



New Data on Line of Business Improve Understanding of U.S. Industry R&D Statistics

by Brandon Shackelford¹

In 2008, an estimated 92% of companies devoted all of their research and development efforts to one line of business, according to the Business R&D and Innovation Survey (BRDIS). The remaining 8% diversified their R&D spending across multiple lines of businesses, and these companies were the ones that tended to heavily invest in R&D. Companies reporting more than one line of business accounted for \$107 billion (33%) of the \$328 billion worldwide R&D expense for U.S. businesses. Survey findings also showed that 82% of companies with R&D expenses derived all of their worldwide sales from one line of business.

Companies typically start out offering a single type of good or service to their customers, but as these companies grow (organically or through acquisitions) they sometimes diversify into offering different types of products. Companies typically group related products together for both management and accounting purposes. This InfoBrief examines companies' R&D statistics in terms of these groups, commonly known as lines of business. Companies located in the United States that received BRDIS were asked to identify

the lines of business in which they operated in 2008 and, for the first time, were asked to report their sales and R&D expenditures for these lines of business.

Comparing Line-of-Business Estimates to Industry Estimates

Most business R&D statistics are collected at the company level, not for each line of business within a company. At the company level, the company's total R&D is assigned to a single primary industry, even if there is evidence that the company has R&D in multiple lines of business.² For example, if a company has a total R&D expense of \$100 million—\$80 million in pharmaceuticals and \$20 million in medical devices—the total R&D expense of \$100 million will be assigned to the pharmaceuticals industry because pharmaceuticals is the largest component of its R&D expense. This can lead to a loss of precision in industry-level estimates if diversified companies have large amounts of R&D in secondary lines of business. Questions on the 2008 BRDIS were developed to help determine how much of an impact these cases have on industry-level R&D statistics.

Table 1 shows the worldwide R&D expense on an industry and corresponding line-of-business level. The former represents the total worldwide R&D expense for all companies where their total R&D was assigned to a single primary industry on the basis of their most important line of business. The latter is the total worldwide R&D expense on a line-of-business basis where R&D was allocated among multiple lines of business. Overall, 86% of the \$328 billion worldwide R&D expense occurred in the primary line of business corresponding to the industry classification of the company's R&D. However, in some cases, the correspondence between the primary industry estimate and the related line-of-business estimate is not this large. Figure 1 illustrates the relationship between worldwide R&D expense estimates for the soap, cleaning compound, and toiletries industry and corresponding lines of business. In this case, only 55% (\$1,933 million) of the industry R&D estimate (\$3,486 million) occurred in lines of business corresponding to this industry, and the remaining 45% occurred in lines of business outside of this industry or was not allocated to a line of business. Similarly, almost

TABLE 1. Worldwide R&D expense classified at the industry level and at the line-of-business level and corresponding classification between the two levels, by selected industry: 2008

(Millions of US dollars)

Industry and NAICS code	Industry estimate	Line-of-business estimate	Correspondence between estimates
All industries, 21–33, 42–81	328,040	328,040	283,391
Pharmaceuticals and medicines, 3254	74,356	72,004	69,672
Software publishers, 5112	35,562	31,369	30,303
Semiconductor and other electronic components, 3344	29,329	29,911	28,236
Automobiles/bodies/trailers/parts, 3361–63	24,314	23,767	23,449
Communications equipment, 3342	15,130	15,179	14,863
Scientific research and development services, 5417	13,095	12,656	11,996
Computer equipment/other electronic products, 3341, 3343, 3346	13,048	13,270	11,338
Aircraft, aircraft engine, and aircraft parts, 336411–13	12,054	7,708	6,956
Computer systems design and related services, 5415	11,112	11,476	10,296
Internet service providers/Web search/data processing services, 518	7,770	8,073	7,490
Medical equipment and supplies, 3391	6,669	11,587	6,256
Electromedical apparatus, 334510, 334517	6,127	3,822	3,246
Basic chemicals, 3251	5,386	3,806	3,238
Electrical equipment, appliances, and components, 335	4,275	4,687	3,640
Search/detection/navigation/guidance instruments, 334511	3,498	1,845	1,384
Soap/cleaning compound/toilet preparations, 3256	3,486	2,787	1,933
Food, 311	2,860	2,983	2,402
Wholesale trade, 42	2,849	720	600
Fabricated metal products, 332	2,631	2,935	2,242
Other miscellaneous manufacturing, 3399	2,548	2,976	2,261
Semiconductor machinery, 333295	2,518	2,553	2,471
Paint, coating, adhesive, and other chemicals, 3255, 3259	2,463	2,152	1,611
Mining/extraction/support activities, 21	2,215	2,380	1,915
Plastics and rubber products, 326	2,187	2,536	1,743
Pesticide/fertilizer/other agricultural chemicals, 3253	1,488	2,100	1,423
Engine/turbine/power transmission equipment, 3336	1,461	2,386	816
All other, nec	39,609	39,712	31,611
Undistributed	na	10,660	na

