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ABSTRACT

This survey was conducted by the Census Bureau under a contract with the National Science Foundation to measure the number of persons working as scientists, engineers, and technicians in the private business sector. A sample was drawn from all active employer establishments in the United States excluding colleges, universities, and governments. The purpose of this study was to provide the necessary information needed to make intelligent policy decisions on the education and supply of these highly trained scientific and technical personnel. Assessment highlights include: (1) employment of scientists and engineers (S/Es) in private industry dropped 6% between 1970 and 1975; (2) a shift in demand for S/E employment from manufacturing to non-manufacturing industries has occurred; and (3) employment of S/Es in research and development was 12% lower in 1975 than in 1970. More detailed discussions of employment patterns by industry, research and development employment, and employment in energy-related activities are among the other sub-topics presented in the report. (MR)

Reviews OF DATA ON SCIENCE RESOURCES

NATIONAL SCIENCE FOUNDATION, WASHINGTON, D C · NSF 78-302 · No. 30, March 1978

Scientific and Technical Personnel in Private Industry, 1960-70 and 1975

Introduction

The major changes in the employment market for scientists and engineers, ranging from strong growth in the 1950-70 period to stagnation and decline for some time thereafter, make clear the importance of being able to project expected requirements of this highly trained pool of talent. Use of these projections to plan effective programs to ensure a balance in the supply and demand of scientific and technical personnel depends to a large degree on the quality and timeliness of the underlying data base.

In addition, emerging areas of concern often overtake the availability of data needed to select appropriate policies; for example, in the field of energy, concerns have been expressed as to the adequacy of manpower availability to conduct the research and development, construction, and operation of future energy options.

To update the data base on employment of scientists, engineers, and technicians in industry, as well as to establish a data base on energy manpower, the National Science Foundation (NSF) contracted with the Census Bureau to conduct the survey, the results of which are reported here. NSF is confident that this and future surveys will contribute to the ability of education, science, and manpower policymakers to make intelligent choices among available policy alternatives.

Highlights

ASSESSMENT HIGHLIGHTS

- Employment of scientists and engineers (S/E's) in private industry was 6 percent lower in 1975 than in 1970. There were two factors directly affecting the level of employment:

  (1) Total spending on research and development (R&D) by industry measured in constant dollars decreased 12 percent between the high point in 1968 and 1975, greatly impacting on the employment of R&D personnel.

  (2) The proportion of S/E's in the "support" staff of six major industries, which had been increasing to about the midsixties, began to decrease. The ratio fell from 21.6 percent in 1964 to 17.0 percent in 1970, which seems to indicate that technical functions were being accorded a lesser priority in these industries or that technicians were being increasingly substituted for S/E's.

- There has been a shifting of demand for S/E employment from manufacturing to nonmanufacturing industries. From 1970 to 1975, a 16-percent drop in durable goods industries employment and an 8-percent decrease in nondurable goods industries was partially offset by an 8-percent employment increase in nonmanufacturing establishments.

- Employment of S/E's in R&D was 12 percent lower in 1975 than 5 years earlier. The decrease in R&D employment accounted for more than 60 percent of the drop in overall S/E employment. Employment of S/E's in R&D, as would be expected, is highly correlated with R&D expenditures in con-

(Prepared in the Utilization Studies Group, Division of Science Resources Studies)

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stant dollars. If past relationships between funds and employment continue, the 6-percent upsurge in R&D expenditures by private industry in 1977 should be accompanied by a substantial increase in R&D employment—in the vicinity of 4 percent.

- Total employment in "high-technology" manufacturing industries (those with the highest concentrations of S/E's) grew faster than that in "low-technology" industries between 1960 and 1975. These high-technology industries, however, showed much more pronounced swings in total employment when compared to medium-technology industries.

DATA HIGHLIGHTS

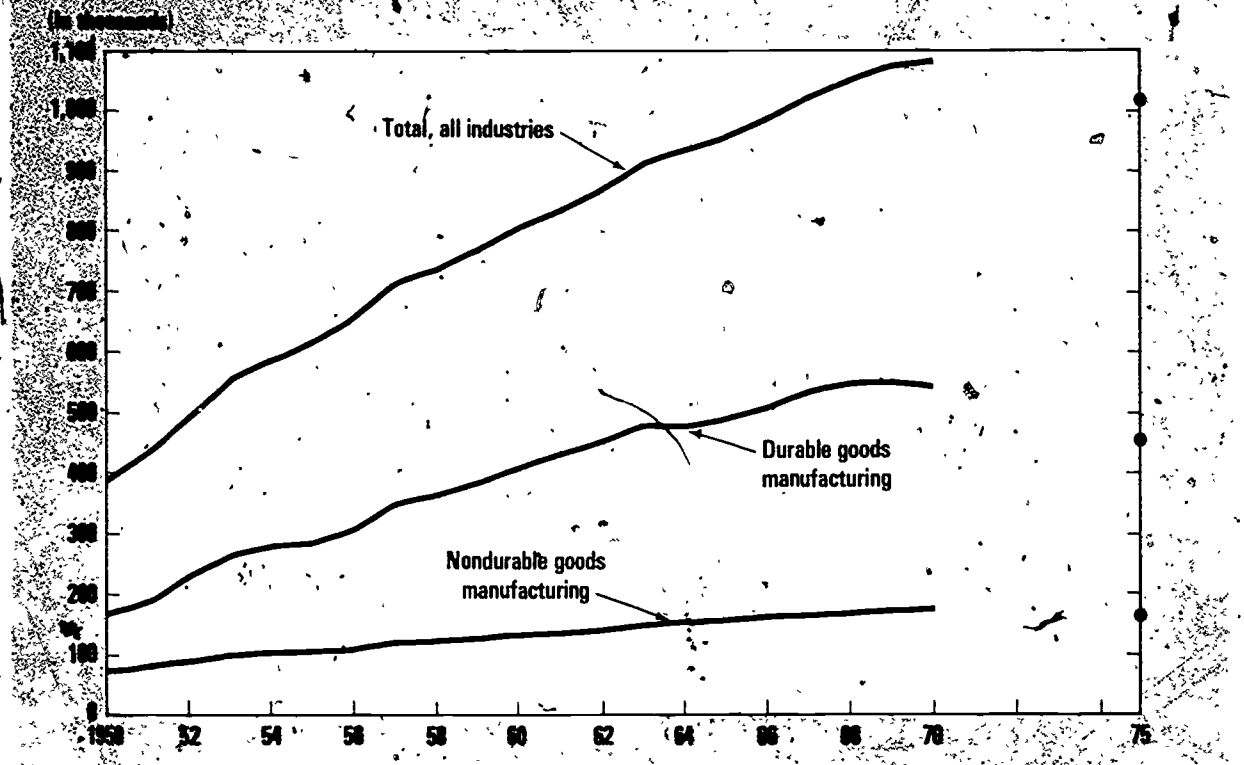
- Private industry is by far the largest employing sector of S/E's in the U.S. economy, using around two-thirds of all persons employed as S/E's.
- Almost one million technicians were employed in 1975 in the private industry sector, with over 14 percent of these engaged in R&D activities.
- The largest group of scientists reported employed in this 1975 survey—computer scientists—as in previous surveys (the last was carried out in 1970), considered such a small group that it was not separately surveyed. Employment in 1975 was 143,000, with nonmanfacturing industries employing 100,000.
- Energy-related activities constituted the primary work of 186,000 S/E's in 1975—approximately 16 percent of the total.
- Engineers (853,000) made up 72 percent of the total S/E's employed by private industry.
- Among the engineering specialties, the largest numbers employed were electrical engineers (292,000) and mechanical/aeronautical engineers (201,000).
- Among physical scientists (104,000), the most numerous specialty was chemists (65,000), of whom more than three-quarters were employed in nondurable goods manufacturing industries, including the chemical industries.
- The electrical equipment industry employed the largest number of S/E's in the durable goods sector (144,000), and also showed the highest ratio of S/E's to total employment (8.2 percent).
- With the exception of the lumber and furniture industry, all durable goods manufacturing industries have S/E employment concentrations of more than 10 percent of nonproduction workers.

