

SECTION B. TECHNICAL NOTES

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INTRODUCTION

This report is the second of two publications produced from the 1993 Survey of Industrial Research and Development. The first, a Data Brief announcing the availability of survey results, contains analytical information and highlights the increasing share of R&D performed by nonmanufacturing industries. This report, the Detailed Statistical Tables report, contains the full set of statistics produced from the survey. Both publications provide statistics on research and development (R&D) funding for the years 1983–93 and on R&D personnel for the period from January 1984 to January 1994.

This report provides national estimates of the expenditures on R&D performed within the United States by industrial firms, whether U.S. or foreign owned. Among the statistics are estimates of total R&D, the portion of the total financed by U.S. Government funds, and the portion financed by the companies themselves (or by other non-Federal sources such as State and local governments or other industrial firms under contracts or subcontracts). Total R&D is also separated into its character-of-work components: basic research, applied research, and development. Other R&D statistics include those of the funds for R&D financed by a domestic firm but performed outside the United States, R&D contracted to organizations outside of firm, and the funds spent to perform energy-related R&D. This report also provides statistics on R&D-performing companies, including domestic net sales, number of employees, number of R&D-performing scientists and engineers, and cost per R&D scientist and engineer.

The Survey of Industrial Research and Development is a sample survey that intends to include or represent all for-profit, nonfarm R&D-performing companies, either publicly or privately held. The survey's primary focus is on U.S. industry as a performer of, rather than as a source of funds for, R&D. Thus, data on Federal support of R&D activities performed by industry are collected and resulting statistics appear in several tables, but statistics on industrial funding of R&D undertaken at universities and colleges and

other nonprofit organizations are not collected and therefore are not included in the tables.¹

Industry statistics are developed from data collected from individual companies or enterprises. Since the survey is enterprise based rather than establishment based, all data collected for the various subparts of each enterprise (plants, divisions, or subdivisions) are tabulated in the major standard industrial classification (SIC) of the company. The resulting industry estimates are reported using the SIC of the companies within each industry. National totals are estimated by summing the industry estimates.

All companies that spend more than \$1 million annually on R&D in the United States or have 1,000 or more employees receive a survey questionnaire every year. Remaining firms are subjected to probability sampling and may or may not receive a questionnaire for a given survey year. Among the organizations purposely excluded from the survey are trade associations and not-for-profit consortia. Although their primary mission is to serve industry, these associations are established as nonprofit organizations.

Respondents receive detailed definitions to help them determine which expenses to include or exclude from the R&D data they provide. Nevertheless, the statistics presented in this report are subject to response and concept errors caused by different respondent interpretations of the definitions of R&D activities and by variations in company accounting procedures. Consequently, the statistics are better indicators of changes in, rather than absolute levels of, R&D spending and personnel.

¹ Data on R&D performed at universities and colleges are collected in the annual Survey of Scientific and Engineering Expenditures at Universities and Colleges. Resumption of a survey of other nonprofit organizations, discontinued in the mid-1970s, is planned. More information about these surveys is available from NSF's Research and Development Statistics Program in the Division of Science Resources Studies at the address given in General Notes, preceding section A.

The National Science Foundation (NSF) has sponsored a survey of industrial R&D since 1953. The two surveys covering the 1953–56 period were conducted by the Bureau of Labor Statistics (BLS), U.S. Department of Labor.² Since 1957, the Bureau of the Census has conducted the survey.³ NSF's Division of Science Resources Studies sponsors and monitors the survey.

The content of the survey has been expanded and refined over the years in response to an increasing need by policymakers for more detailed information on the Nation's R&D effort. For example, questions on energy R&D were added in the early seventies, following the first oil-shortage crisis. On the other hand, the frequency of collection of certain data items has been reduced in recent years in an attempt to alleviate some of the respondent burden that has been placed on industry from all sources. For large firms known to perform R&D, a detailed questionnaire, Form RD-1L, is used to collect data for odd-numbered years and an abbreviated version, Form RD-1S, is used to collect data for even-numbered years. To further limit reporting burden on small R&D performers and on firms that are included in the sample for the first time, an even more abbreviated form, Form

RD-1A, which collects only the most crucial data, is used each year. This report provides data collected from the Forms RD-1L and RD-1A.

Several changes have been made to the survey recently that are of special importance to users of this report. Prior to the 1992 survey, statistics were based on samples selected at irregular intervals (i.e., 1967, 1971, 1976, 1981, 1987). In intervening years a subset of the last sample (called a panel) was used. The most recent sample prior to the 1992 survey was selected and first used for survey year 1987. Estimates for 1988 through 1991 were based on surveys of the panel of companies that reported R&D activity in the 1987 survey. Beginning with the 1992 survey, statistics are based on samples selected annually. Also, beginning with the 1992 survey, the sample size was increased from approximately 14,000 to nearly 23,400 firms. This increase was made for several reasons: (1) to account better for births of R&D-performing establishments in the survey universe, (2) to survey more fully and accurately R&D performed by nonmanufacturing firms (especially in the service sector and by small firms in all industries), and (3) to gather more current information about potential R&D performers.

² See National Science Foundation, *Science and Engineering in American Industry: Final Report on a 1953-54 Survey* (NSF 56-16) and *Science and Engineering in American Industry: 1956* (NSF 59-50) (Washington, DC: Supt. of Documents, GPO, 1956 and 1960).

³ Data obtained in the earlier BLS surveys are not directly comparable with Census figures because of methodological and other differences.

SURVEY METHODOLOGY⁴

REPORTING UNIT

The reporting unit for the Survey of Industrial Research and Development is the enterprise, or company, defined as a business organization of one or more establishments under common ownership or control. The survey includes two groups of enterprises: (1) companies known to conduct R&D and (2) a sample representation of companies for which information on the extent of R&D activity is uncertain.

FRAME CREATION

The Standard Statistical Establishment List (SSEL), a Bureau of the Census compilation that contains information on more than 3 million establishments with paid employees, was the universe from which the frame used to select the 1993 survey sample was created (see table B-1 for universe and sample sizes). For companies with more than one establishment, data were summed to the company level. The firm was then assigned a single standard industrial classification (SIC) code based on the activity of the establishment(s) having the highest dollar value of payroll. This assignment was done on a hierarchical basis. The enterprise was first assigned to the economic division (manufacturing or nonmanufacturing) with the highest payroll, then to the two-digit SIC code with the highest payroll within the assigned division, then to the three-digit SIC code with the highest payroll within the assigned two-digit industry.

The frame from which the survey sample was drawn included all for-profit companies classified in nonfarm industries. For surveys prior to 1992, the frame was limited to companies above certain size criteria based on number of employees.⁵ These criteria varied by industry. Also, some industries

were excluded from the frame because it was believed that these industries contributed little or no R&D activity to the final survey estimates. For the 1992 sample, new industries were added to the frame⁶ and the size criteria were lowered considerably and applied uniformly to firms in all industries. As a result, nearly 2 million enterprises with five or more employees were given a chance of selection. For comparison, the frame for the 1987 sample included 154,000 companies of specified sizes and industries. The frame used to select the 1993 sample is comparable with the 1992 frame.

External information about the likelihood that a company conducted R&D was used to identify nearly 10,000 companies that were included in the survey sample with certainty. Sources included the 1992 survey, directories that include company information on R&D reported to the Securities and Exchange Commission, commercially available directories of R&D performing companies, Department of Defense directories of contracts awarded for R&D, and various publications and newsletters that highlight firms conducting R&D. In addition, all companies in the frame with 1,000 employees or more were selected with certainty.

SAMPLE SELECTION

Probability Proportionate to Size

As with most types of economic surveys, the sample was selected using probabilities proportionate to size. That is, large companies had a higher probability of selection than did small companies. For this survey, it would have been ideal if company size could have been determined by the amount of R&D expenditures. Unfortunately, except for the companies that were in a previous survey or for which there was information from external sources, it was impossible to know the R&D expenditure values for firms in the universe. Consequently, most companies' R&D expenditures had to be estimated, with the probability of selection based on those estimated values.

Since total employment was known for each company in the universe, it was possible to use an already-

⁴ Information for this section was provided by the Manufacturing and Construction Division of the Bureau of the Census, the collecting and compiling agent for the National Science Foundation. Copies of the technical papers cited can be obtained by contacting NSF's Research and Development Statistics Program in the Division of Science Resources Studies at the address given in General Notes, preceding section A.

⁵ See the Bureau of the Census technical memorandum entitled Evaluation of Total Employment Cut-Offs in the Survey of Industrial Research and Development, Nov. 3, 1994.

⁶ These industries are listed and discussed under Comparability of Statistics, later in this section.

Table B-1: Number of companies in the universe and selected for the sample: 1993

Industry	SIC code	Companies in universe	1993 Survey			Companies reporting R&D expenditures for 1993 3/		Companies reporting zero R&D expenditures for 1993
			Companies selected for 1993 sample	Noncertainties 1/	Certainties 2/	Greater than or equal to \$1 million	Less than \$1 million	
Total.....		1,797,290	24,064	11,838	12,226	2,792	3,637	13,426
MANUFACTURING								
Total.....		196,736	15,105	8,090	7,015	2,118	3,111	7,164
Distribution by industry:								
Food, kindred, and tobacco products.....	20,21	10,308	627	268	359	80	165	286
Textiles and apparel.....	22,23	16,685	1,084	532	552	54	116	649
Lumber, wood products, and furniture.....	24,25	22,969	1,795	1,255	540	26	207	1,210
Paper and allied products.....	26	3,239	409	248	161	51	55	244
Chemicals and allied products.....	28	5,237	583	150	433	255	186	91
Industrial chemicals.....	281-82,286	902	116	22	94	75	13	16
Drugs and medicines.....	283	795	133	10	123	89	26	11
Other chemicals.....	284-85,287-89	3,540	334	118	216	91	147	64
Oil and Gas Extraction.....	13	5,734	149	73	76	12	13	102
Petroleum refining and related industries.....	29	640	132	33	99	19	36	55
Rubber products.....	30	8,564	503	223	280	91	143	191
Stone, clay, and glass products.....	32	7,328	817	561	256	39	128	486
Primary metals.....	33	3,869	793	431	362	61	140	478
Ferrous metals and products.....	331-32,3398-99	2,022	346	192	154	30	74	195
Nonferrous metals and products.....	333-36	1,847	447	239	208	31	66	283
Fabricated metal products.....	34	21,381	1,916	1,458	458	112	350	1,084
Machinery.....	35	30,482	1,888	937	951	425	577	580
Office, computing, and accounting machines.....	357	1,248	413	205	208	166	78	66
Other machinery, except electrical.....	351-56,358-59	29,234	1,475	732	743	259	499	514
Electrical equipment.....	36	9,263	1,640	690	950	403	477	449
Radio and TV receiving equipment.....	365	407	111	62	49	10	25	53
Communication equipment.....	366	1,028	344	115	229	121	120	39
Electronic components.....	367	3,776	388	108	280	143	101	84
Other electrical equipment.....	361-64,369	4,052	797	405	392	129	231	273
Transportation equipment.....	37	5,724	546	255	291	100	124	217
Motor vehicles and motor vehicles equipment.....	371	2,602	123	23	100	45	32	30
Other transportation equipment.....	373-75,379	2,077	354	225	129	16	79	178
Aircraft and missiles.....	372,376	1,045	69	7	62	39	13	9

See explanatory information and SOURCE at end of table.

