AN EXAMINATION OF EMPLOYMENT IN THE ATOMIC ENERGY FIELD

Joe G. Baker
Manpower Research Programs
Oak Ridge Associated Universities

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SUMMARY

This study, which focuses on the years 1968-1975, singles out important employment trends in the atomic energy field and develops causal explanations for these trends. The study also provides a descriptive profile of employment in the field.

Employment in the atomic energy field has grown from 138,519 in 1963 to 197,466 in 1975, an annual rate of 3.0 percent. Private sector employment, which accounted for only 30 percent of 1968 employment, surpassed government-owned/contractor-operated (GOCO) employment in 1973 and made up 55 percent of the employment in 1975. GOCO employment declined in the early 1970s but increased slightly in 1975.

The deployment of scientists, engineers, and technicians in the GOCO sector changed little from 1968 to 1975, although there was a slight increase in the engineers' share of employment and a decrease in technicians' share of employment. Private sector deployment altered considerably, with a large increase (23 percent to 28 percent) in the engineers' share and decreases in the scientists' share and "other" employment.

Within the scientist group, the GOCO sector employment by field has changed little from 1968 to 1975. Mathematicians increased their share of employment from 14 percent to 16 percent while "all other" life scientists and geologists also increased their employment shares, although both comprise less than two percent of all GOCO scientists. Private sector scientists have seen considerable alteration of their employment; for example, physicists dropped from 32 percent of all private scientists in 1968 to 17 percent in 1975. Biological scientists increased from four percent of private sector scientists to 18 percent over the same period. Mathematicians and chemists also experienced a decline in the private sector.

There has been little change in the employment shares of engineering fields in the GOCO sector for the 1968-1975 period. The percentage of nuclear and reactor engineers and "all other" engineers has increased slightly while the percentage of mechanical and electrical engineers has decreased. Private sector engineers have seen much

greater change, with civil engineers increasing their share of all private sector engineers from six percent in 1968 to 11 percent in 1975. "All other" engineers increased from 13 percent to 19 percent during the same period, with mechanical, electrical, and chemical engineers experiencing a decline.

Of all GOCO technicians, physical science technicians have increased their employment share from 12 percent to 17 percent while "all other" technicians have declined from 20 percent to 12 percent from 1968 to 1975. Of all private sector technicians, draftsmen have increased their share from 29 percent to 37 percent and reactor operators from four percent to seven percent. "All other" technicians and electronic technicians in the private sector decreased their shares of total technician employment.

Total employment in the field is shifting toward smaller firms. In 1968, approximately 19 percent of total employment was concentrated in firms employing less than 500 workers. In 1975, these firms employed 27 percent of the total. This trend is primarily due to private sector growth.

Employment by region has changed considerably in the private sector from 1968 to 1975 with regions V and VI doubling their shares and regions II and III experiencing a decline. GOCO regional employment has also changed; region IX dropped from 20 percent to 16 percent with four other regions experiencing slight increases. The regional distribution of GOCO employment is tied closely to the regional distribution of federal funds while regional private sector employment is related to population and employment centers.

The percentage of scientists and engineers involved in research and development has declined from 68 percent in 1968 to 39 percent in 1975. Although this decline occurred in both the GOCO and private sectors, the GOCO decline was considerably less. The actual number of scientists and engineers involved in research and development in the entire atomic energy field declined from 1968 to 1973, then increased slightly in 1975.

Three private sector industrial segments—reactor design and manufacturing, nuclear facilities design and engineering, and operation and maintenance of reactors—have experienced tremendous growth from 1968 to 1975. Their growth is strongly related to

growth in nuclear electricity production. The processing of reactor fuels segment has experienced an increase in GOCO employment while the GOCO research segment has declined from 52,000 in 1968 to 26,000 in 1975.

INTRODUCTION

The atomic energy field possesses several unique characteristics that distinguish it from other sectors of the American economy. For example, much of the field has been characterized by a partnership between private industry and government. The development of atomic energy by the government commenced during World War II for military purposes. Although the Atomic Energy Act of 1946 gave the Atomic Energy Commission (AEC) the objective of developing peaceful nuclear uses, cold war pressure focused early AEC efforts toward weapons development. The production facilities for this segment, which still constitute a substantial portion of the field, are government-owned. Despite the movement toward peaceful use of the atom (e.g. atoms for peace program), the high cost and risky nature of the field made it impractical for private industry to undertake much atomic research and development. However, the public sector perceived that peaceful development of the atom was in society's long-range interests. This perception, when combined with the classified nature of the work, made it necessary for government to underwrite a large portion of the Research and Development expense. In addition, some technical information is classified and has been excluded from the normal patent system. Therefore, industrial facilities (such as the uranium enrichment facilities) utilizing this knowledge are government-owned. These factors have resulted in a large portion of the work force being employed in government-owned/contractor-operated facilities. The employment trends of these quasi-government facilities are determined to a large degree by the allocation of federal funds to these areas.

Another unique characteristic of the field is the large share of total employment that is composed of high-level manpower. The technical nature of most segments in the field and the numerous Research and Development programs demand a highly skilled, research oriented work force. The need for high-level manpower affects the field's labor market in several ways. The training time required for this type of manpower is usually considerable—often several years. The demand for this manpower is somewhat mercurial due to the large portion of employment that is directly or indirectly related

to government spending. These factors result in a market environment where surpluses or shortages are likely. In addition, a large portion of the work force is involved in Research and Development, an area where labor productivity is difficult to measure. This increases the difficulty of projecting future manpower needs in the field and corresponding training requirements.

The purpose of this report is to explain trends in employment in the atomic energy field. These trends include aggregate employment, scientific and technical employment, employment by size of firm, employment by region, employment by industrial segment, and Research and Development involvement by scientists and engineers.

DATA DESCRIPTION AND DEFINITIONS

The employment data used in this report are from the Bureau of Labor Statistics series Survey of Employment in Nuclear or Nuclear Related Energy Activities.* The series was initiated in 1960 and was sponsored by the AEC. Since 1975 the series has been sponsored by the Energy Research and Development Administration (ERDA).

The survey consists of firms that are engaged wholly or partially in atomic energy related activities including firms in the private sector and GOCO facilities. Excluded are personnel employed in federal, state, or local governments; medical institutions; uranium mining; construction of nuclear-related facilities; and universities. The survey queries each firm about the portion of the work force that is atomic energy related, with detailed information requested for engineer, technician, and scientist occupations within this area. The firm responses are then aggregated by size of establishment (number of employees), industrial segment, GOCO-private employment, geographic region, and individual occupation groups. In addition, data are available on the number of scientists and engineers who spend 50 percent or more of their time in atomic energy related research and development.

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*Prior to 1975 the survey was known as Survey of Scientific and Technical Personnel in the Atomic Energy Field.

There are several problems with the data, however. Data are incomplete in some of the categories for individual survey years. Classification criteria have changed for some of the industrial segments over the survey life. The most difficult problem for trend analysis of the data results from an expansion in the number of establishments queried in 1973 and again in 1975: it is impossible to determine how much of the additional employment shown for these years is due to economic growth or a more comprehensive survey coverage. A detailed discussion of the effects of this expanded universe is presented in Appendix A. The 1968-1971 survey results are fairly consistent in terms of coverage and definitions.

When "adjusted" data base is used in the report, it refers to only those firms that were surveyed prior to 1973, thus excluding employment data from the expanded survey universe. It is referred to as "adjusted data" or the "constant survey universe."

The products produced by the firms studied are not substitutes but range from reactor vessels to nuclear medicine. This lack of competition among some groups of firms does not fit the economic definition of an "industry," hence the use of the term "atomic energy field." Within the field there are 21 defined economic segments, such as the reactor design and manufacturing segment, which more closely conform to the economic term "industry." The field is divided into two types of firms; "GOCO" and "private." GOCO firms are government-owned contractor operated facilities such as the national laboratories or gaseous diffusion plants. In these firms, the plant and equipment are federal property and the workforce is private, operating the facility under contract. Private firm's plant and equipment and workforce are nongovernment. Total employment in the atomic energy field is thus divided between the "GOCO sector" and the "private sector." The term "government" in this report does not include GOCO workers, but refers to federal employees.

CHAPTER 1 1975 DATA PROFILE

The employment data examined in this section are the results of a survey of 1063 establishments engaged in various industrial segments of the atomic energy field. To best approximate the field's employment in 1975, the data presented here include the firms added to the survey since 1973.

AGGREGATE EMPLOYMENT

The results of the 1973 survey of employment in the atomic energy field showed employment in the private sector surpassing GOCO employment for the first time. The 1975 data indicate that this trend is continuing, with the private sector constituting an even larger portion of total employment within the field.

Total survey employment in 1975 was 197,446, a growth of over 26,000 from the 1973 total. Approximately two-thirds of this growth can be attributed to an expansion of the number of firms surveyed in 1975. Of the total employment, the private sector share accounts for almost 55 percent (108,092 workers). This is in marked contrast to the 1968 survey in which only 30 percent of total employment was contained in the private sector.

The atomic energy work force is composed of a large share of high-level manpower, reflecting the highly technical nature of the field. Although emphasis has shifted in recent years toward the commercialization and practical application of atomic energy, the field still contains a large proportion of workers engaged in research and development. The trend toward commercialization is reflected in the increasing share of private employment in the field.

These factors have resulted in a large number of scientists, engineers and technicians in the atomic energy field. In 1975, almost 30 percent of the atomic energy field work force was composed of scientists and engineers compared to approximately two percent of the total U.S. work force (see Figure 1). The relatively larger amount of Research and Development conducted in the GOCO sector is reflected by the large percentage of scientists employed. The private sector, with more emphasis on applied work, has fewer scientists and a much larger share of engineers and technicians.

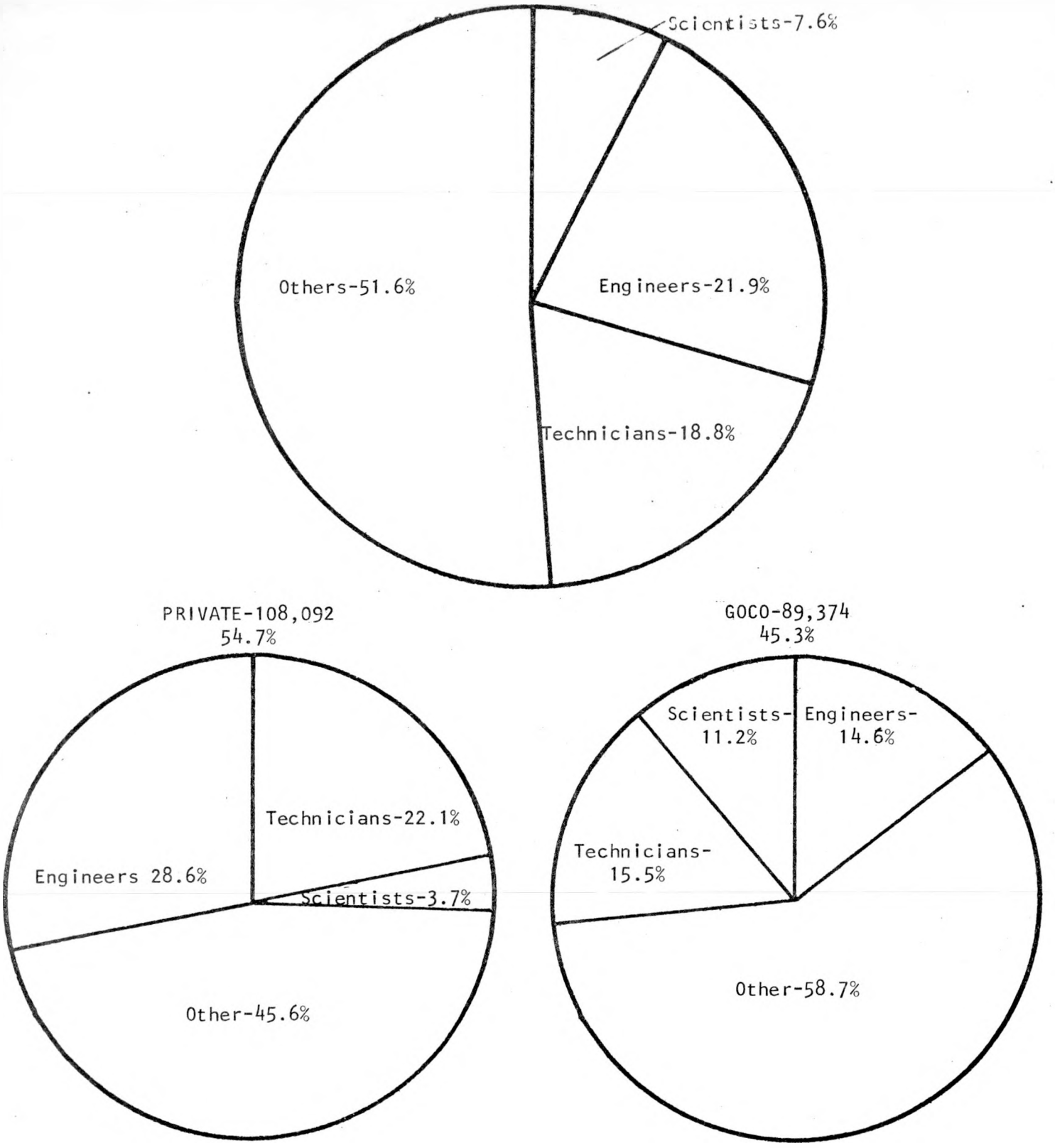


Figure 1. 1975 Total Atomic Energy Employment

ENGINEERS

Figure 2 shows the portion of those in individual engineering occupational fields engaged in research and development. Mechanical engineers made up almost one-third of all engineers in the atomic energy field, followed by electrical with 19 percent and nuclear and reactor with 15 percent. All other engineering fields accounted for less than 10 percent of the total.

Of all engineers employed in the atomic energy field, less than 30 percent were involved in research and development. Almost one-half of all metallurgical engineers (46 percent) were involved in research and development, while only seven percent of the civil engineers were. Other engineering fields heavily involved in research and development were mechanical, chemical and electrical.