Overview

The two decades from 1950 to 1970 saw a dramatic growth in S/E employment in private industry, with the 1970 level over 170 percent higher than 1950 employment (chart 1 and appendix table B-1). Increased defense procurement (caused in part by two wars) contributed to this increase, as did the effort to put a man on the moon, a rapidly expanding consumer economy, the development of new technologies in communications and computing, and many other factors.

In spite of this rapidly increasing utilization of scientific and technical personnel, recipients of bachelor's degrees in S/E fields in the 1954-55 school year totaled about 81,000, only 52 percent of the number of degree recipients in 1950 (appendix table B-2). This anomalous situation was caused by demographic rather than economic factors. Degrees awarded in 1950 included large numbers earned by returning World War II veterans. Thus, data on degrees awarded after the 1952-53 school year are more reflective of the long-run trend. Years following 1956 saw a reversal of this decrease as the space effort got underway and the Federal Government increased its support for science programs and its direct support of students in these fields. As a result, over 305,000 students received bachelor's degrees in S/E fields in the 1973-74 school year. The same rapid increase took place in enrollments for advanced degrees in the 1960-70 decade, to be followed by decreasing enrollments in subsequent years caused both by demographic and economic factors (less favorable job opportunities). These recent decreases have placed burdens on institutions of higher education, forcing cutbacks and closings of some departments. At the same time, expenditures for research and development by all sectors of the economy fell (in constant 1972 dollars) from a level of $29.8 billion in 1968 to $27.2 billion in 1975 (appendix table B-3), further lessening demand for S/E personnel in all sectors of the economy. In private industry, spending on

Chart 1. Employment of scientists and engineers by major industrial sector: 1950-70, and 1975



SOURCES: Bureau of the Census and the National Science Foundation.

research and development was 12 percent lower in 1975 than the high point in 1968.

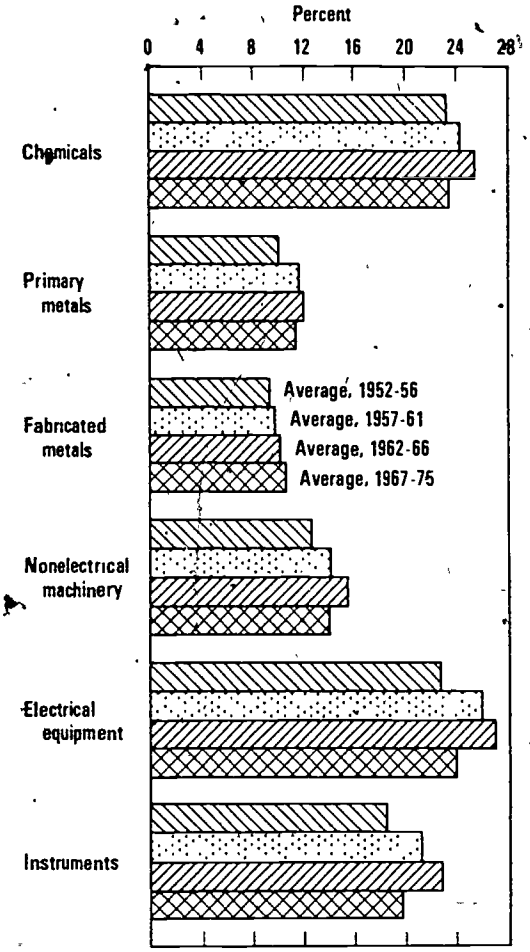
Data for the years 1953-70 and 1975 show that industry's employment of scientists and engineers in research and development is highly correlated with the level of R&D spending by industry. Statistical regression analysis reveals that almost 98 percent of the change in such employment is explained by variations in the level of R&D expenditures. If such past relationships hold, 1977 employment of R&D scientists and engineers in industry may be expected to have increased approximately 4 percent over the 1975 level.

Data on employment of scientists and engineers have been related to total employment of those workers not directly engaged in production work for six industries which are major employers of S/E manpower, and for which consistent estimates are available for the entire 1952-75 period (chart 2). In every industry, the proportion of scientists and engineers showed a significant increase until the midsixties period, after which every industry except fabricated metals showed a decline to 1975. This indicates that for these industries, scientists and engineers are becoming a steadily less significant proportion of the "support" staff of nonproduction workers, which also include managerial, sales, financial, and similar functions.

The effects of all these factors on scientists and engineers in private industry in the post-1970 period led to a decline of 6 percent in employment between 1970 and 1975. The lack of survey data does not permit trend analysis for intervening years but other evidence indicates that S/E employment levels probably were lowest in 1972 or 1973 and showed a slight increase to 1975.[1]

[1] National Science Foundation, *Research and Development in Industry, 1974* (NSF 76-322) (Washington, D.C. 20402. Supt. of Documents, U.S. Government Printing Office, 1976.)

Chart 2. Employment of scientists and engineers as percent of total nonproduction workforce: 1952-75



SOURCES: Bureau of Labor Statistics, Bureau of the Census, and the National Science Foundation

Employment Patterns by Industry

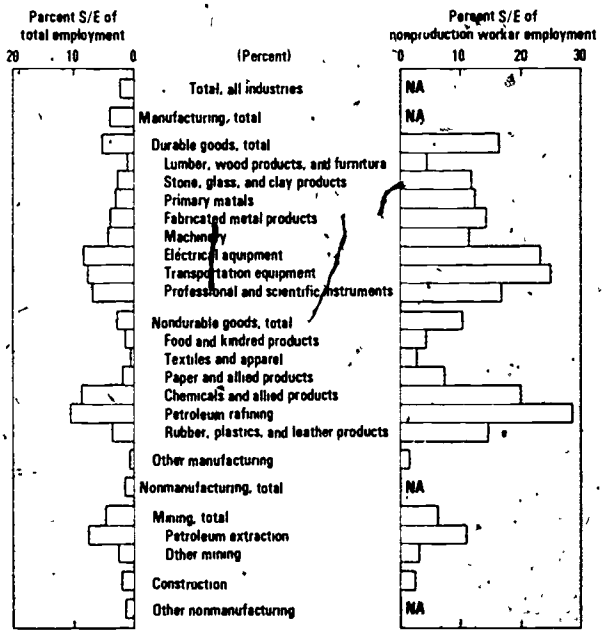
For the first time since 1970, new 1975 survey data are available for all sectors of private industry to show comparisons among them in utilization of scientists and engineers. Table 1 shows, by industry, S/E employment, total employment, and nonproduction worker employment. Ratios of S/E employment to total and nonproduction worker employment are shown graphically in chart 3. Nonproduction worker employment includes all workers not directly engaged in the process of production of physical goods. Nonproduction workers are thus the category in which most S/E employees are likely to be found.

