InfoBrief
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Software R&D: Revised Treatment in U.S. National Accounts and Related Trends in Business R&D Expenditures

by Francisco Moris[1]

Research and development in software contributes to emerging research, investment, and economic policy areas, such as artificial intelligence, information and communication technologies (ICT), and the digital economy.[2] Accordingly, software R&D is an increasingly large technology area of U.S. business R&D expenditures. For example, in 2016, software R&D accounted for $120.8 billion of the $374.7 billion in U.S. business R&D, or 32%, compared with 20% in 2006, as reported by the National Center for Science and Engineering Statistics (NCSES) within the National Science Foundation.

A recent change in the treatment of software R&D in the U.S. gross domestic product (GDP) and other national income and product accounts (NIPAs), published by the Bureau of Economic Analysis (BEA), underscores the importance of software for U.S. R&D statistics. R&D was capitalized, or recognized as investment (gross fixed capital formation [GFCF][3]), for the first time in the U.S. NIPAs in 2013 (Crawford et al. 2014; Moris et al. 2015). At that time, software R&D expenditures were capitalized under software investment—not under R&D—to avoid duplication, because software was already considered a fixed asset.[4] However, this also meant that for NIPA purposes, "R&D investment" was effectively non-software R&D investment, in contrast to NCSES's inclusion of both software and non-software R&D in total U.S. R&D expenditures.

The 2018 Comprehensive Update of the NIPAs reclassified software R&D as R&D investment to resolve the above inconsistency (Chute, McCulla, Smith 2018).[5] This InfoBrief presents updated BEA data on R&D investment and software investment and examines NCSES total R&D expenditures and business software R&D expenditures.

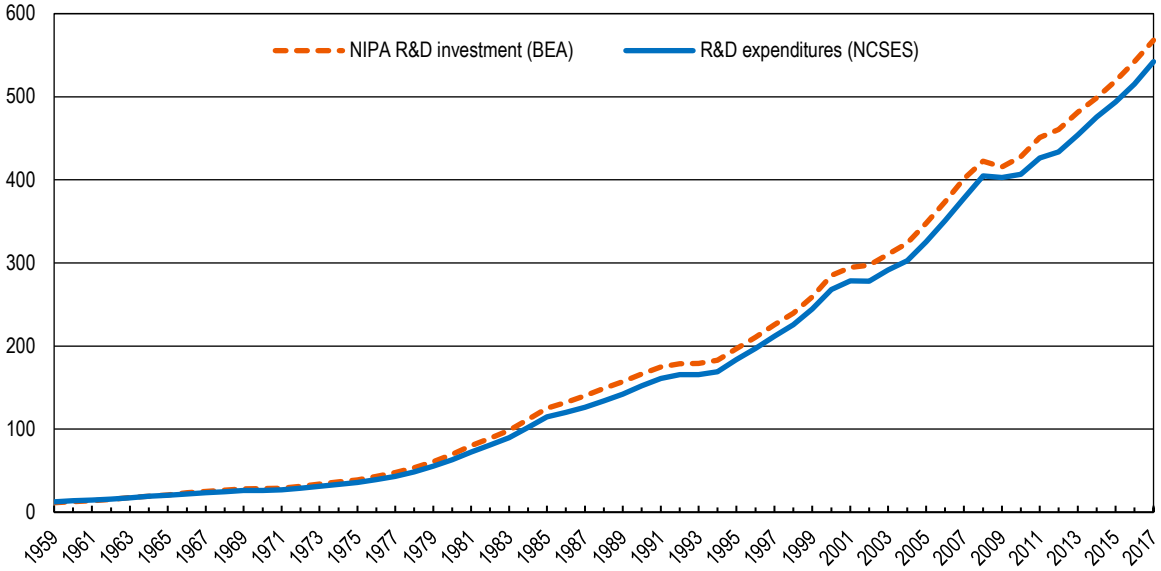
R&D Expenditures, R&D Investment, and Intellectual Property Products

After the 2018 NIPA update, R&D investment as reported by BEA matches all technology areas included in NCSES R&D expenditures statistics. Figure 1 compares total R&D expenditures (NCSES) and total R&D investment (BEA). R&D investment is generally larger than R&D expenditures because the former is designed to reflect the market value of R&D, not the current period's cost, as reflected in R&D expenditures data (Crawford et al. 2014).

