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ABSTRACT

This document discusses and attempts to project scientific and engineering manpower supply and demand trends. Provided are detailed graphical and tabular data relating to science and engineering degrees awarded, enrollment trends, average annual openings for scientific and technical occupations, and projected supply/demand imbalances for scientific and technical occupations. Projections for future trends rely heavily upon federal funding of programs; however, employment for scientists and engineers is considered good when compared to other occupations, although full employment is not anticipated over the next decade. (SL)

SUPPLY and DEMAND for SCIENTISTS & ENGINEERS

A REVIEW OF SELECTED STUDIES

BY

BETTY M. VETTER

SMC
SCIENTIFIC MANPOWER COMMISSION

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February, 1977

The Scientific Manpower Commission is a nonprofit corporation made up of Commissioners representing its eleven member scientific societies.

The Commission is charged with the collection, analysis and dissemination of reliable information pertaining to the manpower resources of the United States in the fields of science, engineering and technology; promotion of the best possible programs of education and training of potential scientists, engineers and technicians; and development of policies of utilization of scientific, engineering and technological manpower by educational institutions, industry and government for optimum benefit to the nation.

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INTRODUCTION

Why is it important to assess whether supply and demand are or will be in fairly good balance over some period in the future? This kind of information is helpful to young people trying to plan their educations toward particular careers; to scientists and engineers already at work in the labor force who need to know where changes in balance are likely to occur; to colleges and universities and other training institutions; and to the employers of scientists and engineers.

Young people thinking about career goals want to know whether there are likely to be opportunities in science and engineering fields, and, in general, what areas of science or engineering are most likely to need significant numbers of new entrants. While no one would advise young people to choose a career solely on the basis of its apparent job opportunities at any particular time, this information helps them to make informed decisions when added to such other information as personal aptitudes and interests, opportunities for education, and willingness to spend long periods of time in preparation before moving into the world of work.

Scientists and engineers who become aware that the field in which they are working is getting over-crowded may wish to examine peripheral fields in which opportunities may be better in the near future, and start preparing themselves to make a shift at the most advantageous time. Those who do not take advantage of opportunities to look ahead may be totally unprepared to face a job shift if one becomes necessary.

Colleges and universities must plan ahead in developing faculty, deciding what courses to teach and preparing for the number of students that will wish to undertake particular curriculums. Such planning is helped when information is available on the job market a few years ahead.

Employers of scientists and engineers, including the colleges and universities that train them, need information about potential shortages or surpluses of scientists and engineers as a part of their long range planning. If there appears to be a shortage of engineers for example, an individual employer might wish to take steps to encourage those already in his employ to stay there, or to see that opportunities for an engineering education are offered to young people in his community who might not otherwise be able to undertake such education.

The kinds of information needed by each of these individuals or groups may be different in its level of sophistication, but knowledge of the general trends is important for each of them.

Assessing the future is difficult in any area, and particularly difficult when trying to anticipate how well the needs for particular kinds of training will match with the number of people trained in a period that must be at least four years and usually eight to ten years ahead. There are a number of unknown factors in the equation needed to make such projections, and some assumption must be made for each of these unknowns.

Making an accurate model to predict whether supply and demand will be in balance at some period in the future requires making an assumption about what young people of appropriate age to begin their training may decide to do, and the basis on which that decision will be made; the level of funding that will be available from any and all sources to pay salaries to the scientists and engineers that will be seeking jobs; and how each of these will affect the other. At present, there are no perfect predictive models, or even any that have consistently worked well in the past.

Several kinds of models are used. One of the major methods is to project what has happened in the past into the future. There are any number of variables that can be used within this kind of trend projection model, including giving heavier weighting to the most recent time period involved in the projection, or weighting for other factors such as an expected increase in the participation of women in areas where they have not previously been engaged in large enough numbers to be significant. The simplest trend models of supply use basic demographic information (such as the number of young people who will reach a particular age such as 18 or 22 in any year ahead); making the assumption that the behavior of this group will be similar to the behavior of young persons in a previous period in terms of the proportion that will choose to enter science and engineering, and thereby estimating the supply of new entrants over some particular period of time in the future. This number will be added to the present supply.

Using available demographic data from the past, such a model will subtract appropriate percentages each year for death and retirement, emigration, and transfers to other fields. The result will be an estimate of the number of persons who should be available and trained at any particular point in the future. Extra weighting may be given to recent years, or it may not. Such trend models have sometimes worked well in the past, and sometimes badly. Trend models may give poor results if that trend reverses direction or even slows or speeds the rate of change. This has happened in some instances for projections made over the past five years.

One way of projecting future demand is to ask the plans of a number of persons who ought to have some expert knowledge in the field, and combining these responses to compile a statistical forecast. For example, if a large number of employers are asked about their plans for hiring more scientists and engineers over certain periods of time in the future, and their responses are aggregated, a picture will emerge of the number of scientists and engineers who are likely to be hired if plans do not change. Of course, plans do change, and if the plans of a number of participants change in the same direction, the estimates will fail substantially to meet the reality.

Projections of demand sometimes are made by estimating a value for some factor such as the Gross National Product, and assuming that some proportion of the GNP can be translated into jobs for scientists and engineers.

Still other projections are based on an effort to predict how much funding will be applied to solve a particular problem such as protecting the environment or working toward energy independence. This kind of projection is not particularly useful in determining total manpower demand for scientists and engineers unless many other problem sectors also are projected at the same time and with the same set of basic assumptions.

For some purposes, it is more useful to anticipate how many chemists or how many electrical engineers may be required to fill the available jobs, while in other instances the broader category of "scientists" or "engineers" is similarly useful.

In every case, when projections for the future are made, some assumptions must be made about both present and future factors that will affect the supply of or the demand for scientists and engineers. The projections themselves may affect the outcome. For example, when high demand is projected for a particular area, more students will enroll in programs that will prepare them for those jobs. More importantly, students who are selecting study fields tend to react to a present employment market, even when they cannot affect that market for four or more years. Thus, when engineering employment is high, freshmen engineering enrollments rise. When new graduates have difficulty finding positions, freshman enrollments drop, thus producing a smaller class four years later.

Since the assessment of future supply and demand is so difficult, and since the projections that are made may turn out to be wrong, it might seem that the process of attempting to project supply and demand is not worth the time and effort required. However, projections are among the tools necessary for planning.

Right or wrong, such assessments, if given widespread publicity, can change the parameters by influencing the actions of potential students, employers, and training institutions. Some of these influences are inadvertent, but some are meant to change the outcome. For example, the amount of support available to assist students obtain training in science and engineering can be modified to increase or decrease the available manpower a few years later. In the past, since most projections indicated a shortage of trained people, this has usually meant an increase in support for the training of scientists or engineers. In the future, at least some of the effort may move in the opposite direction. For example, a recent National Research Council report on the need for biomedical and behavioral scientists[1] indicates that some surplus of trained persons already exists and recommends that support for predoctoral training in some instances should be reduced.

Forecasts of over- or under-supply are among factors used by training institutions in deciding whether to add or drop particular programs. Recent projections of over-supply at the doctorate level have been cited among reasons for dropping doctorate programs at a number of state-supported schools.

Even though the art of forecasting presently is inexact, and indeed sometimes grossly in error, forecasts should be made because they are needed for planning purposes. They also should be monitored on a regular basis and adjustments made when change is indicated.

RECENT SUPPLY/DEMAND IMBALANCES

Beginning during World War II, and continuing until the end of the 1960's, the technological advancements of the United States moved at a rate which not only allowed for the utilization of almost all the scientists and engineers who had been trained, but also displayed a voracious appetite for more. There were chronic shortages of certain kinds of scientists and engineers through the middle fifties, and great efforts were made to increase the number of persons trained in those areas, both for traditional activities and for such exotic programs as space exploration. By the middle sixties, these efforts in the form of scholarships and fellowships and G.I. educational benefits, coupled with a rapid increase in the proportion of young people entering higher education, had resulted in a substantial increase in the number of science and engineering graduates.

Unfortunately, these programs were set in motion with the assumption that shortages would continue indefinitely, and no long range plans for assessing continued need for such programs were formalized. Thus, in 1967, when budgets for the space program hit their peak, young men (and an occasional woman) were still pouring into the bottom of the educational pipeline to prepare for careers in aerospace engineering, and indeed in all fields of engineering. Even by 1969, when budget figures for space and other programs were dropping steadily, freshmen engineering enrollments were still holding at about 75,000 entrants, although a small drop had occured. This meant that the graduating classes of 1970 through 1973 would be about 43,000 per year.

Even as the space program continued reductions in 1969, the economy began to falter following years of inflationary guns-and-butter budgets, and industry as well as

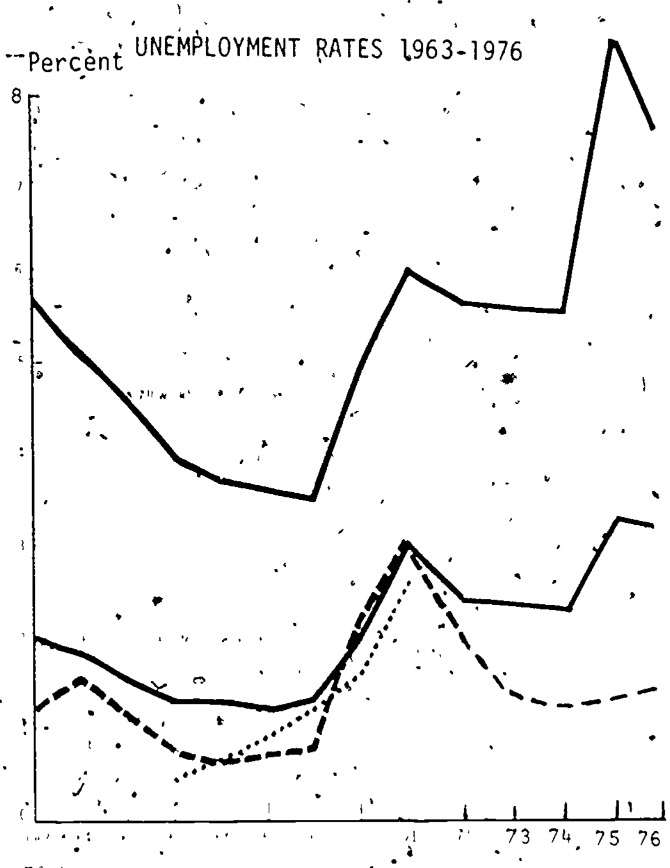


Fig. 1

government not only reduced hiring substantially but also began large layoffs of engineers and scientists. By 1971, the unemployment rate for these highly skilled persons had reached 3% (Fig.1) even as record classes of new graduates at all degree levels poured out of colleges and universities to swell their ranks. "Under-employment," always difficult to measure, probably affected at least as many scientists and engineers as were unemployed and seeking jobs. These two groups were augmented by a third group on whom no accurate data exist - those forced into early retirement in their fifties and early sixties, often with little or no pension rights.

While most employment sectors faltered, employment in aerospace stumbled down hill at a rapid pace, shaking out not only the deadwood, the partially qualified and the upgraded engineers who had been hired in earlier years when aeronautical engineers could not be trained fast enough to fill the demand, but also the highly trained, rigorously skilled specialists of the space age who had made possible Neal Armstrong's "giant step for mankind." With them went whole support teams, honed to a fine edge to work together to reduce the impossible to the difficult.

Some of these jobless men would have had reemployment difficulty even in a steady employment market. Some were not fully trained engineers to begin with, and while they had learned some particular engineering function, their training was often not readily transferrable to another engineering setting. But some of them were the cream of the engineering crop. Their reemployment difficulties stemmed not only from a general job shortage but also from three other factors: unwillingness to relocate (with concomitant loss in selling their homes, etc.); high salary requirements to match what they had been earning; and in the case of the aerospace engineers, a reputation that may or may not have been deserved for having no understanding of the necessity of cost accounting. Industry, required by its nature to show a profit, was often unwilling to hire these specialists accustomed to working with almost unlimited government funds.

By late 1973, employment had risen and unemployment dropped among scientists and engineers, but the trend reversed again in 1975, and unemployment rates have continued to be a problem in 1976, although not to the degree that occured in the 1971 recession. Of course, these rates are low compared to total unemployment rates.

Meantime, a residual effect in attitudes has become apparent and science and engineering professionals have been awakened to the seriousness of over-supply problems. Even those whose jobs have not been directly threatened have felt threatened, and those who have learned through bitter experience that employment stability and government contract work are sometimes incompatible, have became increasingly vocal. Beginning in 1971, the character of professional society meetings changed. Disrupters - not only the student generation but angry men in their forties - broke up meetings and demanded microphones. They also talked to their children and their neighbor's children and were persuasive in their arguments that engineering and physical science offered little in return for long and difficult college preparation.

Newspapers and magazines, too, picked up the stories of cab-driving engineering graduates and aerospace specialists selling real estate. This was news because it was unusual. It made good feature stories.

At the same time, science and technology were getting a bad image with young people because of a perceived relationship to an unpopular war and to environmental degradation. The high school class of 1971 could hardly remember a time when the United States had not been fighting in Vietnam, and they had watched that war through their television screens. Their view of technology was highly colored by the horrors of napalm, defoliant orange, and sophisticated bombs that could not differentiate combatants from civilians.

These young people also were the first generation to be broadly aware of the dangers of environmental polution. They blamed technology, and few of them recognized that the application of responsible technology was the only way to repair past damage and to maintain the planet's habitability.

Both these idealistic young people and many who sought more materialistic rewards in a career, such as prestige, high salaries and job security, expressed their frustration with science and technology when, in the freshman class of 1971, engineering enrollment dropped from 71,500 to 58,500 in one year. Enrollments in physics, mathematics and chemistry also dropped, despite increases in enrollments in all other fields.

This anti-technology focus began to blur in 1974, and by the fall of 1976, when job opportunities for engineering graduates continued to be much better than for graduates in any other field, enrollments in the freshman engineering class were back to the level of the middle sixties.