Table B-1: Number of companies in the universe and selected for the sample: 1993

Industry	SIC code	Companies in universe	1993 Survey			Companies reporting R&D expenditures for 1993 3/		Companies reporting zero R&D expenditures for 1993
			Companies selected for 1993 sample	Noncertainties 1/	Certainties 2/	Greater than or equal to \$1 million	Less than \$1 million	
Professional and scientific instruments.....	38	5,905	767	161	606	319	212	117
Scientific and mechanical measuring instruments.....	381-82	2,937	347	46	301	169	113	27
Optical, surgical, photographic, and other instruments.....	384-87	2,968	420	115	305	150	99	90
Other manufacturing industries.....	27,31,39	39,408	1,456	815	641	71	182	925
NONMANUFACTURING								
Total.....		1,600,554	8,959	3,748	5,211	674	526	6,262
Communication services.....	48	7,660	71	6	65	18	5	36
Electric, gas, and sanitary services.....	49	3,280	175	11	164	45	52	60
Computer programming, data processing, other computer-related engineering, architectural, and surveying services.....	737,871	35,115	684	300	384	177	87	314
Hospitals and medical and dental laboratories.....	806-07	5,809	630	220	410	18	19	500
Research, development, and testing services.....	873	4,694	181	7	174	115	22	26
Other nonmanufacturing industries.....	07-10,12-17, 40-42,44-47 50-59,60-65, 67,701,73 (except 737),75-76 78-79,80-81, (except 806 and 807),83-84,87 (except 871 and 873),89	1,543,996	7,218	3,204	4,014	301	341	5,326

1/ Noncertainties were companies for which probability of selection was less than one.

2/ Certainties were companies for which probability of selection was one. This included companies for which 1992 R&D expenditures were equal to or greater than \$1 million, or 1992 employment was equal to or greater than 1,000, or were selected in order to provide estimates of sufficient accuracy.

3/ This included RD-1L companies for which total R&D expenditure data were imputed.

SOURCE: National Science Foundation/SRS, Survey of Industrial Research and Development: 1993

observed relationship between employment and R&D to estimate R&D expenditure values for companies in the frame. This was the same strategy employed in the 1981 and 1987 sampling operations. For 1993 sampling, data collected in the 1992 survey were used to derive this relationship separately for single-unit companies and multiestablishment companies. The effect in all cases was to give firms with a large number of employees higher probability of selection since it was assumed that large companies were more likely to perform R&D and that the amount of R&D was proportionate to the size of the company.

Sample Stratification and Relative Standard Error Constraints

Even though the particular sample selected was one of a large number of the same type and size that by chance might have been selected, statistics resulting from the different samples would differ somewhat from each other. These differences are represented by estimates of sampling error—the smaller the sampling error, the more precise the statistic.

As a control of sampling error in the statistics resulting from this survey, parameters were specified to allocate the sample across various levels, or strata, that corresponded to industry groupings. These parameters permitted the sample size to be varied to achieve a desired level of sampling error for each stratum and were assigned so that estimated errors of total R&D for industries in these strata did not exceed certain levels. Sample sizes among the strata were only constrained by the limit placed on the total sample size dictated by the available budget.

For sample selections prior to 1992, the strata designations were the published industry categories. The sample was allocated across these industry categories to provide high, medium, and low levels of precision. For the 1992 sample, the criteria for this allocation were modified. For gathering information to review and evaluate the appropriateness of the published industry groupings, the allocation of the sample was controlled for levels of industry detail below those traditionally published. The result was that the frame was partitioned into 95 manufacturing industry strata and 25 nonmanufacturing strata. This stratification was used for the 1993 sample.

Each industry was allocated to one of three groups. The first group was formulated to analyze the distribution of data in manufacturing industries. In this group, each three-digit manufacturing industry was considered a separate stratum. The second group was formulated to improve coverage and to identify emerging industries. In this group, selected two-digit and three-digit nonmanufacturing industries each were considered a separate stratum. The industries were identified as those for which statistics had been published previously and those with high concentrations of scientists and engineers as reported in occupational surveys. The third group was a large stratum of companies in nonmanufacturing industries that had not been included in previous sampling frames or for which there was little indication of R&D activity.

Once the strata were defined, the following criteria were used to achieve the target sampling error for total R&D:

- Sampling error not to exceed 2 percent for 44 three-digit manufacturing industries that contribute to a current publication level below the two-digit industry level and for 15 three-digit nonmanufacturing industries that represent a current publication level or for which there is a high concentration of scientists or engineers.
- Sampling error not to exceed 5 percent for 51 three-digit manufacturing industries that are part of currently published two-digit or aggregations of two-digit industries; 9 two-digit nonmanufacturing industries for which R&D activity was likely, and 1 stratum of remaining nonmanufacturing industries for which there was little prior indication of R&D activity.

Based on the desired precision represented by these sampling error estimates, the criteria suggested a total sample size of approximately 23,000.

A limitation of the sample allocation process should be noted. Sampling errors were controlled by using a universe total that, in large part, was improvised. That is, as previously noted, an R&D value was assigned to every company in the frame, even

though many of these companies actually may not have had R&D expenditures. The value assigned was imputed for the majority of companies in the frame, and, as a consequence, the estimated universe and the distribution of individual company values did not necessarily reflect the true distribution. Estimates of sampling variability were nevertheless based on this distribution. The presumption was—and this had been confirmed using the previous sample selection—that actual variation in the sample design would be less than that estimated, because many of the sampled companies have true R&D values of zero, not the widely varying values that were imputed using total employment as a predictor of R&D. Thus, the 2-percent and 5-percent error levels described earlier are conservative. (See table B-2 for a list by industry of the actual standard error estimates for selected items.)

In addition to sampling error, the estimates are subject to nonsampling error. Errors are grouped into five categories: specification, coverage, response, nonresponse, and processing. For detailed discussions on the sources, control, and measurement of each of these types of error, see the technical reports.⁷

Sample Size and Weighting

The sample was selected with a target sample size of 23,000 and with other parameters set to ensure compliance with the standard error constraints. An actual sample of 24,064 was selected. The actual sample size differed from the target for two reasons. First, the sample frame was subjected to independent sampling. Each company in the frame had an independent chance of selection based on its assigned probability; i.e., selection of a company was completely independent of the selection of any other company. In independent sampling, sample size itself is a random variable. Theoretically, a sample of size zero or a sample the size of the entire universe is possible, but the probabilities of these extremes are so small that these are nearly impossible situations. The actual sample size is usually quite close to the specified size. If there is too much deviation, the selection is simply executed again.

Second, a minimum probability rule was imposed. As noted earlier, probabilities of selection proportionate to size are assigned to each company, where size is the imputed R&D value assigned each company. Selected companies that report actual R&D expenditures vastly larger than their assigned values can have adverse effects on the statistics, which are based on the weighted value of survey responses.⁸ So that the effects on the final statistics would be lessened, the maximum weight a company could assume was arbitrarily controlled by specifying the probability of the company's selection. If the probability, based on company size, was less than the arbitrarily set minimum, then the probability was set equal to the minimum value. The consequence of raising these original probabilities to the minimum probability was to raise the expected sample size. It is likely that most of the difference between the size of the target sample and the actually selected sample was because of this rule.

Third, between the time that the frame was created and the survey was prepared for mailing, the operational status of some companies changed—that is, they were merged with or acquired by another company, or they were no longer in business. Before preparation of the survey for mailing, the operational status is updated to identify these changes. As a result, the number of companies mailed a survey form is somewhat smaller than the number of companies initially selected for the survey.

SURVEY QUESTIONNAIRES

Two questionnaires are used each year to collect data for the survey. For large firms known to perform R&D, a detailed questionnaire, Form RD-1L, is used to collect data for odd-numbered years and an abbreviated version, Form RD-1S, is used to collect data for even-numbered years. The questionnaires are cycled in this manner to reduce reporting burden on survey respondents.

The Form RD-1L requests data on sales or receipts, total employment, employment of scientists and engineers, expenditures for R&D performed within the company with Federal funds and with company and

⁷ U.S. Department of Commerce, Bureau of the Census, *Documentation of Nonsampling Issues in the Survey of Industrial Research and Development*, RR94/03 (Washington, DC, Sept. 1994) and U.S. Department of Commerce, Bureau of the Census, *A Study of Processing Errors in the Survey of Industrial Research and Development*, ESMD-9403 (Washington, DC, Sept. 1994).

⁸ The weight given to a company selected for the survey is the inverse of its probability of selection. Companies selected for the sample with certainty (see Frame Creation earlier in this section) represented only themselves, and each had a weight of 1.0.

Table B-2. Relative standard error of estimate (percentage) for selected items,
by industry and size of company: 1993

Industry	SIC code	Number of R&D-performing companies	Domestic net sales of R&D performers	Domestic employment of R&D performers	Number of FTE scientists and engineers	Total R&D	Company and other funds for R&D
		6,429	0.8	0.7	2.8	2.7	3.2
Food, kindred, and tobacco products.....	20,21	245	0.7	1.7	4.9	1.1	1.1
Textiles and apparel.....	22,23	170	5.9	2.4	6.4	3.4	3.6
Lumber, wood products, and furniture.....	24,25	233	1.8	2.6	32.8	2.0	2.0
Paper and allied products.....	26	106	1.6	2.0	2.0	2.9	3.0
Chemicals and allied products.....	28	441	0.7	1.1	3.7	3.3	3.6
Industrial chemicals.....	281-82,286	88	0.7	0.7	0.5	0.2	0.2
Drugs and medicines.....	283	115	1.1	2.1	7.2	6.5	6.5
Other chemicals.....	284-85,287-89	238	1.8	2.9	3.1	1.4	1.4
Petroleum refining and extraction.....	13,29	80	0.1	0.3	0.3	0.3	0.3
Rubber products.....	30	234	6.5	5.4	4.8	4.1	4.1
Stone, clay, and glass products.....	32	167	1.2	1.6	2.1	1.5	1.6
Primary metals.....	33	201	1.3	1.4	16.0	11.0	10.6
Ferrous metals and products.....	331-32,3398-99	104	1.7	1.6	27.5	14.8	12.4
Nonferrous metals and products.....	333-36	97	1.6	2.6	16.0	15.7	15.9
Fabricated metal products.....	34	462	1.1	1.3	3.2	2.4	4.2
Machinery.....	35	1,002	1.1	1.2	5.1	1.4	1.4
Office, computing, and accounting machines.....	357	244	0.9	0.7	1.3	1.1	1.1
Other machinery, except electrical.....	351-56,358-59	758	1.4	1.6	9.8	3.0	3.0
Electrical equipment.....	36	880	0.4	0.6	1.6	0.9	1.1
Radio and TV receiving equipment.....	365	35	4.0	3.4	7.3	9.0	7.0
Communication equipment.....	366	241	0.8	1.1	1.0	0.7	0.8
Electronic components.....	367	244	1.3	2.0	2.7	2.2	2.4
Other electrical equipment.....	361-64,369	360	0.3	0.4	4.4	0.5	0.6
Transportation equipment.....	37	224	0.7	0.8	0.6	0.2	0.3
Motor vehicles and motor vehicles equipment.....	371	77	1.0	1.0	0.2	0.0	0.0
Other transportation equipment.....	373-75,379	95	1.3	1.8	2.9	5.5	6.1
Aircraft and missiles.....	372,376	52	0.7	1.4	1.0	0.4	0.9
Professional and scientific instruments.....	38	531	1.1	1.7	13.2	2.0	2.7
Scientific and mechanical measuring instruments.....	381-82	282	1.6	2.3	3.3	0.9	1.5
Optical, surgical, photographic, and other instruments.....	384-87	249	1.6	2.5	39.3	4.5	4.6
Other manufacturing industries.....	27,31,39	253	4.7	5.7	40.7	7.0	7.0
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-85,87,89	1,200	2.6	2.0	7.3	10.0	11.8
Distribution by size of company: (Based on number of employees)							
Total.....		6,429	0.8	0.7	2.8	2.7	3.2
Fewer than 500.....		3,924	9.6	6.6	13.1	19.2	20.6
500 to 999.....		783	2.3	2.7	2.9	2.0	2.0
1,000 to 4,999.....		1,180	0.0	0.1	0.0	0.0	0.0
5,000 to 9,999.....		237	0.0	0.0	0.0	0.0	0.0
10,000 to 24,999.....		181	0.0	0.0	0.0	0.0	0.0
25,000 or more.....		124	0.0	0.0	0.0	0.0	0.0

See explanatory information and SOURCE at end of table.