In national economic accounting, R&D investment along with software and entertainment, literary, and artistic originals are intangible assets under the intellectual property products (IPPs) account. In turn, IPPs are a component of fixed investment along with structures and equipment for both private and government sectors, as defined in the NIPA context (Moris et al. 2015). The shares of IPPs in total fixed investment have increased from around 15% in the 1960s, to around 20% in the 1990s, to over 25% in recent years (figure 2). Even though R&D was recognized by BEA as investment after software had already been recognized as investment, software is of course a more recent activity. Thus, based on the revised BEA investment data, over 80% of IPPs were categorized as R&D investment in the late 1950s. Since then, the share decreased to around 60% in the mid-1990s and has fluctuated narrowly around 55% since the late 1990s (figure 3). The share of software investment increased steadily to over 30% in the "dot com" era of late 1990s and early 2000s, reaching just

FIGURE 1. NIPA R&D investment versus R&D expenditures: 1959–2017

(Billions of current U.S. dollars)

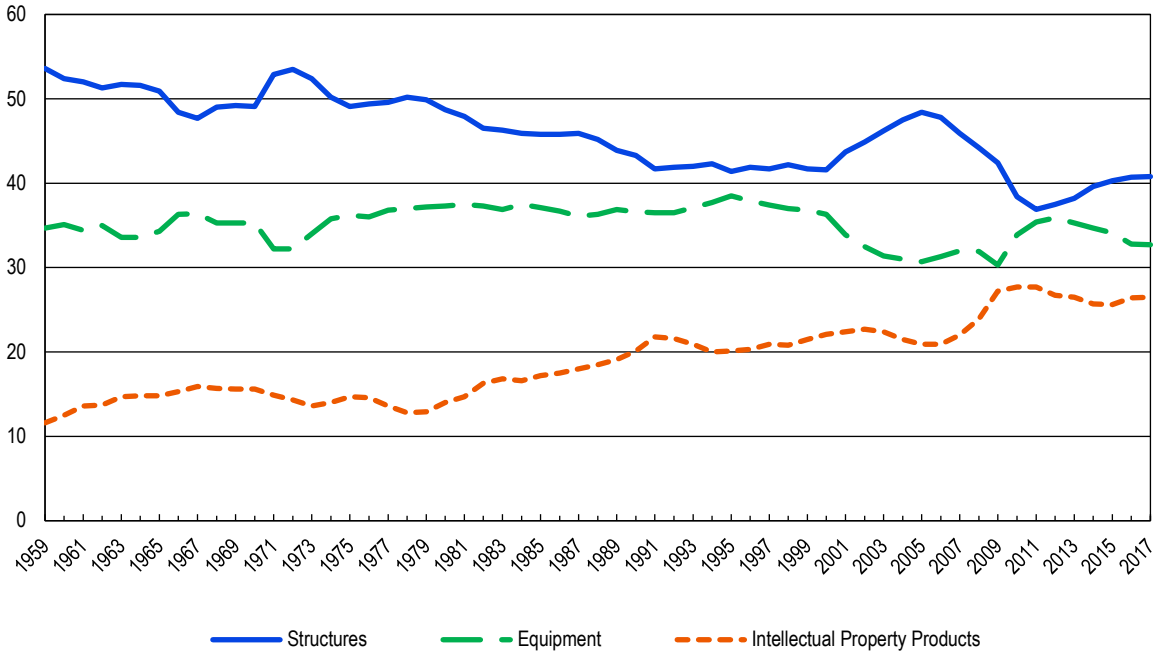


BEA = Bureau of Economic Analysis; NCSES = National Center for Science and Engineering Statistics; NIPA = national income and product account.

SOURCES: BEA R&D investment from NIPA tables are available at https://apps.bea.gov/iTable/index_nipa.cfm, accessed 25 August 2018. R&D expenditures are from the National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series).