One other major change that occurred in the first half of the seventies was the new emphasis on equal opportunities for women and for minorities, and especially in professional areas such as engineering where their representation has been negligible. Between fall 1969 and fall 1975, the number of first-year women in engineering school increased an astonishing 470 percent, although women were still only 8.9% of the freshman class of 1975.[9] The 314 black engineering graduates of 1969 more than doubled to 734 in 1975, although the proportion of the total that is black remains under two percent. Women and probably minority members will continue to enter science and engineering in increasing proportions, and this change will need to be considered in projecting future supply.

SUPPLY

The science and engineering manpower pool is made up of persons already trained and in the labor force with new additions and subtractions constantly occurring. Persons are lost from this pool by death, retirement, and transfer out of these professions. Persons are added in four ways: by the input of new graduates at all degree levels; the immigration of previously trained scientists and engineers from other countries; the transfer from other related disciplines; and by "upgrading." This latter process usually results from on-the-job experience, but sometimes it happens just because qualified entrants cannot be recruited. Thus, the "upgraded" entrant, particularly in engineering where he is a major component of the engineering workforce in most statistical data, may be qualified only within narrow limits.

New Graduates

The entrance of new graduates is the least difficult segment to project, at least over a short range of years. In engineering, for example, we can begin the count at the freshman year, and in the sciences, where a graduate degree is more likely to represent the professional entrance level, studies of junior year enrollments and trends provide the beginnings of a data base from which to project degrees.

Over the past several years, as more and more students have entered the nation's institutions of higher education, including its graduate schools, enrollments in the physical sciences and engineering have fallen both as a percentage of all students enrolled and, in the past few years, in actual numbers (Figs. 2, 3 and 4).

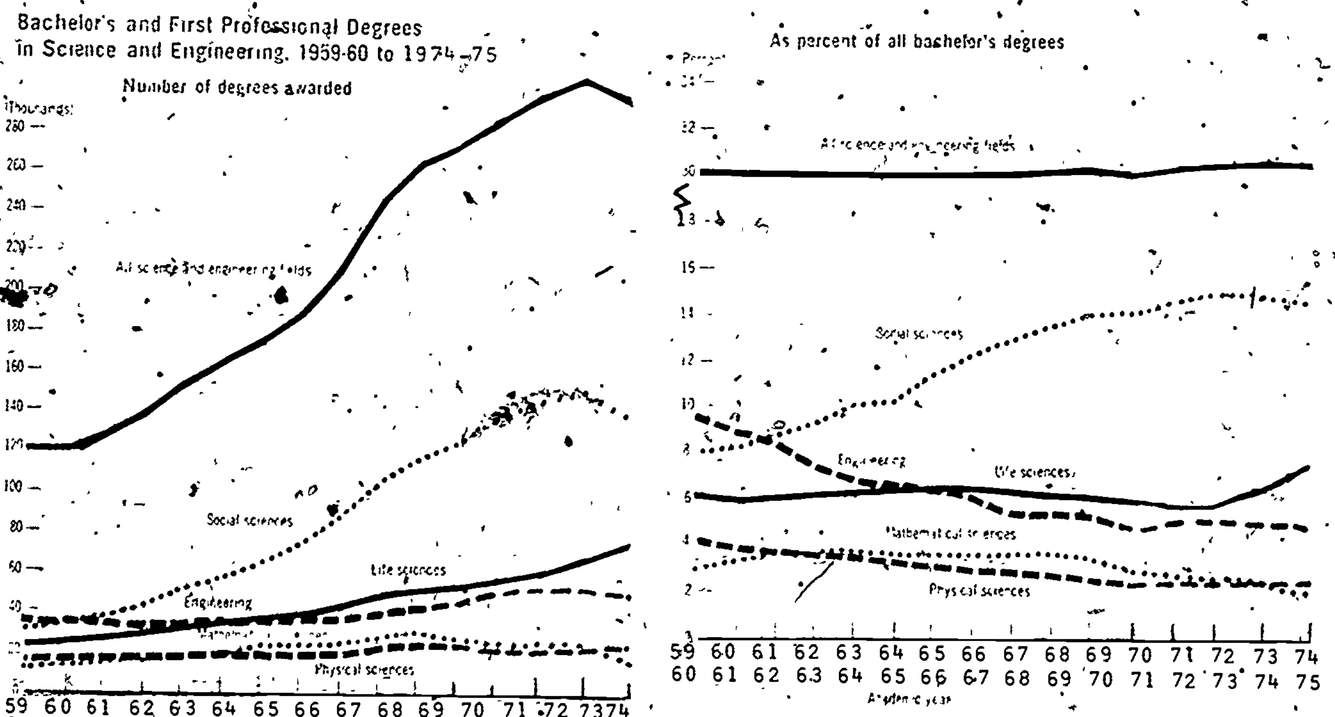


Fig. 2

Master's Degrees in Science and Engineering, 1959-60 to 1974-75

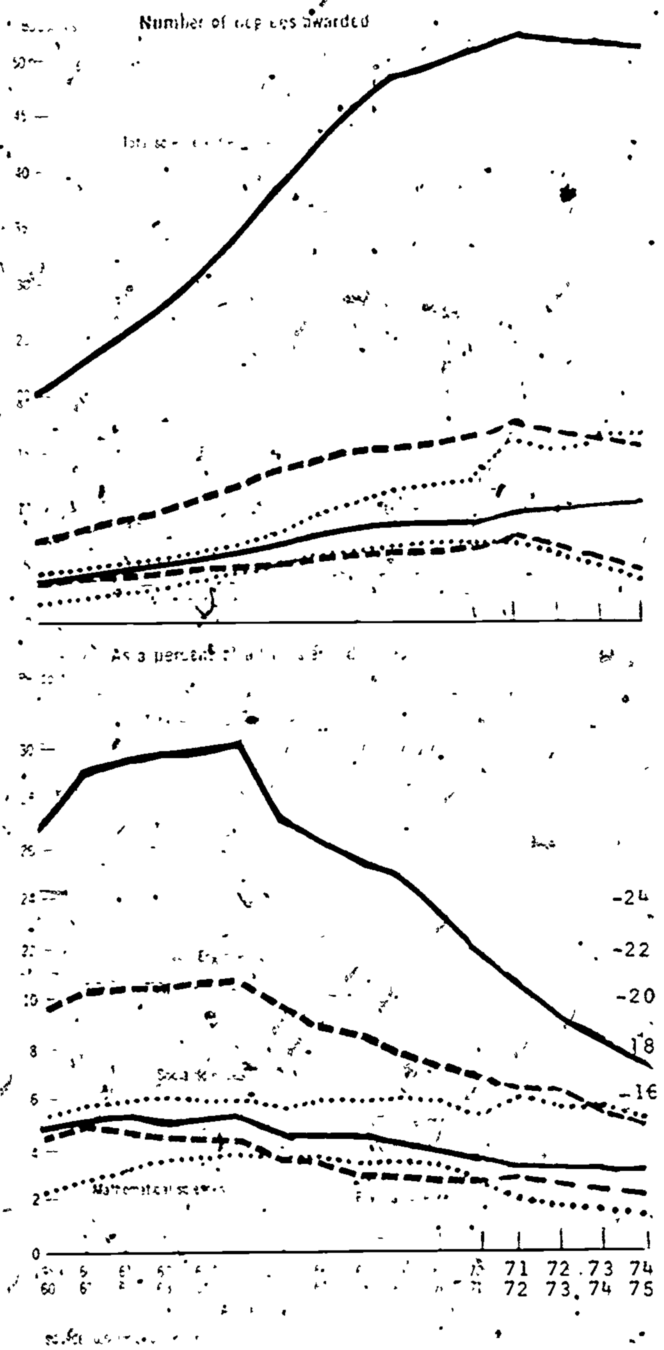


Fig. 3

Doctor's Degrees in Science and Engineering, 1959-60 to 1974-75

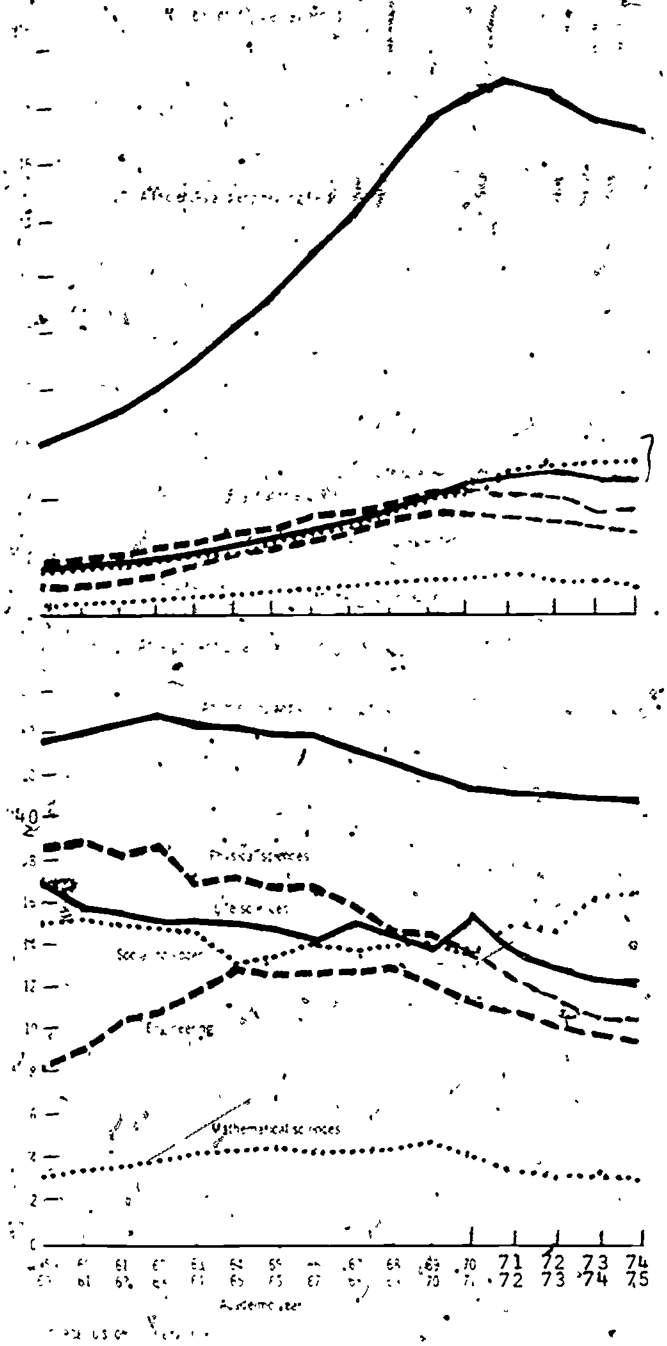
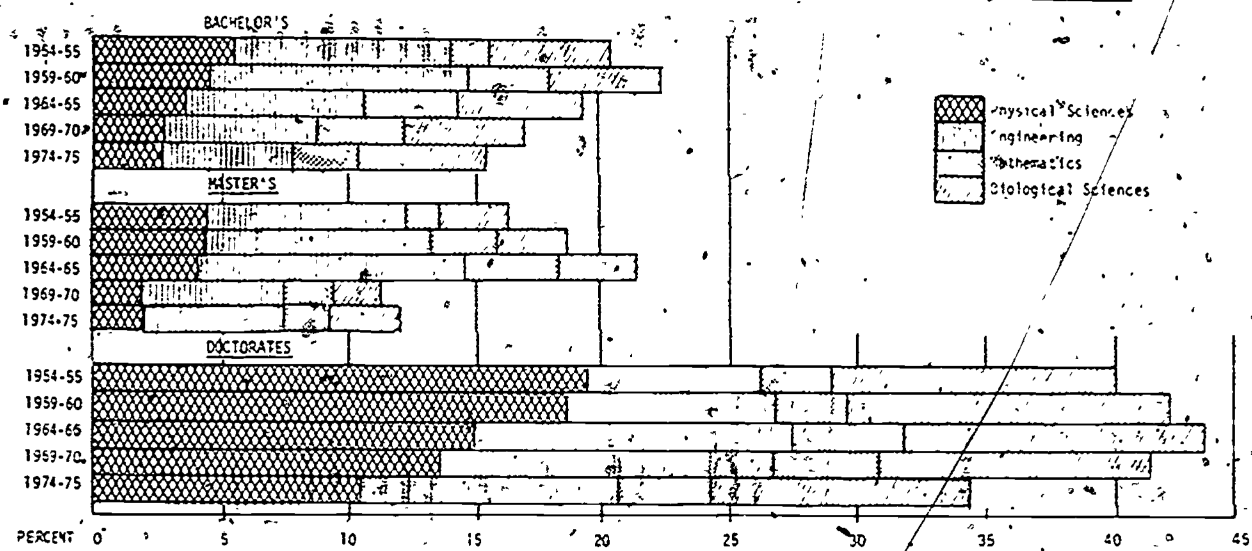


Fig. 4

As a percentage of all bachelor's degrees granted, the combined total of those in physical sciences and engineering fell from 20% in 1950 to 14% in 1960, to 8% in 1970 and to 7.2% in 1974-75 (Fig. 5). Current projections by the National Center for Education Statistics indicate about the same proportion in 1985. At the master's level,

PHYSICAL SCIENCE, ENGINEERING, MATHEMATICS AND BIOLOGICAL SCIENCE DEGREES AS A PERCENTAGE OF ALL DEGREES GRANTED



Source. Series of Earned Degrees Conferred, U. S. Office of Education

Fig. 5

the percentage of physical science and engineering degrees together has dropped from 14.6% to 7.2% in the past ten years. That drop is expected to continue through 1985. The doctorate pattern is similar.

Despite the falling proportions in the physical and engineering sciences, because of the increasing size of the college population the actual number of degrees granted in these fields generally held steady or increased through the sixties at all degree levels while those in the social and life sciences rose rapidly. However, while the college population is still expanding as it will for another five years, both the percentage and the number of degrees in science and engineering have fallen over the past four years, except in the life and social sciences.