Table B-2. Relative standard error of estimate (percentage) for selected items,
by industry and size of company: 1993

Industry	SIC code	Company-financed R&D performed outside of U.S.	Company-financed R&D contracted to outside organizations	Federal funds for R&D	Total funds for basic research	Total funds for applied research	Total funds for development
		1.0	2.3	2.9	2.8	4.0	3.9
Food, kindred, and tobacco products.....	20,21	0.0	1.0	0.0	4.1	0.5	1.8
Textiles and apparel.....	22,23	0.0	11.1	0.5	12.7	2.5	6.5
Lumber, wood products, and furniture.....	24,25	0.1	17.8	3.8	13.0	3.3	2.2
Paper and allied products.....	26	0.0	0.2	0.0	7.8	1.2	7.6
Chemicals and allied products.....	28	0.0	0.6	0.3	0.6	10.1	0.3
Industrial chemicals.....	281-82,286	0.0	2.5	0.0	0.3	0.2	0.2
Drugs and medicines.....	283	0.1	0.7	31.0	0.8	17.7	0.5
Other chemicals.....	284-85,287-89	0.0	0.3	0.0	6.5	3.1	1.5
Petroleum refining and extraction.....	13,29	0.5	0.5	0.0	0.6	0.0	0.8
Rubber products.....	30	0.0	56.0	0.0	12.0	16.0	4.0
Stone, clay, and glass products.....	32	2.4	3.7	4.0	4.6	1.5	1.0
Primary metals.....	33	2.3	10.5	47.3	4.1	0.8	19.5
Ferrous metals and products.....	331-32,3398-99	0.0	13.8	63.3	7.8	2.1	25.8
Nonferrous metals and products.....	333-36	2.5	0.4	0.0	3.7	0.1	28.1
Fabricated metal products.....	34	0.4	38.6	0.2	1.2	2.8	2.6
Machinery.....	35	0.2	3.0	1.0	3.8	5.2	0.8
Office, computing, and accounting machines.....	357	0.3	2.8	1.7	9.6	3.5	1.1
Other machinery, except electrical.....	351-56,358-59	0.3	5.2	1.1	3.5	11.4	1.4
Electrical equipment.....	36	0.8	3.0	0.8	4.5	3.0	1.2
Radio and TV receiving equipment.....	365	0.0	6.2	67.7	13.0	24.5	9.6
Communication equipment.....	366	2.6	11.3	1.6	18.6	6.9	0.8
Electronic components.....	367	0.0	11.3	0.0	3.6	7.0	3.1
Other electrical equipment.....	361-64,369	0.4	2.6	0.7	3.4	0.5	0.7
Transportation equipment.....	37	0.0	0.5	0.0	1.0	0.7	0.2
Motor vehicles and motor vehicles equipment.....	371	0.0	0.5	0.0	1.1	0.2	0.0
Other transportation equipment.....	373-75,379	30.2	1.1	0.0	13.5	10.3	10.9
Aircraft and missiles.....	372,376	0.0	2.4	0.0	0.0	1.0	0.4
Professional and scientific instruments.....	38	3.6	39.4	0.3	1.1	3.2	2.2
Scientific and mechanical measuring instruments.....	381-82	0.0	35.6	0.4	0.4	3.0	0.1
Optical, surgical, photographic, and other instruments.....	384-87	4.4	48.6	0.0	1.7	7.9	5.0
Other manufacturing industries.....	27,31,39	0.5	37.8	4.1	39.7	4.6	5.1
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-85,87,89	5.2	2.1	11.5	7.0	10.2	14.2
Distribution by size of company: (Based on number of employees)							
Total.....		1.0	2.3	2.9	2.8	4.0	3.9
Fewer than 500.....		20.6	15.4	39.9	9.0	23.4	35.4
500 to 999.....		0.2	2.8	1.2	6.1	1.9	2.7
1,000 to 4,999.....		0.1	0.0	0.0	0.1	0.0	0.0
5,000 to 9,999.....		0.0	0.0	0.0	0.0	0.0	0.0
10,000 to 24,999.....		0.0	0.0	0.0	0.0	0.0	0.0
25,000 or more.....		0.0	0.0	0.0	0.0	0.0	0.0

NOTE: A description of the standard error of estimate is given in section A under "Methodology of Survey."
The percentage (or relative) standard errors in this table may be converted to standard errors of estimate by multiplying the percentages shown by the associated estimates. For example, the relative standard error of estimate for R&D performance for all company size groups in the chemicals industry (SIC 28) is shown as 1.4 percent, and the associated total R&D estimate for this industry is shown as \$16,711 million in table A-3, "Total (company and Federal) funds for industrial R&D performance by industry and size of company: 1982-92." The standard error of estimate, then, is .014 times 16,711 or 234.

other funds, character of work (basic research, applied research, and development), company-sponsored R&D expenditures in foreign countries, R&D performed under contract by others, expenditures for pollution abatement and energy R&D, detail on R&D by product field, Federal R&D support to the firm by contracting agency, domestic R&D expenditures by State, and foreign R&D by country. The Form RD-1S requests the same information except for the last four items. Because companies receiving the Forms RD-1L and RD-1S generally have participated in previous surveys, computer imprinted data reported by the company for the previous year are supplied for reference. Companies are encouraged to revise or update this imprinted data if they have more current information.

As a further limit on reporting burden on small R&D performers and on firms that are included in the sample for the first time, an even more abbreviated form is used each year. Form RD-1A collects data only on R&D, sales, employment, and operational status and includes a screening item that allows respondents to indicate that they do not perform R&D. No prior-year information is available since the majority of the companies have not reported previously.

For the 1993 survey, about 2,300 companies that reported \$1 million or more in R&D spending in the 1992 survey received Form RD-1L and nearly 21,600 received Form RD-1A. Of the 23,900 firms, 6,400 reported R&D expenditures. Both questionnaires and the instructions provided to respondents are reproduced in section C, Survey Documents.

FOLLOW-UP FOR SURVEY NONRESPONSE

The 1993 survey questionnaires were mailed in May 1994, and recipients were asked to respond within 60 days. Thirty days later, letters were mailed to all survey recipients reminding them that their completed questionnaire was due within the next 30 days. Copies of the Form RD-1A and instructions were faxed to respondents who called a toll-free telephone number indicated in the follow-up letters. After 60 days, follow-up letters were sent to all nonresponding firms. Two additional follow-up mailings were made to persistent nonrespondents, after 90 and 120 days.

In addition to the mailings, telephone follow-up was used to encourage response from those firms ranked among the 300 largest R&D performers, based on total R&D expenditures reported in the previous survey. Telephone follow-up was also used for these firms during the initial data edit phase of survey operations if data items were missing or unclear. Table B-3 shows the number of companies in each industry or industry group that received a questionnaire and the percentage that responded to the survey.

IMPUTATION FOR ITEM NONRESPONSE

For various reasons, many firms chose to return the survey questionnaires with one or more blank items.⁹ For instance, the internal accounting procedures of the firm may not have allowed it to quantify the pollution-abatement expenditures portion of R&D. In addition, some firms, as a matter of policy, refused to answer any voluntary questions.¹⁰

When respondents did not provide the requested information, estimates for the missing data were made using imputation algorithms. In general, the imputation algorithms computed values for missing items by applying the average percentage change for the target item in the nonresponding firm's industry to the item's prior-year value for that firm, reported or imputed. This approach, with minor variation, was used for most items.¹¹ Table B-4 contains imputation rates for the principal survey items.

⁹ For detailed discussions on the sources, control, and measurement of error resulting from item nonresponse, see the technical report: U.S. Department of Commerce, Bureau of the Census, *Documentation of Nonsampling Error Issues in the Survey of Industrial Research and Development*, RR94/03 (Washington, DC, Sept. 21, 1994). For a general discussion of the problems stemming from item nonresponse, see the technical report: National Science Foundation, *Estimating Basic and Applied Research and Development in Industry: A Preliminary Review of Survey Procedures*, NSF 90-322 (Washington, DC, 1990).

¹⁰ All but four items—total R&D, Federal R&D, net sales, and total employment—which are included in the Census Bureau's annual mandatory statistical program, are voluntary. See further discussion under Response Rates and Mandatory Versus Voluntary Reporting, later in this section.

¹¹ For detailed descriptions and analyses of the imputation methods and algorithms used, see the technical report: U.S. Department of Commerce, Bureau of the Census, *An Evaluation of Imputation Methods for the Survey of Industrial Research and Development*, ESMD-9404 (Washington, DC, Sept. 1994).

Table B-3: Unit response rates—percentage of companies responding to survey, by industry: 1993

Industry	SIC code	Number of companies that received questionnaire	Response rate 1/
Total, all companies.....		23,923	81.8
Distribution by industry:			
Food, kindred, and tobacco products.....	20,21	623	83.6
Textiles and apparel.....	22,23	1,079	75.3
Lumber, wood products, and furniture.....	24,25	1,794	80.2
Paper and allied products.....	26	406	85.7
Chemicals and allied products.....	28	576	88.4
Industrial chemicals.....	281-82,286	116	86.2
Drugs and medicines.....	283	130	89.2
Other chemicals.....	284-85,287-89	330	88.8
Petroleum refining and extraction.....	13,29	280	83.2
Rubber products.....	30	503	82.1
Stone, clay, and glass products.....	32	812	80.0
Primary metals.....	33	789	85.4
Ferrous metals and products.....	331-32,3398-99	345	86.1
Nonferrous metals and products.....	333-36	444	84.9
Fabricated metal products.....	34	1,910	80.6
Machinery.....	35	1,869	81.9
Office, computing, and accounting machines.....	357	409	70.4
Other machinery, except electrical.....	351-56,358-59	1,460	85.1
Electrical equipment.....	36	1,628	79.4
Radio and TV receiving equipment.....	365	110	79.1
Communication equipment.....	366	338	79.9
Electronic components.....	367	387	81.1
Other electrical equipment.....	361-64,369	793	78.4
Transportation equipment.....	37	539	79.6
Motor vehicles and motor vehicles equipment.....	371	122	86.1
Other transportation equipment.....	373-75,379	352	76.4
Aircraft and missiles.....	372,376	65	84.6
Professional and scientific instruments.....	38	756	81.7
Scientific and mechanical measuring instruments.....	381-82	340	85.9
Optical, surgical, photographic, and other instruments.....	384-87	416	78.4
Other manufacturing industries.....	27,31,39	1,454	80.8
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-85,87,89	8,905	82.9

See explanatory information and SOURCE at end of table.