na = not applicable.

NAICS = North American Industry Classification System; nec = not elsewhere classified.

NOTES: Detail may not add to total because of rounding. Industry classification based on a company's primary business code for its domestic R&D performance. For companies that did not report business codes, classification used for sampling was assigned. Line-of-business classification based on a breakdown of all of the business codes a company reported for its domestic R&D performance.

SOURCE: National Science Foundation/National Center for Science and Engineering Statistics, Business R&D and Innovation Survey, 2008.

one-third (\$854 million) of the business code estimate was from companies where this code was not the primary line of business.

Larger R&D industries tend to have a greater correspondence between industry and line-of-business estimates than the industry presented in figure 1. The largest industry in terms of

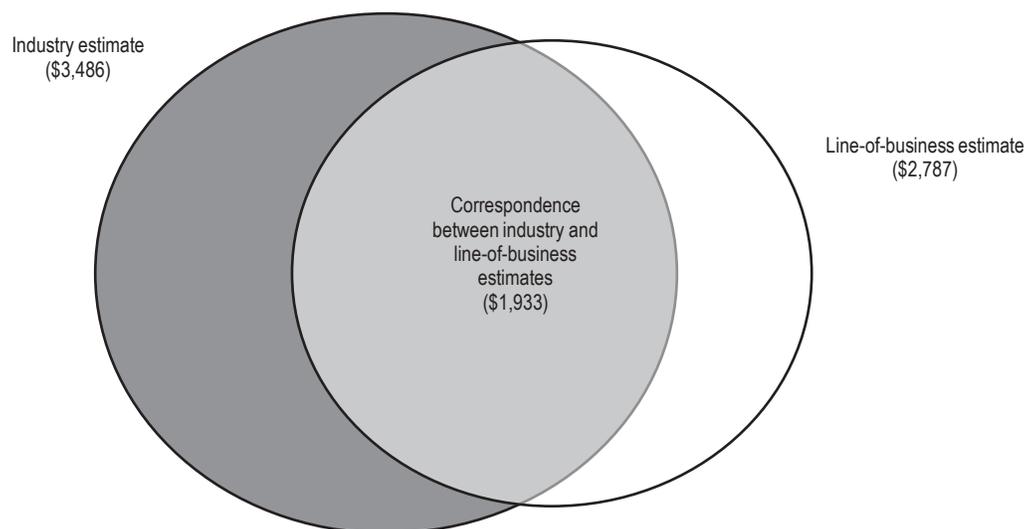
worldwide R&D expense is the pharmaceuticals and medicines industry (North American Industrial Classification System [NAICS] code 3254). In 2008, the worldwide R&D expense of companies classified in this industry was \$74.4 billion, and 94% of this estimate was from R&D reported in lines of business related to the pharmaceuticals and medicines industry.

Similarly, 96% of the estimate for the semiconductor and other electronic components (NAICS 3344) industry, the third largest industry in terms of worldwide R&D expense, occurred in lines of business corresponding to this industry.