FIGURE 2. Types of fixed investment: 1959–2017

(Percent)

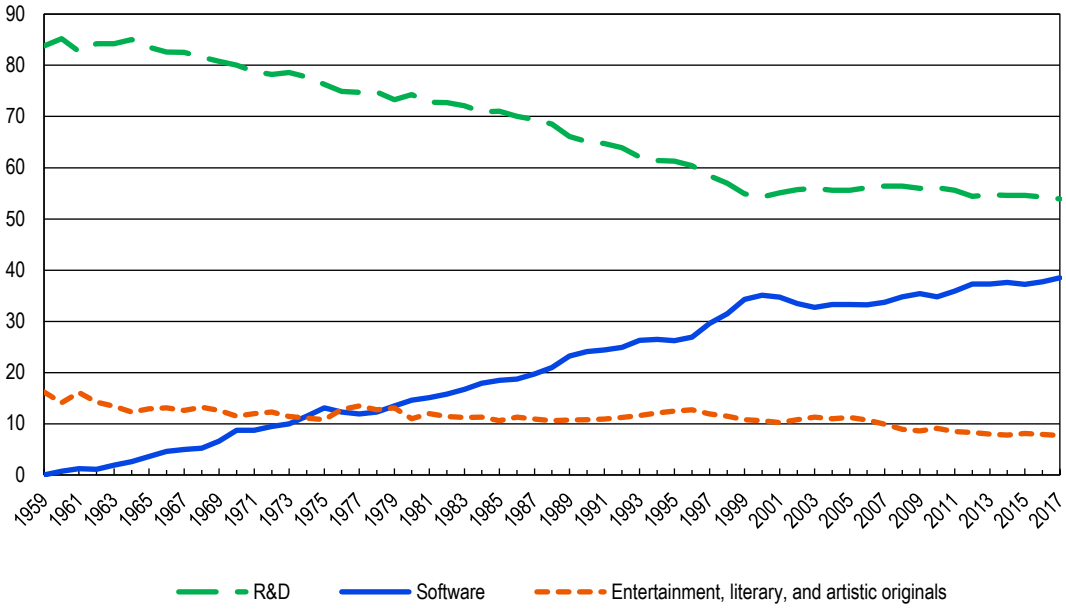


BEA = Bureau of Economic Analysis; NIPA = national income and product account.

SOURCE: BEA NIPA tables available at https://apps.bea.gov/iTable/index_nipa.cfm, accessed 25 August 2018.

FIGURE 3. Types of intellectual property products: 1959–2017

(Percent)



BEA = Bureau of Economic Analysis; NIPA = national income and product account.

SOURCE: BEA NIPA tables available at https://apps.bea.gov/iTable/index_nipa.cfm, accessed 25 August 2018.

below 40% in recent years. The balance is captured by investment in entertainment, literary, and artistic originals.

Between 2000 and 2002, the average annual total software R&D investment was on the order of $30 billion, most of it in the private sector,[6] compared with business R&D expenditures on software totalling $24 billion in 2002, according to NCSES data.

Trends in Business R&D Expenditures on Software

According to NCSES statistics, U.S.-located, for-profit businesses (regardless of ownership and industry classification) performed $120.8 billion in software R&D in 2016, or 32% of $374.7 billion in domestic business R&D, more than double its 13% share in 2002. Over the past 10 years, software R&D increased annually at a 9.6% compound average growth rate, compared with a rate of 4.2% for total business R&D (table 1). Since 2006, manufacturing industries exhibited larger growth rates of software R&D than did nonmanufacturing industries, although most R&D in this area is still performed by the nonmanufacturing industries. Figure 4 shows an increasing trend in software R&D relative to total business R&D.[7] And figure 5 shows that in contrast to overall U.S. business R&D, software R&D is concentrated in nonmanufacturing companies.

Along with computer and communications equipment, software is a component of ICT (NSB 2018; OECD 2017). For purposes of U.S. business R&D statistics, ICT industries comprise computer and electronic products manufacturing (NAICS 334) and selected services industries within the information sector (NAICS 51) and the professional, scientific, and technical services sector (NAICS 54), which is consistent with international ICT statistics (Shackelford, Jankowski 2016; Mas et al. 2017). As discussed next, ICT industries are the top performers of software R&D.

Table 2 shows a profile of software R&D by industry and funding source. By industry of performance, the 30% share of software R&D in manufacturing is concentrated in computer and electronics products (NAICS 334), which includes semiconductor and other electronic components manufacturing as well as navigational, measuring, electromedical, and control instruments (the latter is included in the electronic products aggregate). Another notable industry is other transportation equipment, which includes the defense-related industry of aerospace products and parts (NAICS 3364).