Table B-3: Unit response rates—percentage of companies responding to survey, by industry: 1993

Industry	SIC code	Number of companies that received questionnaire	Response rate 1/
Total, companies receiving Form RD-1L.....		2,256	88.1
Distribution by industry:			
Food, kindred, and tobacco products.....	20,21	66	86.4
Textiles and apparel.....	22,23	36	86.1
Lumber, wood products, and furniture.....	24,25	22	90.9
Paper and allied products.....	26	41	95.1
Chemicals and allied products.....	28	220	89.5
Industrial chemicals.....	281-82,286	69	92.8
Drugs and medicines.....	283	69	87.0
Other chemicals.....	284-85,287-89	82	89.0
Petroleum refining and extraction.....	13,29	27	92.6
Rubber products.....	30	65	84.6
Stone, clay, and glass products.....	32	31	96.8
Primary metals.....	33	52	94.2
Ferrous metals and products.....	331-32,3398-99	28	96.4
Nonferrous metals and products.....	333-36	24	91.7
Fabricated metal products.....	34	85	95.3
Machinery.....	35	334	86.8
Office, computing, and accounting machines.....	357	111	82.0
Other machinery, except electrical.....	351-56,358-59	223	89.2
Electrical equipment.....	36	317	88.0
Radio and TV receiving equipment.....	365	8	87.5
Communication equipment.....	366	92	89.1
Electronic components.....	367	126	88.1
Other electrical equipment.....	361-64,369	91	86.8
Transportation equipment.....	37	88	89.8
Motor vehicles and motor vehicles equipment.....	371	42	95.2
Other transportation equipment.....	373-75,379	13	76.9
Aircraft and missiles.....	372,376	33	87.9
Professional and scientific instruments.....	38	275	87.3
Scientific and mechanical measuring instruments.....	381-82	151	91.4
Optical, surgical, photographic, and other instruments.....	384-87	124	82.3
Other manufacturing industries.....	27,31,39	58	89.7
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-85,87,89	539	85.9

See explanatory information and SOURCE at end of table.

Table B-3: Unit response rates—percentage of companies responding to survey, by industry: 1993

Industry	SIC code	Number of companies that received questionnaire	Response rate 1/
Total, companies receiving Form RD-1A.....		21,667	81.1
Distribution by industry:			
Food, kindred, and tobacco products.....	20,21	557	83.3
Textiles and apparel.....	22,23	1,043	74.9
Lumber, wood products, and furniture.....	24,25	1,772	80.0
Paper and allied products.....	26	365	84.7
Chemicals and allied products.....	28	356	87.6
Industrial chemicals.....	281-82,286	47	76.6
Drugs and medicines.....	283	61	91.8
Other chemicals.....	284-85,287-89	248	88.7
Petroleum refining and extraction.....	13,29	253	82.2
Rubber products.....	30	438	81.7
Stone, clay, and glass products.....	32	781	79.4
Primary metals.....	33	737	84.8
Ferrous metals and products.....	331-32,3398-99	317	85.2
Nonferrous metals and products.....	333-36	420	84.5
Fabricated metal products.....	34	1,825	79.9
Machinery.....	35	1,535	80.8
Office, computing, and accounting machines.....	357	298	66.1
Other machinery, except electrical.....	351-56,358-59	1,237	84.4
Electrical equipment.....	36	1,311	77.3
Radio and TV receiving equipment.....	365	102	78.4
Communication equipment.....	366	246	76.4
Electronic components.....	367	261	77.8
Other electrical equipment.....	361-64,369	702	77.4
Transportation equipment.....	37	451	77.6
Motor vehicles and motor vehicles equipment.....	371	80	81.3
Other transportation equipment.....	373-75,379	339	76.4
Aircraft and missiles.....	372,376	32	81.3
Professional and scientific instruments.....	38	481	78.6
Scientific and mechanical measuring instruments.....	381-82	189	81.5
Optical, surgical, photographic, and other instruments.....	384-87	292	76.7
Other manufacturing industries.....	27,31,39	1,396	80.4
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-85,87,89	8,366	82.7

1/ The calculation of the response rate was based on all companies that responded to the survey, including those that reported they were out of scope, out of business, or had merged with another company. It excludes RD-1L companies for which total R&D expenditure data were imputed.

SOURCE: National Science Foundation/SRS, Survey of Industrial Research and Development: 1993

Table B-4. Imputation rates for selected items, by industry: 1993

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Industry	SIC code	Net sales	Total employment	R&D scientists and engineers	R&D		
					Total	Company	Federal
[Percent]							
Total.....		5.4	6.1	29.6	5.0	5.2	4.3
Food, kindred, and tobacco products.....	20,21	7.5	10.7	31.2	6.1	6.4	-
Textiles and apparel.....	22,23	17.4	15.7	33.4	18.9	16.2	92.3
Lumber, wood products, and furniture.....	24,25	1.8	12.9	11.4	3.2	2.9	30.6
Paper and allied products.....	26	7.9	8.8	24.1	3.2	3.3	0.0
Chemicals and allied products.....	28	10.5	8.6	26.8	4.0	4.2	1.8
Industrial chemicals.....	281-82,286	6.2	5.1	34.3	4.0	5.1	0.1
Drugs and medicines.....	283	1.2	1.6	22.5	1.0	1.0	0.0
Other chemicals.....	284-85,287-89	23.0	20.8	25.7	15.8	15.0	95.9
Petroleum refining and extraction.....	13,29	4.4	4.5	35.5	1.2	1.7	3.2
Rubber products.....	30	3.7	9.3	24.4	4.3	4.5	0.0
Stone, clay, and glass products.....	32	4.5	5.0	16.2	5.7	6.9	0.1
Primary metals.....	33	4.6	5.6	25.6	8.2	8.1	9.4
Ferrous metals and products.....	331-32,3398-99	1.5	1.8	15.2	6.6	7.0	0.0
Nonferrous metals and products.....	333-36	10.4	12.1	36.1	9.4	8.9	37.1
Fabricated metal products.....	34	1.6	2.7	21.1	0.9	1.7	0.1
Machinery.....	35	9.9	11.1	22.2	12.3	12.7	7.4
Office, computing, and accounting machines.....	357	14.8	26.3	23.8	15.4	15.9	0.1
Other machinery, except electrical.....	351-56,358-59	8.3	7.0	20.7	8.1	8.1	11.9
Electrical equipment.....	36	8.1	4.1	35.5	12.7	12.3	16.0
Radio and TV receiving equipment.....	365	20.4	15.4	34.9	0.0	0.0	56.5
Communication equipment.....	366	32.7	2.4	68.6	33.5	37.6	0.0
Electronic components.....	367	5.5	5.8	18.6	6.6	3.3	8.4
Other electrical equipment.....	361-64,369	2.4	3.3	19.0	1.1	1.3	79.5
Transportation equipment.....	37	1.2	2.0	31.9	0.5	0.6	0.2
Motor vehicles and motor vehicles equipment.....	371	0.1	0.4	37.5	0.1	0.2	53.0
Other transportation equipment.....	373-75,379	20.4	18.1	67.6	30.9	22.2	0.0
Aircraft and missiles.....	372,376	1.5	2.3	26.7	0.4	0.7	99.5
Professional and scientific instruments.....	38	11.2	10.2	59.1	6.5	8.7	0.1
Scientific and mechanical measuring instruments.....	381-82	5.6	4.6	73.1	4.4	7.8	0.7
Optical, surgical, photographic, and other instruments.....	383-87	16.7	16.8	30.8	9.3	9.4	0.6
Other manufacturing industries.....	21,27,31,39	2.3	5.7	19.7	4.2	4.4	4.6
Nonmanufacturing industries.....	07-10,12-17,40-42,44-49,50-59,60-65,67,701,73,75-76,78-79,80-81,83-85,87,89	3.7	4.3	15.8	4.2	2.7	0.0
							11.3

See explanatory information and SOURCE at end of table.

Table B-4. Imputation rates for selected items, by industry: 1993

Industry	SIC code	R&D by cost			R&D by state	Energy R&D	Pollution abatement	Outside company	Foreign R&D
		Wages	Materials	Other costs					
		[Percent]							
Total.....		45.9	46.3	47.3	41.0	6.6	7.1	18.3	5.6
Food, kindred, and tobacco products.....	20,21	37.5	38.4	37.4	33.9	-	56.9	4.0	20.6
Textiles and apparel.....	22,23	51.8	51.5	51.4	46.8	-	0.0	9.5	0.0
Lumber, wood products, and furniture.....	24,25	43.3	31.8	59.5	48.9	17.3	32.3	6.4	3.7
Paper and allied products.....	26	76.0	85.1	81.5	74.8	6.2	3.4	94.3	0.2
Chemicals and allied products.....	28	43.4	45.0	41.8	43.3	2.4	13.2	23.1	1.5
Industrial chemicals.....	281-82,286	56.2	55.8	56.2	67.0	2.4	7.5	73.4	0.6
Drugs and medicines.....	283	35.5	35.4	35.4	27.5	-	0.0	12.0	0.1
Other chemicals.....	284-85,287-89	31.3	29.6	31.3	31.4	0.0	76.6	42.8	5.5
Petroleum refining and extraction.....	13,29	37.9	38.2	38.2	30.2	13.4	10.5	25.0	4.5
Rubber products.....	30	37.6	36.7	36.8	37.4	28.0	44.4	1.3	0.6
Stone, clay, and glass products.....	32	34.8	35.6	34.5	32.9	0.0	0.0	44.9	0.0
Primary metals.....	33	45.2	55.8	45.0	44.8	0.0	0.0	36.0	3.4
Ferrous metals and products.....	331-32,3398-99	20.8	22.5	20.7	15.3	0.0	0.0	47.1	0.0
Nonferrous metals and products.....	333-36	65.1	64.6	66.5	65.3	0.0	0.0	0.0	3.7
Fabricated metal products.....	34	60.4	59.8	59.6	59.8	0.0	2.9	7.2	11.0
Machinery.....	35	40.1	39.1	45.6	35.9	5.2	0.8	19.5	12.4
Office, computing, and accounting machines.....	357	43.5	43.1	47.9	34.8	-	0.0	30.7	14.2
Other machinery, except electrical.....	351-56,358-59	34.8	36.3	40.7	37.7	5.2	0.8	8.8	11.6
Electrical equipment.....	36	56.5	51.1	53.9	43.7	0.0	0.0	1.0	27.1
Radio and TV receiving equipment.....	365	32.5	28.8	28.4	85.8	-	-	0.0	0.0
Communication equipment.....	366	77.8	77.8	77.8	63.8	0.0	0.0	0.0	79.1
Electronic components.....	367	52.7	54.7	53.6	35.9	0.0	0.0	4.3	2.7
Other electrical equipment.....	361-64,369	33.8	33.5	33.6	34.3	0.0	0.0	0.4	2.0
Transportation equipment.....	37	53.0	48.8	61.6	51.7	0.8	2.2	19.3	5.0
Motor vehicles and motor vehicles equipment.....	371	35.1	33.9	34.1	34.3	0.0	0.0	12.6	0.0
Other transportation equipment.....	373-75,379	85.5	90.7	89.3	92.5	-	0.0	44.2	0.0
Aircraft and missiles.....	372,376	68.9	66.6	75.5	64.5	0.8	3.8	54.3	43.7
Professional and scientific instruments.....	38	79.8	79.5	81.0	56.7	0.0	0.0	7.1	5.8
Scientific and mechanical measuring instruments.....	381-82	82.0	82.4	82.0	69.2	-	0.0	4.2	29.5
Optical, surgical, photographic, and other instruments.....	383-87	76.8	76.5	79.0	38.3	0.0	0.0	7.8	0.3
Other manufacturing industries.....	21,27,31,39	46.3	48.4	52.8	38.9	-	0.0	1.1	3.4
Nonmanufacturing industries.....	07-10,12-17,40-42,44-49,50-59,60-65,67,701,73,75-76,78-79,80-81,83-85,87,89	20.9	21.9	20.0	18.6	7.0	25.7	13.5	4.3

- = no basis for imputation

SOURCE: National Science Foundation/SRS, Research and Development in Industry: 1993

RESPONSE RATES AND MANDATORY VERSUS VOLUNTARY REPORTING

Current survey reporting requirements divide survey items into two groups: mandatory and voluntary. Response to four data items on the questionnaires, total R&D expenditures, Federal R&D funds, net sales, and total employment, is mandatory, whereas response to the remaining items is voluntary. During the 1990 survey cycle, NSF conducted a test of the effect of reporting on a completely voluntary basis to determine if combining both mandatory and voluntary items on one questionnaire influences response rates. For this test, the 1990 sample was divided into two panels of approximately equal size. One panel, the mandatory panel, was asked to report as usual (four mandatory items and the remainder voluntary), and the other panel, the voluntary panel, was asked to report all items on a completely voluntary basis. The result of the test was a decrease in the overall survey response rate to 80 percent from levels of 88 percent in 1989 and 89 percent in 1988. The response rates for the mandatory and voluntary panels were 89 percent and 69 percent, respectively. Detailed results of the test were published in *Research and Development in Industry: 1990*. For firms that reported R&D expenditures in 1993, table B-5 shows the percentage that also reported data for other selected items.