TABLE 1
FULL-TIME FRESHMAN ENROLLMENTS AND BACCALAUREATE DEGREES IN ENGINEERING, 1964-65 TO 1976-77

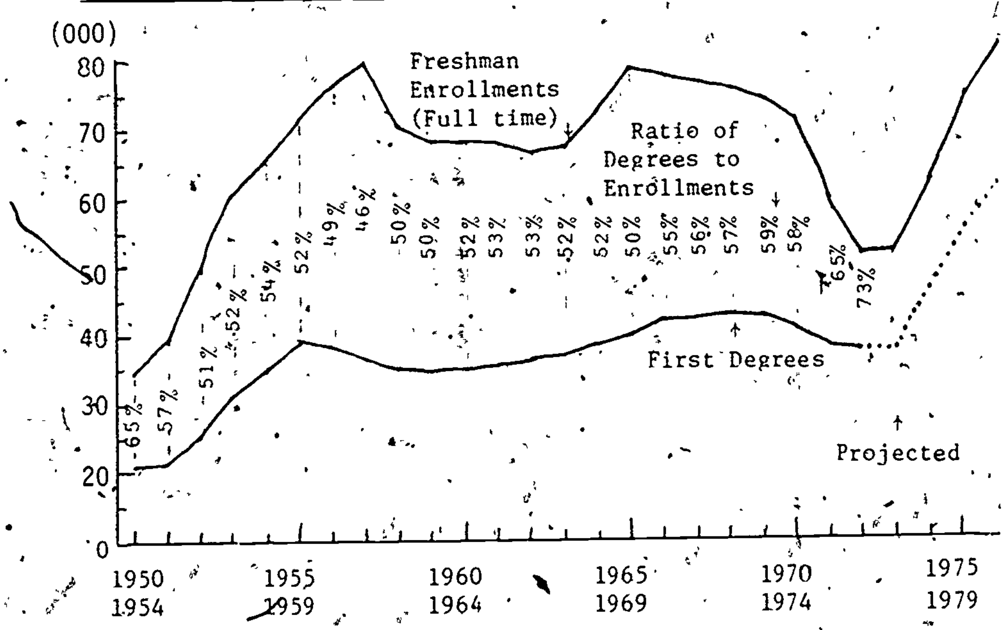
Year	Full-Time Freshman Enrollment	BS Degrees Granted
1964-65	73,682	36,691
1965-66	79,872	35,815
1966-67	78,400	36,186
1967-68	77,551	38,002
1968-69	77,484	39,972
1969-70	74,113	42,966
1970-71	71,661	43,167
1971-72	58,566	44,190
1972-73	52,100	43,429
1973-74	51,925	41,407
1974-75	63,440	38,210
1975-76	75,343	37,970
1976-77	82,500	*37,900

*Estimated
Source: Engineering Manpower Commission

In engineering, where we can measure intended majors even at the freshman year, the enrollment drop from the fall of 1970 to the fall of 1971 was a whopping 18% followed by a further 11% drop in the fall of 1972. Enrollments leveled off in 1973 and started up again in 1974, with an increase in the proportion of women. Women made up nine percent of the freshman class in 1975, up from less than two percent six years earlier. The freshman class increased 18 percent in fall 1975, and is up another 9.5% in 1976.[2]

When freshman enrollment is plotted against first degrees four years later, (Fig. 6) we see not only the abrupt shifts in popularity of engineering among freshman, but also a major change in the ratio of baccalaureate degrees to freshman enrollments four and a half years earlier.

ENGINEERING FRESHMAN ENROLLMENTS, FIRST DEGREES, AND DEGREE RATIOS



Source: Engineering Manpower Commission

Fig. 6

The freshman class is reduced by attrition, especially after the freshman year, and augmented by input from two year colleges (particularly at the junior year level) and transfers from other subject areas. Whether the reduced attrition from freshman year to first degree is a continuing trend is not yet certain.

In physics, the enrollment drop is similar to engineering and the number of bachelor's degrees granted began to fall in 1969-70. The drop contined through 1975 and will fall again in 1976 (Table 2). Women made up 9.6% and 7.8% respectively of the lower degree graduates, and 4.8% of the doctorates in physics in 1975.

TABLE 2

PHYSICS ENROLLMENTS AND DEGREES IN THE U.S.

Academic Year (July 1 to June 30)	Physics Degrees Granted			Undergraduate Physics Majors Enrolled		Graduate Students Enrolled	
	Bachelor's	Master's	Doctorate	Junior Year	Senior Year	Total	First Year
1962-63	5.452	1,850	858	7,873	6,386	12,256	
1963-64	5,611	1,907	792	7,520	6,676	13,046	4,061
1964-65	5,517	2,045	983	7,132	5,514	13,629	4,167
1965-66	5,037	2,050	948	7,014	6,296	14,876	4,358
1966-67	5,236	2,193	1,233	7,845	5,992	15,504	4,162
1967-68	5,522	2,077	1,325	7,822	6,704	15,395	4,010
1968-69	5,975	2,223	1,355	7,587	7,019	15.475	3,669
1969-70	5,782	2,263	1,545	7,480	6,700	14,372	3,918
1970-71	5,765	2,300	[illegible]	6,884	6,663	14,327	3,494
1971-72	5,262	2,113	1,438	6,593	6,162	13,276	3,336
1972-73	4,923	1.961	1.445	6,012	5.806	11,804	2.904
1973-74	4,652	1,772	1,236	5,858	5,608	11.119	2,680
1974-75	4,571	1,557	1,167	5,660	5,409	10,410	2,668

Source: American Institute of Physics

TABLE 3

DEGREES IN GEOLOGY & EARTH SCIENCES

Year	Bachelor's	Master's	Doctorates
1970-71	3330	1084	440
1971-72	3861	1299	580
1972-73	4273	1416	577
1973-74	4834	1604	570
1974-75	4825	1512	492

SOURCE: NCES

In the geological sciences, where demand is increasing as a result of the energy problems of the country, degrees are dropping, (Table 3). The only reason they did not fall earlier is the increased enrollment of women, who made up almost 19% of the undergraduate enrollment in 1974, 14% of master's enrollment and 10% of enrollment for doctoral degrees. These figures represent increases of 34% from the previous year for women undergraduates and 21% for women doctoral students.

Table 4
CHEMISTRY DEGREES

Year	Bachelor's	Master's	Doctorates
1964-65	10,047	1715	1414
1965-66	9,735	1839	1571
1966-67	9,872	1831	1744
1967-68	10,847	2014	1757
1968-69	11,807	2070	1941
1969-70	11,617	2146	2208
1970-71	11,183	2284	2160
1971-72	10,721	2259	1971
1972-73	10,222	2230	1882
1973-74	10,517	2138	1828
1974-75	10,549	1986	1822

Sources: USOE, NCES

In chemistry, the drop in bachelor's degrees began in 1970; graduate degrees a year later (Table 4). Bachelor's degrees have risen slightly in the past two years, but graduate degrees are still dropping. The number of new Ph.D.'s is expected to fall below 1,500 in 1976. Women chemists earned 22% and 20% of the bachelor's and master's degrees in 1975, and 11% of the doctorates, up from 7% a decade earlier.

Table 5
DEGREES IN THE LIFE SCIENCES

Year	Bachelor's	Master's	Doctorates
68-69	43,260	8239	3779
69-70	48,713	7997	4131
70-71	52,129	8185	4534
71-72	53,484	8914	4478
72-73	59,486	9080	4524
73-74	68,226	9605	4220
74-75	68,237	9231	4216

SOURCE: NCES

In the life sciences, degrees awarded during the seventies have continued to rise rapidly at the bachelor's and master's levels, where women make up almost a third of the graduates (Table 5). The number of doctorates peaked in 1973. Women have earned almost a fourth of bioscience doctorates during the seventies. Enrollments in the health fields also are rising rapidly.

TABLE 6
DEGREES IN MATHEMATICS

Year	Bachelor's	Master's	Doctorates
1971-72	23,848	5209	1128
1972-73	23,223	5033	1068
1973-74	21,813	4840	1031
1974-75	18,181	4327	975

SOURCE: NCES

Mathematics, too, is a field with a significant proportion of women. In 1975, women earned 42% of the bachelor's, 33% of the master's and 11% of the doctorate degrees. As in the physical sciences, degrees in this field are dropping steadily at all levels (Table 6).

TABLE 7

DEGREES IN SOCIAL SCIENCES

Year	Bachelor's	Master's	Doctorates
1971-72	133,604	15,176	5073
1972-73	140,579	14,976	5200
1973-74	145,449	15,974	5449
1974-75	150,467	18,483	4100

Source: NCES

In the social sciences, the number of degrees has continued to climb steadily for two decades, although the social sciences proportion of all degrees is now dropping (Table 7). In 1974-75, the number of bachelor's and masters degrees continued to rise, but the doctorates dropped in that year. Women earned 43% of the bachelor's, 34% of the master's and 33% of the doctorates in the social sciences in 1975.

TABLE 8

SCIENCE AND ENGINEERING DEGREES AS A PERCENTAGE OF ALL DEGREES GRANTED

Year	Mathematics and statistics	Computer and information sciences	Engineering	Physical sciences	Biological sciences	Agriculture and natural resources	Social science	Psychology
				Bachelor's				
1964–65	3.9		7.7	3.6	5.0	1.5	16.4	2.9
1974–75	2.2	0.6	5.0	2.2	5.1	1.7	16.1	5.7
1984–85	1.7	0.9	5.7	2.1	4.9	1.8	14.7	7.7
				Master's				
1964–65	3.6	0.1	10.3	4.2	3.1	1.4	8.2	1.9
1974–75	1.7	0.9	5.4	2.1	2.3	1.0	6.5	2.4
1984–85	1.3	1.5	5.1	1.6	2.2	1.0	5.8	2.5
				Doctor's				
1964–65	4.1		13.0	17.2	11.7	4.0	11.2	5.1
1974–75	2.9	0.8	9.8	10.0	10.2	2.8	11.8	7.4
1984–85	1.7	0.8	6.2	7.1	8.3	2.2	10.6	9.3

NOTE.—Data are for 50 States and the District of Columbia for all years. Because of rounding, details may not add to totals.

Less than 0.05

Source: National Center for Education Statistics

The degree pattern of the past ten years looks fairly clear (Table 8). Students have continued to major in fields that are already over-crowded: psychology, social sciences, education and humanities, while degrees have been dropping in fields such as engineering, chemistry, geology and mathematics. Projections 10 years ahead show a general continuation of this trend. The proportion of women is rising in all these fields, but is still far below their proportion among all students.

An examination of changes in graduate enrollment over a five year period as measured by the Council of Graduate Schools shows the picture clearly (Table 9). Enrollment has been rising, and fairly rapidly, in fields where surpluses already exist and more are predicted. Enrollments have fallen in the physical sciences and engineering where, below the doctorate at least, jobs are generally expected to be in balance with supply.

Enrollments, however, may have turned up again at the graduate level in some of these fields. The National Science Foundation reports that between 1972 and 1973, graduate enrollments in a set of matched departments dropped in all areas except the life sciences (Table 10).

TABLE 9

PERCENT CHANGE IN TOTAL GRADUATE ENROLLMENTS BY FIELD, 1970-71 TO 1975-76

FIELD	1970-71 TO 1971-72	1971-72 TO 1972-73	1973-74 TO 1974-75	1974-75 TO 1975-76
Education	+6.0%	+5.7%	+8.5%	+3.5%
Humanities	+1.1	+2.8	+2.1	+0.6
Social Sciences	+3.3	+3.2	+2.7	+2.5
Biological Sciences	+9.6	+4.5	+9.3	+6.1
Physical Sciences	-1.9	-6.5	-1.9	+1.7
Engineering	-	-2.0	No Change	+3.0
Total All Fields	+3.4	+1.9	+4.4	+1.5

Source: Council of Graduate Schools of the U.S.

TABLE 10

PERCENT CHANGE IN GRADUATE ENROLLMENT[1] 1972 TO 1973

Area & Field of Science	1972	1973	Percent Change
Total	160,302	157,306	-1.9
Engineering	40,960	39,525	-3.5
Civil	6,555	6,508	-.7
Electrical	11,542	10,636	-8.3
Mechanical	5,793	5,566	-3.9
All Other	17,070	16,865	-1.2
Physical Sciences	26,387	25,777	-2.3
Chemistry	11,482	11,067	-3.6
Geosciences	3,935	4,104	4.3
Physics	8,907	8,402	-5.7
All Other	2,[illegible]63	2,204	6.8
Mathematical Sciences	14,825	14,379	-3.0
Applied Math	3,388	3,574	5.5
Mathematics	10,119	9,440	-6.7
Statistics	1,318	1,365	3.6
Life Sciences	30,959	31,651	2.2
Agriculture	7,665	7,857	2.5
Biochemistry	3,227	3,257	.9
Biology	6,365	6,459	1.5
All Other	13,702	14,078	2.7
Psychology	13,436	13,246	-1.4
Social Sciences	33,735	32,728	-3.0
Economics	7,057	6,878	-2.5
Political Science	7,752	7,435	-4.1
Sociology	7,662	7,011	-8.5
All Other	11,264	11,404	1.2

[1]Based on full and part-time enrollment in 3,374 matched departments reporting for each of the years.
SOURCE: National Science Foundation

Between 1974 and 1975, however, matched departments reported increases in enrollment in almost all fields of science (Table 11). The increase continues to be rapid in the social sciences, following the pattern of the past several years.