Within information industries, the largest performer of software R&D is publishing (NAICS 511), which includes software publishers (NAICS 5112, not available separately). The

TABLE 1. Total domestic business R&D and software R&D expenditures: 2006 and 2016
(Millions of current U.S. dollars)

Year and Industry	Total business R&D	Software R&D
2006		
All industries	247,669	48,299
Manufacturing	171,814	10,720
Nonmanufacturing	75,855	37,579
2016		
All industries	374,685	120,824
Manufacturing	250,553	35,984
Nonmanufacturing	124,132	84,840
2006–16 annual growth rate (%)[a]		
All industries	4.2	9.6
Manufacturing	3.8	12.9
Nonmanufacturing	5.0	8.5

[a] Calculated as compound average growth rate.

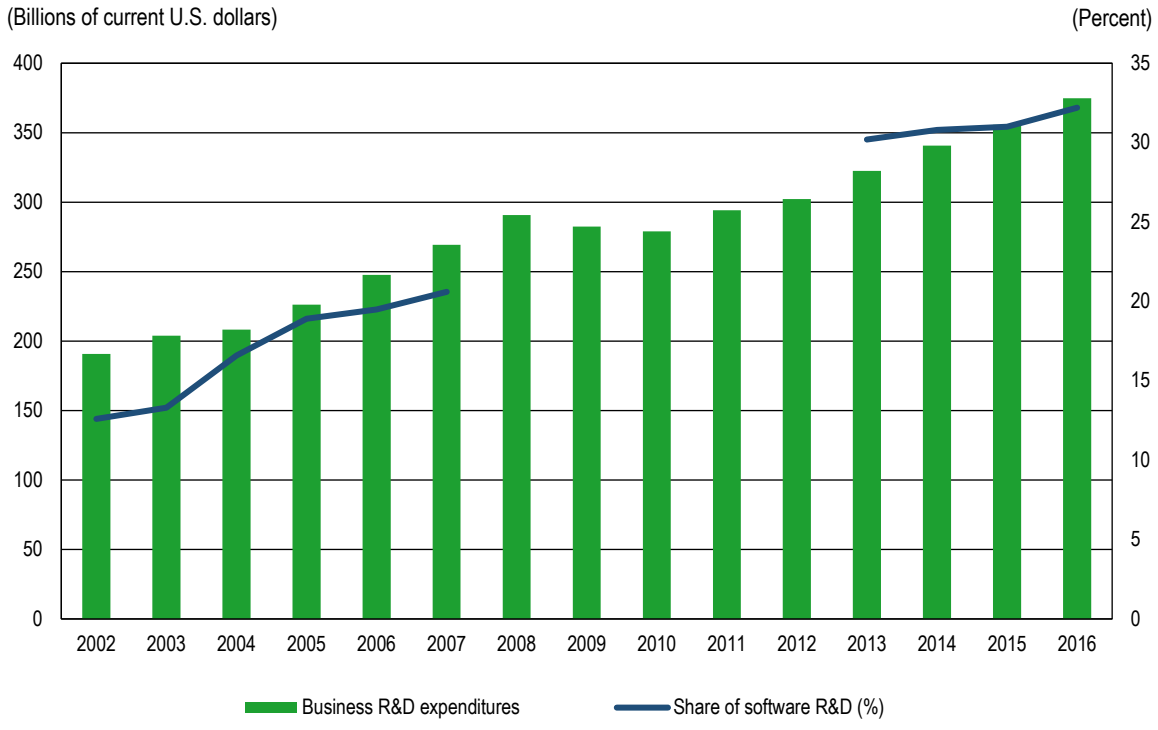
NOTE: For relative standard errors and other information, see "Data Sources and Limitations."

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and U.S. Census Bureau, Survey of Industrial R&D, 2006 (detailed statistical table 7) and Business R&D and Innovation Survey, 2016 (detailed statistical table 80).

largest performer of software R&D in professional, scientific, and technical services industries is other professional, scientific, and technical services, which includes computer systems design and related services (NAICS 5415, not available separately).

About 93% of software R&D is funded by the performing companies (table 2), compared with 85% for overall business R&D in 2016 (Wolfe 2018). However, of the amount paid by others, federal sources represent 50% for software R&D compared with 42% for overall business R&D paid by others. Further, for software R&D performed in the manufacturing sector, federal sources funded over two-thirds of software R&D paid by others.