CHARACTER OF WORK

Response to questions about character of work (basic research, applied research, and development) declined in the mid-1980s, and, as a result, imputation rates increased. The general imputation procedure described above became increasingly dependent upon information imputed in prior years, thereby distancing current-year estimates from any reported information. Because of the increasing dependence on imputed data, NSF chose not to publish character-of-work estimates in 1986. Consequently, the imputation procedure used to develop these estimates was revised in 1987 for use with 1986 and later data and differs from the general imputation approach. The new method calculates the character-of-work distribution for a nonresponding firm only if that firm reported a distribution within a five-year period, extending from two years before to two years after the year requiring imputation. Imputation for a given year is initially performed in the year the data are collected and is based on a character-of-work distribution reported in either of the two previous years, if any. It is again

performed using new data collected in the next two years. Thus, character-of-work estimates are revised as newly reported information becomes available and are not final for two years following their initial publication.

If no reported data are available for a firm, character-of-work estimates are not imputed. As a consequence, only a portion of the total estimated R&D expenditures are distributed at the firm level. Those expenditures not meeting the requirements of the new imputation methodology are placed in a "not distributed" category. Tables B-6, B-7, and B-8 show the character-of-work estimates along with the "not distributed" component for 1991, 1992, and 1993, respectively.

NSF's objective in conducting the survey has always been to provide estimates for the entire population of firms performing R&D in the United States. However, the revised imputation procedure would no longer produce such estimates because of the "not distributed" component. So, a baseline estimation method was developed to allocate the "not distributed" amounts among the character-of-work components. In the baseline estimation method, the "not distributed" expenditures are allocated by industry group to basic research, applied research, and development categories, using the percentage splits in the distributed category for that industry. The allocation is done at the lowest level of published industry detail only; higher levels are derived by aggregation (just as national totals are derived by aggregation of individual industry estimates) and result in higher performance shares for basic and applied research and lower estimates for development's share than would have been calculated using the previous method.¹² The estimates of basic research, applied research, and development provided in section A of this report were calculated using the baseline estimation method.

¹² See the NSF technical report cited previously for an explanation of the uncertainties in the data and to quantify their sensitivity to the choice of various possible imputation procedures.

Table B-5. Item response rates—percentage of R&D-performing companies that responded to selected survey items: 1993

Data item	Response rate 1/	
	Form RD-1L 2/	Form RD-1A 2/
Sales.....	98.7	99.1
Total employment.....	97.8	98.5
Scientists and engineers.....	79.1	85.3
Federal R&D	99.3	98.8
Company R&D	3/	3/
Total R&D	100.0	100.0
Foreign R&D.....	44.9	53.0
Contracted out.....	37.2	60.1
Energy R&D.....	45.2	4/
Pollution abatement R&D.....	45.2	4/

1/ Response rates are based on reported data for companies that reported total R&D expenditures. Imputed data are not included. Companies that reported that they were out of scope, out of business, merged with another company, or had no R&D expenditures for 1993 were excluded from the calculation of response rates.

2/ See technical notes for descriptions of the survey questionnaire forms.

3/ Item response for "Federal R&D" and for "Company R&D" were considered together; companies that reported "Total R&D" and either of these expenditures implicitly reported both company and Federal R&D, since these two items sum to total R&D.

4/ The Form RD-1A did not include these items. See technical notes for more information about contents of the questionnaire.

SOURCE: National Science Foundation/SRS, Survey of Industrial Research and Development: 1993

Table B-6. Funds for performance of basic research, applied research, and development, funds not distributed, and percent of funds not distributed, by industry and source of funds: 1991

Distribution by industry	SIC code	Total			Basic			Applied		
		Total	Federal	Company	Total	Federal	Company	Total	Federal	Company
[Dollars in millions]										
Total.....		\$116,952	\$26,372	\$90,580	\$6,490	\$1,220	\$5,270	\$22,319	\$4,808	\$17,511
Food, kindred, and tobacco products.....	20,21	1,277	0	1,277	126	0	126	386	0	386
Textiles and apparel.....	22,23	(D)	(D)	236	13	0	13	(D)	(D)	29
Lumber, wood products, and furniture.....	24,25	(D)	(D)	200	13	0	13	61	0	61
Paper and allied products.....	26	(D)	(D)	1,174	(D)	0	(D)	(D)	(D)	(D)
Chemicals and allied products.....	28	14,648	209	14,439	1,304	7	1,297	3,882	(S)	3,855
Industrial chemicals.....	281-82,286	5,390	165	5,225	447	4	443	(D)	(D)	1,160
Drugs and medicines.....	283	(D)	(D)	6,947	(D)	(D)	738	(D)	(D)	1,993
Other chemicals.....	284-85,287-89	(D)	(D)	2,267	(D)	(D)	116	705	3	702
Petroleum refining and extraction.....	13,29	2,498	11	2,487	(D)	(D)	(D)	(D)	(D)	715
Rubber products.....	30	(D)	(D)	(D)	(D)	(D)	(D)	237	0	237
Stone, clay, and glass products.....	32	(D)	(D)	455	48	0	48	(D)	(D)	154
Primary metals.....	33	714	8	706	33	0	33	(D)	(D)	(S)
Ferrous metals and products.....	331-32,3398-99	(D)	(D)	225	8	0	8	(D)	(D)	(D)
Nonferrous metals and products.....	333-36	(D)	(D)	481	25	0	25	(D)	(D)	(D)
Fabricated metal products.....	34	974	226	748	38	0	38	(D)	(D)	(D)
Machinery.....	35	14,775	1,055	13,720	(D)	(D)	288	(D)	(D)	1,749
Office, computing, and accounting machines.....	357	(D)	(D)	10,419	(D)	(D)	(D)	(D)	(D)	1,053
Other machinery, except electrical.....	351-56,358-59	(D)	(D)	3,301	(D)	(D)	(D)	714	18	696
Electrical equipment.....	36	13,415	4,550	8,865	230	21	209	(D)	(D)	1,985
Radio and TV receiving equipment.....	365	102	0	102	(D)	0	(D)	8	0	8
Communication equipment.....	366	(D)	(D)	(S)	(D)	(D)	(D)	(D)	(D)	552
Electronic components.....	367	3,465	288	3,177	(D)	(D)	96	739	(S)	696
Other electrical equipment.....	361-64,369	(D)	(D)	2,403	(D)	(D)	(D)	(D)	(D)	729
Transportation equipment.....	37	27,428	12,570	14,858	383	227	156	(D)	(D)	(D)
Motor vehicles and motor vehicles equipment.....	371	(D)	(D)	9,063	70	0	70	(D)	(D)	(D)
Other transportation equipment.....	373-75,379	(D)	(D)	262	(S)	0	(S)	(D)	(D)	(D)
Aircraft and missiles.....	372,376	16,983	11,450	5,533	290	227	63	1,667	830	837
Professional and scientific instruments.....	38	8,705	1,865	6,840	(D)	(D)	361	1,976	373	1,603
Scientific and mechanical measuring instruments.....	381-82	(D)	(D)	3,017	(D)	(D)	138	(D)	(D)	933
Optical, surgical, photographic, and other instruments.....	383-87	(D)	(D)	3,823	(D)	(D)	223	(D)	(D)	670
Other manufacturing industries.....	27,31,39	(D)	(D)	(D)	64	0	64	(D)	(D)	65
Nonmanufacturing industries.....	07-10, 12-17, 40-42, 44-49, 50-59, 60-65, 67, 701, 73, 75-76, 78-79, 80-81, 83-84, 87, 89	28,446	5,505	22,941	3,239	950	2,289	5,786	1,260	4,526

See explanatory information and SOURCE at end of table.

Table B-6. Funds for performance of basic research, applied research, and development, funds not distributed, and percent of funds not distributed, by industry and source of funds: 1991

Distribution by industry	SIC code	Development			Expenditures not distributed			Percent of expenditures not distributed		
		Total	Federal	Company	Total	Federal	Company	Total	Federal	Company
[Dollars in millions]										
Total.....		\$66,317	\$14,749	\$51,568	\$21,826	\$5,595	\$16,231	18.7%	21.2%	17.9%
Food, kindred, and tobacco products.....	20,21	576	0	576	189	0	(S)	14.8	0.0	14.9
Textiles and apparel.....	22,23	134	6	128	(D)	(D)	(S)	30.7	60.0	27.1
Lumber, wood products, and furniture.....	24,25	(D)	(D)	100	26	0	(S)	(D)	0.0	13.0
Paper and allied products.....	26	437	0	437	214	0	(S)	(D)	0.0	18.2
Chemicals and allied products.....	28	6,734	62	6,672	(D)	(D)	2,616	(D)	(D)	18.1
Industrial chemicals.....	281-82,286	2,760	58	2,702	(D)	(D)	920	(D)	(D)	17.6
Drugs and medicines.....	283	2,725	0	2,725	1,491	0	1,491	(D)	0.0	21.5
Other chemicals.....	284-85,287-89	1,249	4	1,245	(D)	(D)	204	10.2	78.9	9.0
Petroleum refining and extraction.....	13,29	992	5	987	(D)	0	(D)	(D)	0.0	(D)
Rubber products.....	30	413	0	413	462	0	(S)	(D)	0.0	(D)
Stone, clay, and glass products.....	32	(D)	(D)	229	24	0	(S)	(D)	0.0	5.3
Primary metals.....	33	308	2	306	(D)	(D)	(S)	13.4	12.5	13.5
Ferrous metals and products.....	331-32,3398-99	(D)	(D)	100	(D)	0	(D)	(D)	(D)	5.3
Nonferrous metals and products.....	333-36	(D)	(D)	(S)	85	(D)	(D)	(D)	25.0	(D)
Fabricated metal products.....	34	(D)	(D)	461	160	(D)	(D)	16.4	(D)	(D)
Machinery.....	35	9,862	574	9,288	2,428	(S)	(S)	16.4	3.2	17.4
Office, computing, and accounting machines.....	357	(D)	(D)	7,125	2,084	(D)	(D)	(D)	0.6	(D)
Other machinery, except electrical.....	351-56,358-59	(D)	(D)	2,163	344	(D)	(D)	(D)	17.1	(D)
Electrical equipment.....	36	7,369	2,671	4,698	(D)	(D)	(S)	18.6	11.4	22.3
Radio and TV receiving equipment.....	365	82	0	82	(D)	0	(D)	(D)	0.0	(D)
Communication equipment.....	366	(D)	(D)	1,447	(D)	(D)	(D)	32.6	25.6	36.1
Electronic components.....	367	(D)	(D)	2,076	336	(S)	309	9.7	9.4	9.7
Other electrical equipment.....	361-64,369	(D)	(D)	1,093	591	(D)	(D)	11.7	3.0	21.3
Transportation equipment.....	37	18,359	8,249	10,110	(D)	(D)	(D)	(D)	(D)	(D)
Motor vehicles and motor vehicles equipment.....	371	(D)	(D)	(D)	(D)	(D)	(D)	26.2	0.4	(D)
Other transportation equipment.....	373-75,379	(D)	(D)	(D)	7	0	7	(D)	0.0	2.7
Aircraft and missiles.....	372,376	11,580	7,541	4,039	3,446	(S)	(S)	20.3	24.9	10.7
Professional and scientific instruments.....	38	4,533	1,107	3,426	(D)	(D)	(S)	(D)	(D)	21.2
Scientific and mechanical measuring instruments.....	381-82	(D)	(D)	1,342	(D)	(D)	604	20.3	20.8	20.0
Optical, surgical, photographic, and other instruments.....	383-87	(D)	(D)	2,084	(D)	(D)	(S)	21.8	5.7	22.1
Other manufacturing industries.....	27,31,39	391	60	331	38	0	(S)	(D)	(D)	(D)
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-84,87,89	15,057	1,650	13,407	4,364	1,645	2,719	15.3	29.9	11.9

KEY: (D) = Data have been withheld to avoid disclosing operations of individual companies.
(S) = Data have been withheld because of imputation of more than 50 percent.