National Science Foundation projections of graduate enrollment by field of science in 1980 and 1985 are shown in Table 12.[3]

TABLE 11

Graduate science enrollment by field, 1974-75[1]

Area and field of science	1974	1975	Percent change
Total	265 982	290 662	9 3
Engineering	58 082	62 580	7 7
Chemical	4 559	4 920	7 9
Civil	9 954	11,113	11.6
Electrical	15,105	15 229	8
Industrial	7 981	9 176	15 0
Mechanical	7 789	7 839	6
All other	12,694	14 303	12 7
Physical and environmental sciences	34 233	34 977	2 2
Physical sciences total	24,534	24 549	1
Astronomy	602	606	7
Chemistry	13 605	13,917	2 3
Physics	10 327	10 026	−2 9
Environmental sciences total	9,699	10 428	7 5
Atmospheric	1 008	988	−2 0
Geosciences	6,708	7 394	10 2
Oceanography	1,983	2 046	3 2
Mathematical sciences	19 652	20,337	3 5
Applied mathematics	6 089	6 760	11 0
Mathematics	11 744	11 522	−1 9
Statistics	1 819	2 055	13 0
Life sciences	62,980	68,886	9 4
Agriculture	10 316	11 435	10 8
Biochemistry	3 678	3 653	− 7
Biology	10,004	11 783	17 8
Botany	2,642	2 730	3 3
Microbiology	3 849	3 953	2 7
Nutrition	2,651	2,697	1 7
Physiology	2 320	2 338	8
Zoology	3 574	3 574	0
Other biosciences	9 111	10 342	13 5
Clinical medical	14 835	16,381	10 4
Psychology	25 052	27 123	8 3
Social sciences	65 983	76 759	16 3
Anthropology	5,675	6 086	7 2
Economics	10 550	11 528	9 3
Linguistics	7 227	8 464	17 1
Political science	15 228	19 657	29 1
Sociology	13 224	14 101	15 0
All other	14 079	16 833	19 6

[1]Based on full and part time enrollment in 7 664 graduate departments
SOURCE National Science Foundation

TABLE 12

ENROLLMENT FOR ADVANCED DEGREES IN SCIENCE/ENGINEERING FIELDS: TOTAL, FALL 1960-85

Year	Total S/E	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences
			Total			
1960	120 638	25 707	36 636	11 770	19 715	26,810
1961	128,794	26 553	39,367	12 671	21,446	28 757
1962	142 433	28,591	43,850	14 121	23,953	31 918
1963	158 051	30 959	48 917	15 974	26,888	35,313
1964	178,123	34 061	54,318	18 805	30,787	40,152
1965	195,346	36,506	57 516	21 014	34,749	45,561
1966	207,049	37,950	58,338	23 150	37,007	50,604
1967	224,468	40 447	62 633	26,066	39,954	56 368
1968	234 661	40,037	63 662	26 840	41,676	61,546
1969	243 715	39 685	65,048	29 175	44,203	65 404
1970	252,159	40 113	64,788	30,608	46,260	70,890
1971	246,100	38,928	59 321	28,847	47,662	71 342
1972*	242 988	36 047	55,847	28 064	49,118	73,912
1973*	244 354	35 995	54,567	27,023	50,714	76 055
Projected						
1980 Probable	237 000	26 500	48,100	22,900	52,500	87,000
1980 Static	287 400	31 100	55,100	28,700	66 800	105,700
1985 Probable	210,000	19 000	45,000	18,100	47,900	80,600
1985 Static	314,800	27 100	57,900	29,100	78,800	121 900

*Data not available when projections were made.
Sources: 1960-73 data, NCES. Projections, NSF.

Immigrants

New graduates make up only a part of the entrants to supply. The number of scientists and engineers who immigrated to the U.S. peaked in FY 1970 at 13,300, but fell to 6,600 in FY 1973, down more than 50% from the peak, because of stiffer restrictions on immigrant scientists and engineers entering the U.S. to work, which were established in February 1971 (Table 13). A report in preparation at NSF provides data which indicate that the level established in 1973 has continued through 1975.

TABLE 13

IMMIGRANT SCIENTISTS AND ENGINEERS

Fiscal Year	Total Scientists & Engineers	Engineers*	Natural Scientists*	Social Scientists*
1949	1,369**	956	413	NA
1950	2,045**	1,279	766	NA
1951	2,098**	1,591	507	NA
1952	3,449	2,399	805	245
1953	2,866	2,064	654	148
1954	3,336	2,400	800	136
1955	3,002	2,071	791	140
1956	3,952	2,804	986	162
1957	6,046	4,547	1,345	154
1958	5,380	4,032	1,212	136
1959	5,290	3,950	1,188	152
1960	4,550	3,354	1,043	153
1961	4,171	2,890	1,102	170
1962	4,297	2,940	1,165	192
1963	5,933	4,014	1,688	231
1964	5,762	3,725	1,754	283
1965	5,345	3,446	1,597	302
1966	7,205	4,915	1,949	341
1967	12,523	8,821	3,158	544
1968	12,973	9,313	3,110	550
1969	10,255	7,150	2,601	504
1970	13,337	9,305	3,264	768
1971	13,102	9,015	3,456	631
1972	11,323	7,436	3,271	616
1973	6,632	4,443	1,790	399

*Includes professors and instructors

**Total excludes a small number of social scientists for whom data are not available.

Source: National Science Foundation

Engineers typically have made up 65 to 70 percent of the total of immigrant scientists and engineers, with the remainder distributed through the natural and social sciences. Immigrant scientists and engineers make up only a small segment of the total U.S. science and engineering manpower pool.

TABLE 14

PHYSICIAN AND SURGEON IMMIGRANTS COMPARED WITH NUMBERS OF U.S. MEDICAL GRADUATES

Fiscal Year	U.S. Medical Graduates	Immigrant Physicians
1962	7,168	1,797
1963	7,264	2,093
1964	7,336	2,249
1965	7,409	2,012
1966	7,574	2,552
1967	7,743	3,326
1968	7,973	3,128
1969	8,059	2,756
1970	8,367	3,158
1971	8,974	5,756
1972	9,551	7,143
1973	10,391	7,119
1974	11,613	6,321
1975	12,714	5,361

Sources: National Science Foundation
Journal of the American Medical Association, v. 234, No. 13

Physician entrants, however, constituted about 40% of the total of new U.S. graduates plus immigrant physicians in 1973 (Table 14). Some of these immigrant physicians take other roles in the life sciences, and never become licensed as U.S. physicians.

Other Entrants

A third source for new supply, particularly in engineering, is the rest of the technological pool itself. Technicians and others with less than a bachelor's degree in engineering often are classified and employed as engineers without the formal education of engineers. Additionally, a smaller group of persons transfer into engineering from other disciplines, usually mathematics or the physical sciences, to add to this pool. The number of 'upgraded' technicians or "practical" engineers is uncertain, but these individuals become important on the supply side because their numbers increase during periods of expanding demand and/or falling supply of new graduates. They are also in the forefront of layoffs and the tail of reemployment - creating considerable human tragedy. Transfers from one field to another within the science and engineering pool also are common.

Existing Pool of Trained Scientists and Engineers

New graduates, new immigrants and newly classified engineers and scientists move into the existing manpower pool. This technological pool is constantly depleted as well, through deaths, retirements and transfers into other fields or into management areas. A conservative estimate of annual depletion is 1.5%.

One major source of information about the existing science and engineering manpower pools is the 1970 Census and the 1972 and 1974 Postcensal surveys of scientific and technical manpower.

A national sample of scientists and engineers, identified from the 1970 Census, was surveyed in 1972 and again in 1974. The 1974 survey forms one part of a three-part Manpower Characteristics System of the National Science Foundation. The second part consists of biennial surveys of a selected sample of doctoral scientists and engineers performed by the Commission on Human Resources of the National Academy of

Sciences, and the third part estimates new entrants from Universities and colleges. Field identification of the 1974 National Sample and in the combined Manpower Characteristics System is shown in Table 15. The National Sample represents about 55% of the total, with the proportion being higher in some fields, notably the physical sciences, and lower in the life and social sciences and psychology.

Table 15
U.S. SCIENTISTS AND ENGINEERS BY FIELD, 1974
NATIONAL SAMPLE AND TOTAL, MCS

FIELD	National Sample Number	Percent	Total Manpower Characteristics System Number	Percent
Total, All Fields	1,079,698	100.0	1,973,200	100.0
Physical Scientists	121,011	11.2	188,300	9.5
Chemists	87,334	8.1	138,000	7.0
Physicists/Astronomers	27,519	2.5	42,400	2.1
Other Physical Scientists	6,158	.6	7,800	.4
Mathematical Scientists	27,833	2.6	60,400	3.1
Mathematicians	20,076	1.9	43,500	2.2
Statisticians	7,757	.7	16,900	.9
Computer Specialists	55,186	5.1	125,500	6.4
Environmental Scientists	29,466	2.7	52,000	2.6
Earth Scientists	24,589	2.3	45,600	2.3
Oceanographers	1,563	.1	2,000	.1
Atmospheric Scientists	3,314	.3	4,300	.2
Engineers	687,911	63.8	1,071,800	54.3
Life Scientists	75,462	7.0	193,900	9.8
Biological Scientists	35,935	3.3	118,000	6.0
Agricultural Scientists	28,790	2.7	57,900	2.9
Medical Scientists	10,737	1.0	18,100	.9
Psychologists	34,889	3.2	94,700	4.8
Social Scientists	47,940	4.4	186,700	9.5
Economists	19,754	1.8	54,600	2.8
Sociologists/Anthropologists	11,158	1.0	50,400	2.6
Other Social Scientists	17,028	1.6	81,700	4.1

SOURCE: National Science Foundation, NSF 75-333 and NSF 76-312.

In the 1974 total estimates, the National Science Foundation finds only 185,000 women (8,000 engineers, or .75% of the total, and 178,000 scientists (20%) for a total representation of less than 10%.[4]

In 1972, the National Science Foundation found that the proportion of persons in each occupation whose highest degree is in some other field ranged from 28.4% of the mathematical specialists to 9.6% of the psychologists, thus adding another complication to estimating supply on the basis of degrees granted by field. Among those identified as physical or life scientists, for example, less than 80% held their highest degree in these broad fields. Within more detailed fields, the variation is wider. Among 104,413 chemists, 77% held their highest degree in chemistry, but among 106,309 computer specialists, only 6% held their highest degree in computer science and systems analysis.

The proportion of each group that has no degree or less than a baccalaureate degree ranges from 11% of the engineers to less than one percent of the life and social scientists.

These groups also vary widely in the level of formal education achieved. The proportion with doctorates ranges from less than 4% of engineers to almost 50% of psychologists (Table 16).

TABLE 16

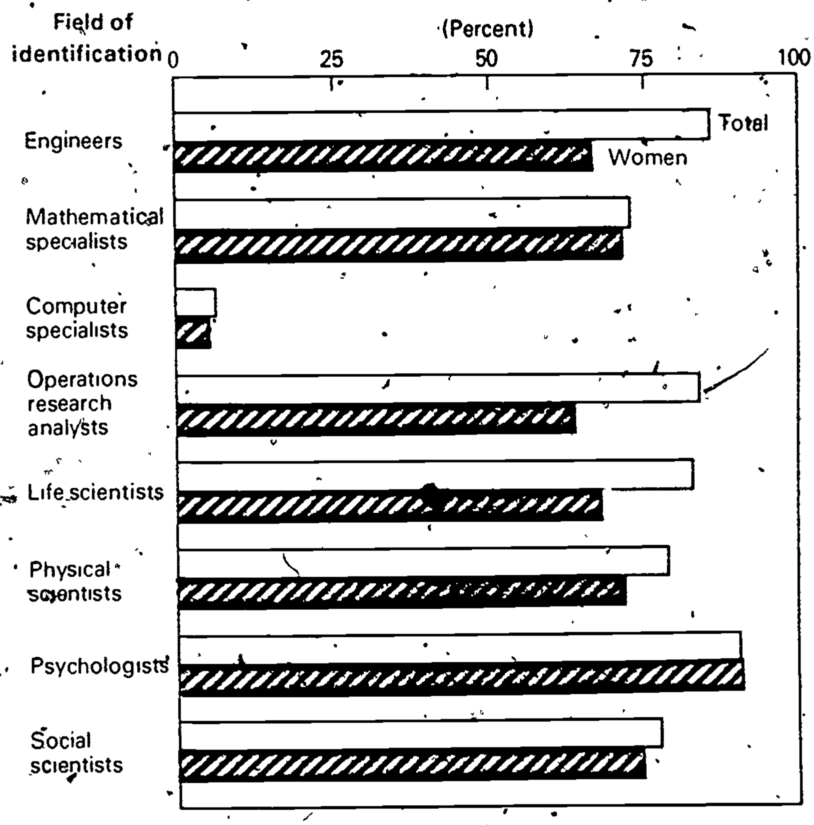
FIELD OF IDENTIFICATION OF SCIENTISTS AND ENGINEERS, AND PROPORTIONS WITH HIGHEST DEGREE IN THAT FIELD, WITH NO DEGREE AND WITH DOCTORATE, 1972

Field of Identification	Total	% With Highest Degree (1972) in Field of Professional Identification	% With Less Than B. S. Degree	% With Doctorate
Engineers	840,000	82.9	10.9	3.8
Math Specialists	31,132	71.6	6.0	30.1
Life Scientists	77,163	79.7	10.6	32.5
Physical Scientists	179,812	78.7	2.2	35.0
Social Scientists	59,232	77.1	0.6	32.4
Psychologists	36,684	90.4	0.5	49.7

Source: National Science Foundation

Women were less likely than men in 1972 to be working in the field of their highest degree.[5] (Fig. 7)

Percent of scientists and engineers, total and women, whose field of study for highest degree held[a] was same as field of identification, 1972



