



PhD Researchers in the Business Sector: Domestic and Foreign Employment and Industry-Level Characteristics of Domestic R&D

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Research and development is performed globally by multinational enterprises (MNEs) and other businesses engaged in foreign investment or international trade. At the same time, R&D activities by MNEs based in high-income countries have been found to be more concentrated in the home country compared with other MNE activities (Belderbos, Leten, and Suzuki 2013). Even when firms increase the level or the geographic dispersion of foreign R&D, intellectual property may be easier to protect close to headquarters locations or the required skilled labor for some R&D activities may be more readily available in the home country. In 2016, U.S. MNEs employed 66.3% of their total workforce (28.0 million of 42.3 million workers) and performed 84.7% of their worldwide R&D (\$296.9 billion of \$350.3 billion) in the United States (BEA 2018). This InfoBrief presents new information on domestic versus foreign distribution of PhD researchers by U.S.-located companies that is consistent with these observations. Data in this InfoBrief are based on business statistics published by the National Center for Science and Engi-

neering Statistics (NCSES) within the National Science Foundation. The InfoBrief also presents related employment, sales, and R&D expenditures statistics at the industry level for domestic activities.² For demographic characteristics of U.S.-trained scientists and engineers with PhDs, see NSF/NCSES (2018).

Worldwide, domestic, and foreign employment and R&D employment

U.S.-located businesses engaged in R&D performance or funding (termed R&D active) employed an estimated 30.7 million workers (headcounts) worldwide in 2016, little changed from the previous 2-year average, based on the Business R&D and Innovation Survey (BRDIS) published by NCSES (table 1).

R&D employees comprise three functional or occupational components: researchers (including scientists and engineers performing R&D and their managers), technicians, and support staff (OECD 2015, paragraph 5.33). See “Data Notes” for detailed definitions. Across all industries, researchers account for about 70% of R&D

employees, technicians 20%, and support staff the remaining 10%.

Of the estimated 30.7 million of worldwide employees of companies within scope of the 2016 BRDIS (see “Data Notes”), 19.3 million, or about 63%, were located in the United States, with a higher share (about 72%) for the nonmanufacturing sector. For business R&D employees and researchers, the domestic shares across all industries were marginally higher at about 70% each. But for the subset of PhD researchers, the domestic share across all industries was just over 80% (120,000 of 149,000) (table 1).

Domestic R&D, sales, employment, and PhD researchers by industry

U.S.-located businesses performed \$374.7 billion in R&D in 2016. These companies reported domestic net sales of \$9.2 trillion in 2016, resulting in an overall R&D-to-sales ratio of 4.1%. For manufacturers, this ratio was 4.6%; for nonmanufacturers, 3.3% (table 2). The R&D-to-sales ratios are a financial measure of R&D intensity (Wolfe 2018). A complementary measure of

TABLE 1. Worldwide, domestic, and foreign business employment and R&D employment, by R&D occupation: 2014–16
(Thousands)

Category	All industries			Manufacturing, 2016	Nonmanufacturing, 2016
	2014	2015	2016		
Worldwide					
Total employment	31,881	29,240	30,667	17,557	13,111
R&D employment	2,167	2,178	2,195	1,318	878
Researchers	1,535	1,539	1,551	956	595
PhD researchers	141	143	149	99	51
Technicians	410	409	431	222	209
Support staff	222	231	213	139	74
Domestic					
Total employment	21,540	18,915	19,293	9,879	9,414
R&D employment	1,514	1,543	1,522	912	610
Researchers	1,060	1,075	1,064	646	418
PhD researchers	113	115	120	77	42
Technicians	295	302	306	164	142
Support staff	158	167	152	102	51
Foreign					
Total employment	10,341	10,325	11,374	7,678	3,697
R&D employment	653	635	674	406	268
Researchers	475	464	488	310	177
PhD researchers	28	28	30	21	8
Technicians	114	107	126	58	67
Support staff	64	64	61	38	23
Share of domestic employment (percent)					
Total employment	67.6	64.7	62.9	56.3	71.8
R&D employment	69.9	70.8	69.3	69.2	69.5
Researchers	69.1	69.9	68.6	67.6	70.3
PhD researchers	80.1	80.4	80.5	77.8	82.4
Technicians	72.0	73.8	71.0	73.9	67.9
Support staff	71.2	72.3	71.4	73.4	68.9

NOTES: Details may not add to totals because of rounding. R&D employment is the sum of researchers, technicians, and support staff. Researchers are R&D scientists and engineers and their managers. PhD researchers is a subset of researchers. Technicians and equivalent staff contribute to R&D by performing technical tasks under the supervision of researchers. Support staff are not directly involved with the conduct of R&D, but support researchers and technicians. For more details, see "Data Notes."