NOTE: The character-of-work estimation procedure was revised for 1986 and later years; hence, these data are not directly comparable with data for 1985 and earlier years. See technical notes for a more complete discussion of this change.

SOURCE: National Science Foundation/SRS, Survey of Industrial Research and Development: 1993

Table B-7. Funds for performance of basic research, applied research, and development, funds not distributed, and percent of funds not distributed, by industry and source of funds: 1992

Distribution by industry	SIC code	Total			Basic			Applied		
		Total	Federal	Company	Total	Federal	Company	Total	Federal	Company
[Dollars in millions]										
Total.....		\$119,110	\$24,722	\$94,388	\$6,094	\$912	\$5,182	\$22,817	\$4,329	\$18,488
Food, kindred, and tobacco products.....	20,21	1,386	0	1,386	116	0	116	400	0	400
Textiles and apparel.....	22,23	(D)	(D)	261	23	0	23	(D)	(D)	28
Lumber, wood products, and furniture.....	24,25	(D)	(D)	234	(D)	0	(D)	75	0	75
Paper and allied products.....	26	(D)	(D)	1,182	(D)	0	(D)	(D)	(D)	421
Chemicals and allied products.....	28	15,381	(S)	15,091	(D)	(D)	1,714	4,422	16	4,406
Industrial chemicals.....	281-82,286	5,165	(S)	4,911	(D)	(D)	481	1,099	14	1,085
Drugs and medicines.....	283	7,944	(S)	7,934	(D)	(D)	1,104	(D)	(D)	2,568
Other chemicals.....	284-85,287-89	2,272	(S)	2,246	(D)	(D)	129	(D)	(D)	743
Petroleum refining and extraction.....	13,29	2,277	9	2,268	(D)	(D)	(D)	788	0	788
Rubber products.....	30	(D)	(D)	1,256	63	0	63	161	0	161
Stone, clay, and glass products.....	32	(D)	(D)	479	(D)	(D)	40	(D)	(D)	168
Primary metals.....	33	522	(S)	514	(D)	(D)	27	208	(S)	201
Ferrous metals and products.....	331-32,3398-99	(D)	(D)	221	(D)	(D)	(D)	91	0	91
Nonferrous metals and products.....	333-36	(D)	(D)	293	(D)	0	(D)	117	(S)	110
Fabricated metal products.....	34	1,017	294	723	(D)	(D)	(D)	(D)	(D)	125
Machinery.....	35	14,938	1,035	13,903	(D)	(D)	(D)	(D)	(D)	1,493
Office, computing, and accounting machines.....	357	(D)	(D)	10,614	(D)	(D)	(D)	(D)	(D)	743
Other machinery, except electrical.....	351-56,358-59	(D)	(D)	3,289	(D)	(D)	138	769	19	750
Electrical equipment.....	36	13,360	3,844	9,516	(D)	(D)	279	(D)	(D)	2,151
Radio and TV receiving equipment.....	365	(D)	(D)	93	8	(D)	(D)	8	0	8
Communication equipment.....	366	(D)	(D)	3,381	(D)	(D)	(D)	(D)	(D)	491
Electronic components.....	367	3,567	247	3,320	111	(D)	(D)	824	53	771
Other electrical equipment.....	361-64,369	(D)	(D)	2,722	(D)	(D)	(D)	(D)	(D)	881
Transportation equipment.....	37	27,494	11,202	16,292	336	214	122	2,132	(D)	(D)
Motor vehicles and motor vehicles equipment.....	371	(D)	(D)	9,133	62	0	62	(D)	(D)	(D)
Other transportation equipment.....	373-75,379	(D)	(D)	289	26	0	26	(D)	(D)	(D)
Aircraft and missiles.....	372,376	17,158	(S)	6,871	248	214	34	1,606	889	717
Professional and scientific instruments.....	38	9,542	2,221	7,321	407	(D)	(D)	2,052	364	1,688
Scientific and mechanical measuring instruments.....	381-82	5,156	2,143	3,013	(D)	(D)	(D)	(D)	(D)	955
Optical, surgical, photographic, and other instruments.....	384-87	4,386	78	4,308	(D)	(D)	260	(D)	(D)	733
Other manufacturing industries.....	27,31,39	(D)	(D)	599	71	0	71	(D)	(D)	84
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-84,87,89	28,933	5,570	23,363	2,044	655	1,389	6,531	1,417	5,114

See explanatory information and SOURCE at end of table.

Table B-7. Funds for performance of basic research, applied research, and development, funds not distributed, and percent of funds not distributed, by industry and source of funds: 1992

Distribution by industry	SIC code	Development			Expenditures not distributed			Percent of expenditures not distributed		
		Total	Federal	Company	Total	Federal	Company	Total	Federal	Company
[Dollars in millions]										
Total.....		\$72,826	\$16,309	\$56,517	\$17,373	\$3,185	\$14,188	14.6%	12.9%	15.0%
Food, kindred, and tobacco products.....	20,21	705	0	705	165	0	(S)	11.9	0.0	11.9
Textiles and apparel.....	22,23	143	4	139	(D)	(D)	(D)	29.1	58.8	27.2
Lumber, wood products, and furniture.....	24,25	(D)	(D)	124	19	0	(S)	(D)	0.0	8.1
Paper and allied products.....	26	409	0	409	(D)	0	(D)	(D)	0.0	17.4
Chemicals and allied products.....	28	(D)	(D)	7,050	1,960	(S)	(S)	12.7	10.7	12.8
Industrial chemicals.....	281-82,286	(D)	(D)	2,890	460	6	455	8.9	2.4	9.3
Drugs and medicines.....	283	(D)	(D)	2,977	(D)	(D)	(S)	(D)	(D)	16.2
Other chemicals.....	284-85,287-89	(D)	(D)	1,183	(D)	(D)	(S)	(D)	(D)	8.5
Petroleum refining and extraction.....	13,29	768	8	759	(D)	0	(D)	(D)	0.0	(D)
Rubber products.....	30	(D)	(D)	814	218	0	(S)	(D)	0.0	17.4
Stone, clay, and glass products.....	32	(D)	(D)	250	21	0	(S)	(D)	0.0	4.4
Primary metals.....	33	(D)	(D)	252	35	0	(S)	6.7	0.0	6.8
Ferrous metals and products.....	331-32,3398-99	(D)	(D)	107	(D)	0	(D)	6.7	0.0	(D)
Nonferrous metals and products.....	333-36	(D)	(D)	145	(D)	0	(D)	6.7	0.0	(D)
Fabricated metal products.....	34	645	227	418	198	(D)	(D)	19.5	(D)	(D)
Machinery.....	35	9,891	571	9,320	(D)	(D)	(D)	(D)	(D)	(D)
Office, computing, and accounting machines.....	357	(D)	(D)	7,175	(D)	(D)	(D)	19.6	0.6	21.2
Other machinery, except electrical.....	351-56,358-59	(D)	(D)	2,145	267	(S)	(S)	(D)	(D)	7.8
Electrical equipment.....	36	7,516	2,298	5,218	(S)	(S)	(S)	17.9	13.5	19.6
Radio and TV receiving equipment.....	365	(D)	(D)	72	(D)	0	(D)	(D)	0.0	(D)
Communication equipment.....	366	(D)	(D)	1,664	(D)	(D)	(D)	(D)	26.9	(D)
Electronic components.....	367	2,438	165	2,273	194	(D)	(D)	5.4	(D)	(D)
Other electrical equipment.....	361-64,369	(D)	(D)	1,209	589	(D)	(D)	(D)	3.9	(D)
Transportation equipment.....	37	20,677	9,117	11,560	4,349	(D)	(D)	15.8	(D)	(D)
Motor vehicles and motor vehicles equipment.....	371	(D)	(D)	(D)	(D)	(D)	(D)	30.2	0.2	(D)
Other transportation equipment.....	373-75,379	(D)	(D)	(D)	(D)	0	(D)	(D)	0.0	(D)
Aircraft and missiles.....	372,376	13,961	8,268	5,693	1,343	(S)	(S)	7.8	8.9	6.2
Professional and scientific instruments.....	38	5,823	1,835	3,988	1,260	(D)	(D)	13.2	(D)	(D)
Scientific and mechanical measuring instruments.....	381-82	3,363	1,775	1,588	346	(D)	(D)	6.7	(D)	(D)
Optical, surgical, photographic, and other instruments.....	384-87	2,460	60	2,400	914	0	914	20.8	0.0	21.2
Other manufacturing industries.....	27,31,39	(D)	(D)	377	67	0	67	(D)	0.0	11.2
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-84,87,89	17,040	1,905	15,135	3,318	1,593	1,725	11.5	28.6	7.4

KEY: (D) = Data have been withheld to avoid disclosing operations of individual companies.
(S) = Data have been withheld because of imputation of more than 50 percent.

NOTE: The character-of-work estimation procedure was revised for 1986 and later years; hence, these data are not directly comparable with data for 1985 and earlier years. See technical notes for a more complete discussion of this change.

SOURCE: National Science Foundation/SRS, Survey of Industrial Research and Development: 1993

Table B-8. Funds for performance of basic research, applied research, and development, funds not distributed, and percent of funds not distributed, by industry and source of funds: 1993