[a]Bachelor's or higher degree.
SOURCE National Science Foundation

Fig. 7

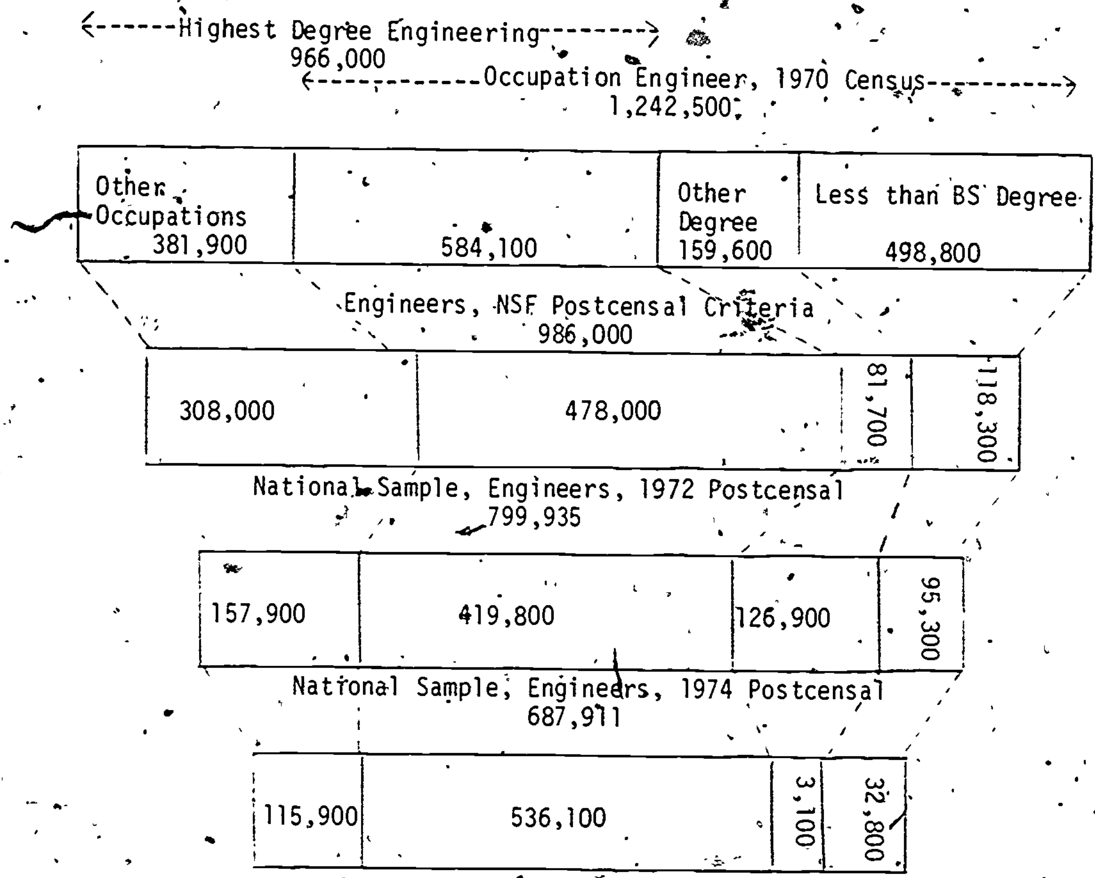
To show some of the difficulty in defining the manpower pool for any field, we can use engineering as an example.

Examining the figures from the 1970 Census and the 1972 Postcensal survey in another way, we find that among the 966,000 whose highest degree was in engineering, only 584,100 were working as engineers while 382,800 were in other occupations. Among the 1,242,500 listed as engineers in the 1970 Census, only 854,100 have an engineering degree; 159,600 had a degree in another field, and 498,800 had not earned a baccalaureate degree.

Schematically, this engineering population of 1,242,500 from the 1970 Census, can be reduced to 986,000 remaining after filtering through the National Science

Foundation postcensal criteria. The remainder of this group, as re-surveyed in 1972 and 1974 reduces further (Fig. 9).

ENGINEERS



Sources: U.S. Census Bureau, National Science Foundation

Fig. 9

National Science Foundation's estimate of 1,082,000 engineers in 1974 compares with BLS figures of 1,170,000 employed as engineers in that year. Most of this difference appears to be non-degreed engineers.

Probably the best measure of the science/engineering manpower pool, at least for 1970, comes from the National Science Foundation's "redefined" augmented Census sample of scientists and engineers, which used a series of criteria including self-identification, educational degree level and study field, labor force participation and other professional characteristics to identify scientists and engineers. The 1972 and 1974 sampling is less comprehensive, since some persons in the longitudinal study fail to respond to successive surveys. The estimated 1974 science and engineering population (Table 15) includes new entrants to the workforce since 1970.

Doctoral Scientists and Engineers

The doctoral workforce in science and engineering is of specific concern in relation to academic and research activities.

In 1975, the Commission on Human Resources of the National Academy of Sciences reports, a total of 279,400 doctoral scientists and engineers who had received their doctorate prior to July 1, 1974 were living in the United States.[4] Within this total, 13,900 were retired or were not in the labor force for some other reason, bringing the number to 265,500. By 1976, the labor force of doctoral scientists and engineers had increased to approximately 277,500, following the addition of new doctorates from the FY 1975 class, and the normal losses to emigration, death and retirement.

The study of doctorates in 1975 provides useful information about some characteristics of this population.

- Distribution by field of the doctorate and field of employment is shown in Table 17. A net influx from field of doctorate to field of employment appears in earth science, medical science and non-science employment, while physics, chemistry,

TABLE 17

Distribution of Doctoral Scientists and Engineers in the United States. 1930-74 Graduates by Field of Doctorate and Field of Employment, 1975

	Field of Doctorate		Field of Employment	
	N	%	N	%
All Fields	279,351	100.0	262,991+	100.0
Mathematics	15,989	5.7	16,815	6.4
Physics/Astronomy	25,085	9.0	17,880	6.8
Chemistry	43,248	15.5	33,077	12.6
Earth Sciences	8,813	3.2	12,149	4.6
Engineering	41,228	14.8	41,616	15.8
Biosciences				
Agricultural Sciences	13,145	4.7	13,170	5.0
Medical Sciences	7,547	2.6	13,329	5.1
Biological Sciences	50,085	17.9	38,294	14.6
Psychology	29,435	10.5	28,901	11.0
Social Sciences	39,272	14.1	31,380	11.9
Nonsciences	5,519	2.0	12,958	4.9
No Report	184	*	3,422	1.3

*Less than 1%

+Includes postdoctoral appointees as well as full-time and part-time employed.

Source: National Academy of Sciences

biological and social sciences show substantial net loss from degree field to employment field.

● Only 9.5% of the doctoral scientists and engineers in 1975 were women. Fields showing highest proportions were psychology (22.3%), the biosciences (12.8%) and the social sciences (12.3%). Women made up 17.2% of the non-science doctorates working in science, but only 0.5% of all doctoral engineers were women. Racial minority groups comprised a little over six percent of the total including eleven percent of the engineers and more than six percent of the bioscientists.

● About 2,500 of this group were unemployed and seeking employment, for an overall unemployment rate of one percent. However, 3% of the women and only 0.8% of the men reported involuntary unemployment.

● Almost five percent of science and engineering doctorates were working in non-science fields in 1975, while two percent of doctorates employed in science or engineering held a non-science doctorate. Among the most recent graduates, (1974) 5.1% were employed in non-science fields one year after earning the doctorate.

DEMAND

Estimates of long range future demand usually are either projections based on past trends which incorporate certain demographic statistics, or surveys based on the hiring plans of major employers.

The Bureau of Labor Statistics regularly forecasts employment trends ten years ahead, using economic trend models hedged by consideration of expected federal R & D budgets, defense expenditures, and industrial expansion to meet demand for more goods and services. Estimates are provided as averages over a decade, without specific reference to the irregularly spaced dips and rises in demand which occur repeatedly in engineering and scientific employment.

The BLS projections examine demand for an entire profession, combining all degree levels and breaking down the components of demand only by employment changes and replacement needs. 1976 projections[7] by BLS of average annual openings in scientific and technical occupations for the period of 1974 to 1985 are shown in Table 18.

TABLE 18

ESTIMATED 1974 EMPLOYMENT, PROJECTED 1985 REQUIREMENTS, AND AVERAGE ANNUAL OPENINGS, SCIENTIFIC AND TECHNICAL OCCUPATIONS, 1974 - 1985

Occupation	Estimated employment 1974	Projected requirements 1985	Percent change 1974-85	Annual average openings, 1974-85		
				Total	Employment change	Replacement needs[3]
Scientific and technical occupations						
Conservation occupations						
Foresters	24,000	29,000	20 5	950	450	500
Forestry technicians	10,500	13,800	32 1	500	300	200
Range managers	2,500	3,850	53.9	150	100	50
Engineers *	1,100,000	1,500,000	32.8	52,500	33,500	19,000
Aerospace	52,000	58,300	12 1	1,100	550	550
Agricultural	12,000	15,900	32 5	550	350	200
Biomedical	3,000	4 000	33 3	150	100	50
Ceramic	12 000	15,900	32 5	550	350	200
Chemical	50,000	62,800	25 6	1,850	1,200	650
Civil	170,000	228,100	36 6	9,300	5,600	3,700
Electrical	290,000	378 900	32 0	12 200	8 400	3,800
Industrial	180 000	227 100	26 2	7,200	4,300	2,900
Mechanical	185 000	237,000	29 5	7 900	4,900	3,000
Metallurgical	17 000	20,000	21 2	550	300	250
Mining	5,000	7,100	42 0	850	200	150
Petroleum	12,000	18,200	51 7	750	550	200
Environmental scientists						
Geologists	23,000	32,000	39 4	1,300	800	500
Geophysicists	8,200	11,400	39 4	450	300	150
Meteorologists	5,600	6,900	23 3	200	100	100
Oceanographers	2,500	3,100	22 5	100	50	50
Life science occupations						
Life scientists	190,000	245,000	29.0	10,700	5,400	5,300
Mathematics occupations						
Mathematicians	40,000	46,100	16 5	1,550	600	950
Statisticians	24,000	31,000	32 6	1,450	650	800
Physical scientists						
Astronomers	2,000	2,100	4 0	30	10	20
Chemists	135,000	173,000	28 6	6,400	3,500	2,900
Physicists	48,000	59,400	25 0	1,700	1,100	600
Other scientific and technical occupations						
Broadcast technicians	22 000	26,000	18 2	1,350	350	1,000
Drafters	313,000	444,000	41 7	17,300	12,000	5,300
Engineering and science technicians	560,000	794,000	41 4	32,000	21,000	11,000
Surveyors	55,000	86,600	59 2	3,600	2,700	900
Computer and related occupations						
Programmers	200,000	285,000	42.5	13,000	7,800	5,200
Systems analysts	115,000	190,000	65.2	9,100	7,000	2,100
Social scientists						
Anthropologists	3,800	5,400	42.9	250	150	100
Economists	71,000	104,000	45 9	4,700	3,000	1,700
Geographers	9,000	13,000	42.8	650	350	300
Historians	26 000	32 000	19 8	1,300	500	800
Political scientists	11,500	14,500	27.5	600	300	300
Psychologists	75,000	105,000	40.7	5,200	2,800	2 400
Sociologists	14,000	18,000	28 7	750	350	400

*Totals do not equal sum of individual estimates because all branches of engineering are not covered separately.

Source: Bureau of Labor Statistics

TABLE 19

Requirements for Engineers and Scientists by Type in Selected Energy-Related Sectors in the United States, Assuming Maximum Effort to Develop Domestic Fuel Sources, 1970, 1980 and 1985

ENGINEERS	1970	1980	1985
Construction Engineers	2,500	3,100	3,300
Chemical Engineers	33,600	42,300	51,500
Civil Engineers	14,200	18,300	27,200
Electrical Engineers	25,600	50,000	65,500
Industrial Engineers	6,000	8,700	12,000
Mechanical Engineers	8,000	19,900	30,500
Metallurgical Engineers	900	1,900	2,700
Mining Engineers	700	1,400	2,200
Nuclear Engineers	600	3,600	6,200
Petroleum Engineers	5,600	7,300	9,600
Sales Engineers	900	1,900	2,600
Engineers, Nec	3,700	9,700	11,600
Engineers, Total	101,300	168,500	224,700
SCIENTISTS	**1970**	**1980**	**1985**
Agricultural Scientists	400	400	500
Biologists	900	1,300	1,500
Chemists	13,200	19,100	27,800
Geologists and Geophysicists	8,100	9,900	11,100
Marine Scientists	38	41	46
Mathematicians	7,500	10,000	13,900
Physicists	8,000	16,500	22,800
Life and Physical Scientists, Nec	1,613	3,600	4,900
Scientists, Total	39,700	61,000	82,800
GRAND TOTAL	141,000	229,500	307,500

Source: National Planning Association.

Some long range demand studies deal with job opportunities or needs only in a particular project area without reference to demand in other sectors of the economy for the same kind of professionally trained people. A typical example is a National Planning Association study of demand through 1985 for scientists and engineers in selected energy related industries.[8] The author, Ivars Gutmanis, found the 1970 employment of engineers in these industries to be 101,300 or about 12% of the engineering workforce. By 1985, Gutmanis projects an increase of 122% to 224,700 engineers in these energy-related industries (Table 19). Making rough estimates of supply at 840,300 in 1970, increasing by roughly 31,000 new graduates and 2,000 immigrant engineers per year minus 1.5% per year attrition through 1985, the engineering work force in 1985 might be about 1,109,400. The energy-related engineer requirement of 224,700 in 1985 would thus represent 20% of the total engineering workforce in that year, compared to 12% in 1970. Dr. Gutmanis estimates that more than 30% of the engineer supply will be needed in these industries by 1985.

A much more conservative estimate of increased manpower demand for energy activities comes from a report by an Energy Task Force of the National Academy of Engineering[9] which estimates a need for 30,000 additional engineers by 1985 to eliminate or substantially reduce energy imports over the coming decade.

For scientists, principally chemists, physicists and geoscientists, the NSF-sponsored report by the National Planning Association says that manpower demand would rise from 39,700 in 1970 to 82,800 in 1985 - an increase of 108%. Assuming a continuing drop in the number of physical science graduates for a few more years, followed by a steady state through 1980 and a slight rise thereafter as projected by the National Center for Education Statistics[10], the proportion of the scientific workforce required in these energy-related industries also will rise. Gutmanis estimates that by 1985, about one third of all physical science graduates would be required in seven energy-related industries, compared to about 15% of the total so employed in 1970. This study also stresses the need for experienced scientists and engineers in these areas, as well as the need for persons with training beyond the bachelor's degree.