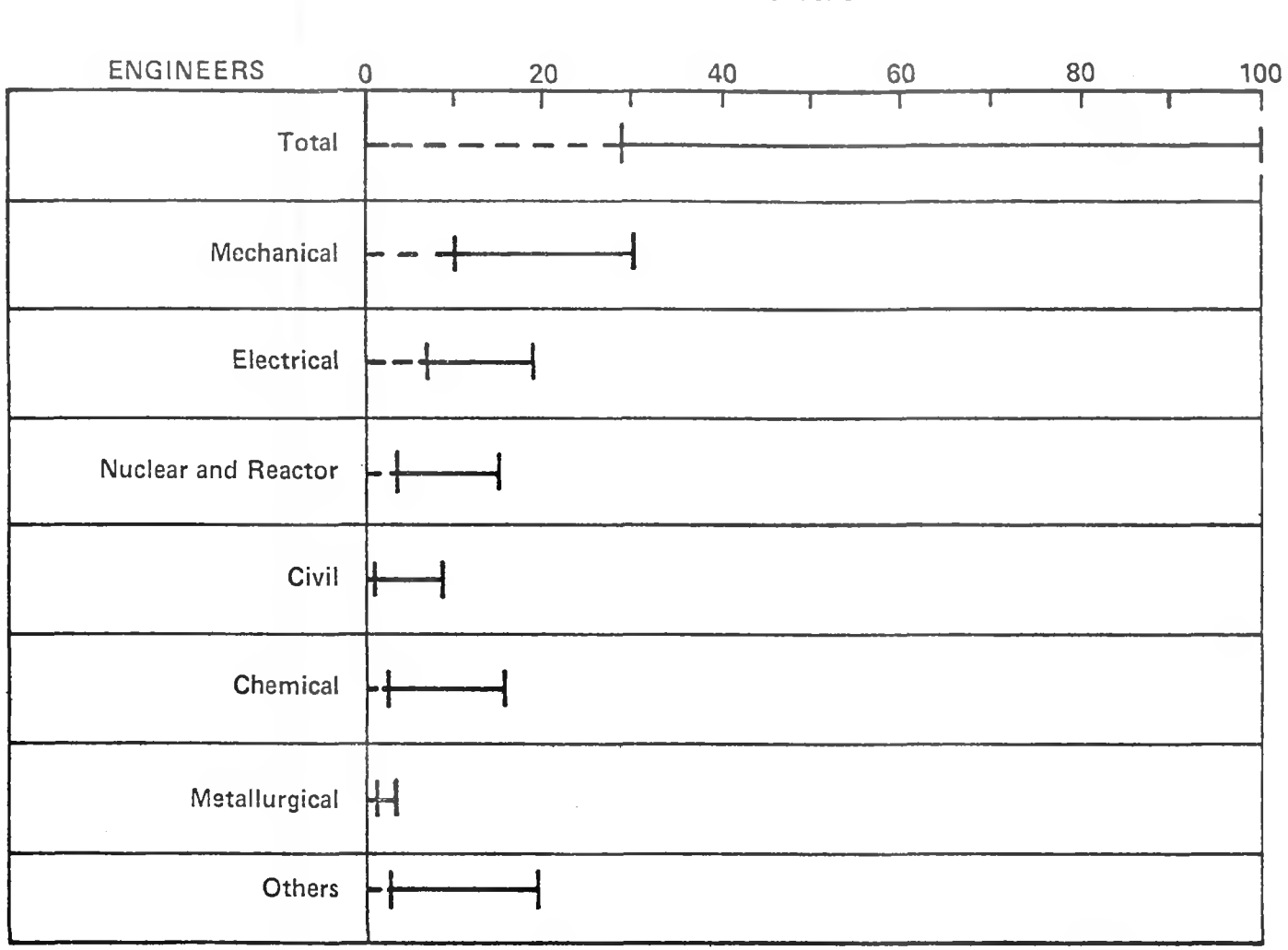
SCIENTISTS

Figure 3 is a breakdown of the scientific occupations. Almost two-thirds of this group consists of physical scientists, followed by life scientists with 22 percent and mathematicians with 14 percent. Physicists and chemists account for over 80 percent of all physical scientists, with the remainder scattered over serveral fields. A higher percentage of physical scientists (73 percent) are involved in research and development than any other engineering or scientific group. Physicists, with 86 percent involved in research and development activities, are the most research oriented group in the entire atomic energy field. As one would expect, the GOCO sector employs the majority of physicists (79 percent) in the field.

The life scientist group is dominated by biologists and health physicists, who together constitute 77 percent of all life scientists. The life scientists are not engaged in research to the extent of the physical scientists. Approximately two-thirds of all scientists are engaged in research and development, with 53 percent of all mathematicians engaged in research and development.

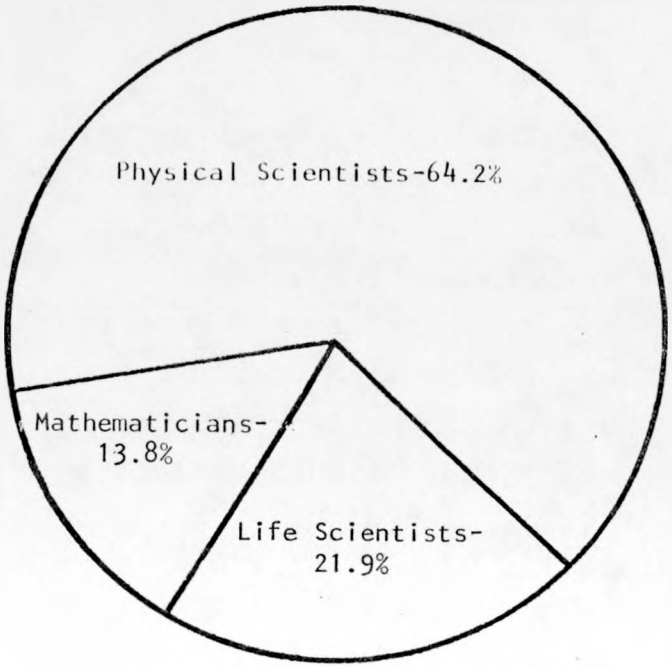
REGIONAL EMPLOYMENT

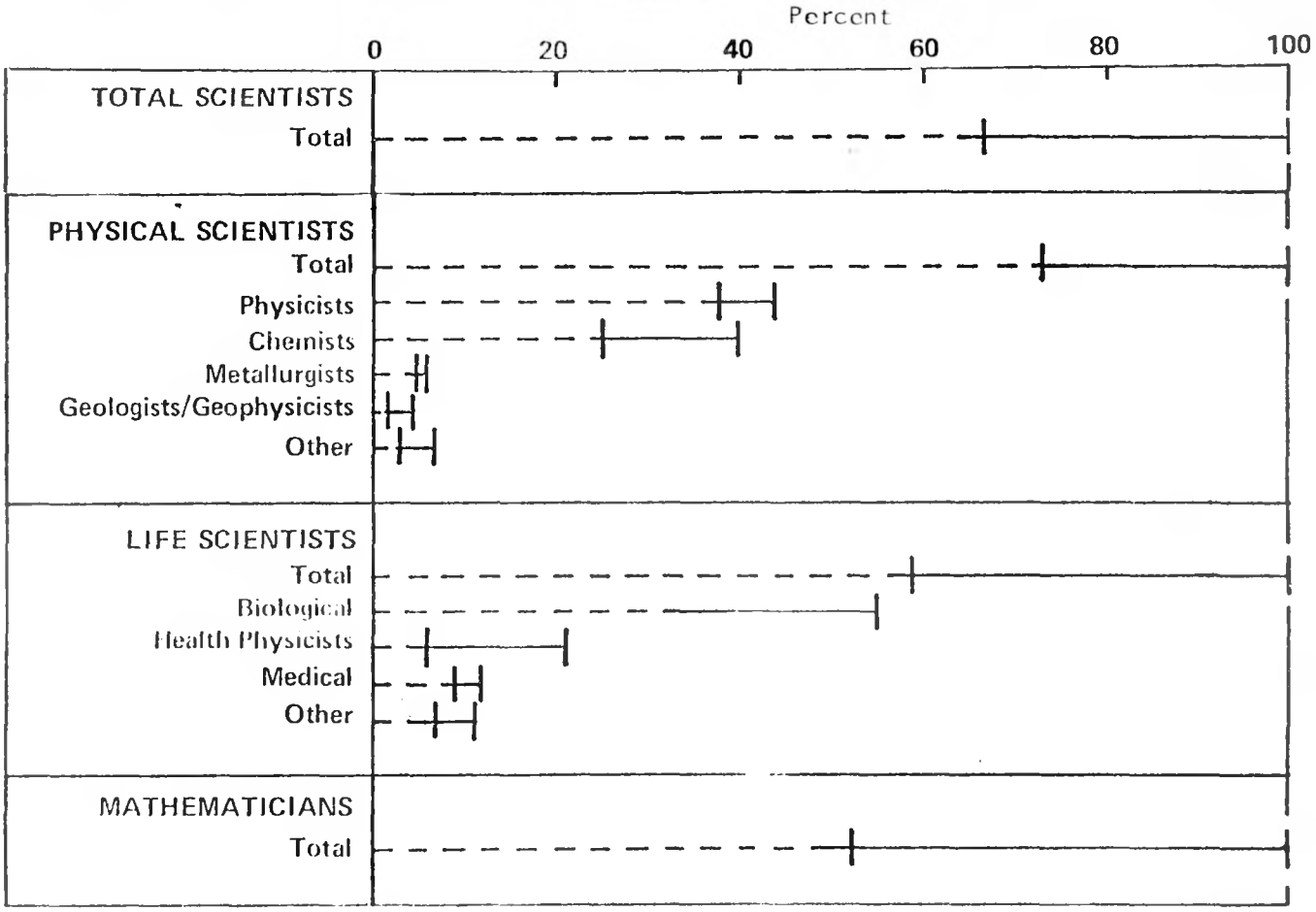
Employment in 1975 was fairly well dispersed geographically, although the western regions made up a large portion of the total (see Figure 4). The Mountain and Pacific regions together account for approximately one-third of the total atomic energy field employ-



---------Field involved in R&D.

Figure 2. 1975 Engineering Fields by Research and Development Share





------Field involved in Research and Development

Figure 3. 1975 Scientific Fields by Research and Development Shares.

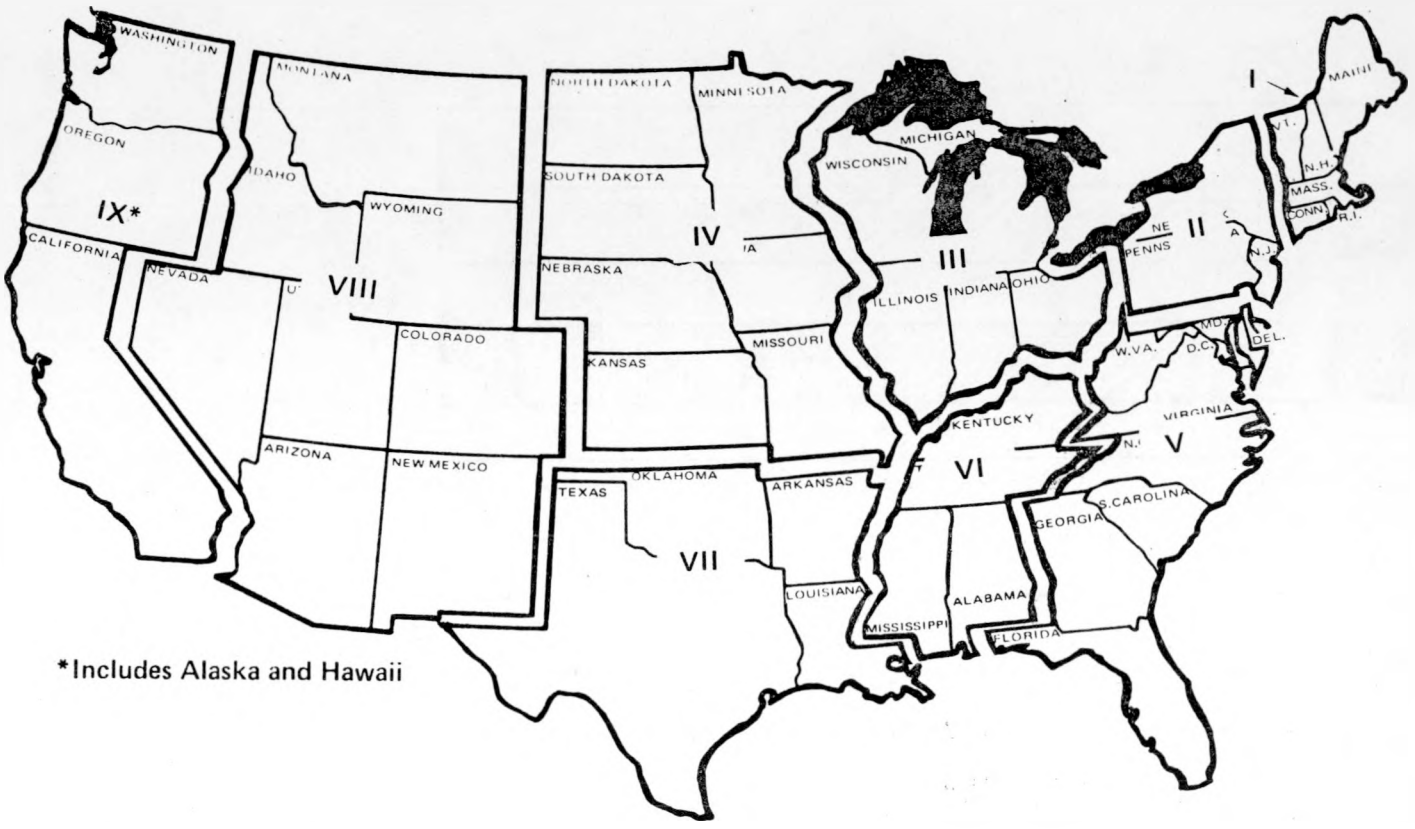
ment, while these two regions make up only 18 percent of the total economy's work force. The Middle Atlantic region is also a large employer of atomic energy workers, with over 34,000 employed in 1975. The West North-Central and West South-Central regions had quite small work forces in the field.

Figure 5 breaks out the relative occupational shares by region for the atomic energy field. With the exception of the technician category, the occupations show a large amount of variance among the different regions. The variances reflect to a large degree the type of atomic energy activity within the region. Regions VIII and IX are research oriented and contain a large amount of GOCO employment. The scientific share in these regions is larger than the other regional shares. Regions I and IV both have very small amounts of research and employment shares of scientists. The two largest regions, II and IX, have similar occupational patterns for engineers, technicians, and "other" category.