Distribution by industry	SIC code	Total			Basic			Applied		
		Total	Federal	Company	Total	Federal	Company	Total	Federal	Company
[Dollars in millions]										
Total.....		\$118,334	\$22,813	\$95,521	\$7,173	\$987	\$6,186	\$22,144	\$4,796	\$17,348
Food, kindred, and tobacco products.....	20,21	1,338	0	1,338	83	0	83	367	0	367
Textiles and apparel.....	22,23	(D)	(D)	288	31	0	31	(D)	(D)	26
Lumber, wood products, and furniture.....	24,25	(D)	(D)	248	(D)	(D)	13	79	0	79
Paper and allied products.....	26	(D)	(D)	1,252	167	0	167	(D)	(D)	457
Chemicals and allied products.....	28	(D)	(D)	16,747	2,121	13	2,108	(D)	(D)	5,289
Industrial chemicals.....	281-82,286	(D)	(D)	5,274	(D)	(D)	885	(D)	(D)	1,201
Drugs and medicines.....	283	9,147	14	9,133	(D)	(D)	1,068	3,379	8	3,371
Other chemicals.....	284-85,287-89	(D)	(D)	2,340	(D)	(D)	155	(D)	(D)	718
Petroleum refining and extraction.....	13,29	2,117	14	2,103	(D)	(D)	(D)	(D)	(D)	615
Rubber products.....	30	(D)	(D)	1,092	(D)	0	(D)	(D)	(D)	125
Stone, clay, and glass products.....	32	(D)	(D)	535	(D)	(D)	(D)	(D)	(D)	165
Primary metals.....	33	669	23	646	(D)	(D)	43	(D)	(D)	195
Ferrous metals and products.....	331-32,3398-99	289	17	272	(D)	(D)	19	(D)	(D)	77
Nonferrous metals and products.....	333-36	380	6	374	24	0	24	(D)	(D)	(S)
Fabricated metal products.....	34	(D)	(D)	920	(D)	(D)	(D)	(D)	(D)	160
Machinery.....	35	8,270	88	8,182	(D)	(D)	(D)	1,376	19	1,357
Office, computing, and accounting machines.....	357	4,811	33	4,778	(D)	(D)	75	(D)	(D)	794
Other machinery, except electrical.....	351-56,358-59	3,457	55	3,404	(D)	(D)	(D)	(D)	(D)	563
Electrical equipment.....	36	12,686	1,402	11,285	(D)	4	(D)	(D)	(D)	2,016
Radio and TV receiving equipment.....	365	(D)	(D)	84	(D)	0	(D)	(D)	(D)	11
Communication equipment.....	366	(D)	(D)	3,129	(D)	(D)	(D)	167	0	167
Electronic components.....	367	5,316	(S)	5,089	(D)	1	(D)	960	(S)	925
Other electrical equipment.....	361-64,369	(D)	(D)	2,983	(D)	(D)	(D)	(D)	(D)	913
Transportation equipment.....	37	27,501	10,438	17,063	(D)	246	(D)	1,822	839	983
Motor vehicles and motor vehicles equipment.....	371	(D)	(D)	10,653	74	0	74	(D)	(D)	463
Other transportation equipment.....	373-75,379	(D)	(D)	165	(D)	0	(D)	(D)	(D)	7
Aircraft and missiles.....	372,376	15,615	9,369	6,246	(D)	246	(D)	1,318	805	513
Professional and scientific instruments.....	38	10,288	2,767	7,521	(D)	(D)	349	1,987	336	1,651
Scientific and mechanical measuring instruments.....	381-82	5,901	2,670	3,231	(D)	(D)	129	1,353	311	1,042
Optical, surgical, photographic, and other instruments.....	383-87	4,387	97	4,290	(D)	(D)	220	634	25	609
Other manufacturing industries.....	27,31,39	(D)	(D)	763	120	0	120	70	0	70
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-84,87,89	31,320	5,782	25,538	2,738	342	2,396	6,270	2,477	3,793

See explanatory information and SOURCE at end of table.

Table B-8. Funds for performance of basic research, applied research, and development, funds not distributed, and percent of funds not distributed, by industry and source of funds: 1993

Distribution by industry	SIC code	Development			Expenditures not distributed			Percent of expenditures not distributed		
		Total	Federal	Company	Total	Federal	Company	Total	Federal	Company
[Dollars in millions]										
Total.....		\$77,502	\$16,393	\$61,109	\$11,515	\$637	\$10,878	9.7%	2.8%	11.4%
Food, kindred, and tobacco products.....	20,21	701	0	701	187	0	187	14.0	0.0	14.0
Textiles and apparel.....	22,23	(D)	(D)	143	(D)	0	88	32.8	71.4	30.6
Lumber, wood products, and furniture.....	24,25	(D)	(D)	130	(D)	0	26	10.3	0.0	10.5
Paper and allied products.....	26	442	0	442	187	0	187	(D)	(D)	14.9
Chemicals and allied products.....	28	(D)	(D)	7,696	(D)	(D)	1,654	9.1	0.0	9.9
Industrial chemicals.....	281-82,286	(D)	(D)	2,965	(D)	(D)	(S)	3.4	0.0	(S)
Drugs and medicines.....	283	(D)	(D)	3,429	1,266	0	1,266	13.8	0.0	13.9
Other chemicals.....	284-85,287-89	(D)	(D)	1,302	166	0	166	(D)	(D)	7.1
Petroleum refining and extraction.....	13,29	757	11	745	(D)	0	(D)	(D)	0.0	(D)
Rubber products.....	30	702	0	701	235	0	235	(D)	(D)	21.5
Stone, clay, and glass products.....	32	285	4	281	(D)	(D)	41	23.1	96.5	7.7
Primary metals.....	33	374	16	358	(D)	0	(S)	(S)	0.0	(S)
Ferrous metals and products.....	331-32,3398-99	(D)	(D)	147	(S)	0	(S)	(S)	0.0	(S)
Nonferrous metals and products.....	333-36	(D)	(D)	211	21	0	21	5.5	0.0	5.6
Fabricated metal products.....	34	674	203	471	218	0	218	(D)	(D)	23.7
Machinery.....	35	5,314	63	5,251	(D)	(D)	(S)	(D)	(D)	(S)
Office, computing, and accounting machines.....	357	3,169	28	3,141	(S)	0	(S)	(S)	0.0	(S)
Other machinery, except electrical.....	351-56,358-59	2,145	35	2,110	(D)	(D)	562	(D)	(D)	16.5
Electrical equipment.....	36	6,656	1,098	5,558	(D)	(D)	3,458	(D)	(D)	30.6
Radio and TV receiving equipment.....	365	(D)	(D)	59	(D)	0	(D)	(D)	(D)	(D)
Communication equipment.....	366	(D)	(D)	1,689	(D)	(D)	(D)	35.2	8.1	(D)
Electronic components.....	367	(D)	(D)	2,329	(D)	(D)	(D)	(D)	(D)	(D)
Other electrical equipment.....	361-64,369	(D)	(D)	1,502	(D)	(D)	464	12.7	0.2	15.6
Transportation equipment.....	37	24,060	8,954	15,106	1,252	(D)	(D)	4.5	(D)	(D)
Motor vehicles and motor vehicles equipment.....	371	(D)	(D)	10,071	45	0	45	(D)	(D)	0.4
Other transportation equipment.....	373-75,379	(D)	(D)	72	(D)	(D)	(D)	43.0	100.0	(D)
Aircraft and missiles.....	372,376	12,903	7,940	4,963	(D)	(D)	(D)	(D)	(D)	(D)
Professional and scientific instruments.....	38	7,170	2,407	4,763	(D)	(D)	(S)	(D)	(D)	10
Scientific and mechanical measuring instruments.....	381-82	4,127	2,341	1,786	(D)	(D)	(S)	(D)	(D)	8.5
Optical, surgical, photographic, and other instruments.....	383-87	(D)	(D)	2,977	(D)	(D)	(S)	(D)	(D)	11.3
Other manufacturing industries.....	27,31,39	(D)	(D)	433	140	0	140	(D)	(D)	18.3
Nonmanufacturing industries.....	07-10,12-17, 40-42,44-49, 50-59,60-65,67, 701,73,75-76, 78-79,80-81, 83-84,87,89	21,234	2,905	18,329	1,078	58	1,020	3.4	1.0	4.0

KEY: (D) = Data have been withheld to avoid disclosing operations of individual companies.
(S) = Data have been withheld because of imputation of more than 50 percent.

NOTE: The character-of-work estimation procedure was revised for 1986 and later years; hence, these data are not directly comparable with data for 1985 and earlier years. See technical notes for a more complete discussion of this change.

SOURCE: National Science Foundation/SRS, Survey of Industrial Research and Development: 1993

COMPARABILITY OF STATISTICS

This section summarizes the statistical revisions that have been made because of changes in survey procedures and practices.¹³

CURRENT-YEAR CONSIDERATIONS

Revisions to Immediate Prior-Year Statistics

As has been the practice throughout the history of the survey, results from the current-year survey are used not only to develop current-year statistics, but also to revise immediate prior-year statistics. Differences between originally developed statistics and revised statistics occur for three reasons: industry shifts, data revisions, and the effects of a new sample design.

Industry shifts. The movement of a company from one industry into another can be caused by several factors, including changes in a company's payroll composition, which is used to determine the industry classification code (see earlier discussion under Frame Creation); changes in the industry classification system itself; and changes in the way the industry classification code is assigned or revised during survey processing. These are described below.

Payroll composition. A company's payroll composition may change because of a number of events. Among them are (1) the growth or decline of product or service lines; (2) the merger of two or more companies; (3) the acquisition of one company by another; (4) divestitures; and (5) the formation of conglomerates. When it is determined that a company's payroll composition—and therefore its industry classification—has changed, the company's data are reclassified into the new industry beginning in the year of the change.

Industry classification system. From time to time the standard industrial classification (SIC) coding system, which is used by most Federal Government agencies that publish industry statistics, is

revised to reflect the changing composition of U.S. industry. For statistics developed for 1988-91 from the 1988-91 surveys, companies retained the industry classifications assigned for the 1987 sample. These classifications were based on the 1977 SIC system. The last major revision of the SIC system was for 1987, so this new system was used to classify companies in the 1992 and 1993 surveys. Consequently, the 1993 statistics and revised 1992 statistics in this report were developed using the 1987 SIC system, and minor data shifts are attributable to the system change only when comparing current statistics with pre-1987 statistics. For example, the 1987 system expanded SIC 30, rubber products, to include a variety of specific plastic products that may have been classified elsewhere using the 1977 system.

Processing changes. In response to perceived changes in the amount and dispersion of R&D among industries and findings of various quality improvement initiatives and other research undertakings, the sponsor of the survey, in consultation with the compiling agent, from time to time seeks to improve the coverage of the survey by revising the method used to classify firms. Research has shown that there is no impact on the aggregated statistics because of these processing changes and the impact on individual industry estimates is minor.¹⁴ The current method used to classify firms is discussed earlier under Frame Creation. Methods used for past surveys are discussed in a technical paper.¹⁵ There was no change in the way firms were classified or in the way data were processed for the 1993 survey compared with the 1992 survey.

Data revisions. Changes to reported data can come from two sources: from respondents (see earlier discussion under Survey Questionnaires) and

¹³ See also the technical paper U.S. Department of Commerce, Bureau of the Census, *Design of the Survey of Industrial Research and Development: A Historical Perspective* (Washington, DC, 1995)

¹⁴ The effects of recent changes in the way companies are classified during survey processing are discussed in detail in a Bureau of the Census technical memoranda entitled *Reclassification of Companies in the 1992 Survey of Industrial Research and Development for the Generation of the Analytical Series*, Oct. 25, 1994, and *Comparison of Company Coding Between 1992 and 1993 for the Survey of Industrial Research and Development*, Nov. 3, 1994.

¹⁵ U.S. Department of Commerce, Bureau of the Census, *Design of the Survey of Industrial Research and Development: A Historical Perspective* (Washington, DC, 1995).

from analysts involved in survey and statistical processing. Respondents from companies that were in both the 1992 and 1993 surveys may have revised previously reported data for 1992. Analysts, while performing follow-up, may have corrected incorrectly reported or supplied missing 1992 data.

Effects of a New Sample Design.

Changes to the sample design can dramatically affect revisions to immediate prior-year estimates. The most profound influence on the revisions to the 1991 statistics was the new sample design for the 1992 survey (see *Research and Development in Industry: 1992* for a detailed discussion). The sample design used for the 1993 survey was the same design used for the 1992 survey so revisions to the original 1992 estimates were primarily because of industry shifts and data revisions.

Recent Survey Improvements¹⁶

Before the 1992 survey, the sample of firms surveyed was selected at irregular intervals.¹⁷ In intervening years, a panel of the largest firms known to perform R&D was surveyed. For example, a sample of about 14,000 firms was selected for the 1987 survey. For the 1988 through 1991 studies, about 1,700 of these firms were annually resurveyed; the other firms did not receive another questionnaire, and their R&D data were estimated. This sample design was adequate during the early years of the survey because the performance of R&D remained concentrated in the manufacturing industries. However, as more and more firms began entering the R&D-performing arena, the old sample design proved increasingly deficient because it did not capture births of new R&D-performing firms. The entry of fledgling R&D performers into the marketplace was simply missed during panel years. Additionally, beginning in the early 1970s, the need for more detailed R&D information for nonmanufacturers was recognized. At that time, statistics for the broad industry classifications miscellaneous business services and miscellaneous services were added to the list of industry groups for which statistics were

published. By 1975, about 3 percent of total R&D was performed by firms in nonmanufacturing industries.