In the durable goods manufacturing sector, the largest employment of scientists and engineers is found in the electrical equipment industry. Measured as a percent of total employment, this industry also shows the highest concentration of these personnel (8.2 percent). As a percent of nonproduction workers, however, the concentration in electrical equipment (23.2 percent) is second to the transportation equipment industry (24.7 percent). Except for the lumber and furniture industry, all durable goods manufacturing industries have S/E employment concentrations of more than 10 percent of nonproduction workers.

In the nondurable goods manufacturing sector, concentration rankings are the same whether technical employment is compared to total employment or to nonproduction worker employment. Petroleum refining and the chemicals industry show the greatest utilization of scientists and engineers on either basis.

Among the nonmanfacturing industries, petroleum extraction shows the greatest concentration with scientists and engineers comprising 7.4 percent of the total, and 10.8 percent of nonproduction worker employment being scientists and engineers.

Chart 3. Scientists and engineers employed in industry: 1975



NA = Not Available

SOURCES Bureau of Labor Statistics, Bureau of the Census, and the National Science Foundation

TABLE 1 —EMPLOYMENT BY INDUSTRY: 1975

[In thousands]

Industry	SIC codes[1]	Total employment	S/E employment	Non-production worker employment
Total, all industries	—	51,421 2	1,183 6	NA
Manufacturing, total	—	17,919 1	669 8	NA
Durable goods, total	—	10,103 9	490 6	2,949 7
Lumber, wood products, and furniture	24,25	1,007 6	8 2	179 5
Stone, glass, and clay products	32	613 5	15 6	129 0
Primary metals	33	1,179 7	32 8	260 7
Fabricated metal products	34	1,335 8	49 1	339 8
Machinery	35	2,068 8	83 7	722 8
Electrical equipment	36	1,760 6	144 3	620 9
Transportation equipment	37	1,649 1	123 9	501 2
Professional and scientific instruments	38	488 8	33 0	195 8
Nondurable goods, total	—	6,253 2	170 8	1,646 1
Food and kindred products	20	1,676 4	23.2	540 4
Textiles and apparel	22,23	2,136 6	7 8	293 2
Paper and allied products	26	642 7	11.8	160 1
Chemicals and allied products	28	1,012 5	87.5	442 7
Petroleum refining	29	197 4	20 6	72 5
Rubber, plastics, and leather products	30,31	587 6	19 9	137 2
Other manufacturing	21,27,39	1,562 0	8 4	552 2
Nonmanufacturing, total		39,502 1	513 8	NA
Mining total	10-14	744 9	34.4	565 0
Petroleum extraction	13	335 7	24 9	230 5
Other mining	10,11,12,14	409 2	9 6	334 5
Construction	15-17	3,457 0	83 0	2,762 0
Other manufacturing	40-47, 50-67			
	70-891	35,300 2	416 3	NA

[1] Industries are classified according to the *Standard Industrial Classification Manual, 1972*
NA = Not available

Sources S/E employment Bureau of the Census, adjusted by the National Science Foundation, total employment and nonproduction worker employment Bureau of Labor Statistics

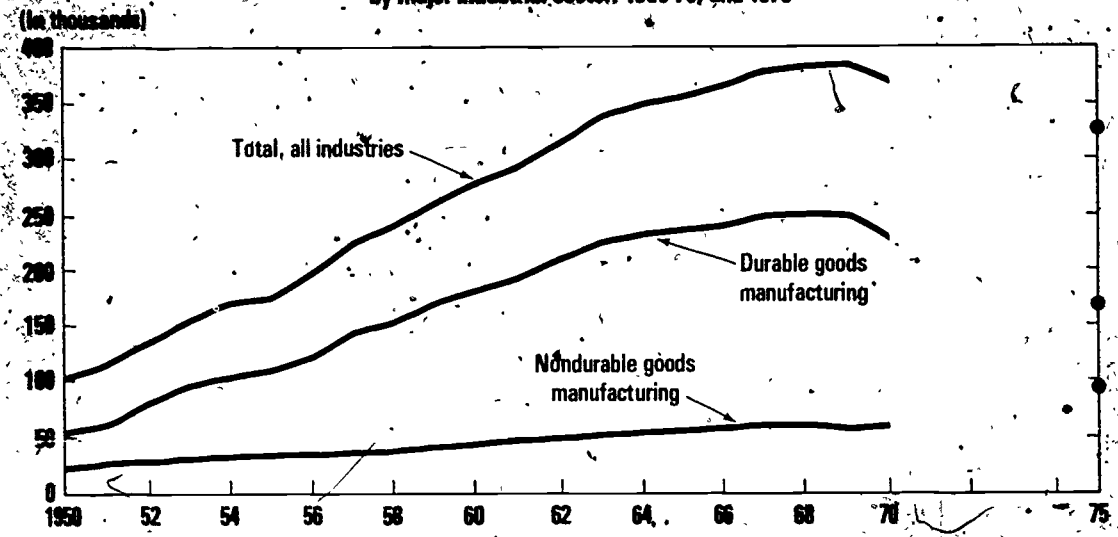
R&D Employment

Employment of scientists and engineers engaged in R&D activities in private industry shows much the same pattern over the 1950-75 period as does total employment of scientists and engineers (chart 4 and appendix table B-4). After showing strong growth for over [illegible] years, employment levels responded to the stagnation in R&D funding levels in the late sixties by showing slow growth between 1967 and 1969 and slight decline in 1970. The 1975 employment level was some 12 percent lower than that shown in 1970, although other evidence indicates a bottoming-out in employment in 1972 or 1973, with a slight increase to 1975,[2] and a 5-percent gain from 1975 to 1977.

Excluding the amorphous "other nonmanufacturing" sector, the heaviest user of technical personnel for R&D purposes, in absolute terms as well as in percentage terms, is the electrical equipment industry (table 2). The second greatest employer in research and development according to all employment and percentage measures is the chemicals industry. Other industries which utilize over 30 percent of their scientists and engineers in R&D activities include lumber and furniture, transportation equipment, instruments, and foods and kindred products. The least R&D-intensive industry on this basis is the construction industry, which reported only 3.7 percent of its scientists and engineers in research and development.

[2] Ibid

Chart 4. Employment of scientists and engineers engaged in R&D activities by major industrial sector: 1950-70, and 1975



SOURCES: Bureau of the Census and the National Science Foundation.