SEGMENT EMPLOYMENT

Figure 6 details employment by segment by GOCO and private establishments for the field in 1975. With the increasing commercial utilization of nuclear power, the design of nuclear facilities segment has surpassed the weapons development and research segments to become the largest employer of all economic segments. Only seven percent of the design of nuclear facilities segment work force is in GOCO facilities compared with 99 percent for the weapons segment and 79 percent for the research segment. The fourth largest segment, reactor design and manufacturing, contains no GOCO employment. Of the 20 basic economic segments utilized in data collection, the top three segments (reactor design and manufacturing, weapons development, and design of nuclear facilities) account for 47 percent of the field's total employment.

A recent study conducted by the Bureau of Labor Statistics (BLS) has shown that the survey methodology employed to develop segment employment estimates results in upward bias in some segments and



Region		1975 Employment	Percent
I	New England	10,529	5.3
II	Middle Atlantic	34,194	17.3
III	East North-Central	25,626	13.0
IV	West North-Central	6,534	3.3
V	South Atlantic	24,731	12.5
VI	East South-Central	24,199	12.2
VII	West South-Central	4,885	2.5
VIII	Mountain	27,565	14.0
IX	Pacific	39,203	19.8
	Total	197,466	100.0

Figure 4. 1975 Employment by Region

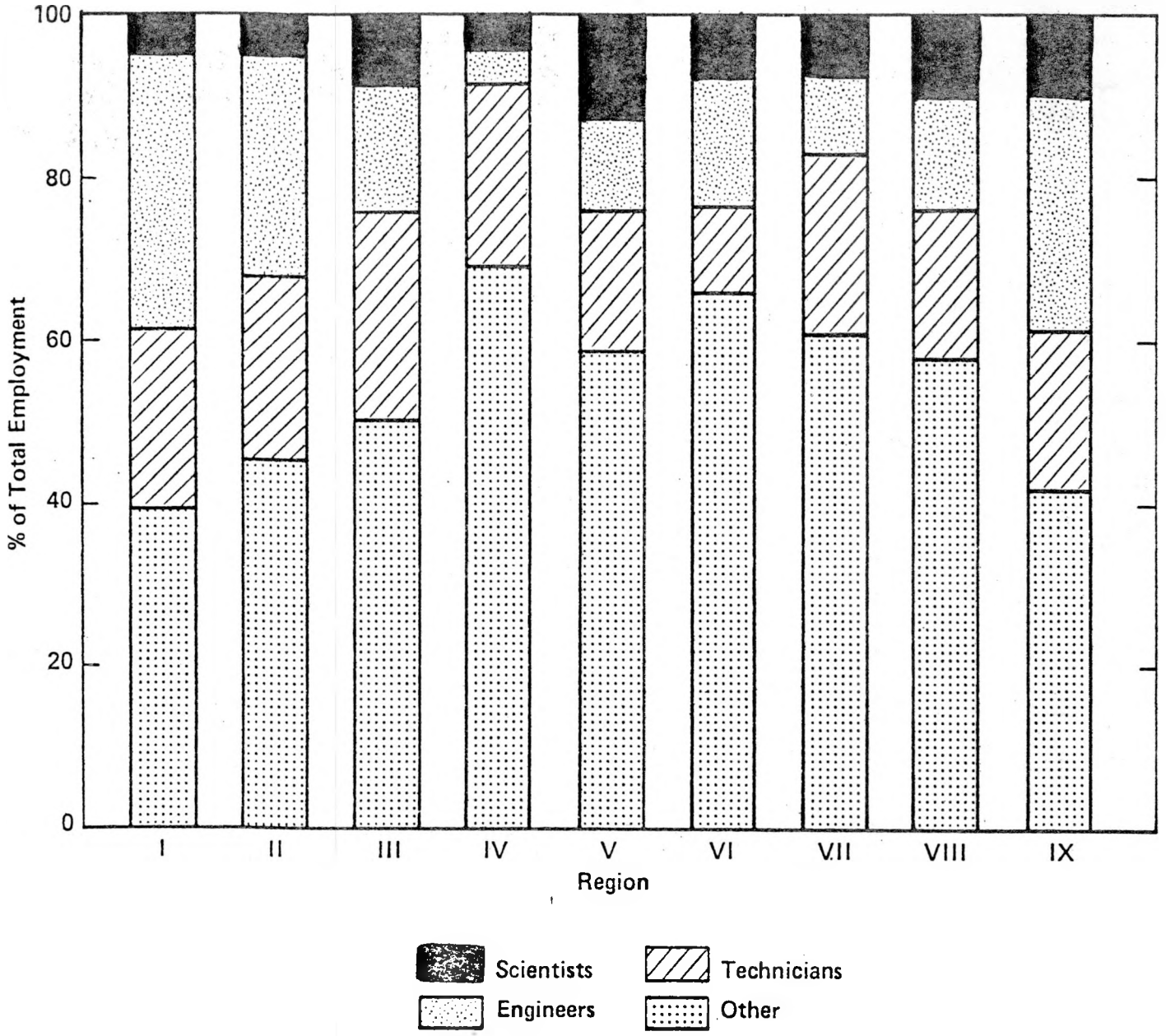
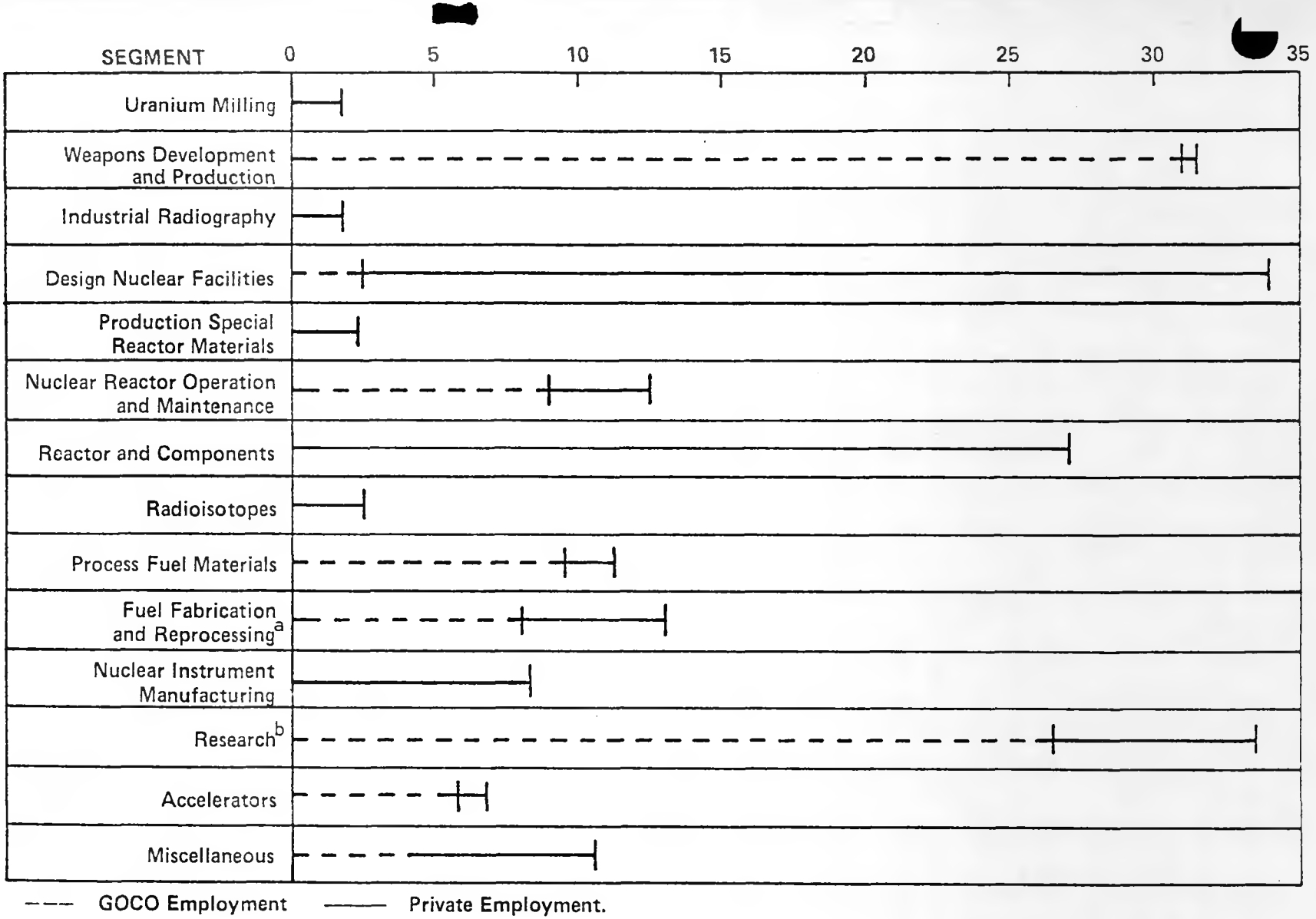


Figure 5. Occupational Shares by Region, 1975



[a]The fuel fabrication and reprocessing segment is composed of the fuel fabrication segment, transportation of nuclear materials segment; and chemical reprocessing of fuel segment.

[b]The research segment is the sum of environmental and ecological research, reactor research and development and evaluation, biological and medical research, health and industrial safety, and research and development in atomic energy.

Figure 6. 1975 GOCO/Private Employment by Economic Segment
(1000's of workers)

downward bias in others.[1] Although data concerning GOCO and private sector biases are unavailable, Appendix B shows the affect of this error upon total employment by segment.

EMPLOYMENT BY FIRM SIZE

Figure 7 shows a breakdown of how employment in the atomic energy field was distributed by firm size. The industry is dominated by very large firms; almost two-thirds of all employment was concentrated in firms with 1000 or more employees. Many of the very large firms are GOCO facilities. Although their share of employment is growing, firms employing less than 100 workers still contain less than 10 percent of the industry's total employment.

[1] U.S. Department of Labor, Bureau of Labor Statistics, "1975 Nuclear Energy Survey - Multiple Segment Reports," Xeroxed, 1977. When a firm is involved in more than one economic segment, it is classified in the segment where the largest portion of its workers are involved. All of the firm's workers are counted in this primary segment even though some are actually working in other segments.

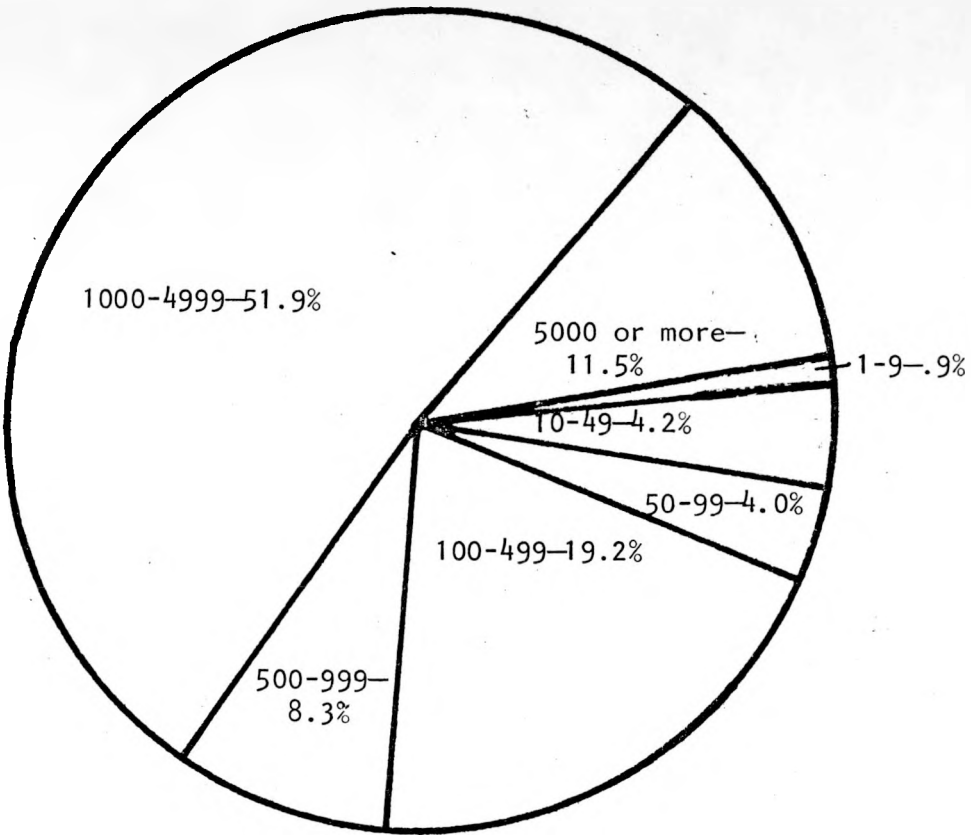


Figure 7. 1975 Employment by Firm Size

CHAPTER 2
EMPLOYMENT TRENDS IN THE ATOMIC ENERGY FIELD

This chapter examines employment trends in the atomic energy field for the years 1968-1975. Although data are available for years prior to 1968, missing data in some of the employment categories and changes in economic segment definitions prevent their use. The 1968-1975 data base was selected because the data are comparable. To provide historical perspective, results of the 1963 survey are presented.[1]