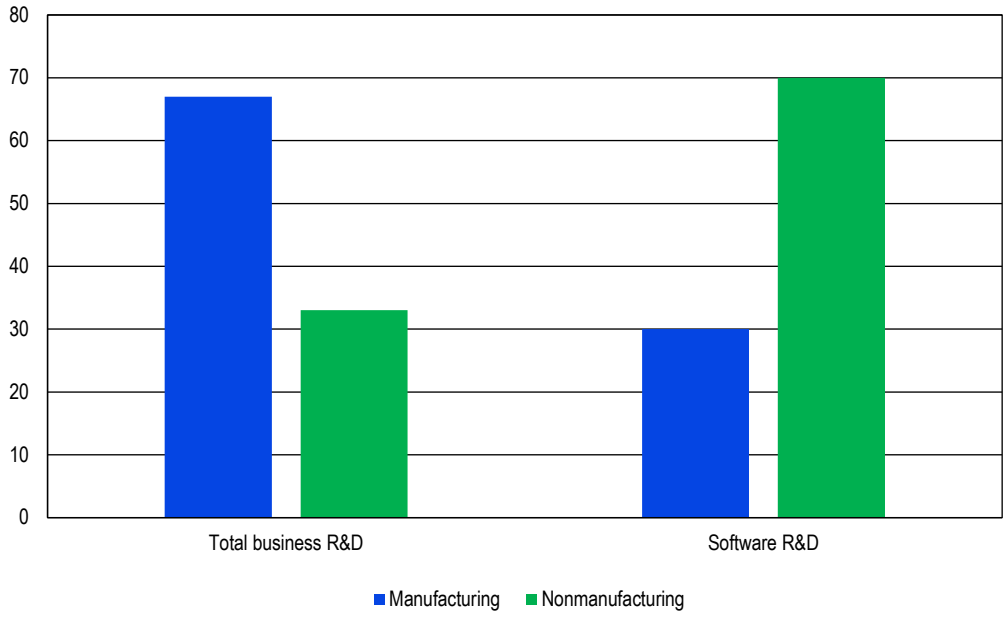
FIGURE 4. Business R&D performance and share of software R&D: 2002–16



NOTES: Total software R&D from the Business R&D and Innovation Survey, and thus the corresponding shares relative to business R&D, are not available for 2008 to 2012. Software R&D includes R&D on software products and R&D on software embedded in other products, funded by the performer or by others. For more information, see "Data Sources and Limitations."

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and U.S. Census Bureau, Survey of Industrial R&D (2002–07) and Business R&D and Innovation Survey (2008 forward).

FIGURE 5. Business R&D and software R&D, by major industrial category: 2016
(Percent)



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, and U.S. Census Bureau, Business R&D and Innovation Survey, 2016.

Data Sources and Limitations

BEA's NIPA data in this InfoBrief were downloaded in early to mid-August 2018. For current data on GDP, fixed assets, and IPPs investment, see https://apps.bea.gov/iTable/index_nipa.cfm. In the *2008 System of National Accounts* (SNA) (EC et al. 2009), the statistical manual that guides the economic accounts, the definition of R&D is consistent with the Organisation for Economic Co-operation and Development's Frascati Manual 2015 (paragraph 2.5). The SNA's definition of R&D investment is the following: "IPPs include the results of R&D…. Research and [experimental] development consists of the value of expenditures on creative work undertaken on a systematic basis in order to increase the stock of knowledge…and use of this stock of knowledge to devise new applications…. The value of R&D should be determined in terms of the economic benefits it is expected to provide in the future." (EC et al. 2009: paragraph 10.103). For BEA NIPA methodology, see https://www.bea.gov/resources/methodologies/nipa-handbook.

NCSES statistics on total U.S. R&D expenditures were obtained from *National Patterns of R&D Resources* reports, available at https://www.nsf.gov/statistics/natlpatterns/. These annual publications provide a comprehensive account of total U.S. R&D performance and funding across all sectors. NCSES estimates on U.S. business and software R&D expenditures were derived from the Survey of Industrial R&D [SIRD] (up to 2007) and Business R&D and Innovation Survey [BRDIS] (2008 forward). In SIRD, software development was defined as "the formulation of programs, applications, routines, etc., for computers, excluding those used exclusively for internal company operations."