Relationship of S/E Employment to Trends in Total Employment

Does the concentration of S/E employment have any relationship to the growth of total employment in an industry? Table 3 presents data which allow an exploration of this question for 15 industry groups in the manufacturing sector. The industry groups are ordered by their rank in the proportion of total employment of scientists and engineers to nonproduction worker employment in 1975. The category "nonproduction workers" includes most scientists and engineers and shows the least variation due to cyclical changes in the economy. This table also presents each industry's rank based on its proportion of employment of R&D personnel to nonproduction worker employment. The data columns show percentage changes in total employment from 1960-65, 1965-70, and 1970-75.

Whether ranked on the basis of ratios of total scientists and engineers or those in R&D employment to nonproduction worker employment, the industries cluster into three groups of five industries, which one may call, respectively, high, medium, and low technology-intensive industries. Table 3 and chart 5 reveal that high technology-intensive industries showed significantly stronger employment growth than low technology-intensive industries. At the same time, however, high technology-intensive industries suffered from more volatile swings in

TABLE 2.—EMPLOYMENT OF SCIENTISTS AND ENGINEERS ENGAGED IN R&D ACTIVITIES BY INDUSTRY: 1975

Industry	R&D scientists & engineers (thousands)	As percent of: Total employment	As percent of: All S/E employment
Total, all industries	345	0 6	29 1
Manufacturing, total	243	1 4	36 2
Durable goods, total	180	1 8	36 7
Lumber, wood products, and furniture	3	3	32 9
Stone, glass, and clay products	4	7	28 2
Primary metals	6	5	19 2
Fabricated metal products	10	8	21 2
Machinery	21	1 0	25 2
Electrical equipment	78	4 4	54.1
Transportation equipment	47	2 8	37 8
Professional and scientific instruments	10	2 1	31.5
Nondurable goods, total	59	9	34 7
Food and kindred products	8	5	34 5
Textiles and apparel	1	1	14 1
Paper and allied products	2	3	16 9
Chemicals and allied products	41	4 0	46 4
Petroleum refining	4	2 2	20 9
Rubber, plastics, and leather products	3	6	16 6
Other manufacturing	4	2	41 7
Nonmanufacturing, total	102	3	19 8
Mining, total	9	1 2	25 6
Petroleum extraction	6	1 9	25 3
Other mining	3	6	26 0
Construction	2	1	3 7
Other monmanufacturing	91	3	21 7

Note Data may not add to totals because of rounding Percentages calculated from unrounded data

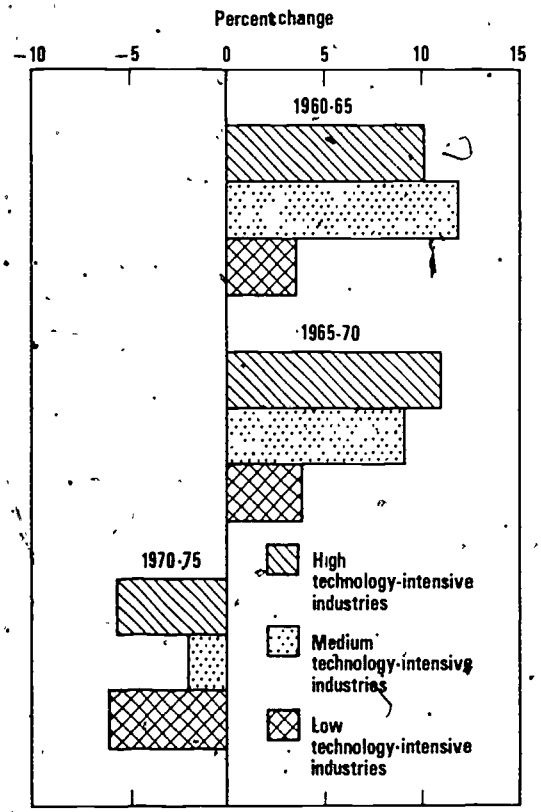
Source Bureau of the Census, as adjusted by the National Science Foundation

TABLE 3 —EMPLOYMENT GROWTH RATES IN MANUFACTURING INDUSTRIES, 1960-75, CLASSIFIED BY RELATIVE IMPORTANCE OF S/E EMPLOYMENT

Industry	Rank		Percent change, total employment		
	Total scientists and engineers[1]	R&D scientists and engineers[2]	1960-65	1965-70	1970-75
All manufacturing			7 8	7 5	-4 6
High concentration industries			10 1	11 0	-5 7
Petroleum refining	1	5	-13 7	4 3	3 5
Transportation equipment	2	3	10 9	3 4	-8 3
Electrical equipment	3	2	13.1	15 5	-8 2
Chemicals and allied products	4	4	9 6	15 6	-3 5
Professional and scientific instruments	5	1	9 8	18 4	6 2
Medium concentration industries			11 9	9 1	-1 9
Fabricated metal products	6	8	11 8	8 8	-3 2
Rubber, plastics, and leather products	7	7	24 2	23 2	1.3
Primary metals	8	10	5 7	1 1	-10 3
Stone, glass, and clay products	9	6	4 0	1 9	-4 2
Nonelectrical machinery	10	9	17 3	14 2	4 4
Low concentration industries			3 5	3 8	-6 0
Paper and allied products	11	13	6 3	10 4	-8 9
Lumber, wood products, and furniture	12	11	2 8	- 5	-2 4
Food and kindred products	13	11	1 9	1 5	-6 0
Textiles and apparel	14	15	5 7	2 7	-8 7
Other manufacturing	15	14	6 5	8 4	-3 0

[1] Based on ratio of total S/E employment to total nonproduction worker employment in 1975
[2] Based on ratio of S/E employment in R&D to total nonproduction worker employment in 1975
Source: National Science Foundation

Chart 5. Employment growth rates in manufacturing industries: 1960-75



SOURCE: Bureau of Labor Statistics

employment than the medium technology-intensive industries.

The low technology-intensive industries experienced the lowest growth rate in total employment over the 15-year period, i.e., 3.5 percent, 3.8 percent, and minus 6.0 percent during the 1960-65, 1965-70, and 1970-75 periods, respectively. This group's decline in total employment between 1970 and 1975 was the greatest in both absolute terms and on a relative basis, compared to those industries with a more technically oriented workforce. The decline in total employment between 1970 and 1975 was 86 percent of the gain in employment experienced in the prior 10-year period.

On the other hand, the group of five high technology-intensive industries was the most volatile in its swing between rapid growth and decline, increasing by 10 percent and 11 percent, respectively, during 1960-65 and 1965-70, but dropping almost as much as the low technology-intensive industries between 1970 and 1975—5.7 percent. The middle technology-intensive group of industries showed the most stability over the period, experiencing growth on a par with the high technology-intensive industries between 1960 and 1970, but dropping by only 1.9 percent between 1970 and 1975.

Employment by Occupation and Major Industrial Sector

Over 40 percent of all S/E employment in 1975 was accounted for by the durable goods manufacturing sector (table 4 and chart 6). This sector also accounted for almost one-half of engineering employment.

Chemists - Employment of chemists was reported as 65,000, with over 75 percent of this total in the nondurable goods manufacturing industries.

Physicists - Of the 11,000 physicists estimated to be employed in 1975, over 80 percent were employed in durable goods manufacturing industries.

Metallurgists - Almost 100 percent of the 9,000 metallurgists reported were working in the durable goods manufacturing sector.