During the mid-1980s, there was evidence that an increasing number of nonmanufacturing firms were conducting a significant amount of R&D, and again the number of industries used to develop the statistics for nonmanufacturers was increased. Consequently, the annual reports in this series for 1987 and since have included separate R&D estimates for firms in the communication, utility, engineering, architectural, research, development, testing, computer programming, and data processing service industries; hospitals; and medical labs. Approximately 9 percent of the estimated industrial R&D performance during 1987 was undertaken by nonmanufacturing firms.

After the list of industries for which statistics were published was expanded, it became clear that the sample design itself should be changed to reflect the widening population of R&D performers among firms in the nonmanufacturing industries¹⁸ and small firms in all industries, to account better for births of R&D performing firms and to produce statistics that are generally more reliable. Beginning with the 1992 survey, NSF decided to (1) draw new samples with broader coverage annually and (2) increase the sample size to approximately 23,000 firms.¹⁹ As a result of the sample redesign, for 1992, the reported nonmanufacturing share was estimated to be 25 percent of total R&D.

¹⁸ For the 1992 survey, 25 new nonmanufacturing industry and industry groups were added to the sample frame: agricultural services (SIC 07); fishing, hunting, and trapping (09); wholesale trade–nondurables (51); stationery and office supply stores (5112); industrial and personal service paper (5113); groceries and related products (514); chemicals and allied products (516); miscellaneous nondurable goods (519); home furniture, furnishings, and equipment stores (57); radio, TV, consumer electronics, and music stores (573); eating and drinking places (581); miscellaneous retail (59); nonstore retailers (596); real estate (65); holding and other investment offices (67); hotels, rooming houses, camps, and other lodging places (70); automotive repair, services, and parking (75); miscellaneous repair services (76); amusement and recreation services (79); health services (80); offices and clinics of medical doctors (801); offices and clinics of other health practitioners (804); miscellaneous health and allied services not elsewhere classified (809); engineering, accounting, research, management, and related services (87); and management and public relations services (874).

¹⁹ Annual sampling also remedies the cyclical deterioration of the statistics that results from changes in a company's payroll composition because of product line and corporate structural changes.

¹⁶ See also National Science Foundation, *SRS Data Brief*, 1992 R&D Spending by U.S. Firms Rises, NSF Survey Improved (NSF 94-325), (Arlington, VA, Sept. 9, 1994).

¹⁷ During the early years of the survey, until 1967, samples were selected every 5 years. Subsequent samples were selected for 1971, 1976, 1981, and 1987.

Time Series Analyses

As discussed earlier, the statistics resulting from the survey are better indicators of changes in, rather than absolute levels of, R&D spending and personnel. Nevertheless, the statistics are often considered as a continuous time series that has been prepared using the same collection, processing, and tabulation methods. Such uniformity during preparation has not been the case. Since the survey was first fielded, improvements have been made to increase the reliability of the statistics and to make the survey results more useful. To that end, existing practices have been changed and new procedures have been instituted. Preservation of the comparability of the statistics has been an important consideration when improvements have been made, however. Changes to survey definitions, the industry classification system, and the procedure used to assign industry codes to multi-establishment companies²⁰ have had some, though not substantial, effects on the comparability of statistics.²¹ The aspect of the survey that had a greater effect on comparability was the selection of samples at irregular intervals (i.e., 1967, 1971, 1976, 1981, 1987, 1992) and the use of a subset or panel of the last sample drawn to develop statistics for intervening years. As discussed earlier, this practice introduced cyclical deterioration of the statistics.

As compensation for this deterioration, periodic revisions have been made to the statistics produced from the panels surveyed between sample years. Early in the survey's history, various methods were used to make these revisions.²² Since 1976, a linking procedure called wedging has been used.²³ Simply

²⁰ For discussions of each of these, see the Bureau of the Census technical memorandum entitled *Wedging Considerations for the 1992 Research and Development (R&D) Survey*, June 10, 1994.

²¹ See the Bureau of the Census technical memoranda entitled *Reclassification of Companies in the 1992 Survey of Industrial Research and Development (R&D) for the Generation of the Analytical Series*, Oct. 25, 1994, and *Effects of the 1987 SIC Revision on Company Classification in the Survey of Industrial Research and Development (R&D)*, Dec. 6, 1993.

²² See U.S. Department of Commerce, Bureau of the Census, *Survey Design of the Survey of Industrial Research and Development: A Historical Perspective* (Washington, DC, 1995).

²³ The process was dubbed wedging because of the wedgelike area produced on a graph that compares originally reported statistics with the revised statistics that result after linking.

described, in wedging, the two sample years on each end of a series of estimates serve as benchmarks in the algorithms used to adjust the estimates for the intervening years.

Wedging Methodology

For a full discussion of the mathematical algorithm used for the wedging process that linked statistics from the 1992 survey with those from the 1987 survey, see the technical memorandum cited below.²⁴ In general, the memorandum states that wedging—

takes full advantage of the fact that in the first year of a new panel [when a new sample is selected], both current-year and prior-year estimates are derived. Thus, two independent estimates exist for the prior year. The estimates from the new panel are treated as superior primarily because the new panel is based on updated classifications [the industry classifications in the prior panel are frozen] and is more fully representative of the current universe (the prior panel suffers from panel deterioration, especially a lack of birth updating). The limitations in the prior panel caused by these factors are naturally assumed to increase with time, so that in the revised series, we desire a gradual increase in the level or revision over time which culminates in the real difference observed between the two independent sample estimates of the prior year. At the same time, we desire that the annual movement of the original series be preserved to the degree possible in the revised series.

To that end, the wedging algorithm does not change estimates from sample years and adjusts estimates from panel years, recognizing that deterioration of the panel is progressive over time.

Wedged Versus Not-Wedged Statistics

One of the primary reasons for the decision to select a new sample annually rather than at irregular intervals was to avoid the necessity to apply global revision processes such as wedging. Consequently, the 1992 survey was intended to be the last one to employ the wedging procedure.

²⁴ Bureau of the Census technical memorandum, *Wedging Considerations for the 1992 Research and Development (R&D) Survey*, June 10, 1994.

REVISIONS TO HISTORICAL STATISTICS

Throughout the history of the survey, during regular survey processing, all immediate prior-year statistics have been subject to revision with results from the current year's survey. Changes to older statistics, however, usually have been limited to revisions because of changes in the industry classification of companies caused by changes in payroll composition detected when a new sample was drawn. Various

methodologies have been adopted over the years to revise, or backcast, the data when revisions to historical statistics have become necessary.

Documented revisions to the historical statistics from post-1967 surveys are summarized in *Research and Development in Industry: 1991* (NSF 94-325). Detailed descriptions of the specific revisions made to the statistics from pre-1967 surveys are scarce. However, summaries of some of the major revisions are included in the technical paper cited below.²⁵

²⁵ U.S. Department of Commerce, Bureau of the Census, *Survey Design of the Survey of Industrial Research and Development: A Historical Perspective* (Washington, DC, 1995).

SURVEY DEFINITIONS

COST PER R&D SCIENTIST OR ENGINEER

The arithmetic mean of the numbers of full-time equivalent (FTE) scientists and engineers engaged in the performance of R&D reported for January in two consecutive years divided into the total R&D expenditures of the earlier year, with the ratio attributed to the earlier year. For example, the mean of the numbers of FTE R&D scientists and engineers in January 1992 and January 1993 is divided into total 1992 R&D expenditures for a total cost per R&D scientist or engineer in 1992.

EMPLOYMENT, FTE R&D SCIENTISTS AND ENGINEERS

Persons employed by the company during the January following the survey year who are engaged in scientific or engineering work at a level that requires knowledge of physical, life, engineering, or mathematical science equivalent at least to that acquired through completion of a 4-year college program with a major in one of those fields. The statistics in this

report show the FTE employment. The FTE is the number of scientists and engineers in the company who are assigned full time to R&D projects plus the number of non-full-time R&D scientists and engineers prorated according to the fraction of their total work time spent on R&D projects.

EMPLOYMENT, TOTAL

Number of persons domestically employed by R&D-performing companies in all activities during the pay period that includes the 12th of March.

Federally Funded R&D Centers (FFRDCs)

R&D-performing organizations administered by industrial, educational, or other institutions on a nonprofit basis, exclusively or substantially financed by the Federal Government. R&D expenditures of the FFRDCs that are industry administered are included with the Federal R&D data of the industry classification of each of the administering firms. The industry-administered FFRDCs included in the 1993 survey are listed as follows.

FFRDCs Supported by the Department of Energy:

Bettis Atomic Power Laboratory
Westinghouse Electric Corp.
West Mifflin, PA

Energy Technology Engineering Center
Rockwell International Corp.
Canoga Park, CA

Hanford Engineering Development Laboratory
Westinghouse-Hanford Corp.
Richland, WA

Idaho National Engineering Laboratory
EG&G Idaho, Inc.;
Westinghouse Electric Corp.
Argonne National Laboratory, West;
Rockwell International Corp.;
Idaho Falls, ID

Knolls Atomic Power Laboratory
General Electric Co.
Schenectady, NY

Oak Ridge National Laboratory
Martin Marietta Energy Systems, Inc.
Oak Ridge, TN

Sandia National Laboratories
Western Electric Co., Inc.–Sandia Corp.
Albuquerque, NM

Savannah River Laboratory
Westinghouse Electric Corp.
Aiken, SC

FFRDCs Supported by the National Institutes of Health, Department of Health and Human Services:

NCI Frederick Cancer Research Facility
Program Resources, Inc.
Frederick, MD

FUNDS FOR R&D, COMPANY (AND OTHER)

Cost of R&D actually performed within the company and funded by the company itself or by other

non-Federal sources by contract, not including the cost of R&D supported by companies but contracted to outside organizations such as research institutions, universities and colleges, nonprofit organizations, or (to avoid double-counting) other companies.

FUNDS FOR R&D, FEDERAL.

Receipts for R&D performed by the company under Federal R&D contracts or subcontracts and R&D portions of Federal procurement contracts and subcontracts.

FUNDS FOR R&D, TOTAL.

Operating expenses incurred by a company in the conduct of R&D in its own laboratories or other company-owned or -operated facilities including wages and salaries, materials and supplies, property and other taxes, maintenance and repairs, depreciation, and an appropriate share of overhead, not including capital expenditures.

NET SALES AND RECEIPTS.

Dollar values for goods sold or services rendered by R&D-performing companies to customers (outside the company), including the Federal Government, less such items as returns, allowances, freight, charges, and excise taxes. (Domestic intracompany transfers and sales by foreign subsidiaries are excluded, but transfers to foreign subsidiaries and export sales to foreign companies are included.)

RESEARCH AND DEVELOPMENT.

Basic and applied research in the sciences and engineering and the design and development of prototypes and processes, excluding quality control, routine product testing, market research, sales promotion, sales service, other nontechnological activities or routine technical services, and research in the social sciences or psychology.

Basic research.

Original investigations for the advancement of scientific knowledge not having specific immediate commercial objectives, although such investigations may be in fields of present or potential interest to the reporting company.

Applied research.

Investigations for the discovery of new scientific knowledge having specific commercial objectives with respect to products or processes. (Applied research differs from basic research chiefly in terms of the objectives of the reporting company.)

Development.

Technical activities not routine in nature concerned with translating research findings or other scientific knowledge into products or processes. Not included are routine technical services to customers or other activities excluded above.