Annual samples for BRDIS are selected to represent for-profit, nonfarm companies (publicly or privately held) with five or more U.S. employees. Company is defined as a U.S.-located business, either U.S. owned or a U.S. affiliate of a foreign parent company, that performs or funds R&D. Software R&D is defined by BRDIS as "R&D activity in software and Internet applications refers to activities with an element of uncertainty and that are intended to close knowledge gaps and meet scientific and technological needs. Software R&D expenditures are reported regardless of who is the eventual user of the R&D (internal or external)." Further, "R&D activity in software *includes* the following:

- Software development or improvements that expand scientific or technological knowledge
- Construction of new theories and algorithms in the field of computer science

and *excludes* the following:

- Software development that does not depend on a scientific or technological advance (such as supporting

TABLE 2. Total domestic business R&D and software R&D expenditures, by selected industry: 2016
(Millions of current U.S. dollars)

Industry	NAICS code	Business R&D expenditures	Software R&D expenditures				Share of software R&D in business R&D (%)	Share of industry in software R&D (%)
			Total	Paid by company	Paid by others	Federally funded		
All industries	-	374,685	120,824 i	111,933 i	8,890	4,481 i	32.2	100.0
Manufacturing industries	31–33	250,553	35,984 i	31,527 i	4,457	3,057 i	14.4	29.8
Chemicals	325	73,575	575 i	430 i	145 i	1 i	0.8	0.5
Basic chemicals	3251	2,545	41	41	0	0	1.6	**
Pharmaceuticals and medicines	3254	64,628	302 i	165	137 i	1 i	0.5	0.2
Other chemicals	other 325	6,402	232 i	224 i	8	0	3.6	0.2
Machinery	333	12,585	1,290	1,245	44	D	10.3	1.1
Agricultural implement	33311	1,565	187	185	2	2	11.9	0.2
Semiconductor machinery	333242	3,411	222	212 i	9	*	6.5	0.2
Engine, turbine, and power transmission equipment	3336	1,959	217	216	1	0	11.1	0.2
Other machinery	other 333	5,650	664 i	632 i	32	D	11.8	0.5
Computer and electronic products	334	77,385	24,540 i	22,935 i	1,606	D	31.7	20.3
Semiconductor and other electronic components	3344	31,391	8,134 i	8,033 i	101	D	25.9	6.7
Other electronic products	other 334	45,993	16,406	14,902 i	1,504	D	35.7	13.6
Electrical equipment, appliances, and components	335	4,771	855 i	616 i	238 i	1 i	17.9	0.7
Transportation equipment	336	51,275	6,301	3,903	2,398	D	12.3	5.2
Automobiles, bodies, trailers, and parts	3361–63	22,042	1,592	1,456	136 i	1	7.2	1.3
Other transportation	other 336	29,234	4,709	2,446 i	2,262	D	16.1	3.9
Nonmanufacturing industries	21–23, 42–81	124,132	84,840 i	80,406 i	4,434 i	1,424	68.3	70.2
Information	51	70,748	63,213 i	62,870 i	343	11	89.3	52.3
Publishing	511	33,574	27,864	27,689	176	3	83.0	23.1
Telecommunications	517	D	2,996 i	D	D	0	D	2.5
Data processing, hosting, and related services	518	11,914	11,233	11,171	62	6	94.3	9.3
Other information	other 51	D	21,120 i	D	D	2	D	17.5
Professional, scientific, and technical services	54	37,595	14,185 i	10,174 i	4,011 i	1,411	37.7	11.7
Architectural, engineering, and related services	5413	3,412	515 i	231 i	284 i	209 i	15.1	0.4
Scientific research and development services	5417	14,842	2,060 i	363 i	1,698 i	768	13.9	1.7
Other professional, scientific, and technical services	other 54	19,341	11,610 i	9,581 i	2,029 i	435	60.0	9.6

* = amount < $500,000; ** = < 0.05%; D = data withheld to avoid disclosing operations of individual companies; i = > 50% of the estimate is a combination of imputation and reweighting to account for nonresponse.

NAICS = 2012 North American Industry Classification System.

NOTES: Detail may not add to total because of rounding or sub-categories that are not available. For relative standard errors and other information, see "Data Sources and Limitations."

