depreciation of their R&D capital are additions to value added when treating R&D as an investment. The value added for non-R&D industries does not change. The Total Industry Output column equals the sum of the intermediate inputs and value added for each industry, R&D and non-R&D industries.

Capital Flow and Stocks Tables

A standard Capital Flow Table shows the structure of flows of new capital goods used by each industry. It presents the destination of new investment in equipment, software, and structures by industries purchasing or leasing the new capital commodity.

Table 3. IRDSA Capital Flow Table

			Industries	Total fixed investment
			R&D 5417 All Other indusries	
			I_1 . . . . . I_N	
R&D commodities	For-sale			
	Own-account	C_1 . . . . . C_N		
	Total own-account			
Total R&D commodities				
Other investment commodities	Software			
	Structures			
	Equipment			
Total other investment commodities				
Total industry use of new equipment, structures, software and R&D				

The IRDSA Capital Flow Table, Table 3, expands the gross private fixed investment component of the I-O use table to show the types of equipment, structures, software, and R&D purchased for use by each industry. Like the standard capital flow table, the capital flow table of the IRDSA is organized in a commodity-by-industry matrix. It modifies the standard table, and adds R&D investment. The IRDSA Capital Flow Table shows how investment, R&D, and non-R&D, is allocated to the using industries. Like the Make and Use tables, it shows R&D commodities produced for sale and for own account. Non-R&D investment follows the standard capital flow table.

Table 3 shows five major rows. The first set, R&D Commodities, is divided by R&D for sale and own-account R&D. The second row shows Total Industry R&D investment commodities. The third and fourth rows show other investment commodities – equipment, structures, software – and the total of these investment commodities. The fifth row is the sum of total industry R&D fixed investment and the sum of all other fixed investment. This table may be viewed as a "R&D funders" table[15] because it shows the sources of funds for R&D capital investment, separating R&D commodities by whether the R&D commodity was produced for sale or for own use (own account).

The Capital Stocks Table (Table 4) includes gross investment expenditures from the current period and the accumulation over multiple periods to form net capital stocks of equipment, structures, software, and R&D. The R&D Capital Stocks table supplements the R&D Capital Flow Table. The R&D Capital Stocks Table shows net stocks of R&D capital accumulated across multiple periods in addition to the stock produced in the current period. Net capital stock equals the existing stock less

[15] If the transactions could be classified as sales and as subsidies, this connection with funders would be broken for subsidized R&D.

depreciation plus current period gross investment. The table presents estimates of total R&D capital stock and total non-R&D capital stock by industry.

Table 4. Capital Stocks Table

	Commodities						Industry total	
	R&D			Non-R&D				
	Fixed investment		Cumulative capital stock	Fixed investment	Cumulative capital stock		Total fixed investment	Total cumulative capital stock
	C_1 … … … C_N	Total	C_1 … … … C_N	Total				
Industries								
I_1								
.								
.								
.								
.								
.								
.								
.								
.								
.								
.								
.								
.								
I_N								
Commodity total								

Employment and Compensation Table

The Employment and Compensation Table (Table 5) shows the domestic labor supply used in the production of R&D and the associated labor cost.[16] It presents data by industry and total for all industries on the occupational category of labor used to produce R&D for sale and for own account. Employment and compensation for non-R&D commodities are measured separately.

Table 5. Employment and Compensation Table

		Employment								**Compensation**							
		R&D						**Non-R&D**	**Total**	**R&D**						**Non-R&D**	**Total**
		For-sale			**Own-account**					**For-sale**			**Own-account**				
		Scientists and engineers	Staff	Total	Scientists and engineers	Staff	Total			Scientists and engineers	Staff	Total	Scientists and engineers	Staff	Total		
Industries /1/	I_1 . . . . . I_N																
Total industries																	

/1/ List of industries includes private business, nonprofit, and government.

[16] The tables are presented here in nominal dollars.

Practical Considerations and Empirical Implementation

While this framework provides a model for estimating the IRDSA, its implementation may involve changes in some details. Estimating the IRDSA hinges on development of methodologies and the availability of data to measure R&D commodities produced at the level of detail required. The framework serves as a guide for using available data to provide reasonable first approximations of the R&D investments by industry, nonprofits, and government, and for collecting additional detailed data needed to produce a complete IRDSA. Several methodological issues also need to be addressed to implement the conceptual framework: Adjustment of BEA's annual I- O estimates, GDP-by-industry estimates, and the benchmark I-O estimates to treat R&D as investment; allocation of enterprise-based R&D survey data to the establishments that supply R&D output; and assignment of this output to the establishments that acquire the R&D as investment. In addition, industry prices for R&D output need to be developed. Each of these issues is discussed below, along with data availability issues.