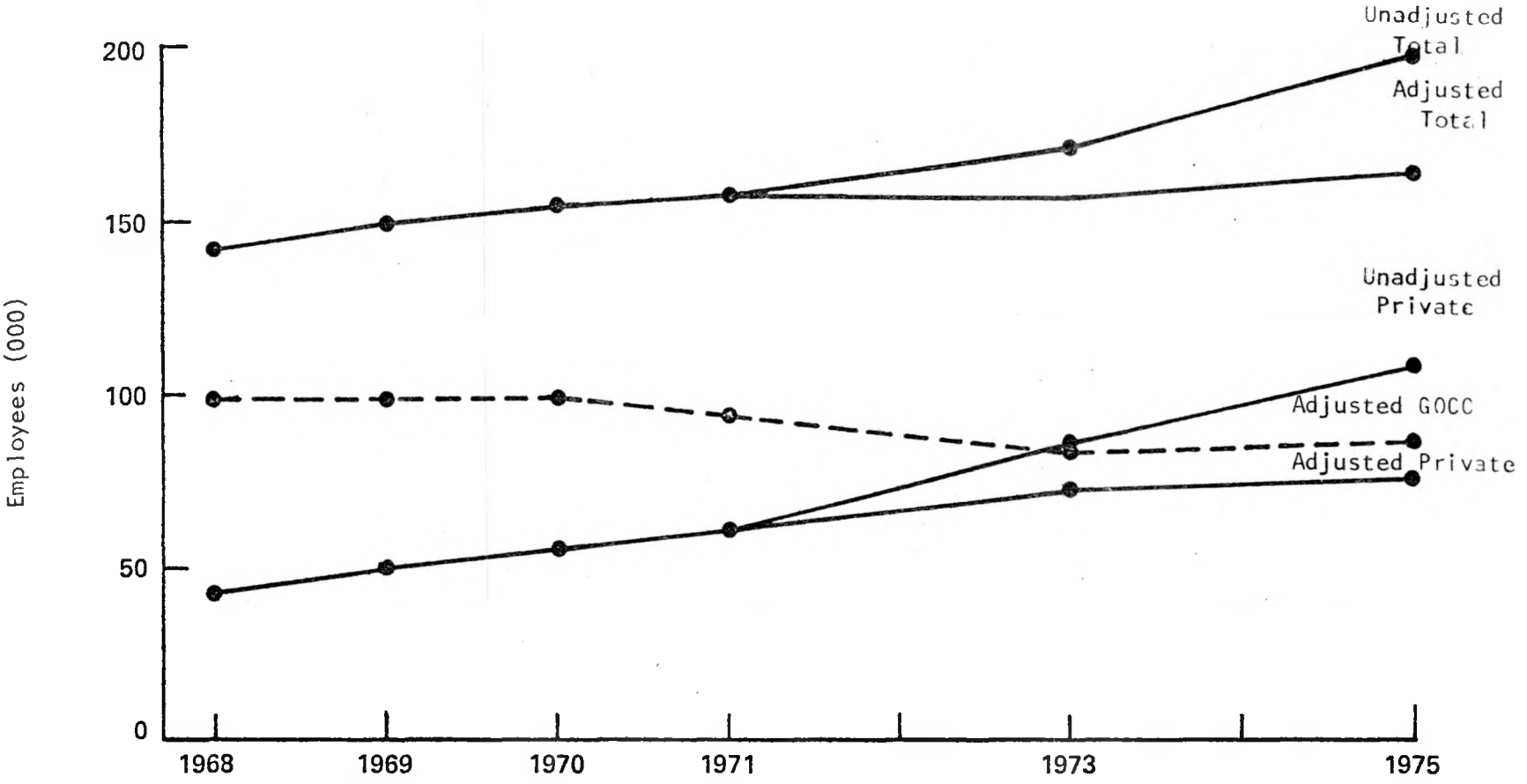
Changes in employment are the result of several factors; the most important is final demand for the goods or service produced by the work force. Changes in the mix of economic segments in the field affect the work force by changing the mix of occupations required. The occupational mix is also affected by changes in the way goods or services are produced, i.e., technological change. In light of this, we will examine changes in atomic energy field employment in terms of employment levels and changes in the structure of employment.

TOTAL EMPLOYMENT TRENDS

Total employment in the field has grown from a known universe of 138,519 in 1963 to 197,466 in 1975. This yearly growth rate of 3.0 percent compares to a growth rate in the total economy's employment for this period of only 2.5 percent. Virtually all of the growth in employment in the field has been in the private sector. The "watershed" year was 1973; the unadjusted survey results showed private sector employment exceeding GOCO employment for the first time.

While the private sector was showing healthy growth, the GOCO segment actually declined in total employment. As shown in Figure 8, the total GOCO employment figure remained fairly constant from 1968 through 1970. The 1971 and 1973 surveys showed a decrease in

[1] In 1963 workers who spent any time in nuclear-related activities were counted in the field. In 1968, this was changed to only those workers who spent 50 percent or more time in nuclear-related activities.



Note: Adjusted and unadjusted figures for the GOCO sector vary by only a small amount. The unadjusted GOCO trend line was therefore excluded from the chart.

Figure 8. Adjusted and Unadjusted Aggregate Employment Trends in the Atomic Energy Field

total GOCO employment. Combined with the rapid growth of the private sector, this decrease resulted in the 1973 watershed year. GOCO employment recovered slightly in the 1975 survey.

The demand for workers in the GOCO sector is related directly to the level of government spending in this area. Utilizing AEC and ERDA financial reports, these data show that GOCO employment is highly correlated with operations expenditures in real terms for these years[1] (see Table C-1). Total operations expenditures were fairly constant with only slight declines during the early 1970s; however, inflation was substantially reducing the level of real expenditures. Employment declined accordingly.

The basis of aggregate employment trends in the private sector is not as easily uncovered. This sector has no single measure of demand, such as federal expenditures, but consists of a large number of firms engaged in several different industrial segments within the field. However, data are available on the total value of shipments for selected services and products in the atomic energy field.[2]

Using the constant dollar figure of total value of shipments as an index of total demand, there is a strong correlation between this measure of demand and total private employment[3] (see Table C-2).

SCIENTISTS, ENGINEERS, AND TECHNICIANS

The structure of employment in the atomic energy field by the three occupational clusters (scientist, engineer, and technician) has remained fairly stable over the years examined. Table 2-1 shows the adjusted and unadjusted percentage distribution of these occupational clusters for the 1968 survey year and 1975. Engineers, especially in the private sector, have increased their share of

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[1]The linear coefficient of correlation indicated that 85.8 percent of the GOCO employment variance was explained by funding levels.

[2]Department of Commerce, Bureau of Census, Current Industrial Reports Selected Atomic Energy Products, Series MA-38Q.

[3]The linear coefficient of correlation is greater than 80 percent for both adjusted and unadjusted data.

total employment at the expense of the scientists and "other" occupational clusters.[1] The engineering cluster also increased by a small amount in the GOCO sector, but overall the occupational structure of the GOCO sector is very stable. Table C-3 shows the employment figure trends for these occupational clusters.

TABLE 2-1

Percentage Distribution of Scientists, Engineers, and Technicians in the Atomic Energy Field, 1968 and 1975

	1968	1975	
		Adjusted	Unadjusted
Scientists			
GOCO	10.7	11.3	11.0
Private	5.6	3.8	4.9
Engineers			
GOCO	13.0	14.6	14.6
Private	22.9	28.5	27.9
Technicians			
GOCO	16.6	15.5	15.8
Private	21.1	22.1	21.2
Other			
GOCO	59.7	58.7	58.5
Private	50.4	45.5	46.0
Total			
GOCO	100.0	100.0	100.0
Private	100.0	100.0	100.0

Table 2-2 shows the adjusted and unadjusted percentage distribution of specific fields within the scientists group for both the GOCO and private sectors. The GOCO percentages under each field show that field's share of total GOCO employment for that year. Most of the specific scientific field shares have remained stable over the years examined.

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[1]The "other" occupational category is defined as those who are not scientists, engineers, or technicians. This group includes craftsmen, operatives, and clerical workers.

TABLE 2-2

Percentage Distribution Trends of
Nuclear-Related Scientists

	1968	1971	1973 Adj.	1973 Unadj.	1975 Adj.	1975 Unadj.
Total Scientists						
GOCO	10,631	9,782	9,622	9,746	9,729	9,871
Private	2,393	2,675	2,927	3,819	2,889	5,281
Mathematicians						
GOCO	14.1%	14.4%	14.6%	14.5%	16.1%	16.1%
Private	12.4	10.4	12.1	10.9	12.2	9.4
Chemists						
GOCO	28.3	28.9	28.4	28.1	25.8	25.6
PRivate	32.5	31.2	25.3	25.9	27.7	24.5
Geologists & Geophysicists						
GOCO	.5	.6	1.0	1.0	1.6	1.5
Private	1.8	2.0	2.6	2.5	2.4	5.0
Physicists						
GOCO	34.6	33.5	33.7	33.7	34.4	34.3
Private	32.3	27.1	16.7	17.3	17.3	16.8
Metallurgists						
GOCO	5.5	4.3	4.9	4.9	3.8	3.7
Private	7.3	6.2	6.7	6.2	5.0	4.0
Other Physical Scientists						
GOCO	4.1	4.0	2.4	2.5	4.0	4.1
Private	1.6	1.6	3.6	3.4	4.5	4.3
Biological Scientists						
GOCO	7.7	7.1	8.1	8.3	7.0	7.2
Poivate	3.9	9.7	22.6	24.0	18.2	21.5
Medical Scientists						
GOCO	.8	.9	.6	.6	1.0	1.0
Private	.6	1.2	.6	1.0	2.6	5.8
Health Physicists						
GOCO	4.2	4.9	4.6	4.7	3.7	3.8
Private	7.4	9.2	9.3	8.4	8.3	6.3
All Other Life Scientists						
GOCO	.3	1.2	1.7	1.6	2.6	2.5
Private	.2	.6	.3	.4	1.7	2.3

See Table C-4 for absolute numbers.

The mathematician group has increased from 14.1 percent to 16.1 percent of all GOCO scientists; the "all other life scientists" group has increased ninefold, from 0.3 percent in 1968 to 2.6 percent in 1975; and the percentage share of geologists and geophysicists has tripled from 0.5 to 1.5. Metallurgists and chemists have both experienced a declince in their employment shares.

The distribution of private sector scientists by field of specialization is more dynamic, with several occupational fields showing large variations in employment shares over the years examined. Physicists in particular have shown a large decrease in relative employment, dropping from a high of almost one physicist for every three scientists employed in 1968 to one in six in 1975. The percentage shares of mathematicians and chemists have also dropped appreciably. The biological scientists increased rapidly over this same time frame, from approximately four percent of the total in 1968 to over 18 percent in 1975. Other fields experiencing substantial growth were the "other physical scientists" group; medical scientists; and the "all other life scientists" group. (see Table C-3 for the number employed in each scientific field.)

Table 2-3 shows the adjusted and unadjusted distribution of specific fields within the engineering occupational cluster. As a group, engineers have been increasing their share of total employment in the atomic energy field, with a compound growth rate of 12 percent in the private sector for the constant survey universe 1968 to 1975 (see Table C-3). The number of engineers employed in the GOCO sector actually declined during this period for the constant survey universe, but by a smaller amount than total GOCO employment. This slightly increased the engineer's share of total GOCO employment. Mechanical engineers have dominated both the GOCO and private sectors over the years examined. As with scientists, the structure of engineers' employment by occupational field within the GOCO sector has changed little over the years examined for both adjusted and unadjusted data. Nuclear and reactor engineers and "all other" engineers have increased their share slightly at the expense of the mechanical and electrical and electronic engineering fields.

TABLE 2-3

Percentage Distribution Trends of
Nuclear-Related Engineers

	1968	1971	1973 Adj.	1973 Unadj.	1975 Adj.	1975 Unadj.
Total						
GOCO	12,833	12,818	11,726	11,943	12,705	13,056
Private	9,802	14,781	18,430	21,098	21,597	30,179
Chemical						
GOCO	11.6%	12.2%	12.2%	12.1%	11.3%	11.1%
Private	5.5	4.0	4.2	4.2	3.0	3.3
Civil						
GOCO	3.0	3.2	3.4	3.3	2.9	3.0
Private	6.4	8.0	9.7	8.9	11.1	11.1
Electrical and Electronics						
GOCO	25.3	24.7	25.4	25.3	23.7	23.6
Private	19.1	17.3	18.1	17.8	17.5	16.3
Mechanical						
GOCO	31.1	29.8	32.5	32.4	29.8	29.6
Private	35.5	36.1	33.2	32.9	30.5	30.3
Nuclear and Reactor						
GOCO	8.8	10.5	7.5	7.9	9.9	10.3
Private	16.2	15.7	16.3	16.8	16.9	16.7
Metallurgical						
GOCO	3.7	3.8	3.9	3.9	4.0	4.0
Private	4.3	3.5	3.2	3.1	3.1	3.1
All Other						
GOCO	16.8	15.8	14.9	15.0	18.3	18.4
Private	12.9	15.3	15.4	16.2	17.7	19.2

The employment shares of the engineering occupational fields in the private sector are more dynamic, with large variations for some occupational fields. As with the GOCO sector, the mechanical and electrical and electronic engineering field shares have declined, although by a larger amount than the GOCO decline. The civil engineering field has almost doubled its share of total engineering employment, increasing from 6.4 percent of the total in 1968 to 11.1 percent in 1975. In addition to civil engineers, the "all other" engineering group has increased its share of total engineering employment. While there has been little change in the occupational structure of GOCO scientist and engineer employment, technicians have changed.

Table 2-4 shows trends in the occupational fields within the technician group for 1968 to 1975. Utilizing the constant survey universe, these data show that GOCO sector does not exhibit stability to the degree demonstrated within the GOCO scientist and engineer groups, although the distribution is more stable than the private technician distribution. Physical science technicians within the GOCO sector have increased their share of total technician employment from 11.6 percent in 1968 to 18 percent in 1975. The "all other" technician category has decreased by 8 percent during this same period. The other technician shares in the GOCO sector have remained fairly constant.

Within the private sector, nuclear reactor operators and draftsmen have increased their share of the total adjusted private technician employment at the expense of the physical science technician group, the "all other" category, and the electrical and electronic technician fields. As a group, the share of total employment constituting all technicians in both the GOCO and private sector has changed little over the years examined (see Table 2-1).

Given the occupational structure of each economic segment within the atomic energy field, one could explain the changes in the occupational mix of the field by examining changes in the economic segment mix. However, data were not collected by occupation by economic segment, so the analysis is impossible.

Trends in the occupational structure of the field suggest several things. The occupational structure of the GOCO segment has been fairly stable over the years, largely reflecting its concentration of employment in three economic segments: processing reactor fuels, research, and weapons development and production. The influence of research by the GOCO sector is evident in its occupational structure. The GOCO sector employs a relatively larger number of scientists in the physics and mathematics fields, both of which are heavily oriented to research.

The private sector's occupational structure has changed over the survey years, reflecting the rapid growth of this sector and the wider range of involvement by economic segments. The trend of the private sector is one of decreasing emphasis upon research

TABLE 2-4

Percentage Distribution Trends of
Nuclear-Related Technicians

	1968	1971	1973 Adj.	1973 Unadj.	1975 Adj.	1975 Unadj.
All Technicians						
GOCO	16,386	15,383	13,450	13,905	13,496	14,142
Private	9,007	14,332	15,638	17,928	16,714	22,915
Draftsmen						
GOCO	12.5%	14.1%	14.7%	14.3%	13.5%	13.4%
Private	29.2	34.8	34.9	33.2	37.6	36.7
Electrical and Electronics						
GOCO	23.5	22.3	23.1	22.4	22.6	21.8
Private	15.5	12.2	11.6	11.9	11.2	10.7
All Other Engineers						
GOCO	21.2	23.1	22.9	22.7	22.3	21.9
Private	16.5	16.1	22.2	21.6	18.8	17.8
Physical Science						
GOCO	11.6	14.1	18.2	17.7	18.0	17.4
Private	6.5	6.0	3.8	3.9	3.2	3.4
Life Science						
GOCO	2.6	2.4	3.3	3.7	3.7	4.0
Private	1.1	.6	.7	1.3	1.0	2.5
Health Physics Technicians						
GOCO	5.8	7.0	7.4	7.5	6.5	6.5
Private	3.7	4.3	5.0	4.8	4.9	4.2
Nuclear Reactor Operator						
GOCO	3.0	2.2	1.8	2.5	2.5	3.3
Private	4.3	6.9	7.8	7.0	8.8	6.9
All Other						
GOCO	19.7	14.7	8.5	9.2	10.9	11.6
Private	23.1	19.0	13.9	16.3	14.4	17.8

and development and increasing commercialization and application of atomic power; this trend is reflected in the growing importance of engineers in the private sector, particularly the civil engineering group. The trend is also evident in the employment of technicians, where the draftsman and nuclear reactor operator groups have shown relatively large increases. These data are consistent with the rapid growth of the design of nuclear facilities segment and the nuclear reactor operation and maintenance segment.