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, and U.S. Census Bureau, Business R&D and Innovation Survey, 2016.

or adapting existing systems, adding functionality to existing application programs, or routine debugging of existing systems and software)

- Creation of new software based on known methods and applications
- Conversion or translation of existing software and software languages
- Adaptation of a product to a specific client, unless knowledge that significantly improved the base program was added in that process." (BRDIS 2016 survey form page 3)

Software R&D refers to R&D performed by any company, not just companies classified in the software industry, on software products and on software embedded in other products. These components of software R&D are potentially difficult to separate out for reporting purposes. Totals for software R&D from BRDIS are not available for 2008 to 2012. For these years, the survey collected separately the two potentially overlapping software R&D components, so even though these components are available they should not be summed to obtain total domestic software R&D performed by the business sector. Further, for 2008 to 2010, software R&D data were collected only for company-funded R&D.

In BRDIS, software R&D activity is collected as percentage of specific expenditure totals in sections devoted to "technology focus." (Technology focus also includes items on biotechnology and nanotechnology. Data collection on artificial intelligence is being tested.) Further, these data are collected only for domestic R&D performed by large R&D companies. For 2016, the standard (longer) form, BRDI-1, was sent to companies having $1 million or more worldwide total R&D activity in 2014 or 2015. The screener form, BRDI-1(S), was sent to all other companies. Software R&D is included in R&D totals for both forms. However, technology focus detail was collected only in BRDI-1. (SIRD also used long- and short-survey forms for a given year, but software R&D detail was collected in both forms.) In the 2016 BRDIS, software R&D was collected in BRDI-1 items 4–12 (company-funded R&D) and 4–24 (R&D funded by others). For survey forms, see https://www.nsf.gov/statistics/srvyindustry/#qs.

In this InfoBrief, money amounts are expressed in current U.S. dollars. Statistics are subject to sampling and non-sampling errors. The full set of 2016 BRDIS detailed statistical tables, including imputation rates, relative standard errors, and technical notes will be available at https://www.nsf.gov/statistics/srvyindustry/. Historical SIRD data are available at https://www.nsf.gov/statistics/iris/. For further information on business R&D statistics, see Wolfe (2018).

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Notes

1. Francisco Moris, Research and Development Statistics Program, National Center for Science and Engineering Statistics, National Science Foundation, 2415 Eisenhower Avenue, Suite W14200, Alexandria, VA 22314 (fmorisor@nsf.gov; 703-292-4678).

2. The digital economy includes Internet services and transactions, information and communications technologies and infrastructure, and databases. For example, ICT-enabled services trade is delivered over wireless or mobile networks. See Barefoot et al. (2018) and Grimm (2016).

3. Fixed capital or fixed assets are produced assets that are used repeatedly, or continuously, in production for more than one year (EC et al. 2009: paragraph 10.11). GFCF (capital formation or investment for short) is the value of net acquisition of fixed assets, either purchased or produced on own account (internally developed) (EC et al. 2009: paragraphs 1.52, 10.32). Fixed assets consist of equipment, structures, and intellectual property products (IPPs). In the United States, IPPs include software; R&D; and entertainment, literary, and artistic originals.

4. Computer software was capitalized in the U.S. NIPA accounts in 1999. Software investment consists of prepackaged software (excluding software embedded, or bundled, in computers and other equipment), custom software, and own account software. Software R&D was considered part of own account software (OECD 2010).

5. There were two major definitional changes in the national accounts affecting software and R&D investment. In addition to the reclassification of software R&D, depreciation in own account software and in own account R&D was replaced with a measure of capital services (a measure reflecting both depreciation and the return to capital) (Chute, McCulla, Smith 2018). For data year 2016, private R&D investment was revised up by $78.2 billion because of definitional changes: $68.4 billion from the software R&D classification and $9.8 billion from the introduction of capital services in own-account R&D. Private software investment was revised down by $64.4 billion, which includes the $68.4 billion in software R&D reclassified into R&D investment and an offsetting increase of $4 billion from the capital services adjustment (see table 5 in Kelly, McCulla, Wasshausen 2018).

6. Based on table 2 in Crawford et al. (2014) and on BEA's 2018 update in the treatment of software R&D. In the NIPAs, the private sector includes for profit-businesses, non-profit institutions, and private academic institutions.

7. Totals for software R&D from BRDIS, and thus the corresponding shares, are not available for 2008 to 2012. For more information, see "Data Sources and Limitations."