TABLE 20

ESTIMATED EMPLOYMENT IN SIX ENERGY-RELATED INDUSTRIES* BY OCCUPATION, 1970 and 1980

	1970**	1980***	Change Number	%
Professional/Technical Kindred Workers	457,203	761,000	303,797	69
(Engineers)	(124,856)	(252,000)	(127,144)	(102)
Crafts and Kindred	744,332	1,385,000	640,668	86
Operatives	422,170	715,000	292,830	69
Laborers	243,007	487,500	244,493	101
Sales/Clerical/Service	352,143	663,000	310,857	88
TOTAL	2,212.855	4,011,500	1,798,645	81

*General Contractors (except building); Mfg. of Engines, Turbines; Crude Petroleum & Natural Gas Extraction; Petroleum Refining; Electric Utilities; Coal Mining
**From 1970 Census
***FEO Intermediate Scenario for Project Independence

Source: U.S. Department of Labor

In a study made a few months earlier by the Manpower Administration of the Labor Department[11], the Secretary of Labor, reporting on the impact of energy shortages including fuel rationing upon manpower needs, discusses the impact of current employment and provides projections from 1970 to 1980 in six positively-affected industries: general contractors (except building); manufacturing of engines and turbines; crude petroleum and natural gas extractions; petroleum refining; electric utilities and coal mining. As shown in Table 20, this report projects an increase of 102% in the number of engineers needed in these industries between 1970 and 1980, with the actual numbers increasing from 124,856 to 252,000.

A study done earlier in 1974 by the National Planning Association[12] on the

TABLE 21

Estimated Employment Requirements for Scientists and Engineers, Selected Industries* and Pollution Abatement Scenarios, 1970, 1980 and 1985

Category	Employment in 1970 (†)	Baseline Scenario	Projected Employment Requirements in 1980: Present Policy Scenario	Environmental Goals Scenario	in 1985: Present Policy Scenario	Environmental Goals Scenario
Scientists	80,400	113 332	127 620	143 767	136,481	150,913
Engineers	100 200	138,403	158 190	174 042	171 180	180,739
Total	180,600	251,725	285 810	317,809	307 661	331,625

* Industries referred to are food, chemicals, paper, primary metals, and petroleum refining

† NPA estimate based on weighting of Census and estimates by the Bureau of Labor Statistics

Source: National Planning Association

demand for scientists and engineers for environmental pollution abatement found 80,400 scientists and 100,200 engineers working in pollution abatement industries in 1970. In 1980, assuming a middle ground scenario that continues present policies, the demand rises to 127,620 scientists and 158,190 engineers. By 1985, the same middle ground scenario shows need for 136,480 scientists and 171,180 engineers (Table 21). This means that while 30% of the scientists were working in pollution abatement industries in 1970, that proportion was projected to rise to 55% in 1985. For engineers, the 12% of the 1970 workforce would increase to 26% by 1985, according to the NPA study.

According to these studies, for energy and pollution abatement alone, 63% of the scientists and approximately 55% of the engineers would be required. The projections might have been different if these studies had looked at a wider picture of demand for scientists and engineers, recognizing that none of these project activities occur in a vacuum, but are, instead, related to all other technological efforts being carried out at the same time.

These studies, of course, make particular assumptions about the amount of funding that will be applied to such subjects. If the Congress decides that federal resources should be allocated in smaller proportions to activities such as energy and environmental problems that have high technological manpower content, and instead funds programs that have a low science and engineering manpower component, the demand for scientists and engineers could be reduced substantially.

Current and Short Range Demand

There are several short-range or current demand studies, performed on a continuing basis. Some measure demand for new graduates while others examine the job market for experienced scientists and engieers. These two markets operate differently and often independently, employing different recruitment methods and different techniques. Some companies actively recruit new science and engineering graduates even as they are laying off older scientists and engineers. There are a number of reasons for this, the principal one being that different kinds of jobs are involved in the two markets. New scientists or engineers are needed for entry level positions with high technical content, and for management training. Openings for experienced engineers and scientists usually are much more specific in terms of job requirements, particularly on the technical side. Older scientists and engineers sought for management positions may be required to have extensive experience in a particular industry or product area. Additional factors that enter the job hiring picture are the relative differences in cost of employing new graduates versus those with several years of experience; and the malleability of the younger persons, not only in terms of technical work placement but also in an easier ability to make geographic shifts. Thus, the job market for new graduates is often out of phase with that for experienced scientists and engineers, providing a continuing problem of career instability, particularly for the older engineer, which adds to the difficulty of attracting young people into the field. This phenomenon is relatively new in the sciences, but the unemployment problems of older physicists and chemists over the past few years have had an obvious impact on career choices of young people which show up in falling enrollments in the physical sciences at a time of generally rising enrollments.

Demand for New Graduates

Demand for new graduates is measured principally by two ongoing surveys - one done quarterly (and summarized annually by recruitment year) by the College Placement Council (CPC); and one conducted annually by Frank Endicott of Northwestern University.

The CPC survey is in two parts. The first measures actual job offers by business and industry to new graduates including median salary offers by degree level. The other CPC survey, conducted each December, covers positions that are expected to be available over the coming year in business, industry, government, and nonprofit and educational institutions, except for teaching positions. This survey examines potential job opportunities in four broad discipline categories at all degree levels: engineering; science-math-other technical; business; and other non-technical.

The December 1976 Survey[13] finds that openings anticipated by more than 600 employers indicate they expect to hire 24% more engineers in the 1976-77 recruiting season than in 1975-76. The "sciences/math/other technical" category shows an indicated 13% gain, with prospects for Ph.D. candidates in those fields up 19%. Hiring patterns in 1975-76 and those anticipated for 1976-77 are shown in Table 22.

TABLE 22

NUMBER OF HIRES AND PERCENTAGE CHANGE BY CURRICULAR GROUPINGS AND DEGREE LEVELS
(1976-77 Anticipated; 1975-76 Actual)
December 1976

	Bachelor's 1976-77	Bachelor's 1975-76	Master's 1976-77	Master's 1975-76	Ph.D.'s 1976-77	Ph.D.'s 1975-76	Total--Curriculum 1976-77	Total--Curriculum 1975-76
Engineering	17,889	14,484	2,840	2,223	583	479	21,371	17,229
	+24%		+28%		+22%		+24%	
Sciences, Math., & Other Tech.	8,645	7,737	1,382	1,210	785	660	10,839	9,620
	+12%		+14%		+19%		+13%	
Business	20,199	19,207	5,062	4,342	32	20	25,358	23,622
	+ 5%		+17%		**		+ 7%	
Other Non-Technical	17,568	16,639	1,208	683	57	53	18,835	17,408
	+ 6%		+77%		+ 8%		+ 8%	
Unclassified as to Curriculum	3,484	3,669	113	85	60	101	4,364	4,485
	- 5%		+33%		-41%		- 3%	
Total Degree	67,785	61,736	10,605	8,543	1,517	1,313	80,767	72,364*
	+10%		+24%		+16%		+12%	

* Final totals represent data reported by 616 companies and include those unclassified by degree.

** Percentages not meaningful because of small volume.

Source: College Placement Council

The 1976 Endicott Survey of 215 firms[14] found that these companies expected to hire 16% more graduates at the bachelor and master levels than in 1975-76, with demand for graduates in engineering up 29%. Starting salaries, one peripheral measure of demand, are expected to go up between four and seven percent with engineering salaries increasing about 6.6%. At the master's level, engineering hires are expected to rise 10% while all master's level hiring will increase 16% within these companies. MBA's and accounting graduates show the largest increases.

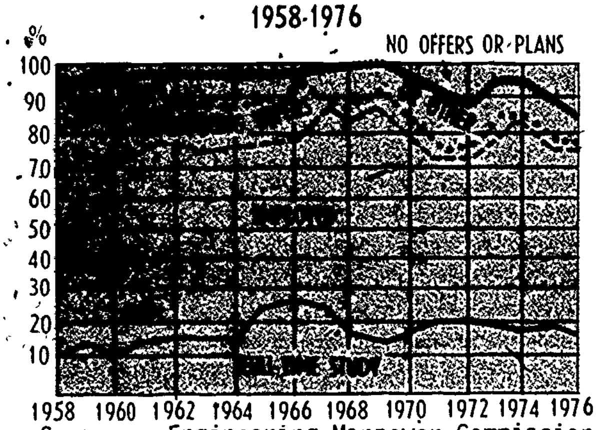
TABLE 23

PLACEMENT STATUS OF 1976 ENGINEERING AND TECHNOLOGY GRADUATES

	Engineering Deg. Bach.	Engineering Deg. Mast.	Engineering Deg. Dr.	Techn'l'gy Deg. Asso.	Techn'l'gy Deg. Bach.
Employed, New	56%	42%	65%	49%	68%
Employed, Returning to Job	2	17	11	9	6
Full-time Study	18	20	3	24	6
Other Plans	7	10	12	1	6
Considering Job Offers	3	2	1	6	5
Seeking Employment	14	9	8	10	9

Source: Engineering Manpower Commission

PLACEMENT STATUS OF BS ENGINEERING GRADUATES 1958-1976



Source: Engineering Manpower Commission

Fig. 10

The Engineering Manpower Commission examines placement of new engineering graduates each year.[15] Table 23 shows the placement status of the 1976 class, and Fig. 10 compares graduates over a long period of years at the approximate time of graduation. The proportion already employed in 1975-1976 is approximately the same as in the late 1950's prior to the Vietnam War years. Between 1967 and 1970, an engineering job was usually accompanied by an occupational deferment from the draft. The higher proportions entering graduate study between 1965 and 1967 (when deferments for new graduate students ended) also can be attributed to the conditions of the Vietnam era.

The drop in the number still considering job offers at the time of graduation corroborates other evidence that new graduates are tending to take offers when they are made, so that fewer offers need to be made in order to fill an opening. Among those with no offers are other plans in 1976, about 6% were not seeking employment. Nonetheless, almost 14% of the total whose status was known listed themselves as looking for a job - the highest proportion of any graduating class in the years since 1958 when this survey began. Since the 1975 and 1976 classes also were the smallest in many years, the job outlook for the larger classes that will be graduating over the next few years will be cause for concern if the national economy continues to stagnate.

Within the individual engineering disciplines, there was wide variation. Among petroleum engineers, only one percent had no offers or plans at the time of graduation compared to 35% of the architectural engineers, 22% of the civil, 21% of the nuclear, 18% of the mechanical and 15% of the electrical and industrial engineers. Categories showing the smallest proportion of the class without offers, in addition to the petroleum group, were mining and geological engineers, chemical engineers, and ceramic engineers, all under 10%.

At the master's level, 9% of the group had no offers or plans, ranging from 7% of the chemical to 13% of the civil engineers. At the doctoral level, only the mechanical engineers showed major problems with 16% having no offers or plans compared to 8% of the total.

It would appear that most of the new graduates were absorbed into the job market by the end of the summer. The Bureau of Labor Statistics showed an overall unemployment rate for engineers of only 1.3% for the second quarter and 1.5% for the third quarter of 1976. This proportion is less than half that which occurred in most recent recessions. However, some of these 1976 graduates may have found work in non-engineering jobs.

Bachelor of technology graduates in 1976 were in stronger demand, both in relation to the 1975 class and to the engineering graduates of 1976 since only 10% of the bachelor of technology graduates were still seeking employment at the end of the school year. (Table 23)

Comparable information on placement of new graduates in other fields is not available. However, in spite of problems encountered by new engineering graduates in locating jobs, this group apparently had far better employment prospects than graduates in most other occupational groups. Salary information, one indicator of demand, shows that engineers continued to top all bachelor degree graduates in terms of beginning salary levels and were about equal at the master's and doctoral levels to the business and science fields. Chemical engineers headed all salary groups at both the master and doctoral levels.

The distribution of offers by curriculum group from the College Placement Council data for 1976 is shown in Table 24. These figures indicate that the problem

TABLE 24

DISTRIBUTION OF COLLEGE GRADUATES AND JOB OFFERS BY CURRICULUM GROUP 1975-76 SCHOOL YEAR

Category	BS % Degrees	BS % Offers	MS % Degrees	MS % Offers
Engineering	6	50	9	32
Science & Math.	14	8	14	8
Business	18	33	20	57
Hum. & Soc. Sci.	62	8	58	3

Source: % Degrees derived from Projections of Educational Statistics to 1984 85, National Center for Education Statistics % Offers derived from College Placement Council, Inc. Salary Survey, Final Report, July 1976. Comparable salary data for PhDs not available.

TABLE 25

Educational status of the labor force and the unemployed, by sex and race, March 1975

(Percent distribution)

Years of school completed and labor force status		Total, 16 years and over	Men	Women	White	Negro and other races
CIVILIAN LABOR FORCE						
Total		100 0	100 0	100 0	100 0	100 0
Elementary school	Less than 8 years[1]	5 7	6 7	4 1	4 7	13 3
	8 years	6 0	6 6	5 0	6 0	5 8
High school	1 to 3 years	17 5	17 5	17 5	16 8	23 0
	4 years	39 7	36 3	44 8	40 3	34 7
College	1 to 3 years	15 4	15 5	15 3	15 8	[illegible] 4
	4 years or more	15 7	17 3	13 3	16 3	[illegible] 8
4 years of high school or more		70 8	69 1	73 4	72 4	57 9
UNEMPLOYED						
Total		100 0	100 0	100 0	100 0	100 0
Elementary school	Less than 8 years[1]	7 7	9 5	5 1	6 7	12 3
	8 years	7 4	8 4	5 9	7 7	6 0
High school	1 to 3 years	28 9	28 8	29 2	27 7	34 4
	4 years	39 4	37 0	42 8	40 2	35 9
College:	1 to 3 years	11 6	11 4	11 9	12 3	8 5
	4 years or more	5 0	4 9	5 0	5 4	2 9
4 years of high school or more		56 0	53 3	59 8	57 9	47 3

[1] Includes persons reporting no school years completed

NOTE: Sums of individual items may not equal totals because of rounding.

is concerned with an economy that cannot readily absorb the newly available college graduate entrants, rather than a problem in placement of engineers. To maintain perspective, we should note that the unemployment rates for non-graduates are much more of a problem.