TRENDS IN EMPLOYMENT BY FIRM SIZE

Table 2-5 details the percentage distribution of total employment among the various size firms in 1968 and 1975. The 1975 data include those firms added to the survey universe in 1973 and 1975 (adjusted data are unavailable by firm size). It is therefore not possible to determine how much of the change in firm size distribution is due to growth or the expanded universe.

Private sector data show that there has been little change in the employment distribution of all firms employing less than 500 workers. For the larger size firms, however, employment shares have varied considerably over the period examined, with the data showing a large shift from the 500-999 size group to the 1000-4999 size group. While no private firms appeared in the 5000+ category in 1968, one private sector firm appeared there in 1975 (see Table C-7). Because of the small number of firms in the large size groups, the employment percentages are more sensitive to individual firm employment decisions.

TABLE 2-5

Percentage Distribution by Firm Size

	Private		GOCO		Total	
Firm Size	1968	1975[a]	1968	1975[a]	1968	1975[a]
1-9	1.2	1.4	0	0	0.3	0.8
10-49	7.8	7.5	.1	.2	2.4	4.2
50-99	7.5	7.0	.2	.5	2.4	4.0
100-499	35.7	32.1	4.6	3.6	14.0	19.2
500-999	20.4	10.7	4.6	5.5	9.3	8.3
1000-4999	27.4	36.6	44.8	70.4	39.6	51.9
5000+	0	4.7	45.7	19.7	31.9	11.5
	100.0	100.0	100.0	100.0	100.0	100.0

[a]These data are unadjusted.

Because the number of GOCO firms surveyed changed little from 1968 to 1975, one can consider the GOCO data in Table 2-5 as representative of employment changes rather than survey universe changes. Like the private sector distribution, the GOCO sector exhibits relative stability in the size distribution of employment for small (less than 500 workers) firms. This relative stability is also evident in the 500-999 size firms in the GOCO sector.

In the two largest size categories, the GOCO sector exhibits considerable shifts in employment shares from 1968 to 1975. Total GOCO employment declined by over 10,000 workers during this time period, so these changes are a result of reductions rather than growth in the GOCO sector. Approximately 26 percent shifted from the largest size category to the 1000-4999 size group from 1968 to 1975. Most of this shift is explained by the loss of about 6000 workers in five giant GOCO firms.[1] This reduction in employment resulted in a reclassification of these firms into the next smallest size group, thereby shifting over 23,000 workers from the largest group to the 1000-4999 size group in 1975.

The firm size distribution of total employment shows a trend toward smaller size firms. In 1968, only 19 percent of total employment was concentrated in firms employing less than 500 workers. In 1975, these firms employed over 27 percent of the total. The trend towards smaller firms is partially explained by the increasing share of total employment made up of private sector firms that have a larger percentage of total employment in the smaller size groups.

Table 2-6 details the distribution of scientists, engineers, and technicians within each firm size group for the 1968-1975 period. As is the case for all the firm size group data, the 1975 figures are unadjusted.

Within the private sector, there does not seem to be any unifying trend characteristic of occupational employment by firm size. The two smallest size groups exhibit fairly stable occupational distributions with the technician groups showing the most

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[1] GOCO Employment Summary Report, Division of Labor Relations, Energy Research and Development Administration.

TABLE 2-6

Percentage Distribution of Scientists, Engineers, and Technicians by Firm Size in the Atomic Energy Field[a]

	Private		GOCO	
	1968	1975[b]	1968	1975[b]
1-9				
Scientists	17.1	15.5	0	100.0
Engineers	23.9	23.3	0	0
Technicians	44.2	37.2	0	0
10-49				
Scientists	12.7	11.8	3.3	21.0
Engineers	21.5	22.9	16.5	5.1
Technicians	31.4	28.8	31.9	14.0
50-99				
Scientists	6.2	8.5	12.6	20.3
Engineers	25.7	22.2	13.6	16.5
Technicians	31.6	23.4	8.4	16.5
100-499				
Scientists	6.1	5.7	19.7	18.3
Engineers	23.2	21.9	13.1	16.6
Technicians	21.1	20.0	31.7	27.2
500-999				
Scientists	1.2	2.1	11.9	7.2
Engineers	19.5	23.0	10.1	16.8
Technicians	18.4	18.2	10.6	22.9
1000-4999				
Scientists	5.0	2.8	9.7	10.4
Engineers	24.8	35.0	14.1	14.4
Technicians	16.2	21.7	16.7	14.0
5000+				
Scientists	-	1.9	10.7	12.4
Engineers	-	42.5	12.2	14.5
Technicians	-	12.3	15.4	18.3

[a]Table shows percentage of total employment in each firm size group composed of scientists, engineers and technicians. Totals do not add to 100.0 due to exclusion of "other" employees.

[b]These percentages computed from unadjusted data.

change. The 50-99 size group has an increasing share of scientists and decreasing relative employment of engineers, both of which are counter to the trends in the shares of these groups for the private sector as a whole. The large size groups (500 or more employees) are characterized by increasing employment shares for engineers and decreasing shares for scientists.

In the GOCO sector, those firms in size groups of less than 1000 employees have dynamic occupational distributions over the years examined. The 10-49 firm size group in particular has large shifts in the percentage of scientists, engineers, and technicians employed from 1968 to 1975. The occupational distributions of the two largest GOCO size groups are fairly stable over the years examined.

TRENDS IN EMPLOYMENT BY REGION

Table 2-7 shows the percentage distribution of total employment by geographic region in 1968, 1971, and 1975. The 1975 data include those firms added to the survey universe in 1973 and in 1975 (adjusted data are not available by geographic region). Changes in regional employment distribution result from both growth and an expanded survey universe. Table C-8 shows the states included in the various regions.

TABLE 2-7

Percentage Distribution of Employment by Region

	Private			GOCO			Total		
Region	1968	1971	1975[a]	1968	1971	1975[a]	1968	1971	1975[a]
I	10.0	8.9	9.6	.8	.3	.2	3.6	3.7	5.3
II	26.1	21.8	22.0	9.9	9.9	11.6	14.8	14.5	17.3
III	19.4	19.3	14.6	8.9	9.8	11.1	12.1	13.5	13.0
IV	1.5	2.0	1.6	7.9	10.5	5.4	6.0	7.2	3.3
V	8.7	18.2	16.5	7.3	7.1	7.7	7.8	11.5	12.5
VI	3.5	4.9	7.0	15.5	16.6	18.6	11.9	12.0	12.2
VII	1.8	2.1	2.7	1.3	1.8	2.2	1.5	1.9	2.5
VIII	5.9	3.5	2.9	28.0	26.7	27.3	21.3	17.6	14.0
IX	23.0	19.0	23.1	20.1	17.4	15.9	21.0	18.0	19.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a]These data are unadjusted.

Private sector employment within some regions has shown considerable change over the years examined. Regions V and VI have almost doubled their employment shares from 1968 through 1971. Regions II and III both experienced substantial decline in their shares of employment.

The GOCO sector, like the private sector, shows considerable variation in employment distribution over the years examined. The GOCO sector was virtually unaffected by the expansion of the survey universe, so the 1975 distribution results from declining trends in GOCO employment. Region IX suffered a large drop in employment from 1968 to 1975. During this same period, region VI had a slight increase in employment, which resulted in a large increase in its regional share. Regions II, III, and VII also increased their shares during this period. The largest region, region VIII, had a slight reduction in its share from 1968 to 1975.

The distribution of total employment by region exhibits considerable instability over the period examined. These shifts are the result of changes in the GOCO and private sector regional distribution of employment and also changes in private and GOCO shares of total employment. In 1968, the private sector composed approximately 30 percent of the total employment in the atomic energy field. In 1975, the private sector's share of the total unadjusted employment had grown to approximately 55 percent. Thus, although the share of total GOCO employment in the largest region (region VIII) changed little from 1968 to 1975, the small share of private sector employment in this region caused a rapid reduction in its share of total 1975 employment. Regions II and V experienced increases in shares of 1975 total employment largely because of substantial shares of 1975 private employment.

To explain GOCO employment distribution by region, one could examine the levels of federal funding by region. Using cross-sectional analysis, the employment distribution by region for a given year would be explained by the regional distribution of federal funding for that year. The data show this relationship, with patterns in funding by region highly correlated with the regional distribution of GOCO employment[1] (see Table C-9).

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[1]The linear coefficient of correlation is 95.9 percent for 1968, 88.2 percent for 1971, and 84.3 percent for 1975.

To explain trends in employment by region, however, one must examine the relationship of federal funding for a given region for a series of years to employment for those years. The results of this longitudinal approach were mixed: some regions displayed a strong relationship between GOCO employment and funding through time and other regions displayed an insignificant or negative relationship (see Table C-10). One possible reason for these mixed results is that funds allocated to a region are not necessarily spent in that region, i.e., the employment impact occurs elsewhere. It appears, then, that the structure of GOCO spending by year influences the regional employment makeup more than the regional funding trends over the years.

There are several factors that could account for the regional distribution of private sector employment. One would expect that private industry would develop where GOCO employment is concentrated. Statistically, however, there does not appear to be a relationship between private employment and GOCO employment by region, either cross-sectionally or longitudinally. Another possible explanation of regional distribution in the private sector would be the location of electric generating plants. Using 1975 data on regional megawatt capacity, the private employment by region shows only a moderate relationship to plant location.

Cross-sectionally, there is good correlation between 1975 private sector employment by region and total nonagricultural employment by region.[1] These data suggest that industrial location of private sector firms is only partially affected by the location of GOCO firms or electric generating plants. Regional economic and employment centers, however, affect the location somewhat more.

Table 2-8 details the regional percentage distribution of scientists, engineers, and technicians in the GOCO and private sectors for 1968 and 1975. These percentages are based on the unadjusted survey results. The private sector data are characterized by shifts in occupational structures for most regions during the period examined. The private sector as a whole showed an increase in engineers, a decrease in the share of scientists, and virtually no change in the technicians' share (see Table 2-1). These regional data show that those overall trends are the result of a variety of occupational share trends in the regions.

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[1] The linear R^2 is 58.0 percent.

TABLE 2-8

Percentage Distribution of Scientists, Engineers, and Technicians by Region, 1968 and 1975[a]

Region	1968		1975[b]	
	Private	GOCO	Private	GOCO
I.				
Scientists	7.4	11.2	6.3	4.8
Engineers	27.1	21.6	32.8	24.7
Technicians	26.4	36.5	22.2	9.6
II.				
Scientists	5.3	13.4	4.7	8.6
Engineers	25.4	20.6	27.3	25.2
Technicians	31.6	26.0	23.2	20.7
III.				
Scientists	2.6	16.9	4.3	14.8
Engineers	15.3	10.9	25.4	11.3
Technicians	15.6	17.8	23.6	17.7
IV.				
Scientists	7.4	5.7	7.7	3.6
Engineers	16.4	10.0	17.2	13.7
Technicians	28.3	11.0	26.8	6.6
V.				
Scientists	4.2	6.2	2.5	6.2
Engineers	28.4	11.0	24.4	10.7
Technicians	29.1	13.2	20.3	12.5
VI.				
Scientists	3.1	11.9	2.8	10.3
Engineers	12.9	9.6	27.6	10.2
Technicians	17.9	11.8	17.6	8.4
VII.				
Scientists	20.0	2.8	9.8	4.0
Engineers	18.6	5.7	12.7	6.6
Technicians	27.4	7.3	32.6	8.7
VIII.				
Scientists	3.0	8.4	5.0	10.3
Engineers	5.0	13.3	8.3	15.2
Technicians	7.8	17.2	13.9	18.3
IX.				
Scientists	7.7	12.6	6.3	18.2
Engineers	32.3	13.8	35.0	16.4
Technicians	16.5	17.0	18.0	21.1

[a]Table shows percent of total employment in region that is composed of scientists, engineers and technicians. "Other" employment is excluded.

[b]These data are unadjusted.

GOCO sector employment is also dynamic within the regions: I, II, and IX show large shifts in the employment structure of scientists, engineers and technicians. Like the private sector, there does not appear to be any overall trends that would account for the trends in total occupational structure of the GOCO sector.

RESEARCH AND DEVELOPMENT TRENDS

Table 2-9 details the trends in the number of scientists and engineers who spent 50 percent or more of their time in atomic energy-related research and development. The 1975 and 1973 data are based on the expanded universe surveyed in those years; adjusted data are not available for research and development involvement.

In 1975, almost one out of every three engineers and two out of every three scientists in the field were involved in research and development. These research and development shares of scientists and engineers have declined monotonically from 1968, when 82 percent of the scientists and 59 percent of the engineers were involved in research and development.

The GOCO sector also exhibits an overall decline in research and development participation; however, the decline is much less rapid, with only a 2.8 percent reduction in the percentage of GOCO engineers involved in research and development. Although the reduction in the percentage of GOCO scientists involved in research and development is more pronounced, most of this decline occurred between the 1973 and 1975 surveys. Because the survey expansions in 1973 and 1975 had little affect on the GOCO sector, one can regard these figures as accurate. Scientists in the GOCO sector are highly oriented toward research and development.

The private sector is characterized by rapid declines in research and development involvement for both scientists and engineers over the years examined. In 1968 approximately one of every two scientists and engineers in the private sector was involved in research and development. This figure has declined monotonically to one of every six scientists and engineers in 1975. These trends indicate a de-emphasis upon research and development in the private sector as commercialization and application of existing technology increased.