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

intensity is the ratio of R&D employment to total employment. Across all industries, R&D-active businesses employed 19.3 million workers in the United States, of which 1.5 million were R&D employees, resulting in a R&D employment-to-employment ratio of 7.9%. For manufacturers the R&D employment-based intensity was 9.2%; for nonmanufacturers, 6.5%.³

Of the 1.5 million business R&D employees in 2016, 1.1 million were

researchers, including 120,000 PhD researchers (table 2).⁴ Table 3 shows the distribution of domestic R&D and R&D employment across industries. The pharmaceuticals and medicine manufacturing industry (NAICS 3254) was notable since it employed a larger share (18.3%) of domestic industry PhD researchers (22,000 of 120,000), in comparison to its smaller share (8.0%) of all researchers (85,000 of 1.1 million) (tables 2 and 3). The former double-digit share is consistent with its 17.2%

share in domestic R&D performance in 2016 (\$64.6 billion of \$374.7 billion). Further, pharmaceuticals and medicine manufacturing had the largest share of research expenditures (basic plus applied research) (26.8%) among large 4-digit industries in 2016 (table 3).

Table 4 shows *within-industry* shares of domestic research versus development expenditures relative to total domestic R&D expenditures for selected industries. It also shows shares of domestic

TABLE 2. Domestic R&D expenditures, sales, employment, and PhD employment, by industry: 2016
(Millions of U.S. dollars; thousands of employees)

Industry	NAICS	Total R&D performed	Research	Development	Net sales	Total employment	R&D employment	Researchers	PhD researchers	R&D performed/sales (%)	R&D employment/employment (%)
All industries	21–33, 42–81	374,685	85,664	289,021	9,191,871	19,293	1,522	1,064	120	4.1	7.9
Manufacturing industries	31–33	250,553	61,325	189,228	5,396,816	9,879	912	646	77	4.6	9.2
Chemicals	325	73,575	25,888	47,687	1,039,760	1,257	173	118	30	7.1	13.8
Pharmaceuticals and medicines	3254	64,628	22,990	41,638	579,390	562	123	85	22	11.2	21.9
Machinery	333	12,585	2,184	10,401	296,633	824	78	55	4	4.2	9.5
Computer and electronic products	334	77,385	12,766	64,619	786,351	1,336	264	215	23	9.8	19.8
Electrical equipment, appliances, and components	335	4,771	1,039	3,732	148,671	306	28	20	2	3.2	9.2
Transportation equipment	336	51,275	10,971	40,305	1,289,540	1,953	168	122	7	4.0	8.6
Automobiles, bodies, trailers, and parts	3361–63	22,042	NA	NA	886,881	1,088	92	72	3	2.5	8.5
Aerospace products and parts	3364	26,645	5,371	21,274	336,565	643	61	42	4	7.9	9.5
Nonmanufacturing industries	21–23, 42–81	124,132	24,338	99,794	3,795,055	9,414	610	418	42	3.3	6.5
Information	51	70,748	8,833	61,916	1,064,822	1,832	277	213	15	6.6	15.1
Publishing	511	33,574	3,938	29,636	399,746	650	143	120	5	8.4	22.0
Software publishers	5112	33,495	NA	NA	396,108	630	142	120	5	8.5	22.5
Telecommunications	517	D	D	D	455,430	684	24	16	*	D	3.5
Data processing, hosting, and related services	518	11,914	NA	10,051	104,974	355	62	40	2	11.3	17.5
Finance and insurance	52	7,331	NA	NA	713,192	1,114	37	12		1.0	3.3
Professional, scientific, and technical services	54	37,595	12,571	25,024	421,882	1,373	240	162	24	8.9	17.5
Architectural, engineering, and related services	5413	3,412	1,753	1,659	100,649	323	46	34	6	3.4	14.2
Computer systems design and related services	5415	15,747	4,215	11,532	175,787	480	92	71	8	9.0	19.2
Scientific research and development services	5417	14,842	5,587	9,255	66,620	264	79	42	9	22.3	29.9
Health care services	621–23	848	NA	NA	79,471	436	4	2	1	1.1	0.9

* = amount < 500. D = suppressed to avoid disclosure of confidential information. NA = not available; industry not included in tables with type of R&D.

NAICS = North American Industry Classification System.

NOTES: Research includes basic and applied research. Researchers are R&D scientists and engineers and their managers. PhD researchers is a subset of researchers. Technicians and equivalent staff contribute to R&D by performing technical tasks under the supervision of researchers. Support staff are not directly involved with the conduct of R&D, but support researchers and technicians.

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

researchers relative to total domestic R&D employment and shows the share of PhD researchers relative to researchers. Across all industries, researchers accounted for about 70% of R&D workers and PhD researchers accounted for 11.3% of researchers in 2016. In terms of type of R&D, most business U.S. R&D expenditures are

concentrated in development activities (77.1% for the all-industries total and close to 90% for some industries) (tables 2 and 4). This suggests that PhD researchers and other highly skilled R&D employees are likely to perform a mix of development and research activities, even in industries with a relatively high share of research expenditures.