As shown in Table 25, the labor force in March 1975 included 16% college graduates, but only five percent of the unemployed population had four or more years of college. Engineers were better off relative to other graduates in terms of job offers than in 1974-75; while the science/math group had relatively fewer prospects (Table 26).

Among new Ph.D.'s in 1975, 20.5% were still seeking employment at the time the degree was awarded including 15% in physics and astronomy, 11% in chemistry, 14% in the earth sciences, 24% in mathematics, 21% in engineering, 12% in the biosciences, 22% in psychology, 13% in economics, 20% in anthropology and sociology and 21% in political science.[16] In the humanities, 31% were still seeking jobs when the degree was received.

TABLE 26

Distribution of College Graduates and Hires by Disciplinary Category; 1974-75 School Year

Category	BS % Degrees	BS % Hires	MS % Degrees	MS % Hires	PhD % Degrees	PhD % Hires
Engineering	5.4	24 6	10.5	23 6	12.7	38.5
Science & Math.	12 6	11.5	12.8	16 4	32.3	48.8
Business	18 7	26.5	20.3	53.2	4.7	2.6
Other Non-Tech.	63.3	37.5	56.4	6.7	50.3	10.2

Source: % Degrees derived from Projections of Educational Statistics to 1983-84. National Center for Education Statistics. % Hires derived from College Placement Council, Inc. Report on Assessment of Recruiting Activity in 1974-75.

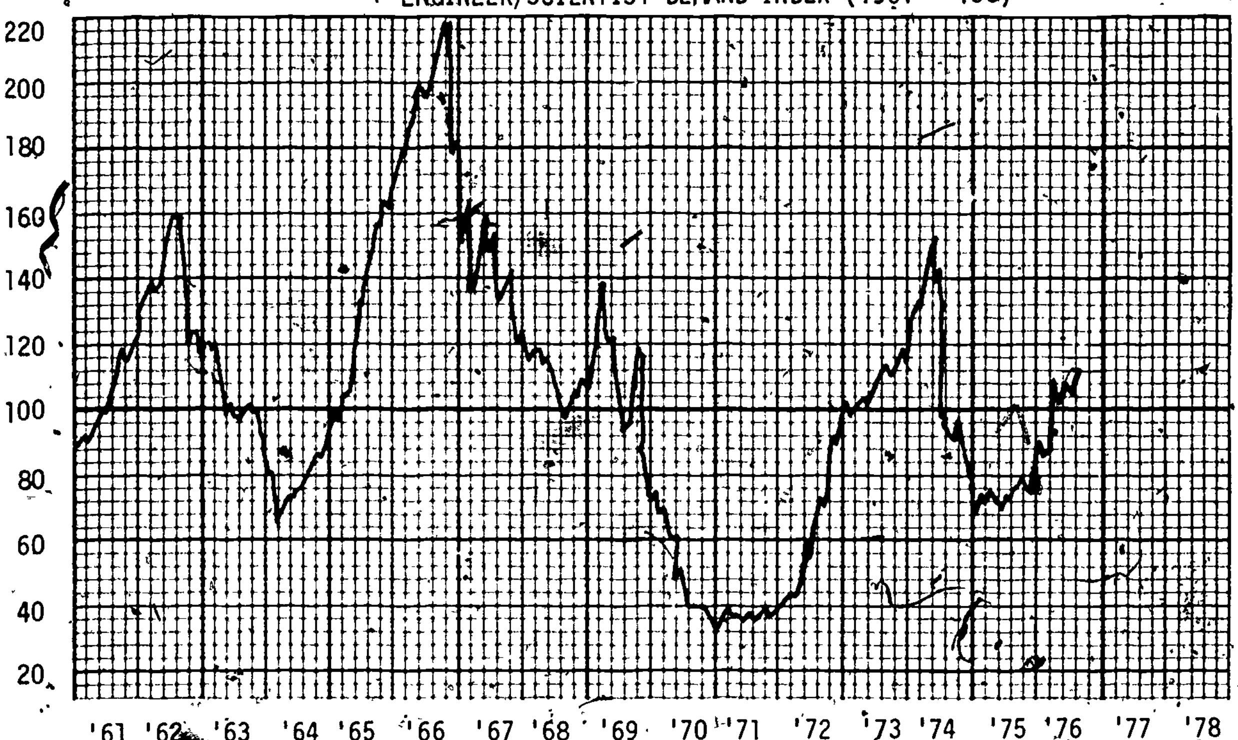
Demand for Experienced Scientists and Engineers

Employment of experienced scientists and engineers is measured by the Bureau of Labor Statistics in its monthly survey of 40,000 households, but the figures are aggregated into the category "professional and technical" which includes many persons who are not scientists and engineers. The unemployment rate for this larger category averaged 2.3% in 1974; 3.2% in 1975 and 3.2% through the first nine months of 1976.

Engineering employment and unemployment is calculated quarterly from this BLS survey. The quarterly unemployment rate averaged 1.3% in the second quarter and 1.5% in the third quarter of 1976.

The Engineer/Scientist Demand Index maintained by the advertising firm of Deutsch, Shea and Evans is another indicator of demand which measures classified advertising for scientists and engineers in newspaper display ads, newspaper classified ads and technical journals. The Index has been maintained monthly since 1961 and the 1961 base equals 100. (Fig. 10)

ENGINEER/SCIENTIST DEMAND INDEX (1961 = 100)



Source: Deutsch, Shea & Evans, Inc.

Fig. 10

After rising fairly steadily from January 1972 through the first half of 1974, the Index dropped sharply through the remainder of the year and stayed low through 1975. By mid year, the index again rose above its baseline, hitting a 25 month high in October, 1976.

Academic Demand

The number of scientists and engineers employed full time by universities and colleges was 230,500 in January 1976, according to the National Science Foundation. Following near-zero growth over the previous six years, the total of all scientists and engineers employed at universities and colleges rose 3% in 1976 to 289,200, with 58,700 being part-time employees. The part-time employees grew 5% and the full-time employees 3% over 1975 with increases ranging from nearly 7% in the social and environmental sciences to 1% in the life sciences and engineering.[17]

The distribution by field and sex of full-time scientists and engineers is shown for January of 1974-76 in Table 27.[18]

TABLE 27
FULL-TIME SCIENTISTS AND ENGINEERS EMPLOYED IN UNIVERSITIES AND COLLEGES, BY FIELD OF EMPLOYMENT AND SEX: JANUARY 1974-76

Field of employment	1974			1975			1976		
	TOTAL	MEN	WOMEN	TOTAL	MEN	WOMEN	TOTAL	MEN	WOMEN
Total	218,843	186,401	32,442	224,784	190,651	34,133	230,539	194,610	35,929
Engineers (Total)	22,764	22,425	339	22,579	22,210	369	22,799	22,352	447
Aeronautical & astronautical engineers	1,023	1,001	22	944	919	25	963	935	28
Chemical engineers	1,522	1,500	22	1,603	1,578	25	1,622	1,585	37
Civil engineers	3,759	3,698	61	3,830	3,769	61	4,008	3,925	83
Electrical engineers	5,404	5,347	57	5,394	5,337	57	5,393	5,319	74
Mechanical engineers	4,255	4,222	33	4,355	4,325	30	4,351	4,306	45
Other engineers	6,801	6,657	144	6,453	6,282	171	6,462	6,282	180
Physical scientists (Total)	33,412	31,146	2,266	33,479	31,158	2,321	34,442	31,942	2,500
Chemists	14,075	12,690	1,385	13,826	12,395	1,431	14,172	12,651	1,521
Earth scientists 1/	6,563	6,236	327	6,789	6,469	320	7,260	6,881	379
Physicists	10,870	10,475	395	10,941	10,554	387	10,867	10,465	402
Other physical scientists	1,904	1,745	159	1,923	1,740	183	2,143	1,945	198
Mathematical scientists (Total)	22,157	19,335	2,822	22,392	19,467	2,925	23,081	19,988	3,093
Life scientists (Total)	88,900	70,844	18,056	92,004	73,447	18,557	92,589	73,910	18,679
Agricultural scientists	12,781	11,320	1,461	13,613	11,817	1,796	12,963	11,546	1,417
Biological scientists	31,539	25,804	5,735	33,490	27,116	6,374	34,744	27,757	6,987
Medical scientists	44,580	33,720	10,860	44,901	34,514	10,387	44,882	34,607	10,275
Psychologists (Total)	14,957	11,769	3,188	15,995	12,407	3,588	16,758	12,781	3,977
Social scientists (Total)	36,653	30,882	5,771	38,335	31,962	6,373	40,870	33,637	7,233
Economists	9,830	9,042	788	10,190	9,327	863	10,410	9,458	952
Sociologists	10,048	7,672	2,376	10,765	8,129	2,636	11,389	8,472	2,917
Political scientists	8,396	7,533	863	8,692	7,796	896	9,027	7,999	1,028
Other social scientists	8,379	6,635	1,744	8,688	6,710	1,978	10,044	7,708	2,336

1/ Includes data for atmospheric scientists and oceanographers

SOURCE: NATIONAL SCIENCE FOUNDATION

The number of women employed full time as scientists and engineers reached

35,900 in January of 1976, but women still make up only 16% of the full-time scientist and engineer total in academic institutions.

The National Science Foundation forecasts a probable science and engineering faculty level of about 230,000 by 1985, down 7% from 1972. In the physical sciences, a drop of 25% is expected.[19]

Demand for Scientists and Engineers in Research and Development

R & D spending is projected by the National Science Foundation to increase about 3% a year from 1974 thru 1985, reaching a total of $38 billion measured in constant 1972 dollars. The gradual decline in the ratio of R & D expenditures to the Gross National Product which has been experienced since 1964 is expected to continue through 1985 when R & D as a percent of GNP is projected to be 2.0% compared to 2.2% in 1976 and 2.9% in 1964. Industrial R & D spending is expected to grow at an annual average rate of 3.5% between 1974 and 1985.[20]

In 1976, R & D expenditures are expected to total 23.5 billion, up 8% from the 1975 level and, for the first time in three years, showing an increase in terms of constant dollars, assuming a 6% inflation rate for 1976.[21]

TABLE 28

Full-time equivalent (FTE) scientists and engineers employed in research and development, by sector, selected years[1]
[In thousands]

Sector	1954	1965	1968	1970	1971	1972	1973	1974	1975[2]
Total	237 1	494 1	550 4	549 6	529 8	521 9	521 1	527 2	530 5
Federal Government[3]	37 7	61 8	68 1	69 8	66 5	65 2	62 3	65 0	64 5
Industry[4 5]	164 1	348 4	381 9	375 5	358 4	353 3	357 4	357 9	358 0
Universities and colleges, total	25 0	53 4	66 0	68 5	68 4	66 5	64 8	66 7	71 0
Scientists and engineers	20 3	40 4	49 0	50 3	49 8	48 9	43 2	49 2	52 6
Graduate students[6]	4 7	13 0	17 0	18 2	18 6	17 6	16 6	17 5	18 4
University associated FFRDC's, total	5 0	11 1	11 2	11 5	11 5	11 7	12 0	12 1	12 8
Scientists and engineers	4 9	10 7	10 7	11 0	11 0	11 3	11 7	11 8	12 4
Graduate students[6]	1	4	4	5	5	4	3	3	4
Other nonprofit institutions[4 7]	5 3	19 4	23 2	24 3	25 0	25 2	24 6	25 5	24 2

[1]Number of full time employees plus the FTE of part time employees Excludes scientists and engineers employed in State and local government agencies

[2]Estimate

[3]Includes both civilian and military service personnel and managers of R&D Military R&D scientists and engineers in the Department of Defense were estimated at 7 000 in 1954 8,400 in 1958 9 200 in 1961 12 000 in 1965 13,000 in 1968 14 000 in 1969 and 1970 12 000 in 1971 10 700 in 1972, 8 100 in 1973 7 600 in 1974 and 7 700 in 1975

[4]Includes professional R&D personnel employed at FFRDC's administered by organizations in the sector

[5]Excludes social scientists

[6]Numbers of FTE graduate students receiving stipends and engaged in R&D

[7]Includes estimate for R&D scientists and engineers employed in State affiliated institutions such as hospitals museums etc

Source: National Science Foundation

Science and engineering employment in research and development is, of course, directly tied to R & D funding. R & D at universities and other nonprofit institutions is projected to grow only 1% per year to $1.1 billion by 1985.

The number of full-time equivalent scientists and engineers employed in research and development by sector in selected years from 1954 to 1975 is shown in Table 28.

Approximately 530,000 scientists and engineers were employed in R & D activities in 1975, with two-thirds working for industry, about 16% employed in universities and colleges and another 12% in the federal government.[22] The number of R & D scientists in universities, by field, is shown in Table 29.

TABLE 29

R&D SCIENTISTS AND ENGINEERS IN PH.D. GRANTING INSTITUTIONS BY FIELD, 1966-74

Field of science	1966	1968	1970	1972	1973	1974 (Prelim.)
	Estimated scientists and engineers (as of January)					
Physics	5,400	6,200	6,500	6,700	6,800	6,700
Biological sciences	29,500	32,700	34,800	34,000	33,400	33,600
Engineering	15,200	16,600	17,200	17,900	18,000	18,000
Chemistry	5,700	6,400	6,800	7 100	7,300	7,800
Clinical medicine	30,200	37,000	43,200	47,400	48,300	48,100
Psychology	3,800	5 000	5,900	6,600	7,100	7,600
Social sciences	15,700	19,700	22 100	24,300	24,900	25,400
Mathematical sciences	6,100	7,600	8,900	9,600	9,700	10,400

SOURCE: National Science Foundation

For all industries, the overall ratio for R & D scientists and engineers per 1,000 employees was 25 in 1972, 1973 and 1974, declining from 26 during the period 1968-71. However, there is considerable variation from one type of industry to another.[23] The number of R & D scientists and engineers employed by industry in January 1974 and 1975 is shown in Table 30.