TABLE 2-9

SCIENTISTS AND ENGINEERS INVOLVED IN RESEARCH AND DEVELOPMENT ACTIVITIES IN THE ATOMIC ENERGY FIELD, 1968-1975[a]

	Total			GOCO			Private		
	Scientists and Engineers	Scientists	Engineers	Scientists and Engineers	Scientists	Engineers	Scientists and Engineers	Scientists	Engineers
1968									
Number	24,078	10,746	13,332	18,068	9,074	8,994	6,010	1,672	4,338
Percent	67.5	82.5	58.9	77.0	85.3	70.0	49.3	69.9	44.3
1969									
Number	23,957	10,487	13,470	18,205	8,811	9,394	5,752	1,676	4,076
Percent	62.4	80.7	54.1	75.3	84.2	71.1	40.5	66.4	34.9
1970									
Number	23,032	10,043	12,989	17,593	8,585	9,008	5,439	1,458	3,981
Percent	59.5	79.3	49.9	75.8	84.5	68.9	35.3	58.2	30.7
1971									
Number	22,033	9,735	12,298	17,054	8,278	8,776	4,979	1,457	3,522
Percent	55.0	78.3	44.6	75.5	84.6	68.5	28.6	54.7	23.8
1973[b]									
Number	20,771	9,604	11,167	16,177	8,132	8,045	4,594	1,472	3,122
Percent	44.6	70.3	33.8	74.6	83.4	67.4	18.4	38.5	14.8
1975[b]									
Number	22,589	10,117	12,472	16,624	7,855	8,769	5,965	2,359	3,606
Percent	38.7	66.8	28.8	72.5	79.6	67.2	16.8	44.6	12.0

[a]The percent rows on this table show the percentage of all in that occupation group involved in research and development.

[b]These data are unadjusted.

Indeed, the number of scientists and engineers involved in research and development in the private sector decreased from 1968 through 1971 in the face of rapid growth for this sector as a whole. The 1975 and 1973 figures reflect the new firms surveyed in those years.

Research and development labor output is difficult to measure. In the GOCO sector, however, one can use federal research and development expenditures in the nuclear area as a surrogate for research and development output and examine the relationship between these expenditures and GOCO research and development employment. Utilizing this approach, AEC and ERDA expenditures for nuclear-related research and development account for over 60 percent of the changes in GOCO research and development employment for the years 1968 to 1975 (see Table C-11).

Table 2-10 details the trends in research and development involvement for 1968 to 1975 by firm size. Every firm size group exhibits a decline in research and development involvement over the years examined. The larger size firms (more than 500 employees) generally are more involved in research and development than the smaller firms. The 10-49 size group and 1000-4999 size group both experienced rapid declines in overall research and development involvement, while the 1-9 size group and 50-99 size group experienced small decreases. The 5000+ size group is composed mainly of GOCO firms and had the highest percentage involved in research and development in 1975.

TRENDS IN EMPLOYMENT BY ECONOMIC SEGMENT

Table 2-11 details employment by economic segment in the atomic energy field for the years 1968 to 1975. The definitions for some of the economic segments have been changed during this period and data may not be strictly comparable. Groups and individual segments displayed in this table are areas where little alteration in definition has occurred. The remaining segment employment was lumped into the Miscellaneous category.

The classification of employment by economic segment is by primary segment. That is, when a firm shows involvement in more than one segment (production of special materials and radioisotopes, for example), all of the firm's employment is counted in the segment

TABLE 2-10

Percentage Involvement of Scientists and Engineers
in Atomic Energy Research and Development by Firm Size

Firm Size	Percent Involved in Research and Development 1968	1971	1975[a]
1-9			
Scientists and Engineers	39.2	25.8	33.1
Scientists	63.5	39.1	44.4
Engineers	21.8	15.2	25.6
10-49			
Scientists and Engineers	49.6	38.9	27.2
Scientists	64.2	49.6	40.7
Engineers	41.0	33.0	20.0
50-99			
Scientists and Engineers	35.6	37.0	29.1
Scientists	57.0	58.6	45.2
Engineers	30.0	29.0	22.3
100-499			
Scientists and Engineers	52.7	33.1	22.6
Scientists	70.3	64.4	55.1
Engineers	44.9	24.9	12.2
500-999			
Scientists and Engineers	51.8	40.9	27.4
Scientists	80.2	79.9	59.3
Engineers	42.6	33.1	21.8
1000-4999			
Scientists and Engineers	71.9	61.8	42.9
Scientists	83.8	76.1	71.2
Engineers	65.5	53.2	33.4
5000+			
Scientists and Engineers	81.1	71.4	60.1
Scientists	89.3	84.0	87.9
Engineers	73.8	64.7	46.5

[a]These data are unadjusted.

TABLE 2-11

Employment Trends by Economic Segment

	1968	1971	1973		1975	
			Adj.	Unadj.	Adj.	Unadj.
Uranium Milling						
GOCO	0	0	0	0	0	0
Private	1,967	1,642	1,302	1,435	1,373	1,704
Processing Reactor Fuels						
GOCO	4,970	6,027	6,644	6,644	9,481	9,481
Private	377	1,105	981	983	1,669	1,889
Prod. Spec. Materials						
GOCO	0	0	142	142	0	0
Private	1,753	1,412	1,834	2,294	1,450	2,395
Reactor Design, Mfg.						
GOCO	1,019	920	0	0	0	0
Private	15,458	21,649	23,116	26,918	20,568	27,135
Fuel Fab., Reprocessing[a]						
GOCO	1,430	1,457	7,608	7,608	8,123	8,123
Private	2,990	6,634	6,004	6,498	3,992	4,898
Design Nucl. Facilities						
GOCO	378	2,027	585	585	1,708	2,406
Private	5,803	11,694	19,428	20,809	25,641	31,777
Nuclear Reactor Operators						
GOCO	168	1,138	166	853	217	1,141
Private	1,052	3,555	6,167	6,657	10,116	11,531
Radioisotopes[b]						
GOCO	0	0	0	0	0	0
Private	688	1,069	1,683	2,669	1,467	2,476
Design, Mfg. Nucl. Inst.[c]						
GOCO	0	0	16	0	0	0
Private	3,458	5,367	6,698	9,114	5,167	8,278
Research[d]						
GOCO	52,194	45,577	32,364	33,216	25,600	26,479
Private	2,314	2,344	2,967	3,812	2,667	7,011
Weapons Dev., Prod.						
GOCO	25,568	31,485	31,208	31,208	31,337	31,337
Private	220	41	46	410	30	347
Industrial Radiography						
GOCO	0	0	0	0	0	0
Private	581	1,603	1,055	1,348	506	1,901
Miscellaneous						
GOCO	NA	NA	4,471	4,852	4,308	4,593
Private	NA	NA	1,835	2,809	1,248	5,900
Accelerators						
GOCO	NA	NA	NA	NA	5,814	5,814
Private	NA	NA	NA	NA	715	850

[a] Fuel Fabrication, Reprocessing includes the following segments in 1973 and 1975: fuel fabrication, transportation of nuclear materials, and chemical reprocessing of fuel. The 1968 and 1971 segments include fuel element fabrication and recovery activities; and radioactive waste disposal. Data may not be comparable.

[b] The 1968 and 1971 definitions for this segment differ from 1973 and 1975 definitions; therefore, data may not be comparable.

[c] This segment includes these segments prior to 1973: nuclear instrument manufacturing; and radioisotope gauges and gauging equipment. Data may not be comparable.

[d] The 1973 and 1975 Research segment is an aggregation of the following: environmental and ecological research; biological and medical research, reactor research and development; commercial lab services; health and industrial safety; and research and development in atomic energy. The 1968 and 1971 Research category includes private research labs and commission research labs. Data may not be comparable.

with the largest percentage of the firm's workers. This causes an overestimation of the employment in the primary segment and an underestimation of employment in the firm's secondary segments. Appendix B examines the affect of this survey methodology in the 1975 data; the affect on trend data, however, is unknown.

Although total employment in the atomic energy field is roughly divided equally between GOCO sector employment and private sector employment, most of the economic segments are dominated by one employment sector. Growth rates also differ greatly among segments, with some growing rapidly and others experiencing employment decline. The basis of these segment employment trends are examined below.

1. Processing Reactor Fuels. This segment, which made up approximately six percent of total 1975 unadjusted employment, is dominated by GOCO workers. Workers are engaged in refining reactor fuel concentrates and converting them into oxides, carbides, and hexaflourides, including pellet and coated-particle production. The bulk of employment in this sector, however, is concentrated in three uranium-235 enrichment facilities. These government-owned facilities provide the majority of enriched uranium in the free world.

Because of differences in the assay of uranium inputs and different grades of enriched output, effort expended in the enrichment process is measured in terms of separative work units (swu) performed rather than amount of output produced.

Table 2-11 shows the metric tons swu and employment in the processing segment for the 1968 to 1975 period. There is a fairly good relation between swu and employment in this segment.[1] The amount of labor demanded in this segment is directly related to the swu performed.

2. Reactor and Reactor Component Design and Manufacturing.

This segment is now composed entirely of private sector firms, accounting for over 14 percent of 1975 unadjusted employment. There was some GOCO employment in the segment through the 1971 survey.

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[1]The linear coefficient of correlation (R^2) was 64.9 percent for the unadjusted data. See Table C-12.

TABLE 2-12

Metric Tons SWU and Processing Employment

	1968	1969	1970	1971	1973	1975
SWU	7,938	6,560	6,179	7,314	10,580	13,155
Processing Employment	5,347	7,202	6,937	7,132	7,702	11,492
					7,625[a]	11,150[a]

[a]These data are adjusted.
Source: ERDA Oak Ridge Operations.

This segment is involved in the design and/or manufacture of nuclear reactors and reactor components for power, test, and research purposes. Also included are reactors and components for missile and space applications. The adjusted data show steady growth up through 1973, with a slight decline to 1975. The unadjusted data show no decline, with the unadjusted 1975 employment figure approximately 30 percent greater than the unadjusted figure.

Table 2-13 shows the constant dollar amounts of the value of shipments of selected reactor components and reactors. Assuming that most of the manpower effort expended occurred prior to the year when the goods were shipped, the employment figures lag one year behind the value of shipments data.

The relationship between value of shipments for reactors and reactor components and the segment employment is strong for the unadjusted data.[1]

3. Fuel Fabrication and Reprocessing. This segment includes substantial GOCO and private employment and accounted for approximately seven percent of the 1975 unadjusted employment in the field. The definition utilized in this report actually includes two segments: the fuel element fabrication segment, which is involved in the manufacture of fuel elements and fuel element assemblies, and the chemical reprocessing of fuel segment, which includes the separation and

[1]The linear R^2 is 72.5 percent for unadjusted data.

TABLE 2-13

Value of Shipments
Reactors and Components and Reactor Design
and Manufacturing Employment

t	t+1 Value of Shipments (Constant $ Million)	t Reactor Design and Manufacturing Employment
1968	372.7	16,477
1969	486.5	19,178
1970	494.9	21,321
1971	430.3	22,569
1973	548.9	23,116 (26,919)[a]
1975	589.3	20,568 (27,136)[a]

[a]Unadjusted data in parantheses.
Source: Bureau of Census, "Current Industrial Reports, Selected Atomic Energy Products," Washington, D.C.: Government Printing Office, various years.

recovery of by-products from irradiated fuel.[1]

Table 2-14 shows that with the exception of 1970 and 1975, this segment has shown steady growth of approximately 16 percent a year (unadjusted). Also included in the table are the constant dollar value of shipments figures for completed fuel element assemblies for the same period.

The adjusted and unadjusted employment data for this segment differ very little. Both employment data show a strong relationship to the fuel assembly data indicating that manpower requirements in this segment are closely tied to output.[2]

4. Design and Engineering of Nuclear Facilities. The unadjusted 1975 data show that approximately one of every six workers in the field was employed in this segment. Firms engaged in this segment design and engineer nuclear facilities, including nuclear power plants,

[1]Prior to 1973 this segment included fuel element fabrication and recovery and radioactive waste disposal.

[2]The linear R^2 figures are 94.6 for adjusted data and 95.9 for unadjusted data.

TABLE 2-14

Fuel Fabrication, Reprocessing Employment, and Value of Shipments of Fuel Assemblies

Year	Value of Shipments of Fuel Assemblies (Constant $ Million)	Fuel Fabrication and Reprocessing Employment
1968	62.1	4,420
1969	88.5	7,115
1970	70.4	6,654
1971	117.6	8,091
1973	181.1	13,612 (14,106)[a]
1975	183.9	12,115 (13,021)[a]

[a]Unadjusted data in parantheses.
Source: Bureau of Census, "Current Industrial Reports, Selected Atomic Energy Products," Washington, D.C.: Government Printing Office, various years.

but excluding reactors and reactor components.

Table 2-15 shows the rapid growth of this sector from 1968 to 1975, a compound rate of almost 28 percent a year. Table 2-15 also includes figures for the cumulative megawatt capacity of all nuclear electricity plants for the same period. These data show that employment in this sector is very strongly related to the growth in the private use of nuclear power.[1]

5. Nuclear Reactor Operation and Maintenance. While this segment made up only six percent of the unadjusted 1975 employment, it grew at a compound rate of almost 40 percent a year between 1968 and 1975. Workers in this segment are engaged in the operation and maintenance of nuclear power, production, test, and research reactors. Also included are those involved in the operation and maintenance of auxiliary facilities. Like the facility design segment, this segment is dominated by private sector employment.

[1]The linear R^2 figures are 95.0 for adjusted data and 98.3 for unadjusted data.

TABLE 2-15

U.S. Megawatt Nuclear Capacity and Facility Design and Engineering Employment

Year	Megawatt Capacity (Cumulative)	Design and Engineering of Nuclear Facilities Employment
1968	2,733	6,181
1969	4,031	7,752
1970	6,470	9,681
1971	9,183	13,721
1973	20,354	20,013 (21,394)[a]
1975	36,539	27,349 (34,183)[a]

[a]Unadjusted data in parentheses.
Source: "World List of Nuclear Power Plants," Nuclear News Buyers Guide 1976, Vol. 19, No.3 (February 1976), pp. 52-64.

Table 2-16 shows total employment in this segment and cumulative nuclear megawatt capacity for 1968 to 1975. Because staffing requirements for operating nuclear facilities are directly related to the number of plants operating, one finds a very strong relationship between the cumulative megawatt capacity and operation and maintenance employment.[1]

6. Research and Weapons Development/Production. Both the research and the weapons segments are dominated by government employment. The weapons segment has experienced only small changes in employment over the 1968-1975 period, while the research segment has declined considerably. Employment in both of these is affected by government spending patterns. In 1975, these two segments accounted for approximately one-third of the field's total employment.