There are notable exceptions that deserve mention. In absolute terms, the largest

FIGURE 1. Relationship between industry and line-of-business worldwide R&D expense estimates for the soap, cleaning compound, and toiletries industry (NAICS 3256): 2008

Millions of US dollars



NAICS = North American Industry Classification System.

NOTES: Industry classification based on a company's primary business code for its domestic R&D performance. For companies that did not report business codes, classification used for sampling was assigned. Line-of-business classification based on a breakdown of all of the business codes a company reported for its domestic R&D performance.

A total of \$1,553 million of R&D expense at the industry level was classified in different lines of business (\$1,498 million) or was unclassified (\$55 million); \$854 million of the R&D expense at the line-of-business level was from companies classified in different industries.

SOURCE: National Science Foundation/National Center for Science and Engineering Statistics, Business R&D and Innovation Survey, 2008.

difference between the industry and corresponding line of business for worldwide R&D estimates is for the medical equipment and supplies industry (NAICS 3391). Companies in this industry reported that \$6.3 billion (94%) of their \$6.7 billion in worldwide R&D expense estimate occurred in related lines of business. Examining R&D expense on a line of business basis shows that companies in other industries reported \$5.3 billion of R&D in lines of business related to medical equipment and supplies. The lines of business most frequently reported alongside medical equipment and supplies by diversified companies included pharmaceutical products (NAICS 3254) and electromedical apparatus (NAICS 334510, 334517).

Other large R&D industries with sizeable differences between the industry and corresponding line-of-business estimates include software publishers (NAICS 5112) and aircraft, aircraft engine, and aircraft parts (NAICS 336411–336413). In both of these cases, the industry estimate exceeds the corresponding line-of-business estimate by more than \$4 billion, indicating that companies in these two industries conduct a significant amount of their R&D in lines of business outside of their primary industry. In cases such as these where industry and corresponding line-of-business estimates diverge by large amounts it may be helpful to analyze related industries as a group rather than individually.

For example, the information provided above suggests that the R&D estimate for the group of medical products industries (medical equipment and supplies, pharmaceutical products, and electromedical apparatus) could be a more precise measure than the estimates of the component industries individually.

Of the other data items BRDIS collected by line of business, domestic R&D performance (the portion of worldwide R&D expense performed by companies in the United States) displays patterns very similar to worldwide R&D expense, with a large amount of overlap between industry and corresponding line-of-business

estimates. Overall, 86% of the \$233 billion domestic performance of R&D expense classified by primary industry in 2008 is estimated to occur in corresponding lines of business. There is much less overlap between industry and corresponding line-of-business estimates for worldwide sales, domestic sales, and domestic R&D performed by the company and paid for by others. For both sales variables, only 64% of the data for industry-level R&D are esti-

mated to occur in related lines of business. For domestic R&D performed by the company and paid for by others, the correspondence between industry and line-of-business estimates is 60%.

R&D Intensity

The proportion of R&D to sales, or R&D intensity, is a commonly used indicator for comparing the relative importance of R&D across industries and among companies in the same

industry. Calculating this indicator by taking the ratio of industry estimates of company-level R&D and sales can produce quite different results than the ratio of R&D to sales for line of business. Using industry estimates, the semiconductor and other electronic components industry (NAICS 3344) has the highest worldwide R&D intensity at 14.9% (table 2). However, when the line-of-business estimates for R&D and sales are used to calculate R&D

TABLE 2. Worldwide R&D intensity, by select industry and corresponding line-of-business estimates: 2008 (Percent)