Geologists - This specialty is the only one among the physical sciences group whose employment is concentrated outside the manufacturing sector, with about 79 percent of all geologists employed being reported in the nonmanufacturing industries.

Life scientists - Included in this occupational group are such specialties as biochemistry, agricultural sciences, medical sciences (excluding practitioners), and other biological sciences. Reported private sector employment of the group was 60,000, with over 60 percent of this total being employed in the nonmanufacturing industries.

Mathematical scientists - Some 14,000 mathematical scientists were reported employed in 1975, evenly split between manufacturing and nonmanufacturing. Specialties included in this group are mathematicians and statisticians.

Computer scientists - This large group, of whom 143,000 were estimated to be employed, has about 70 percent of its members employed in nonmanufacturing industries. Included in the category "computer scientists" are such job titles as computer systems analyst, systems engineer, computer specialists, data processing systems project planners, software specialists, etc. Not included are computer programmers.

Social scientists - Some 10,000 social scientists were employed by private industry in 1975, slightly over one-half of them in nonmanufacturing industries. Most persons in this group are economists and psychologists.

TABLE 4 —EMPLOYMENT OF SCIENTISTS AND ENGINEERS BY OCCUPATION AND MAJOR INDUSTRIAL SECTOR: 1975

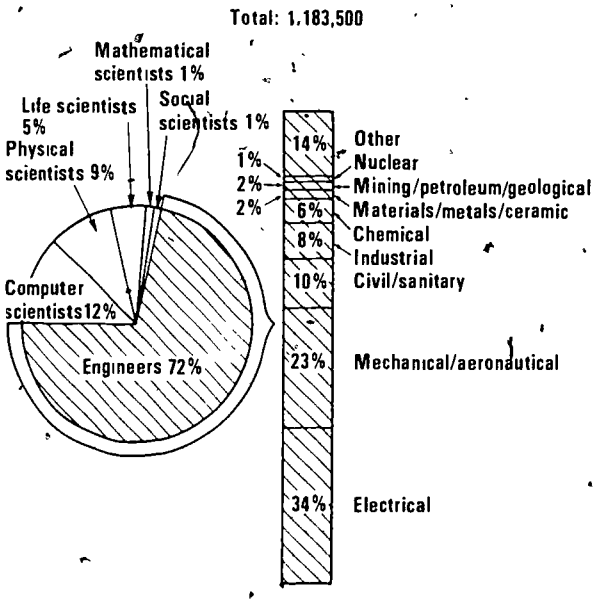
(In thousands)

Occupation	Total	Manufacturing			Nonmanufacturing
		Total	Durable goods	Nondurable goods	
Total scientists and engineers	1,184	670	491	179	514
Total scientists	331	164	68	94	167
Physical scientists	104	85	29	55	19
Chemists	65	59	9	50	6
Physicists	11	10	9	1	1
Other physical scientists	28	16	11	4	12
Metallurgists	9	9	9	(1)	(1)
Geologists	14	3	1	2	11
Other	5	4	2	2	1
Life scientists	60	24	3	20	36
Mathematical scientists	14	7	4	2	7
Computer scientists	143	43	29	14	100
Social scientists (incl psychologists)	10	5	2	3	5
Total engineers	853	507	422	85	346
Chemical	50	41	11	30	9
Civil/sanitary	82	11	8	3	71
Electrical	292	143	137	6	149
Industrial	67	57	45	12	9
Materials/metals/ceramic	20	16	15	1	4
Mechanical/aeronautical	201	157	137	21	44
Mining/petroleum/geological	18	3	2	1	15
Nuclear	7	4	4	(1)	2
Other	117	74	64	11	43

(1) Less than 500 employees

Source: Bureau of the Census, as adjusted by the National Science Foundation

Chart 6. Employment of scientists and engineers in industry by occupation: 1975



SOURCES: Bureau of the Census and the National Science Foundation

Chemical engineers - Almost 50,000 chemical engineers were reported, of whom almost 60 percent worked in nondurable goods manufacturing.

Civil or sanitary engineers - A total of 82,000 of these engineers was reported, over 85 percent working in the nonmanufacturing area, primarily in construction, public utilities, and architecture and engineering consulting work.

Electrical engineers - This is the largest engineering specialty in terms of employment in the private industrial sector, with a total of almost 300,000. This total was almost evenly split between the manufacturing and nonmanufacturing sectors.

Industrial engineers - Over 85 percent of the 67,000 industrial engineers reported worked in manufacturing industries.

Materials/metals/ceramic engineers - This relatively small group, with 1975 employment reported at about 20,000, is also highly concentrated in the manufacturing sector, where over 80 percent of the jobs are located.

Mechanical/aeronautical engineers - Over 201,000 persons were reported employed in these specialties, with over three-fourths of the employment concentrated in the manufacturing sector.

Mining/petroleum/geological engineers - Another relatively small specialty, this is one of the few whose employment is concentrated in the nonmanufacturing sector, where some 83 percent of the 18,000 total were reported.

Employment in Energy-Related Activities

Almost 16 percent of all scientists and engineers in private industry were employed in energy-related activities in 1975 (table 5). These are defined as activities "... relating to the exploration, discovery, extraction, refining, conversion, transportation, transmission, dis-

TABLE 5 —EMPLOYMENT OF SCIENTISTS AND ENGINEERS ENGAGED IN ENERGY-RELATED ACTIVITIES BY INDUSTRY, 1975

[In thousands]

Industry	Employed scientists and engineers in energy-related activities			As percent of total S/E employment
	Total	Scientists	Engineers	
Total, all industries	186	34	152	15 7
Manufacturing total	91	18	73	13 6
Durable goods, total	60	5	55	12 2
Lumber, wood products, and furniture	(1)	(1)	(1)	3 7
Stone, glass, and clay products	2	(1)	1	10 3
Primary metals	3	(1)	2	7 9
Fabricated metal products	17	1	17	34 6
Machinery	12	1	11	14 3
Electrical equipment	13	1	12	9 2
Transportation equipment	8	1	7	6 2
Professional and scientific instruments	5	(1)	5	16 4
Nondurable goods, total	31	13	18	16 3
Food and kindred products	1	(1)	(1)	2.2
Textiles and apparel	1	(1)	1	12 8
Paper and allied products	1	(1)	1	6 5
Chemicals and allied products	7	3	4	6 5
Petroleum refining	15	5	10	71.8
Rubber, plastics, and leather products	6	5	2	31 2
Other manufacturing	(1)	(1)	(1)	3 6
Nonmanufacturing, total	95	16	78	16 4
Mining, total	25	10	15	72 7
Petroleum extraction	21	9	12	84 3
Other mining	4	1	3	41 7
Construction	15	(1)	14	23 5
Other nonmanufacturing	55	6	49	13 1

[1] Represents less than 500 employees

Note Detail may not add to totals because of rounding Percentages calculated from unrounded data

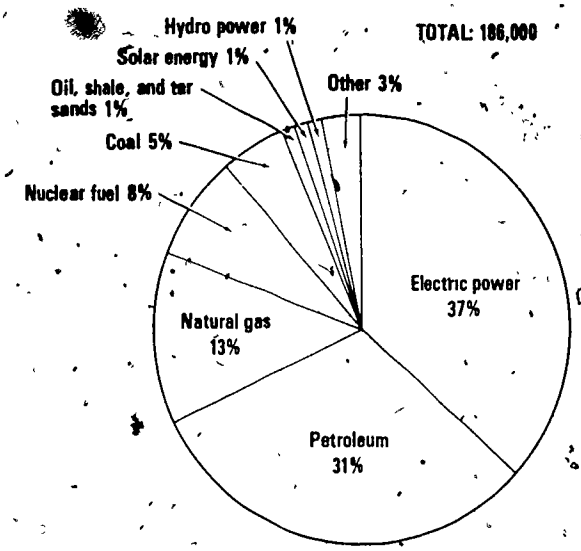
Source Bureau of the Census, as adjusted by the National Science Foundation

tribution, storage, and utilization of energy sources." Also included are persons" . . . concerned with conservation or the environmental aspects of energy sources which may involve any of the aforementioned activities."