2007 R&DSA: Adjustments of Industry Accounts

For 2007, the R&DSA adjusts the standard I-O accounts to include estimates of R&D output, R&D investment, and detailed price indexes for the R&D output. It provides estimates of R&D investment, nominal R&D output, and nominal value added, detailed price indexes for R&D output, real R&D output, and real value added for detailed industries.

The first step in testing our methodology with available data is analyzing R&D investment for the selected group of fourteen industries: Thirteen detailed industries and

one all other industries category for the years 1987 to 2004, using the IRDSA framework. These industries represent the largest business performers of R&D in the domestic economy, and about two-thirds of all industrial R&D expenditures in 2001.[17] These industries are listed in Table 6.

Table 6

Detail Level for Impact on Real Value added, R&D investment and R&D output, and R&D prices, 1987 – 2004	**R&D Activity** (millions of dollars)	**Percent of Total**
All other for profit industries	71,059	35.2
Chemical manufacturing minus pharmaceutical and medicine manufacturing (325 minus 3254)	7,755	3.8
Pharmaceutical and medicine manufacturing (3254)	10,137	5.0
Computers and peripheral equipment manufacturing (3341)	3,178	1.6
Communications equipment manufacturing (3342)	19,019	9.4
Semiconductor and other electronic component manufacturing (3344)	14,358	7.1
Navigational, measuring, electro-medical, and control instruments manufacturing (3345)	12,947	6.4
Other computer and electronic products (other 334)	1,090	0.5
Motor vehicles, bodies and trailers, and parts manufacturing (3361-3363)	17,207	8.5
Aerospace products and parts (3364)	7,868	3.9
Other transportation equipment (3365-3369)	890	0.4
Software publishers (5112)	13,111	6.5
Computer systems design and related services (5415)	9,154	4.5
Scientific R&D services (5417)	14,244	7.1

For the group of industries selected, the 2007 R&DSA provides additional industry detail compared with the 65-industry level of the standard GDP-by-Industry account, showing information about R&D investment for industries such as pharmaceuticals which are usually aggregated in the Chemical manufacturing industry.

[17] Data are from the National Science Foundation, Survey of Industrial Research and Development, 2001.

This preliminary set of accounts shows the differences in the current industry accounts and in the National Income and Product Accounts (NIPAs) that treat R&D as a current expense, and the IRDSA which treats R&D as an investment (R&D for sale and R&D for own-account). It also shows the changes in the level of GDP, fixed investment, private inventories, level of intermediate expenditures, and value added and its components. The impacts on the accounts are discussed below, and Tables 7, 8, and 9 highlight these differences for private industry.

What Data Are Available for What Industries?

Two sets of data are used to estimate the IRDSA. The first set is from the National Science Foundation (NSF). The NSF collects data at the 3- to 4-digit NAICS level of detail on industry R&D expenditures and R&D employment, wages and salaries, and benefits on an enterprise basis.

The second set is from the Census Bureau. This set is used in the current, standard I-O accounts, which explicitly include Scientific R&D services (NAICS 5417) and aggregate R&D expenditures into NAICS 55, the portion of Management of Companies and Enterprises (NAICS 55) undertaking R&D services. Both industries are collected on an establishment basis. These data are available for Quinquennial Economic Census years, as well as in the Services Annual Survey (SAS).

Allocation of Enterprise-based R&D data in the 2007 R&DSA

All data on industries from the NSF are collected on an enterprise basis, and a methodology was needed to translate the NSF enterprise-based R&D private industry

spending into establishment-based R&D spending. The methodology developed to convert enterprise data to establishment basis used a special tabulation of Census employment and payroll data for establishments from the Business Register linked to NSF's industry categories for multiunit companies in the Survey of Industrial Research and Development (SIRD). This tabulation was used to develop ratios of R&D costs by type of establishment to total R&D costs; these ratios were then used to allocate R&D expenditures to R&D labs and company headquarters. The remaining R&D costs were assumed to be performed in establishments in the "primary" industry, because no source data were available to reallocate the R&D output to other industries.[18]

Establishment-based industry estimates of R&D spending were available for NAICS industry 5417, Scientific Research and Development Services auxiliaries, and are collected by the Census Bureau for Economic Census years (every five years). Estimates for these industries were included in the 2007 R&DSA. Although these estimates were less than 20 percent of total estimated total R&D spending in 2002, they provided a basis for evaluating the conversion methodology.