Much of the growth in the atomic energy field is concentrated in those economic segments relating to private sector electricity production. GOCO employment has not grown substantially in any segment save the processing of reactor fuels segment; indeed, it has declined drastically in the research segment. These data indicate

[1]The linear R^2 is 94.7 for adjusted data and 98.4 for unadjusted data.

TABLE 2-16

U.S. Nuclear Megawatt Capacity and
Nuclear Reactor Operation and Maintenance Employment

Year	Cumulative Megawatt Capacity	Nuclear Reactor Oper. and Maintenance Employment
1968	2,733	1,220
1969	4,031	1,726
1970	6,470	2,291
1971	9,183	4,693
1973	20,354	6,333 (7,510)[a]
1975	36,539	10,333 (12,672)[a]

[a]Unadjusted data in parentheses.
Source: "World List of Nuclear Power Plants," Nuclear News Buyers Guide 1976, Vol. 19, No.3, (February 1976), pp. 52-64.

that given the present mix of government support to the atomic energy field, atomic energy is a commercially viable product able to support a growing private sector industry.

1963-1975 TRENDS

This section compares the 1963 atomic energy employment survey results with the 1975 results. Although surveys were conducted prior to 1963, the 1963 data are similar to the 1975 data in terms of tabulation format. In 1963, firms were asked to include workers in the field who spent any time in work related to atomic energy. In 1968, this was changed to workers who spent 50 percent or more time in work related to atomic energy. In addition, some industrial segment definitions were revised, so 1963 data are not comparable to 1975 data in segments, but on the whole the data of the two surveys provide an interesting insight into how the field has changed over the intervening years.

Table 2-17 details the two survey results by various employment groupings. The shares of total employment contained by the GOCO and private sector have shifted dramatically between the

surveys. This shift has been a result of both rapid growth of the private sector (9.3 percent annually) and a decline in total GOCO employment. The growth in the private sectors share of total employment has, in turn, affected the atomic energy field occupational structure, regional distribution, and distribution by size of firm.

TABLE 2-17

Atomic Energy Employment, 1963 and 1975

	1963	Percent	1975[a]	Percent
Total Employment	138,519	100.0	197,466	100.0
GOCO	101,338	73.2	89,374	45.3
Private	37,181	26.8	108,092	54.7
GOCO Employment	101,338	100.0	89,374	100.0
Scientists	8,532	8.4	9,871	11.0
Engineers	12,483	12.3	13,056	14.6
Technicians	15,309	15.1	14,142	15.8
Other	65,014	64.2	52,305	58.5
Private Employment	37,181	100.0	108,092	100.0
Scientists	2,207	5.9	5,281	4.9
Engineers	7,709	20.8	30,177	27.9
Technicians	7,038	18.9	22,915	21.2
Other	20,227	54.4	49,719	46.0
Regional Employment	138,519	100.0	197,466	100.0
I. New England	7,039	5.1	10,529	5.3
II. Middle Atlantic	19,279	13.9	34,194	17.3
III. East North-Central	16,097	11.6	25,626	13.0
IV. West North-Central	11,095	8.0	6,534	3.3
V. South Atlantic	11,013	7.9	24,731	12.5
VI. East South-Central	15,100	10.9	24,199	12.2
VII. West South-Central	1,878	1.4	4,885	2.5
VIII. Mountain	29,123	21.0	27,565	14.0
IX. Pacific	27,895	20.1	39,203	19.8
Firm Size Employment	138,519	100.0	197,466	100.0
1-9	276	.2	1,545	.8
10-49	1,934	1.4	8,226	4.2
50-99	2,464	1.8	8,009	4.0
100-499	15,893	11.5	37,974	19.2
500-999	12,676	9.2	16,461	8.3
1000-4999	59,259	42.8	102,541	51.9
5000+	46,017	33.2	22,710	11.5

[a]These data are unadjusted.

Within the GOCO and private sectors there have been changes in the occupational structure of employment. Both sectors employed a slightly higher percentage of engineers in 1975, with the private sector having almost 4 times the 1968 number of engineers in 1975. The percentage of technicians employed by both sectors increased slightly. The "other" employment group percentage declined in both sectors. Scientists were the fastest growing occupation in the GOCO sector and the slowest growing occupation in the private sector.

The geographic distribution of employment has also changed. This change is the result of the mild decline in GOCO employment and rapid growth of private sector employment. Regions VIII and IX, both of which have large amounts of GOCO employment, experienced a reduction in their shares of total employment. The West North Central region also had a decline in its total employment and employment share. Regions II and V had substantial increases in their employment shares due to rapid private sector growth. The overall 1975 distribution of employment is less concentrated geographically than the 1963 distribution due mainly to changes in the regional distribution and growth in private sector employment.

The large increases in the private sector employment share have also affected the employment distribution by size of firm. As shown on Table 2-5, GOCO sector firms had over 95 percent of their 1975 employment concentrated in large (500 or more employees) firms compared with only about 50 percent for the private sector. The rapid growth of the characteristically smaller firms in the private sector has resulted in an increase in small firms' employment share from 14.9 percent in 1963 to 28.2 percent in 1975.

Table 2-18 details 1963 and 1975 employment for those economic segments where data are comparable. Three predominantly private sector segments have experienced very high growth—reactor and reactor components sector, design and engineering of nuclear facilities segment, and reactor operation and maintenance segment. The growth of these three segments is closely tied to the growth in atomic electricity production. The production of feed materials segment and weapons segment, both predominantly GOCO, experienced

only slight changes (less than two percent annually), in total employment from 1963 to 1975. By contrast, the design and engineering of nuclear facilities segment was growing at an annual compound rate of almost 25 percent, doubling employment in this sector approximately every three years.

TABLE 2-18

Employment by Economic Segment in the Atomic Energy Field, 1963 and 1975

	1963	Percent	1975[b]	Percent
Segment[a]	138,519	100.0	197,466	100.0
Uranium Milling	2,705	2.0	1,704	.9
Production of Feed Materials	9,057	6.5	11,370	5.8
Production of Special Materials	1,854	1.3	2,395	1.2
Reactor and Reactor Components	14,305	10.3	27,135	13.7
Design & Engineering of Nuclear Facilities	2,481	1.8	34,183	17.3
Reactor Oper. and Maintenance	1,143	.8	12,672	6.4
Commercial Labs Service	2,225	1.6	1,350	.7
Weapons Development & Production	37,532	27.1	31,684	16.0
Industrial Radiography	596	.4	1,901	1.0
Other	66,621	51.9	73,072	37.0

[a]The segment definitions have undergone revisions over the survey life. The nine segments presented in this table have not been changed, so 1963 and 1975 data are comparable. All other segment data in these two survey years is not strictly comparable and has been lumped into the "other" category.

[b]These data are unadjusted.

FUTURE EMPLOYMENT TRENDS

The data examined in this report revealed a rapidly growing private atomic energy industry. Much of this growth was related to the increased use of nuclear power for electricity production. In light of present worldwide energy difficulties, atomic power and coal will play major roles in the nation's energy future.

With increasing use of nuclear power, one can expect employment, especially private sector employment, to increase in the atomic energy field. The rapid growth segments examined in this report—design and engineering of nuclear facilities, operation and maintenance of nuclear facilites, and reactor and components design and manufacturing—promise to continue to show healthy growth.

In addition, firms connected with the nuclear fuel cycle should experience employment growth as the demand for nuclear fuel and disposal services increases.

The data in this study revealed that GOCO employment was very closely tied to federal funding patterns. While budget projections are unavailable, one would expect at least a mild growth in the level of federal expenditures for increasing levels of research and development and various support and regulatory activities related to private sector industry. Major demonstration projects such as the centrifuge enrichment plant will affect GOCO employment for several years hence.

The field's employment trends, then, should continue along much the same lines as revealed by this study. The regional distribution, firm size distribution, and occupational makeup of the field's employment will continue to be altered by a rapidly growing private sector. Growth and change in the GOCO sector will occur at a much milder pace and will continue to play an increasingly smaller role in the field as a whole.

APPENDIX A

CHANGES IN THE SURVEY UNIVERSE

This appendix details the changes in the survey universe over the survey life and the affects of these changes.

Table A-1 below shows the changes in the number of reporting units over the survey life. The number of reporting units in the GOCO sector shows very little change; one can utilize the longitudinal data of the yearly surveys with confidence that it reflects true employment trends. The private sector data have undergone substantial change; the universe of responding firms increased by over 50 percent in 1973 and by over 35 percent in 1975. Definition differences and missing data prevented the use of the 1963 results in the trend analysis.

Table A-1

Number of Reporting Units, 1963-1975

	1963	1968	1969	1970	1971	1973	1975
Usable Reports	602	511	498	494	521	802	1063
GOCO	NA	63	63	60	62	64	58
Private	NA	448	435	434	459	738	1005

For those firms added to the survey in 1973 and 1975, it is impossible to know how much of the additional employment was due to growth and how much was due to a more comprehensive survey coverage. However, by examining employment trends in only those 1975 and 1973 survey firms that were also surveyed in 1971, a constant survey universe over these years is obtained and trends within this universe are revealed. This group of firms is referred to in the report as the "constant survey universe" or the "adjusted data."

Table A-2 details that portion of 1973 and 1975 employment that is due to new firms added to the survey universe. Approximately nine percent of the total reported employment in both 1973 and 1975 was from additions to the survey universe. Virtually all of these firms were private sector establishments. The adjustment factor (fraction of the total employment attributable to new firms added to the survey universe) for GOCOs was two percent in 1973, only 0.2

TABLE A-2

ADJUSTMENT FACTORS

Employment Area	1973 Factor	1975 Factor
Total Employment	.09	.09
Sci., Eng., Tech.	.09	.11
Engineers	.09	.13
Mathematicians	.04	.04
Physical Sci.	.06	.07
Life Sci.	.13	.20
Technicians	.09	.10
All Other Employees	.09	.07
GOCO	.02	.002
Private	.15	.17
Economic Segment		
Uranium Milling	.10	.10
Proc. of Reactor Fuel	.01	.02
Prod. of Special Mat.	.19	.24
Reactor Design & Mfg.	.14	.12
Fuel Fabrication	.06	0
Transp. Nuclear Mat.	.21	.43
Chem. Reproc. of Fuel	.01	.03
Design Nuclear Facil.	.03	.12
Nuclear Reactor Oper.	.16	.05
Radioisotopes	.13	.06
Design & Mfg. Nuc. Ins.	.26	.16
Envir. & Ecol. Research	.38	.29
Bio. & Med. Research	.23	.25
Reactor R&D and Eval.	.10	.02
Commer. Lab Service	.34	.34
Health and Indus. Safety	.04	.39
Weapons Devel. & Prod.	.01	0
R&D in Atomic Energy	.01	.10
Indust. Radiography	.22	.66
Miscellaneous	.17	.20
Accelerators	NA	.02

percent in 1975, while the private sector adjustment factors were 15 percent and 17 percent, respectively. Economic segments that had a disproportionate share of the expanded 1973 universe were the environmental and ecological research segment (0.38), commercial lab service segment (0.34), and the design and manufacture of nuclear instruments segment (0.26). Other 1973 segments with large shares were the transportation of nuclear materials segment, biological and medical research segment, and industrial radiography segment.

Economic segments that had a disproportionate share of the expanded 1975 universe were the industrial radiography segment (adding 0.66, or two-thirds again as many employees as existed in the pre-1975 universe), transportation of nuclear materials segment (0.43), health and industrial safety segment (0.39), and commercial lab service segment (0.34). Other segments with large adjustment factors included environmental and ecological research, biological and medical research, and the production of special materials.

In the additional 1973 survey firms, the distribution of engineers, technicians, and "others" was approximately the same as the pre-1973 universe. Within the scientist group, however, life scientists had a larger employment share of the new firms surveyed with mathematicians and physical scientists constituting a smaller portion of the total compared with the old survey universe.

Compared with the pre-1975 universe, the additional 1975 survey establishments contained a slightly larger proportion of high level manpower, with an adjustment factor for scientists, engineers, and technicians of 0.11 compared with 0.09 for total employment. Within the scientist, engineer, and technician group, engineers (0.13) and life scientists (0.20) both had high adjustment factors. The additional survey establishments contained few mathematicians, resulting in an adjustment factor of 0.04.

APPENDIX B

REPORTING BIAS BY ECONOMIC SEGMENT

When a firm reports employment in more than one economic segment, all of the firm's employment is counted in the primary segment. For example, if 40 percent of a firm's employees are engaged in design and engineering of nuclear facilities, 30 percent in radioisotope packaging, and 30 percent in research, then the primary segment is design and engineering of nuclear facilities, and the firm's total employment, including the employment in the two other segments, is counted in the primary segment. This survey methodology results in an upward bias in the primary segment and a downward bias in the two secondary segments, but the bias has absolutely no effect on total employment, employment by region, or individual occupations. It affects only the segment data.

Table B-1 details the effect of this biased reporting on 1975 employment by segment. Although the bias in previous surveys is unknown, the data in the table indicate that the error is considerable for some segments. The 1977 Nuclear Employment Survey will employ a different methodology to improve the accuracy of the segment estimates.

TABLE B-1

OCCUPATIONAL EMPLOYMENT IN THE NUCLEAR ENERGY FIELD, BY SEGMENTS, 1975

	Original Total Employment	Revised Total Employment	Absolute Difference in Total Estimate
All Segments	197,500	197,500	16,800
Design and engineering of nuclear facilities	34,200	33,800	- 400
Weapons development and production	31,700	31,300	- 400
Reactor and reactor component design and manufacturing	27,100	24,300	-2,900
Research and development in nuclear energy	22,000	17,000	-5,000
Nuclear reactor operation and maintenance	12,700	15,500	+2,800
Processing and enrichment of reactor fuel materials	11,400	9,800	-1,600
Chemical reprocessing of irradiated fuel	8,600	4,300	-4,300
Design and manufacturing of nuclear instruments, gauges, and control devices	8,300	9,500	+1,200
Reactor research, development, and evaluation	7,300	8,500	+1,200
Accelerators	6,700	4,500	-2,100
Fuel fabrication	3,700	5,300	+1,600
Radioisotopes	2,500	2,400	- 100
Production of special materials for use in reactors	2,400	3,700	+1,300
Biology and medical research	2,000	3,800	+1,800
Industrial radiography	1,900	2,200	+ 300
Uranium milling	1,700	1,700	-
Commercial laboratory services	1,400	1,400	-
Transportation of nuclear materials	700	900	+ 200
Environmental and ecological research and evaluation	600	1,800	+1,100
Health physics and industrial safety	200	1,400	+1,300
Miscellaneous	10,500	14,600	+4,100

NOTE: Employment data are based on a known universe of establishments identified by ERDA. Detail may not add to totals due to rounding. Dashes indicate less than 50 employees.