Industry and NAICS code	Industry estimate	Line-of-business estimate
All industries, 21–33, 42–81	3.0	3.0
Semiconductor and other electronic components, 3344	14.9	13.6
Semiconductor machinery, 333295	14.1	12.8
Pharmaceuticals and medicines, 3254	13.5	11.9
Communications equipment, 3342	11.3	10.6
Scientific research and development services, 5417	9.0	46.6
Software publishers, 5112	8.9	14.9
Electromedical apparatus, 334510, 334517	7.5	9.2
Internet service providers/Web search/data processing services, 518	5.4	10.9
Computer systems design and related services, 5415	4.4	5.4
Computer equipment/other electronic products, 3341, 3343, 3346	4.1	D
Medical equipment and supplies, 3391	3.7	7.1
Pesticide/fertilizer/other agricultural chemicals, 3253	3.7	5.2
Search/detection/navigation/guidance instruments, 334511	3.6	4.8
Engine/turbine/power transmission equipment, 3336	3.6	2.8
Automobiles/bodies/trailers/parts, 3361–63	3.1	D
Aircraft, aircraft engine, and aircraft parts, 336411–13	2.8	4.5
Electrical equipment, appliances, and components, 335	2.7	3.0
Paint, coating, adhesive, and other chemicals, 3255, 3259	2.7	1.9
Soap/cleaning compound/toilet preparations, 3256	2.1	2.0
Basic chemicals, 3251	1.7	1.4
Fabricated metal products, 332	1.4	1.6
Wholesale trade, 42	1.1	0.1
Plastics and rubber products, 326	1.1	1.6
Food, 311	0.4	0.6
Mining/extraction/support activities, 21	0.3	D

D = data withheld to avoid disclosing operations of individual companies.

NAICS = North American Industry Classification System.

NOTES: R&D intensity is worldwide R&D expense divided by worldwide sales of companies with R&D. Industry estimate tends to be slightly higher than line-of-business estimate because some companies included intercompany sales in their line-of-business estimate. Industry classification based on a company's primary business code for its domestic R&D performance. For companies that did not report business codes, classification used for sampling was assigned. Line-of-business classification based on a breakdown of all of the business codes a company reported for its domestic R&D performance.

SOURCE: National Science Foundation/National Center for Science and Engineering Statistics, Business R&D and Innovation Survey, 2008.

intensity, the semiconductor industry no longer has the highest value for this indicator. The most R&D-intense industry on a line-of-business basis is the scientific R&D services industry (NAICS 5417)—at 46.6% it is a much higher value than the 9.0% that is calculated on an industry basis. Software publishers (NAICS 5112) and Internet service providers/Web search/data processing services (NAICS 518) are two other industries that have much higher R&D intensities when line-of-

business estimates are used to calculate the indicator. This is an indication that some companies classified in these industries report large amounts of sales but relatively little R&D in ancillary lines of business.

Coincidence of Reported Codes

Some combinations of lines of business are much more frequently reported than others among survey respondents. These patterns can provide indications

of lines of business with strong relationships within diversified companies. The lines of business most frequently reported together were codes 32600 (plastics and rubber products manufacturing) and 33200 (fabricated metal products manufacturing), followed by codes 51120 (software publishers) and 54150 (computer systems design and related services) (table 3).³ The line of business for activities in software publishers was also frequently reported alongside data processing, hosting, and related

TABLE 3. Business activities most frequently reported together by respondents to form BRDI-1: 2008 (Percent)

First business activity and business code	Second business activity and business code	Companies reporting first activity that also reported second activity	Companies reporting second activity that also reported first activity
Plastics and rubber products manufacturing, 32600	Fabricated metal products manufacturing, 33200	25.3	26.7
Software publishers (except internet), 51120	Computer systems design and related services, 54150	13.4	16.3
Fabricated metal products manufacturing, 33200	Metalworking and other general purpose machinery manufacturing, 33390	19.4	28.7
Software publishers (except internet), 51120	Data processing, hosting, and related services, 51820	9.6	31.6
Fabricated metal products manufacturing, 33200	Motor vehicle parts manufacturing, 33630	16.1	20.3
Basic chemicals manufacturing, 32510	Paint, adhesive, and other chemical manufacturing, 32592	23.2	29.2
Data processing, hosting, and related services, 51820	Computer systems design and related services, 54150	27.4	10.1
Pharmaceutical, medicinal, botanical, and biological products (except diagnostic) manufacturing, 32541	Scientific research and development services, 54170	10.1	7.2
Fabricated metal products manufacturing, 33200	Architectural, engineering, and related services, 54130	12.2	18.3
Management, scientific, and technical consulting services, 54160	Scientific research and development services, 54170	23.9	6.1
Basic chemicals manufacturing, 32510	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing, 32520	18.8	38.9
Plastics and rubber products manufacturing, 32600	Metalworking and other general purpose machinery manufacturing, 33390	11.1	17.2

BRDI-1 = complete form of Business R&D and Innovation Survey.