Industry Prices for R&D Output in the 2007 R&DSA

Real R&D investment, output, and value added were estimated using two different price scenarios. One scenario is based on input prices, estimated with the cost of producing R&D output (similar to Scenario A in the 2006 preliminary R&DSA). Prices for this scenario were created using methods developed in BEA's 1994 and 2005 R&D satellite accounts, and extended to reflect industry-specific costs. A second

[18]See Robbins, et al, 2007,< http://www.bea.gov/industry/index.htm> for a full description of the methodology used to allocate company-based R&D to establishments for the 2007 R&D Satellite Account.

approach developed in the 2007 satellite account used detailed industry R&D output indexes of individual chain-type Fisher indexes of industry output prices. The aggregate index weighted the output prices by the share of R&D spending to total R&D expenditures of the thirteen R&D-intensive industries. This price scenario used primarily producer price indexes from the Bureau of Labor Statistics (BLS).[19]

Other Tables

The remaining tables included in the IRDSA were not provided in the 2007 R&DSA. They include: The Capital Flow Table, the Capital Stocks Table, and the Employment and Compensation Table. The Capital Flow Table and the Capital Stocks Table would be estimated using the Make and the Use Tables to show which industries purchased equipment, structures, software, and R&D investment. The Capital Stocks table would show the net stock of R&D capital accumulated across periods. The Employment and Compensation Table would use data from the NSF and the BLS to show the domestic labor and compensation paid to produce R&D commodities.

Impact on Production Account from Capitalizing R&D: An Illustration

The industry production account provides a framework for examining differences among industries' investment in R&D and the impact of these investments. To see how incorporating R&D investment in the industry accounts, an example with hypothetical values is presented for the private industry sector to show what changes in the production account for an industry when R&D investment is incorporated into the account. This

[19] See Copeland, et al, 2007 for a complete discussion of the methodology for estimating prices of R&D investment.

methodology was used in estimating the 2007 R&DSA industry component for private industry. Including estimates for non-profits and government investment in R&D are planned for the 2008 R&DSA.

Currently, the production costs of private business, including the costs associated with all R&D, are classified as inputs to production with no corresponding output of R&D.[20] The production costs of nonprofit institutions serving households and general government, including the costs associated with all R&D are recorded directly as the value of output by these sectors and, thus, include a measure of output of R&D. In the proposed treatment from capitalizing R&D, GDP will increase by the value of private businesses' output of all R&D, which will be measured by their R&D production costs, plus the consumption of fixed capital used for R&D (e.g., labs and equipment). As discussed earlier in the paper, for the R&D by nonprofit institutions serving households and by general government, GDP will increase by the consumption of existing fixed capital these sectors used for R&D, plus the consumption of fixed capital on their capital stock of R&D, plus an imputed net return on this capital stock of R&D.

Tables 7-9 illustrate changes to the industry production accounts that result from treating R&D as investment. These tables show the current treatment of R&D as expense; the proposed treatment of R&D as investment; and the differences in the two accounts that result from the new treatment. These tables provide hypothetical numerical values to illustrate changes to various production account measures for private business, nonprofit institutions serving households, and general government.

[20] R&D here refers to production for both own-use, so-called "own-account production" and for eventual sale or licensing.

Impact on Private Business

For private businesses, capitalizing R&D will increase GDP by the value of the additional industry gross output, which will equal the imputed value of their R&D output, measured as the total costs of producing their R&D, plus an adjustment to convert depreciation costs to the consumption of fixed capital used for R&D (e.g., labs and equipment).[21] (table 7). As a result, value added will increase by the amount of the imputed R&D output for the industry. This increase in value added will be recorded as an increase in the business income component of gross operating surplus of the industry. Depreciation of the existing stock of capitalized R&D will reduce the industry's business income, but this reduction will be offset by the depreciation entry within gross operating surplus.

Table 7 provides an example of changes to the production account after capitalizing private business R&D. Under the current treatment, $12 in R&D related expenses are recorded – $5 in intermediate inputs of goods and services, $3 in compensation paid to a researcher, and $4 in consumption of fixed capital for the depreciation of the laboratory used by the researcher – with zero output that results from these expenses. As a result, industry value added equals -$5, and can derived as industry gross output ($0) less intermediate inputs ($5), or conversely, as the sum of the three major components of value added, compensation of employees ($3), gross operating surplus (-$8) and taxes less subsidies (assumed zero in this example). After capitalizing R&D, an imputed value of R&D output, equal to the sum of the costs incurred in producing R&D, plus the consumption of fixed capital used for R&D, is added to the

[21] For example, these total costs of production could include intermediate inputs, compensation, and depreciation related to conducting R&D.

industry's gross output ($14). As a result, value added is increased by $14, from -$5 to $9. This increase in value added is recorded in the industry's gross operating surplus, which increases from -$8 to $6.