The pharmaceuticals and medicine manufacturing (NAICS 3254) and scientific R&D services (NAICS 5417) industries had the largest shares of PhDs researchers relative to their industry's total researchers (25.9% and 21.4%, respectively) among 4-digit industries employing 5,000 or more PhD researchers. Among the same set

TABLE 3. Distribution of domestic R&D expenditures, employment, and PhD employment, by industry: 2016

(Percent)

Industry	NAICS	Total R&D performed	Research	Development	Total employment	R&D employment	Researchers	PhD researchers
All industries	21–33, 42–81	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Manufacturing industries	31–33	66.9	71.6	65.5	51.2	59.9	60.7	64.2
Chemicals	325	19.6	30.2	16.5	6.5	11.4	11.1	25.0
Pharmaceuticals and medicines	3254	17.2	26.8	14.4	2.9	8.1	8.0	18.3
Machinery	333	3.4	2.5	3.6	4.3	5.1	5.2	3.3
Computer and electronic products	334	20.7	14.9	22.4	6.9	17.3	20.2	19.2
Electrical equipment, appliances, and components	335	1.3	1.2	1.3	1.6	1.8	1.9	1.7
Transportation equipment	336	13.7	12.8	13.9	10.1	11.0	11.5	5.8
Automobiles, bodies, trailers, and parts	3361–63	5.9	NA	NA	5.6	6.0	6.8	2.5
Aerospace products and parts	3364	7.1	6.3	7.4	3.3	4.0	3.9	3.3
Nonmanufacturing industries	21–23, 42–81	33.1	28.4	34.5	48.8	40.1	39.3	35.0
Information	51	18.9	10.3	21.4	9.5	18.2	20.0	12.5
Publishing	511	9.0	4.6	10.3	3.4	9.4	11.3	4.2
Software publishers	5112	8.9	NA	NA	3.3	9.3	11.3	4.2
Telecommunications	517	D	D	D	3.5	1.6	1.5	NA
Data processing, hosting, and related services	518	3.2	NA	3.5	1.8	4.1	3.8	1.7
Finance and insurance	52	2.0	NA	NA	5.8	2.4	1.1	0.0
Professional, scientific, and technical services	54	10.0	14.7	8.7	7.1	15.8	15.2	20.0
Architectural, engineering, and related services	5413	0.9	2.0	0.6	1.7	3.0	3.2	5.0
Computer systems design and related services	5415	4.2	4.9	4.0	2.5	6.0	6.7	6.7
Scientific research and development services	5417	4.0	6.5	3.2	1.4	5.2	3.9	7.5
Health care services	621–23	0.2	NA	NA	2.3	0.3	0.2	0.8

D = suppressed to avoid disclosure of confidential information. NA = not available; for R&D expenditures, not available because industry not included in tables with type of R&D; for PhD researchers, not available because numerator is not published.

NAICS = North American Industry Classification System.

NOTES: Research includes basic and applied research. Researchers are R&D scientists and engineers and their managers. PhD researchers is a subset of researchers. Technicians and equivalent staff contribute to R&D by performing technical tasks under the supervision of researchers. Support staff are not directly involved with the conduct of R&D, but support researchers and technicians. Shares are based on data in table 2.

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

of industries, they also had large shares of research relative to total R&D expenditures (35.6% and 37.6%, respectively), compared with 22.9% for the aggregate of all industries.

Data Notes

In this InfoBrief, money amounts are expressed in current U.S. dollars.

BRDIS samples are selected to represent all for-profit, nonfarm companies that are publicly or privately held and have five or more U.S. employees. BRDIS defines a company as a business organization located in the United States, either U.S. owned or a U.S. affiliate of a foreign parent company, of one or more establishments under

common ownership or control. Estimates produced from the survey and presented in this InfoBrief are restricted to companies that perform or fund R&D, either domestically or abroad.

R&D employment is the sum of researchers, technicians, and support staff. PhD researchers is a subset of

TABLE 4. Within-industry shares of domestic R&D by type of R&D, and researcher and PhD researcher shares, by selected industry: 2016

(Percent)