Source: U.S. Department of Labor, Bureau of Labor Statistics, "1975 Nuclear Energy Survey - Multiple Segment Reports," Xeroxed, 1977.

APPENDIX C

Tables and Statistics

TABLE C-1

GOCO, TOTAL EMPLOYMENT, AND FEDERAL EXPENDITURES IN THE ATOMIC ENERGY FIELD, 1962-1975

Year	AEC Operations Expenditures[a] (Millions)	Consumer Price Index (1967=100)	Real AEC Expenditures (Millions)	GOCO Employment (Unadjusted)	Total Employment (Unadjusted)
1962	$2695.9	90.6	$2975.6	123,641	127,017
1967	2446.5	100.0	2446.5	98,871	136,512
1968	2506.8	104.2	2405.8	100,972	141,727
1969	2556.2	109.8	2328.1	99,626	149,420
1970	2503.7	116.3	2152.8	98,857	157,602
1971	2501.4	121.3	2062.2	95,470	156,934
1973	2676.7	133.1	2011.0	85,108	171,013
1975[b]	3556.4	161.2	2206.2	89,374	197,466

[a]These data are for fiscal years.

[b]The 1975 data are expenditures by ERDA rather than the AEC.

Source: AEC Financial Report, various years; ERDA Financial Report, 1975.

Regression Results:

Time Period	n	Dependent Variable	Independent Variable	Equation	R^2
1962-1975	8	GOCO Employment	Real AEC Expenditures	y=18816.7+34.5x	.858

TABLE C-2

REAL VALUE OF SHIPMENTS FOR SELECTED ATOMIC ENERGY PRODUCTS AND PRIVATE EMPLOYMENT IN THE ATOMIC ENERGY FIELD

Year	Total Value Shipments (Constant $1000)	Private Sector Employment
1968	$489,934	$42,728
1969	554,233	49,794
1970	692,117	55,515
1971	728,928	61,464
1973	711,462	73,126 (85,756)[a]
1975	987,440	75,650 (108,092)[a]

[a]Unadjusted data in parenthesis.

Source: Bureau of Census, Current Industrial Reports Selected Atomic Energy Products, various years.

Regression results:

Independent variable = value of shipments

Dependent variable = private employment

	Constant Term	Slope	R^2
1. Adjusted data	-24,052	+.13	.815
2. Unadjusted data	13,858	+.07	.867

TABLE C-3

EMPLOYMENT IN THE ATOMIC ENERGY FIELD, 1968-1975

	1968	1969	1970	1971	1973		1975		1968-1975 Growth Rate (%)	
					Adj.	Unadj.	Adj.	Unadj.	Adj.	Unadj.
Private	42,728	49,794	55,515	61,464	73,126	85,756	75,650	108,092	8.5	14.2
Scientists	2,393	2,524	2,507	2,657	2,927	3,819	2,889	5,281	2.7	12.0
Engineers	9,802	11,690	12,966	14,781	18,430	21,098	21,597	30,177	11.9	17.4
Technicians	9,007	10,939	13,049	14,332	15,638	17,928	16,714	22,915	9.2	14.3
Other	21,526	24,641	26,993	29,694	36,131	42,911	34,450	49,719	6.9	12.7
GOCO	98,999	99,626	98,609	95,470	83,204	85,109	86,949	89,374	-1.8	-1.4
Scientists	10,631	10,468	10,154	9,782	9,622	9,746	9,729	9,871	-1.2	-1.0
Engineers	12,833	13,205	13,065	12,818	11,726	11,943	12,705	13,056	-0.1	0.2
Technicians	16,386	16,138	16,415	15,383	13,450	13,905	13,496	14,142	-2.7	-2.1
Other	59,149	59,815	58,975	57,487	48,406	49,515	51,019	52,305	-2.1	-1.7
Total	141,727	149,430	154,124	156,934	156,330	170,865	162,599	197,466	2.0	4.9

TABLE C-4

OCCUPATIONAL TRENDS FOR

NUCLEAR RELATED SCIENTISTS

Occupation	1968	1969	1970	1971	1973 Adj.	1973 Unadj.	1975 Adj.	1975 Unadj.
Mathematicians								
GOCO	1,495	1,559	1,504	1,414	1,405	1,415	1,572	1,588
Private	297	250	289	279	355	416	354	497
Total Physical Scientists								
GOCO	7,765	7,541	7,271	6,984	6,777	6,846	6,764	6,847
Private	1,807	1,976	1,882	1,825	1,609	2,112	1,646	2,888
Chemists								
GOCO	3,012	2,971	2,828	2,829	2,734	2,743	2,507	2,532
Private	779	816	817	838	742	990	801	1,294
Geologists and Geophysicists								
GOCO	56	59	58	58	94	99	152	152
Private	43	68	63	53	76	94	69	266
Physicists								
GOCO	3,680	3,580	3,531	3,278	3,247	3,284	3,352	3,386
Private	772	835	765	725	488	661	501	887
Metallurgists								
GOCO	581	516	501	423	473	478	366	370
Private	175	206	203	167	197	236	144	214
All Other Physical Scientists								
GOCO	436	415	353	396	229	242	387	407
Private	38	51	34	42	106	131	131	227
Total Life Scientists								
GOCO	1,371	1,368	1,379	1,384	1,440	1,485	1,393	1,436
Private	289	298	336	553	963	1,291	889	1,896
Biological								
GOCO	819	724	686	697	779	808	682	710
Private	93	82	104	260	663	918	527	1,138
Medical								
GOCO	81	69	107	91	57	62	95	103
Private	14	10	13	31	19	38	74	305
Health Physics								
GOCO	442	498	464	480	444	455	365	372
Private	178	194	210	246	272	320	239	333
All Other Life Scientists								
GOCO	29	77	122	116	160	160	251	251
Private	4	12	9	16	9	15	49	120

TABLE C-5

OCCUPATIONAL TRENDS

FOR NUCLEAR-RELATED ENGINEERS

Occupation	1968	1969	1970	1971	1973 Adj.	1973 Unadj.	1974 Adj.	1974 Unadj.
Total Engineers								
GOCO	12,833	13,205	13,065	12,818	11,726	11,943	12,705	13,056
Private	9,802	11,690	12,966	14,781	18,430	21,098	21,597	30,177
Chemical								
GOCO	1,488	1,584	1,517	1,559	1,433	1,444	1,434	1,448
Private	538	558	615	588	776	894	654	1,000
Civil								
GOCO	388	350	385	412	400	401	374	390
Private	630	709	975	1,181	1,795	1,888	2,411	3,336
Electrical & Electronic								
GOCO	3,251	3,237	3,310	3,167	2,985	3,019	3,018	3,080
Private	1,871	2,056	2,458	2,565	3,334	3,760	3,784	4,922
Mechanical								
GOCO	3,992	3,774	3,971	3,815	3,815	3,874	3,783	3,860
Private	3,482	4,345	4,693	5,340	6,116	6,949	6,597	9,151
Nuclear and Reactor								
GOCO	1,132	1,341	1,360	1,345	884	945	1,256	1,350
Private	1,590	1,937	1,907	2,316	3,012	3,537	3,651	5,032
Metallurgical								
GOCO	478	493	477	491	459	471	509	525
Private	426	462	538	525	558	654	677	949
All Other Engineers								
GOCO	2,154	2,426	2,045	2,029	1,750	1,789	2,331	2,403
Private	1,265	1,623	1,780	2,266	2,839	3,416	3,823	5,787

TABLE C-6

OCCUPATIONAL TRENDS FOR

NUCLEAR-RELATED TECHNICIANS

Occupation	1968	1969	1970	1971	1973 Adj.	1973 Unadj.	1975 Adj.	1975 Unadj.
All Technicians								
GOCO	16,386	16,148	16,415	15,383	13,450	13,905	13,496	14,142
Private	9,007	10,939	13,049	14,332	15,638	17,928	16,714	22,915
Draftsmen								
GOCO	2,044	2,136	2,201	2,173	1,976	1,996	1,817	1,893
Private	2,628	3,257	3,920	4,985	5,460	5,948	6,288	8,409
Electrical & Electronic								
GOCO	3,856	4,090	3,918	3,429	3,104	3,110	3,052	3,083
Private	1,400	1,468	1,511	1,745	1,817	2,127	1,872	2,458
All Other Engineering Technicians								
GOCO	3,477	3,373	3,767	3,557	3,084	3,163	3,010	3,103
Private	1,491	2,033	2,227	2,314	3,473	3,874	3,141	4,086
Physical Science								
GOCO	1,902	1,987	2,326	2,178	2,451	2,456	2,435	2,460
Private	584	667	815	867	592	704	541	777
Life Science								
GOCO	434	409	427	363	448	511	496	564
Private	101	127	141	83	109	237	169	566
Health Physics Technicians								
GOCO	944	1,000	998	1,073	990	1,039	881	927
Private	334	502	555	619	783	857	828	975
Nuclear Reactor Operators								
GOCO	500	460	393	342	246	348	333	475
Private	386	615	769	994	1,227	1,260	1,466	1,572
All Other Technicians								
GOCO	3,229	2,693	2,385	2,268	1,151	1,282	1,472	1,637
Private	2,083	2,270	3,111	2,725	2,177	2,921	2,409	4,072

TABLE C-7

EMPLOYMENT OF SCIENTISTS, ENGINEERS, AND TECHNICIANS
BY SIZE OF FIRM IN THE ATOMIC ENERGY FIELD

	Private		GOCO	
	1968	1975[a]	1968	1975[a]
1-9	498	1,543	1	2
Scientists	85	239	0	2
Engineers	119	360	0	0
Technicians	220	574	0	0
10-49	3,349	8,069	91	157
Scientists	427	952	3	33
Engineers	721	1,851	15	8
Technicians	1,051	2,326	29	22
50-99	3,205	7,537	191	472
Scientists	200	645	24	96
Engineers	832	1,677	26	78
Technicians	1,014	1,763	16	78
100-499	15,261	34,731	4,572	3,243
Scientists	933	1,992	903	594
Engineers	3,542	7,607	597	538
Technicians	3,228	6,942	1,452	881
500-999	8,724	11,528	4,519	4,933
Scientists	162	247	536	357
Engineers	1,699	2,655	457	828
Technicians	1,604	2,103	478	1,130
1000-4999	11,691	39,612	44,406	62,929
Scientists	586	1,107	4,302	6,572
Engineers	2,898	13,872	6,244	9,045
Technicians	1,890	8,584	7,440	8,796
5000+	0	5,072	45,219	17,638
Scientists	0	99	4,863	2,191
Engineers	0	2,157	5,499	2,559
Technicians	0	623	6,971	3,235

[a]These data are unadjusted. Adjusted data are unavailable by size of firm.

TABLE C-8

STATE REGIONAL GROUPINGS

Region I - New England

Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

Region II - Middle Atlantic

New Jersey
New York
Pennsylvania
Puerto Rico

Region III - East North-Central

Illinois
Indiana
Michigan
Ohio
Wisconsin

Region IV - West North-Central

Iowa
Kansas
Minnesota
Missouri
Nebraska
North Dakota
South Dakota

Region V - South Atlantic

Delaware
District of Columbia
Florida
Georgia
Maryland
North Carolina
West Virginia
South Carolina
Virginia

Region VI - East South-Central

Alabama
Kentucky
Mississippi
Tennessee

Region VII - West South-Central

Arkansas
Louisiana
Oklahoma
Texas

Region VIII - Mountain

Arizona
Colorado
Idaho
Montana
Nevada
New Mexico
Utah
Wyoming

Region IX - Pacific

Alaska
California
Hawaii
Oregon
Washington

TABLE C-9

GOCO EMPLOYMENT AND FEDERAL FUNDING BY REGION
($1,000)

Region	1968 Funding	1968 Employment	1971 Funding	1971 Employment	1975 Funding	1975 Employment
1	$ 31,850	788	$ 23,393	272	$ 40,878	146
2	256,242	9,869	257,540	9,423	408,834	10,349
3	207,478	8,949	198,351	9,385	423,896	9,886
4	99,232	7,895	109,320	9,992	139,104	4,858
5	171,711	7,311	228,720	6,812	321,735	6,904
6	261,408	15,471	327,303	15,814	659,153	16,673
7	15,648	1,323	24,517	1,698	35,361	1,937
8	474,126	20,077	563,920	25,465	639,472	24,402
9	660,474	27,941	449,108	16,609	648,589	14,219

Cross-sectional regression results:

Independent variable = Funding

Dependent variable = Employment

1968: $y = 1,170 + .04x$ $R^2 = .959$

1971: $y = 5,715 + .04x$ $R^2 = .882$

1975: $y = -2,98.4 + .03x$ $R^2 = .843$

Sources: The funding figures are from the AEC Financial Report, 1968 and 1971. The 1975 figures were computed from partial year funding amounts from ERDA 1975 Financial Report.

TABLE C-10

GOCO EMPLOYMENT AND FEDERAL FUNDING BY REGION:
LONGITUDINAL RESULTS, 1968-1971 AND 1975

Region	Constant Term	Slope	R^2
I	-450	.03	.384
II	5,785	.02	.819
III	9,641	.00	.001
IV	-24,966	.36	.381
V	9,247	-.01	.637
VI	13,122	.01	.881
VII	-48	.09	.996
VIII	19,929	.01	.888
IX	-295	.04	.421

Independent variable = Federal funding

Dependent Variable = GOCO employment

TABLE C-11

GOCO RESEARCH AND DEVELOPMENT EMPLOYMENT AND REAL FEDERAL RESEARCH AND DEVELOPMENT EXPENDITURES IN ATOMIC ENERGY, 1968-1975

Year	R&D Expenditures[a] ($1000)	Consumer Price Index (1967=100)	Real Expenditures	GOCO R&D[b] Employment
1968	946.1	104.2	908.0	18,068
1969	927.1	109.8	844.3	18,205
1970	918.3	116.3	789.5	17,593
1971	919.0	121.3	757.6	17,054
1973	977.1	133.1	734.1	16,177
1975	1,305.0	161.2	809.6	16,624

[a]For Fiscal Years. Source: AEC Financial Report, various years; ERDA Financial Report 1975.

[b]Unadjusted data.

Regression Results:

Independent variable = Real expenditures
Dependent variable = GOCO R&D employment

n	equation	R^2
6	y=9138+10.1x	.612