As might be expected from the foregoing definition, the industries showing the highest concentration of S/E employment in energy-related activities are the petroleum and natural gas extraction industry (84.3 percent) and the petroleum refining industry (71.8 percent). Other industries showing large concentration in energy-related activities include other mining (41.7 percent), fabricated metal products (34.6 percent), and rubber, plastic, and leather products (31.2 percent).

When classified according to energy source, over two-thirds of all scientists and engineers in energy-related activities were working on electric power (69,000) and petroleum (57,000) in 1975 (table 6 and chart 7). When persons working on natural gas (24,000) and nuclear power (15,000) are included, almost 90 percent of all S/E employment in energy-related activities is accounted for

Chart 7. Employment of scientists and engineers in industry in energy-related activities by energy source: 1975



SOURCES: Bureau of the Census and the National Science Foundation

TABLE 6.—EMPLOYMENT OF SCIENTISTS AND ENGINEERS ENGAGED IN ENERGY-RELATED ACTIVITIES, BY ENERGY SOURCE AND ACTIVITY, AND MAJOR INDUSTRY SECTOR, 1975

[In thousands]

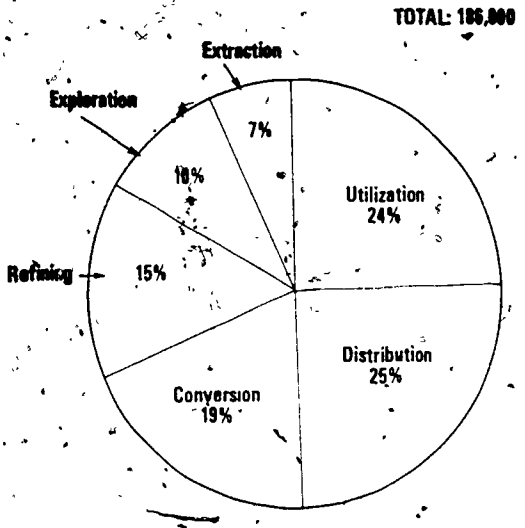
	Total	Manufacturing					Non-manufacturing
		Total	Nondurable goods			Durable goods	
			Total	Chemicals	Petroleum		
	By energy source						
Total	186	91	31	7	15	60	95
Petroleum	57	33	22	1	14	11	24
Natural gas	24	7	2	(1)	1	5	18
Coal	9	4	(1)	(1)	(1)	3	6
Hydropower	2	(1)	(1)	0	(1)	(1)	2
Nuclear fuel	15	13	4	4	(1)	8	3
Oil, shale, and tar sands	1	1	(1)	0	(1)	1	(1)
Solar energy	2	1	(1)	(1)	(1)	1	1
Electric power	69	29	2	1	(1)	27	40
Other	5	4	1	(1)	(1)	3	1
	By energy activity						
Total	186	91	31	7	15	60	95
Exploration and discovery	19	7	4	(1)	3	3	12
Extraction	13	3	2	(1)	1	2	10
Refining	27	20	17	4	8	4	7
Conversion	36	23	1	1	(1)	22	13
Transportation/transmission distribution or storage	46	11	2	1	1	9	35
Utilization	45	27	6	3	1	22	18

(1) Indicates less than 500 employees

Note: Detail may not add to totals because of rounding

Source: Bureau of the Census as adjusted by the National Science Foundation

Chart 8. Employment of scientists and engineers in industry by type of energy-related activity: 1975



SOURCES: Bureau of the Census and the National Science Foundation

Almost one-half of all energy-related employment of scientists and engineers is accounted for by those engaged in utilization (45,000) or transportation, transmission, distribution and storage (46,000) activities (chart 8).[1]

Employment of Technicians

Almost one million technicians were employed in 175 by private industry (table 7). In the manufacturing sector, heaviest users of technicians include the electrical equipment industry (92,000), the machinery industry (71,000), the transportation equipment industry (50,000), and the chemicals industry (47,000). These four industries employ almost two-thirds of all technicians found in the manufacturing sector. Over the 1960-75 period, the ratio of

[1] For a detailed analysis of energy manpower see National Science Foundation *Reviews of Data on Science Resources No. 29 Current and Future Utilization of Scientific and Technical Personnel in Energy-Related Activities* (NSF 77-315) (Washington, D.C. 20402, Supt. of Documents, U.S. Government Printing Office 1977)

TABLE 7 —EMPLOYMENT OF TECHNICIANS ENGAGED IN R&D AND ENERGY-RELATED ACTIVITIES BY INDUSTRY 1975

[In thousands]

Industry	Total	Engaged in—			
		Research and development		Energy-related activities	
		Number	Percent of total	Number	Percent of total
Total all industries	944	141	14.9	131	13.9
Manufacturing total	108	28.4	48	11.6	
Durable goods, total	78	24.8	36	11.4	
Lumber, wood products, and furniture	2	32.1	(1)	NA	
Stone, glass, and clay products	11	3	30.9	1	9.1
Primary metals	21	3	16.0	1	6.1
Fabricated metal products	35	6	16.5	8	22.6
Machinery	71	12	16.6	10	14.1
Electrical equipment	92	33	35.8	10	10.8
Transportation equipment	50	15	29.4	4	7.3
Professional and scientific instruments	29	4	14.9	2	7.3
Nondurable goods, total	90	28	31.2	12	13.4
Food and kindred products	15	4	28.4	(1)	NA
Textiles and apparel	4	1	14.3	(1)	NA
Paper and allied products	5	1	24.0	(1)	NA
Chemicals and allied products	47	18	38.5	3	5.9
Petroleum refining	9	3	28.0	6	65.6
Rubber, plastics, and leather products	9	1	13.2	3	28.6
Other manufacturing	7	2	33.8	(1)	NA
Nonmanufacturing, total	533	32	6.0	83	15.6
Mining, total	24	3	11.8	11	45.0
Petroleum extraction	17	2	9.8	8	47.4
Other mining	7	1	16.9	3	38.5
Construction	66	1	1.2	26	39.3
Other nonmanufacturing	443	29	6.5	47	10.6

[1] Represents less than 500 employees

NA = Not available

Note Detail may not add to total because of rounding Percentages calculated from unrounded data

Source Bureau of the Census, as adjusted by the National Science Foundation

technicians to scientists and engineers in manufacturing industries showed a gradual increase from .55 to .61, indicating the possibility that some substitution of technicians for scientists and engineers was occuring.