NOTE: Only pairs of business codes reported by at least 20 respondents of BRDI-1 are shown.

SOURCE: National Science Foundation/National Center for Science and Engineering Statistics, Business R&D and Innovation Survey, 2008.

services (code 51820). Almost one-third of the companies that reported this last code also reported activity in software publishing (table 3). These relationships in lines of business within companies in BRDIS give researchers a new opportunity to explore industry dynamics and the effect of diversification on R&D, innovation, and productivity.⁴

Data Sources and Limitations

The target population for BRDIS consists of all for-profit, non-farm businesses with five or more employees in the United States, with a particular focus on those that perform R&D in the United States. For 2008, a total of 39,553 companies were sampled, representing 1,926,012 companies in the population. Because the statistics from the survey are based on a sample, they are subject to both sampling and nonsampling errors.

In 2008, two forms were mailed to companies for BRDIS, the complete form (form BRDI-1) and an abbreviated form (form BRDI-1A). The complete BRDIS form asked companies to identify all the lines of businesses in which they operated using a list of business codes and subsequently asked them to report their sales and R&D for each line of business. The abbreviated form asked companies to identify only their single largest line of business in terms of R&D. The complete form was mailed to companies that were known to have performed over \$1.836 million of R&D in recent survey years (4,834 companies in 2008). Because of the

design of the abbreviated form and item nonresponse on the complete form, not all R&D can be allocated to a line of business.

Overall, \$10.7 billion (3%) of the total worldwide R&D expense in 2008 and \$1,092 billion (10%) of the total worldwide sales in 2008 was left unassigned.

The BRDIS forms used the more generic term “business activities” instead of “lines of business.” BRDIS asked companies to report their business activities using a set of business codes, which were based on the 2002 NAICS codes. In some cases these codes may not be sufficiently detailed to capture the full diversity of activities a business may have. For example, only one line-of-business code is provided for software publishers (51120), but a company may have more than one software business (for example, games, business applications, and operating systems).

For an overview of worldwide R&D data collected by BRDIS see NCSES InfoBrief, *U.S. Businesses Report 2008 Worldwide R&D Expense of \$330 Billion: Findings from New NSF Survey* (NSF 10-322) at <http://www.nsf.gov/statistics/infbrief/nsf10322/>. The full set of detailed tables from the 2008 BRDIS will be available in the report *R&D and Innovation in Business: 2008* at <http://www.nsf.gov/statistics/industry/>. Individual detailed tables from the 2008 survey may be available in advance of publication of the full report. For further information, contact Raymond Wolfe.

Notes

1. Brandon Shackelford is principal consultant at Twin Ravens Consulting, Austin, TX. For further information, contact Raymond M. Wolfe, Research and Development Statistics Program, National Center for Science and Engineering Statistics, National Science Foundation, 4201 Wilson Boulevard, Suite 965, Arlington, VA 22230 (rwolfe@nsf.gov; 703-292-7789).
2. Each company was classified into the business code that accounted for the largest amount of total domestic R&D performance using data from question 2-14 plus question 4-5 (<http://www.nsf.gov/statistics/question.cfm#13>). If no business code data was available for a company’s domestic R&D performance, the industry code used for sampling was used. The industry classification assigned to companies for sampling was based on payroll of U.S. establishments.
3. This analysis took into account all business codes reported by companies irrespective of whether R&D was reported in the code. Some companies perform R&D in only a subset of their lines of business.
4. Chang H, Fernando GD, Srinivasan D, Tripathy A. 2011. A re-examination of diversification and firm productivity. Paper presented at the 2012 meeting of the American Accounting Association Management Accounting Section, 15 Aug 2012. Available at <http://ssrn.com/abstract=1909930>.

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