Impact on Nonprofit Institutions Serving Households and General Government

Because the output of nonprofit institutions serving households and general government is currently measured as the sum of production costs, the capitalization of R&D will increase GDP by the consumption of existing fixed capital these sectors used for R&D, plus the consumption of fixed capital on their capital stock of R&D plus an imputed net return on this capital stock of R&D.[22] This increase will also be recorded in these sectors' gross operating surplus, value added, and gross output (tables 8 and 9).

In the domestic income and production account, the R&D output of nonprofit institutions serving households and general government is currently treated as consumption expenditure. After capitalization, the R&D output will be recorded as gross private or government investment, and both personal and government consumption expenditures will be increased by the value of a net return to the newly recognized R&D capital.

[22] In practice, the U.S. industry and domestic production accounts do not include a net rate of return on the consumption of fixed capital of nonprofits serving households or general government.

	Basic data for example	
	Current "Expensed"	Proposed "Capitalized"
Production costs for R&D, total	12	12
Compensation paid researcher	3	3
Consumption of intermediate inputs, R&D	5	5
Consumption of fixed capital, R&D lab & equipment	4	4
Imputed net return on R&D lab & equipment consumed		2
Consumption of existing stock of R&D		1
Imputed net return on existing stock of R&D consumed		0.2

Table 7. - Impact of New R&D Treatment on Production Accounts, Private Business			
	Current	Proposed	Difference
Industry Production Account	"Expensed"	"Capitalized"	
Gross output	**0**	**17**	**17**
R&D production costs, total		**15**	**15**
Imputed net return, R&D lab & equip consumed		**2**	**2**
Less: Intermediate input consumption	**5**	**5**	**0**
Consumption of intermediate inputs, R&D	5	5	0
Equals: Value added	**-5**	**12**	**17**
Compensation of employees	7	7	0
Taxes on production, less subsidies			0
Gross operating surplus	-12	5	17
Consumption of fixed capital	3	4	1
Lab & equipment	3	3	0
Existing stock of R&D		1	1
Business income	-15	1	16
Gross output		17	17
Less: Expenses	15	16	1
Compensation of employees	7	7	0
Consumption of fixed capital	3	4	1
Lab & equipment	3	3	0
Existing stock of R&D		1	1
Consumption of intermediate inputs, R&D	5	5	0

Table 8. - Impact of New R&D Treatment on Production Accounts, Nonprofits Serving Households

Industry production account	Current "Expensed"	Proposed "Capitalized"	Difference
Gross output	**15**	**18.2**	**3.2**
Imputed gross output, R&D	15	17	2
R&D production costs, total	15	15	0
Imputed net return, R&D lab & equip consumed		2	2
Consumption of fixed capital, existing stock of R&D		1	1
Imputed net return, existing stock of R&D consumed 1/		0.2	0.2
Less: Intermediate input consumption	**5**	**5**	**0**
Consumption of intermediate inputs, R&D	5	5	0
Equals: Value added	**10**	**13.2**	**3.2**
Compensation of employees	7	7	0
Taxes on production, less subsidies			
Gross operating surplus	3	6.2	3.2
Consumption of fixed capital	3	4	1
Lab & equipment	3	3	0
Existing stock of R&D		1	1
Imputed net return, R&D		2	2
Imputed net return, existing stock of R&D consumed 1/		0.2	0.2

1/ In practice, the U.S. industry and domestic production accounts do not include a net rate of return on the consumption of fixed capital of nonprofits serving households.

Table 9. - Impact of New R&D Treatment on Production Accounts, General Government			
	Current	Proposed	Difference
Industry production account	"Expensed"	"Capitalized"	
Gross output	**15**	**18.2**	**3.2**
Imputed gross output, R&D	15	17	2
R&D production costs, total	15	15	0
Imputed net return, R&D lab & equip consumed		2	2
Consumption of fixed capital, existing stock of R&D		1	1
Imputed net return, existing stock of R&D consumed 1/		0.2	0.2
Less: Intermediate input consumption	**5**	**5**	**0**
Consumption of intermediate inputs, R&D	**5**	**5**	**0**
Equals: Value added	**10**	**13.2**	**3.2**
Compensation of employees	7	7	0
Taxes on production, less subsidies			
Gross operating surplus	3	6.2	3.2
Consumption of fixed capital	3	4	1
Lab & equipment	3	3	0
Existing stock of R&D		1	1
Imputed net return, R&D		2	2
Imputed net return, existing stock of R&D consumed 1/		0.2	0.2
1/ In practice, the U.S. industry and domestic production accounts do not include a net rate of return on the consumption of fixed capital of general government.			

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