Over 14 percent of technicians were engaged in R&D activities. In the chemicals industry, this concentration was more than 38 percent, while in electrical equipment it approached 36 percent.

Almost 14 percent of the technicians were engaged in energy-related activities; almost two-thirds of the technicians employed in petroleum refining worked in such activities. Concentrations were also well above average in the mining and construction industries.

The most common occupational specialty was the electrical/electronics technician, which accounted for over 32 percent of all technician employment (table 8). When only technicians in energy-related activities are tabulated, the largest specialty is draftsmen, accounting for 34 percent of the total.

TABLE 8.—TECHNICIANS BY OCCUPATION AND MAJOR INDUSTRIAL SECTOR. TOTAL EMPLOYMENT AND THOSE ENGAGED IN ENERGY-RELATED ACTIVITIES, 1975

[In thousands]

Occupation	Total	Manufacturing			Non-manufacturing
		Total	Durable goods	Non-durable goods	
	All technicians				
Total	944	410	314	96	533
Draftsmen	233	119	108	12	114
Electrical/electronic	304	103	95	8	201
Other physical science	129	95	55	39	34
Biological/agricultural/medical	16	10	2	7	6
Other	262	84	54	30	178
	Technicians engaged in energy-related activities				
Total	131	48	36	12	83
Draftsmen	44	19	17	2	26
Electrical/electronic	25	8	8	1	17
Other physical science	31	16	8	8	16
Biological/agricultural/medical	1	(1)	(1)	(1)	1
Other	30	5	3	2	25

(1) Less than 500 employees

Note: Detail may not add to totals because of rounding

Source: Bureau of the Census as adjusted by the National Science Foundation

APPENDIX A

Technical Notes

This survey was conducted by the Census Bureau under a contract with the National Science Foundation to measure the number of persons working as scientists, engineers, and technicians in the private business sector. To meet this objective, a sample was drawn from all active employer establishments in the United States and its possessions, excluding colleges, universities, and governments.

From the sample design outlined above, approximately 27,000 establishments were selected to receive a questionnaire. The establishments selected to receive this form consisted of 14,100 establishments belonging to 5,358 multi-unit companies and 12,700 single unit companies.

Reliability of Data

The statistics in these tables are estimates derived from a sample survey. There are two types of errors possible on a sample survey—sampling and nonsampling. Sampling errors occur because observations are made only on a sample, not on the entire population. Nonsampling errors can be attributed to many sources. Inability to obtain information about all cases in the sample, definitional difficulties, differences in the interpretations of questions, mistakes in recording or coding the data obtained, and other errors of collection, response, processing, coverage, and estimation for missing data. Nonsampling errors also occur in complete censuses. The accuracy of a survey result is determined by the joint effects of sampling and nonsampling errors.

The relative standard error is defined as the standard error divided by the value being estimated. Sampling errors are relative standard errors, presented as a percent of the value being estimated.

In conjunction with its associated estimate, the relative standard error may be used to define confidence intervals, ranges that would include the comparable complete coverage value for specified percentages of all possible samples. The complete-coverage value would be included in the range:

1. From one standard error below to one standard error above the derived estimate for about two-thirds of all possible samples.
2. From two standard errors below to two standard errors above the derived estimate for about 19 out of 20 of all possible samples.
3. From three standard errors below to three standard errors above the derived estimate for nearly all samples.

An inference that the comparable complete-coverage result would be within the indicated ranges is correct in approximately the relative frequencies shown. These proportions, therefore, may be interpreted as defining approximate probabilities that the estimates shown would differ from complete coverage results by as much as one, two, or three standard errors.

Estimates of the standard error for certain of the original employment estimates provided by the Census Bureau are shown in tables A-1 and A-2. It must be emphasized that the employment levels presented in other tables of this report have been adjusted by the National Science Foundation, and hence these standard error estimates do not directly apply to these revised estimates. They are presented here, however, as a gauge of the relative reliability of these estimates.

Adjustment to the Data

In order to make the results of this survey comparable to previous surveys, and to conform to NSF definitions, certain adjustments were made to the results of the 1975 survey.

The first of these adjustments was a subtraction for nonprofit institutions, which were covered in the Census survey but are not included in the NSF definition of private industry. These institutions were also excluded from previous surveys.

The data presented for employment in 1975 alone differ from that for 1975 in the time series analysis in that the latter excludes computer and social scientists for which comparable time series data are not available.

Due to probable undercount in the Census survey for scientists, engineers, and technicians engaged in research and development, adjustments were made to these estimates by extrapolating industry-specific ratios of R&D employment to total S/E employment.

Finally, the original Census estimates carried employment estimates for groups "not specified" by industry, occupation, or both. These groups were prorated to the most detailed relevant subtotal for industry or occupation, e.g. "not specified" engineers were prorated among all engineers, while any "total not specified" by occupation was prorated among all occupations.

Comparability with Other Data

As explained in the previous section, the data reported here for 1975 are not strictly comparable to data on employment of scientists and engineers in industry formerly collected by the Bureau of Labor Statistics.

In addition, the current data on R&D employment are not strictly comparable to those reported in *National Patterns of R&D Resources, Funds and Manpower in the United States, 1953-1977* (NSF 77-310). The data reported here are on an establishment basis, whereas the other survey classifies firms on an enterprise (company) basis. Also, the data presented in this report represent persons devoting the greatest proprtion of their time to R&D activities, while the data in *National Patterns* are on a full-time-equivalent basis. Other variations in the two sets of data may be the result of different offices in the establishment responding to the questionnaires, or the varying response rates of the two surveys.

TABLE A-1 —STANDARD ERRORS OF ESTIMATES OF EMPLOYMENT OF SCIENTISTS AND ENGINEERS BY INDUSTRY: 1975

[Percent]

Industry	All activities			Engaged in research and development		
	Total	Scientists	Engineers	Total	Scientists	Engineers
Total, all industries	4	12	2	3	5	3
Manufacturing, total	1	2	2	2	3	1
Durable goods, total	2	2	2	2	4	2
Lumber, wood products, and furniture	17	26	17	39	64	33
Stone, glass, and clay products	14	18	15	27	27	31
Primary metals	4	9	4	17	23	15
Fabricated metal products	15	10	16	8	22	7
Machinery	2	3	2	3	6	3
Electrical equipment	2	1	2	1	1	1
Transportation equipment	1	2	1	3	3	3
Professional and scientific instruments	3	7	2	5	9	5
Nondurable goods, total	3	4	2	4	5	3
Food and kindred products	15	17	15	29	31	20
Textiles and apparel	9	16	8	20	22	23
Paper and allied products	7	13	8	9	12	14
Chemicals and allied products	1	1	1	1	1	2
Petroleum refining	2	2	2	2	2	2
Rubber, plastics, and leather products	12	27	6	7	8	10
Other manufacturing	13	19	9	29	36	18
Nonmanufacturing, total	9	22	5	9	12	10
Mining, total	8	8	11	13	17	19
Petroleum extraction	11	10	16	18	20	25
Other mining	6	16	8	20	32	13
Construction	6	19	6	21	54	22