Industry	NAICS	Researchers/ total R&D employment	PhD researchers/ researchers	Research/ total R&D performed	Development/ total R&D performed
All industries	21–33, 42–81	69.9	11.3	22.9	77.1
Manufacturing industries	31–33	70.8	11.9	24.5	75.5
Chemicals	325	68.2	25.4	35.2	64.8
Pharmaceuticals and medicines	3254	69.1	25.9	35.6	64.4
Machinery	333	70.5	7.3	17.4	82.6
Computer and electronic products	334	81.4	10.7	16.5	83.5
Electrical equipment, appliances, and components	335	71.4	10.0	21.8	78.2
Transportation equipment	336	72.6	5.7	21.4	78.6
Automobiles, bodies, trailers, and parts	3361–63	78.3	4.2	NA	NA
Aerospace products and parts	3364	68.9	9.5	20.2	79.8
Nonmanufacturing industries	21–23, 42–81	68.5	10.0	19.6	80.4
Information	51	76.9	7.0	12.5	87.5
Publishing	511	83.9	4.2	11.7	88.3
Professional, scientific, and technical services	54	67.5	14.8	33.4	66.6
Architectural, engineering, and related services	5413	73.9	17.6	51.4	48.6
Computer systems design and related services	5415	77.2	11.3	26.8	73.2
Scientific research and development services	5417	53.2	21.4	37.6	62.4

NA = not available; industry not included in tables with type of R&D.

NAICS = North American Industry Classification System.

NOTES: Research includes basic and applied research. Researchers are R&D scientists and engineers and their managers. PhD researchers is a subset of researchers. Technicians and equivalent staff contribute to R&D by performing technical tasks under the supervision of researchers. Support staff are not directly involved with the conduct of R&D, but support researchers and technicians. Shares are based on data in table 2.

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

researchers. Below are detailed definitions of domestic net sales, R&D, types of R&D, and R&D employment from the 2016 BRDIS survey forms, instructions, and other methodology material available at <https://www.nsf.gov/statistics/srvyindustry/#qs>.

Domestic net sales are dollar values for goods sold or services rendered by R&D-performing or R&D-funding companies located in the United States to customers outside of the company, including the U.S. federal government, foreign customers, and the company’s foreign subsidiaries. Included are revenues from a company’s foreign operations and subsidiaries and from discontinued operations. If a respondent company is owned

by a foreign parent company, sales to the parent company and to affiliates not owned by the respondent company are included. Excluded are intracompany transfers, returns, allowances, freight charges, and excise, sales, and other revenue-based taxes.

Research and development (R&D) comprises creative and systematic work undertaken in order to increase the stock of knowledge and to devise new applications of available knowledge. This includes a) activities aimed at acquiring new knowledge or understanding without specific immediate commercial applications or uses (basic research); b) activities aimed at solving a specific problem or meeting a specific

commercial objective (applied research); and c) systematic work, drawing on research and practical experience and resulting in additional knowledge, which is directed to producing new products or processes or to improving existing products or processes (development). R&D expenditures include both direct costs such as salaries of researchers as well as administrative and overhead costs clearly associated with the company’s R&D.

Research is defined as experimental or theoretical work undertaken primarily to acquire new knowledge or understanding of phenomena and observable facts. Research may be either ‘basic’ or ‘applied’ as defined above.

Development is defined as the systematic use of research and practical experience to produce new or improved goods, services, or processes. In simple terms, the intended output of research is ideas and the intended output of development is products.

R&D employees include all employees who work on R&D or who provide direct support to R&D, such as researchers, R&D managers, technicians, clerical staff, and others assigned to R&D groups. The distinction between the different occupation categories is defined primarily by the nature of the employee's work, not the employee's level of education.

- **Researchers** are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned. R&D managers are also included in this Researchers category.
- **R&D technicians and equivalent staff** are persons whose main tasks require technical knowledge and experience in one or more fields of science or engineering, but who contribute to R&D by performing technical tasks under the supervision of researchers. The main distinction between researchers and technicians is that researchers contribute more to the creative aspects of R&D whereas technicians provide technical support. For example, a researcher (scientist or engineer) would design an experiment and a technician would run the experiment and assist in analyzing results.
- **R&D support staff** are not directly involved with the conduct of a research project but support the researchers and technicians. These employees might include clerical

staff, report writers, regulatory experts, quality assurance, safety trainers, and other related employees.

PhD researchers are included in R&D employment totals in all survey years, but PhD information was collected for the first time in the 2008 BRDIS (Moris and Kannankutty 2010) and subsequently for 2009 and 2010 data years. Collection and estimation of PhD researchers was resumed in 2013, but only for large R&D companies, a methodology continued for 2014 to 2016 data years. Through 2016, BRDIS has used at least two survey forms for a given year. 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. PhD researchers were included in R&D employment totals for both forms; however, the education detail was collected only in BRDI-1.

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>. For further information on business R&D statistics see Wolfe (2018).

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Notes

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2. For an overview of business R&D employment statistics see Shackelford and Moris (2016) and Moris and Kannankutty (2010).

3. See Data Notes for definitions and how to access information on relative standard errors and other technical information.

4. Scientists and engineers perform R&D and non-R&D activities in U.S. businesses (Barth et al. 2017). BRDIS data on scientists and engineers focuses on researchers.