Source Bureau of the Census

TABLE A-2.—STANDARD ERRORS OF ESTIMATES OF EMPLOYMENT OF SCIENTISTS AND ENGINEERS BY OCCUPATION: 1975

[Percent]

Occupation	Total	Manufacturing			Nonmanufacturing
		Total	Durable goods	Nondurable goods	
Total scientists and engineers	4	1	2	3	9
Physical scientists	4	4	4	5	12
Chemists	6	2	7	2	32
Physicists	6	3	2	22	18
Other physical scientists	NA	NA	NA	NA	NA
Metallurgists	9	10	10	20	13
Geologists	9	12	34	12	10
Other	8	8	12	8	7
Life scientists	17	8	15	9	26
Mathematical scientists	8	3	2	8	11
Computer scientists	23	2	2	3	32
Social scientists	33	8	11	8	39
Engineers	2	2	2	2	5
Chemical	4	5	18	2	9
Civil/Sanitary	4	8	8	6	5
Electrical	3	1	1	5	8
Industrial	5	2	2	4	29
Material/metals/ceramic	7	7	8	8	16
Mechanical/aeronautical	5	5	5	3	12
Mining/petroleum/geological	12	4	5	8	15
Nuclear	2	2	2	8	4
Other	3	3	3	8	7

NA = Not available
Source Bureau of the Census

APPENDIX B

Detailed Statistical Tables

TABLE B-1.—EMPLOYMENT OF SCIENTISTS AND ENGINEERS BY MAJOR INDUSTRIAL SECTOR, 1950-70 AND 1975

[In thousands]

Year	Total	Manufacturing			Non-manufacturing
		Total	Durable goods	Non-durable goods	
1950	396	245	168	78	151
1951	439	276	189	87	164
1952	500	327	232	95	173
1953	558	371	267	104	187
1954	590	393	284	110	197
1955	610	400	288	112	210
1956	655	427	310	116	228
1957	717	477	353	124	240
1958	740	495	364	131	246
1959	774	519	387	133	255
1960	806	547	410	138	259
1961	836	574	433	141	262
1962	870	598	453	146	271
1963	915	632	483	150	283
1964	937	637	482	156	297
1965	955	651	494	157	304
1966	989	673	509	165	316
1967	1,025	703	537	168	321
1968	1,049	717	551	169	331
1969	1,076	721	551	172	355
1970	1,086	720	544	178	366
1975	1,016	622	459	163	394

Note: The time series data presented in this table are not comparable to 1975 data presented elsewhere in the report as computer scientists and social scientists are excluded.

Detail may not add to totals because of rounding.

Sources: Data for 1950 through 1970 from Bureau of Labor Statistics, data for 1975 from Bureau of the Census, adjusted by the National Science Foundation.

TABLE B-2.—DEGREES AWARDED IN SCIENCE AND ENGINEERING FIELDS: 1947-48 THROUGH 1974-75

[In thousands]

Academic year	Bachelor's	Master's	Ph D
1947-48	95	13	2
1948-49	127	16	3
1949-50	155	17	4
1950-51	126	18	5
1951-52	100	16	5
1952-53	86	14	5
1953-54	82	13	5
1954-55	81	14	5
1955-56	87	14	5
1956-57	99	15	5
1957-58	109	17	5
1958-59	117	19	6
1959-60	121	20	6
1960-61	122	23	7
1961-62	127	25	7
1962-63	136	27	8
1963-64	153	30	9
1964-65	165	34	10
1965-66	173	38	11
1966-67	188	42	13
1967-68	212	45	14
1968-69	225	48	16
1969-70	264	49	18
1970-71	271	51	18
1971-72	281	54	18
1972-73	295	54	19
1973-74	305	54	18
1974-75	295	54	18

Source: National Center for Education Statistics (HEW)

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TABLE B-3.—FUNDS EXPENDED FOR PERFORMANCE OF RESEARCH AND DEVELOPMENT, 1953-75

[Millions of 1972 dollars][1]

Year	Total	Federal Government	Private industry	Universities and colleges	Other nonprofit institutions
1953	$8,702	$1,715	$6,165	$638	$183
1954	9,456	1,709	6,819	722	206
1955	10,121	1,484	7,609	607	221
1956	13,296	1,653	10,501	899	242
1957	15,034	1,876	11,890	1,000	268
1958	16,214	2,080	12,699	1,133	301
1959	18,303	2,429	14,245	1,260	350
1960	19,693	2,514	15,303	1,465	411
1961	20,664	2,705	15,744	1,693	521
1962	21,820	2,973	16,249	1,947	649
1963	23,829	3,183	17,642	2,250	753
1964	25,930	3,903	18,583	2,619	825
1965	26,970	4,162	19,086	2,829	892
1966	28,460	4,195	20,255	3,055	955
1967	29,291	4,298	20,735	3,283	976
1968	29,798	4,230	21,108	3,473	986
1969	29,550	4,039	21,111	3,396	1,003
1970	28,355	4,220	19,770	3,363	1,003
1971	27,697	4,328	19,069	3,350	950
1972	28,257	4,482	19,383	3,440	952
1973	28,642	4,366	19,774	3,551	951
1974	27,712	4,136	19,241	3,335	1,000
1975	27,158	4,240	18,499	3,442	977

[1] Based on the GNP implicit price deflator

Source: National Science Foundation

TABLE B-4.—EMPLOYMENT OF SCIENTISTS AND ENGINEERS ENGAGED IN RESEARCH AND DEVELOPMENT BY MAJOR INDUSTRIAL SECTOR, 1950-70 and 1975

[In thousands]

Year	Total	Manufacturing			Non-manufacturing	Percent change, total
		Total	Durable goods	Non-durable goods		
1950	103	82	58	24	20	
1951	116	94	66	28	22	12 8
1952	139	115	85	30	24	19 9
1953	160	134	101	34	26	15.4
1954	173	145	110	36	28	8 3
1955	180	151	114	37	30	4 2
1956	198	164	125	39	33	9 5
1957	228	191	149	42	37	15 3
1958	242	203	157	46	38	6 0
1959	264	222	174	48	42	9 4
1960	282	238	187	51	45	6.9
1961	297	251	199	52	46	5.1
1962	319	270	215	56	49	7 4
1963	343	290	232	58	53	7 7
1964	351	297	236	60	54	2 3
1965	360	301	238	62	59	2 5
1966	370	307	243	64	63	2.8
1967	384	318	253	64	67	3 9
1968	387	318	254	63	69	0 6
1969	388	317	253	64	71	0.3
1970	372	298	232	66	74	-4 0
1975	329	232	172	60	97	-11 6

Note: The time series data presented in this table are not comparable to 1975 data presented elsewhere in the report as computer scientists and social scientists are excluded.
Detail may not add to totals because of rounding.

Sources: Data for 1950 through 1970 from Bureau of Labor Statistics, data for 1975 from Bureau of the Census, adjusted by the National Science Foundation