TABLE 30

SCIENTISTS AND ENGINEERS IN INDUSTRIAL R&D, 1974 AND 1975

Industry[1]	R&D scientists and engineers: January 1974	R&D scientists and engineers: January 1975
Total	358,200	357,500
Food and kindred products	6,600	7,000
Tobacco manufactures	900	900
Textile mill products	1,600	1,600
Apparel	300	300
Lumber and wood products, except furniture	800	900
Furniture and fixtures	900	1,100
Paper and allied products	4,900	5,300
Printing, publishing, and allied industries	1,000	1,100
Chemicals and allied products	41,600	43,400
Petroleum refining and extraction	8,200	8,400
Rubber products	5,700	5,900
Leather and leather products	200	200
Stone, clay, and glass products	4,100	4,300
Primary metals	5 700	5,900
Fabricated metal products	6,900	7,100
Machinery	43,200	44,900
Electrical equipment and communication	93,500	91,400
Transportation and ordnance	99,200	93,700
Professional and scientific instruments	16,600	16 900
Miscellaneous manufacturing industries	1,900	2,000
Electric, gas, and sanitary services	700	800
Miscellaneous business services	8,200	8,900
Miscellaneous services	3,600	3,700

Source: National Science Foundation

The cost per R & D scientist or engineer in industry rose from an average $32,700 in 1957 to $62,500 in 1974, with cost varying by size of company and industry.[24] Continuing inflation at rates near those of the middle 1970's would continue rapid increases in cost per R & D scientist and engineer, thus wiping out at least some new job opportunities that would otherwise accompany an increase in R & D funding.

PROJECTIONS OF SUPPLY/DEMAND IMBALANCES

TABLE 31

PROJECTED SUPPLY OF COLLEGE GRADUATES, 1974-85 [IN THOUSANDS]

Source	Number
Total	13.108
New college graduates	10.884
Bachelor s degree recipients	9.056
Master s degree recipients	1.262
Doctor s degree recipients	15
First professional degree recipients	541
Military separations	217
Other	2 008

NOTE. Detail may not add to totals due to rounding.

SOURCE: Bureau of Labor Statistics

The Bureau of Labor Statistics estimates that new college graduates will exceed available jobs requiring their skills by about 950,000 by the year 1985.[25] Between 1974 and 1985, about 13.1 million graduates are expected to enter the labor force after receiving their degrees as shown in Table 31. This includes 10.9 million new graduates: 9.1 million at the bachelor's level, 1.3 million at the master's level, 15,000 Ph.D.'s not previously in the labor force at a lower degree level, and 541,000 persons with first professional degrees. In addition, more than 2.2 million college graduates who have not entered the labor force immediately after college will add to the supply of new graduates seeking opportunity. In this group are immigrants, delayed entrants and re-entrants, the latter two categories being composed principally of women. Thus, the new supply of college graduates expected to enter the labor force will total 13.1 million by 1985.

TABLE 32

PROJECTED JOB OPENINGS FOR COLLEGE GRADUATES, 1974-85 [IN THOUSANDS]

Type	Number
Total	12.100
Growth	3.500
Replacement	6.500
Upgrading	2.100

SOURCE: Bureau of Labor Statistics

On the demand side, growth, replacement, and rising entry requirements are expected to open up about 12.1 million jobs, of which 3.5 million will be needed for growth; 2.1 million for higher entry requirements and 6.5 million for replacement (Table 32). The difference between supply and demand leaves almost a million more college graduates than job openings. However, graduates are not expected to experience high unemployment levels. The problems are more likely to center on underemployment and job dissatisfaction as graduates take jobs for which a degree is not required.

TABLE 33

COMPARISON OF ANNUAL GRADUATES AND ANNUAL OPENINGS, 1974-1985

	ANNUAL GRADUATES		ANNUAL OPENINGS
	BS/BA	Advanced	
Engineers	56,700	20,000	23,000
Geologists	4,054	1,168	1,900
Geophysicists	84	103	650
Meteorologists	294	249	200
Oceanographers	237	269	100
Life Scientists	68,400	15,430	16,400
Foresters	2,480	551	950
Range Managers	163	62	150
Mathematicians	19,205	5,871	1,550
Statisticians	257	600	1,450
Chemists	10,064	3,583	10,000
Astronomers	152	159	30
Physicists	3,625	2,308	3,000
Anthropologists	8,396	1,940	250
Economists	13,972	2,932	4,700
Geographers	5,202	1,069	650
Pol. Scientists	32,760	3,420	600
Psychologists	69,045	11,698	5,200
Sociologists	37,150	3,675	750
E/S Technicians	42,408*		32,000

*Vocational Education Completions
SOURCE: Bureau of Labor Statistics.

The problems of oversupply are not universal in all fields (Table 33). Technical and managerial areas are expected to have higher growth rates, and a balance or shortage of new graduates with jobs is expected in engineering, chemistry, geophysics and statistics since a significant fraction of graduates do not enter the field of their major. Large surpluses are forecast in the life and social sciences, with smaller surpluses in mathematics and physics. Humanities graduates are expected to exceed job openings by large margins.

This BLS study does not differentiate among degree levels in its projections of surpluses or shortages. However, it does provide modified data from another recent BLS study of the job situation for doctoral scientists and engineers to 1985,[26] and these data can be compared with a similar study made by the National Science Foundation for the same period.

According to the BLS study (Table 34), about 249,000 science and engineering doctorates were in the labor force in 1974, and that number will increase to 415,000 by 1985. The number of expected science and engineering jobs that will require doctoral training, however, is only 339,200 in 1985, leaving a surplus of 76,000 science and engineering doctorates, or 18% of the total, unable to find jobs in their fields that are commensurate with their training.

Some areas will have less surplus than others. Engineering shows an actual deficit, and chemistry shows only an 8% surplus compared to 25% in the life sciences and 28% in psychology and the social sciences.

TABLE 34
DOCTORATE SUPPLY IN 1974 AND 1985, AND DEMAND IN 1985

FIELD	1974 SUPPLY	1985 SUPPLY	1985 DEMAND	SURPLUS	PERCENT SURPLUS
Physical Sciences	68,500	90,400	86,300	4,200	4.6
Chemistry	[37,700]	[47,100]	[43,300]	[3,800]	[8.1]
Physics	[24,700]	[31,400]	[25,900]	[5,500]	[17.5]
Engineering	35,000	54,500	55,700	- 1,200	- 2.2
Mathematics	14,000	23,200	16,600	6,500	28.0
Life Sciences	60,000	104,800	78,900	25,900	24.7
Social Sciences	71,600	142,100	101,600	40,400	28.4
Psychology	[26,300]	[56,700]	[46,200]	[10,600]	[18.7]
Science/Eng., Total	249,100	415,000	339,100	75,800	18.3

Source: Bureau of Labor Statistics

TABLE 35
DOCTORATE SUPPLY IN 1972 AND 1985, AND DEMAND IN 1985

FIELD	1972 SUPPLY	1985 SUPPLY	1985 DEMAND	SURPLUS	PERCENT SURPLUS
Physical Sciences	65,300	85,200	76,000	9,200	10.8
Engineering	34,000	63,300	45,000	18,300	28.9
Mathematics	12,900	21,600	16,000	5,600	25.9
Life Sciences	56,700	92,100	85,000	7,100	7.7
Social Sciences	52,500	112,700	71,000	41,700	37.0
Total, S/E Fields	221,400	374,900	293,000	81,900	21.8

SOURCE: National Science Foundation
NOTE: Details may not add to totals due to rounding.

The NSF study of doctorate supply and utilization[27] uses 1972 as a base year, estimating new supply and utilization patterns to 1985 (Table 35). The two studies are in general agreement on the available supply in 1985, with the BLS estimates totalling about 10% above those of NSF. The BLS estimates of demand are about 15% higher than the NSF estimates, thus showing slightly less surplus by 1985. The two studies differ substantially in estimates of imbalance in engineering and in the life sciences. Some of the difference is in the projected migration/attrition factor (Table 36).

TABLE 36
NET INCREASE IN SCIENCE AND ENGINEERING DOCTORATES, 1972-85; BY FIELD

	NATIONAL SCIENCE FOUNDATION			BUREAU OF LABOR STATISTICS		
FIELD	New Ph.D's 1972-84	Migration Attrition	Net Incr. 1972-85	New Entrants 1974-85	Migration Attrition	Net Incr. 1974-85
Physical Sciences	39,800	(19,900)	19,900	38,300	(16,400)	21,900
Engineering	40,300	(11,000)	29,300	29,100	(9,600)	12,300
Mathematics	13,300	(4,600)	8,700	12,400	(3,200)	9,200
Life Sciences	62,400	(27,000)	35,400	59,500	(14,700)	44,800
Social Sciences	83,900	(23,700)	60,200	88,800	(18,300)	70,500
TOTAL	239,700	(86,200)	153,500	228,100	(62,200)	165,900

SOURCE: National Science Foundation, NSF 75-301, p. 16., Bureau of Labor Statistics, BLS Bulletin, 1918, p. 21.

The NSF "probable" model assigns double weight to the trends of the past five years, while the BLS model uses the most recent degree projections of NCES[28] to 1985 and assumes continuation of the Ph.D. pattern of use relative to other workers and to the proportion of persons obtaining doctoral degrees. The NSF projections were made in 1975 and the BLS projections in 1976.

Despite some disparities in the numbers, however, these projections have in common one major finding - that is that over the next decade, the number of persons trained to the doctorate level will exceed significantly the number of job openings requiring training to that level. Not only do the persons in this group represent a valuable national resource which should not be wasted, but the cost of doctoral training, if such training is not to be utilized, should be considered. Again, this population is not expected to remain unemployed. There may, however, be significant under-employment with concomitant job dissatisfaction.

To some degree, these projections themselves will change the result on the supply side, since relatively fewer young people may decide to pursue a Ph.D. in the light of projected imbalances.

The National Academy of Sciences estimates that there were 279,400 doctoral scientists and engineers in the United States in 1975, of whom 265,000 were in the labor force.[29] Of these, 2,500 or one percent were involuntarily unemployed. Among those employed, nearly three fifths (57.7%) were in educational institutions and more than a third (36.8%) listed teaching as their primary activity (Tables 37 and 38).

TABLE 37

Type of Employer by Field of Employment for Full-Time and Part-Time Employed Doctoral Scientists and Engineers Excluding Postdoctoral Appointees, 1975

A. Individuals Receiving Doctorates During 1930-1974

1975 Employer	All Fields	Field of Employment									
		Math	Phys	Chem	Earth	Engr	Biosc	Psych	SocSc	Nonsc[5]	No Report
Employed Population N	254,643	16,682	16,866	31,582	11,863	41,398	60,415	28,531	31,056	12,894	3,356
Educational Institution[+]	57 7%	78.7%	61.0%	38.3%	48.7%	34.7%	66.7%	58.2%	81.5%	57.6%	46.7%
Federal Government	8.3	5 2	12.4	5.2	19.1	8.9	11.1	4 2	6.3	5.2	4 2
State/Local Gov't	1 7	.2	*	6	3.7	.8	2.1	3 9	2.2	2 4	1.6
Hospital/Clinic	2.8	.1	.5	1.0	.0	*	3.1	16.2	1	.5	2.5
Other Non-Profit Organization	3 4	1.4	4.4	2.4	4.2	2 9	2.8	3.2	5 0	6.0	7 9
Business/Industry	25 9	14.4	21.7	52 5	24.2	52.6	14.1	14 1	4 8	28 1	29.8
Other/No Report	2	*	.0	*	.0	*	.1	.2	.1	2	7.3

Source: National Academy of Sciences

TABLE 38

Primary Work Activity by Field of Employment for Full-Time and Part-Time Employed Doctoral Scientists and Engineers Excluding Postdoctoral Appointees, 1975

A. Individuals Receiving Doctorates During 1930-1974

1975 Primary Work Activity	All Fields	Field of Employment									
		Math	Phys	Chem	Earth	Engr	Biosc	Psych	SocSc	Nonsc	No Report
Employed Population N	254,643	16,682	16,866	31,582	11,863	41,398	60,415	28,531	31,056	12,894	3,356
Teaching	36.8%	60.7%	34.9%	28.0%	29.6%	22.3%	33 9%	38 7%	63.6%	31 3%	22 1%
Research	25.8	17.3	43.9	34.7	35 6	23.1	37.5	10.1	13.2	5 5	10.9
Administration of:											
--Research/Development	14 5	6 4	11.6	22 1	16.5	22.7	13.0	8.8	8.0	16.0	14.8
-Other	6 3	4.0	1 8	3 6	6 6	6.4	4.0	8.3	6.6	24 9	12.1
Consulting/Prof Services	6 2	2 0	9	1.5	4.6	4.2	4.3	29.8	2.0	5 3	6.1
Design/Development	4 5	6 9	3.5	4.4	1.5	16 7	1 1	.7	.5	1.9	1.4
Report/Marketing/ Production/Inspection	1.9	.5	.7	3.1	1.7	1.8	1.7	.5	1.7	5.7	7.4
Other/No Report	4.0	2.1	2.6	2.6	4.0	2.8	4 5	3.1	4.3	9.3	25.2

Source: National Academy of Sciences

The proportion of each group principally employed in teaching varies from 22% of the engineers and 30% of the physical scientists to 61% of the mathematical scientists and 64% of the social scientists.

Because of the changing size of the group of persons of college age, the education sector is no longer expanding at rates sufficient to utilize even the proportion of doctoral scientists that found academic employment in the past. Reduced employment opportunities in academic settings can be expected to hit hardest in those areas of science where half or more of the work force traditionally has found academic employment - namely in the mathematical and social sciences and in the life sciences.

About one fourth of doctoral scientists and engineers are engaged in research, with another 14.5% employed in the management of R & D. This is the sector where some growth may be contemplated.[30]

Scientists and engineers employed at universities and colleges by primary type of activity: January 1965-76

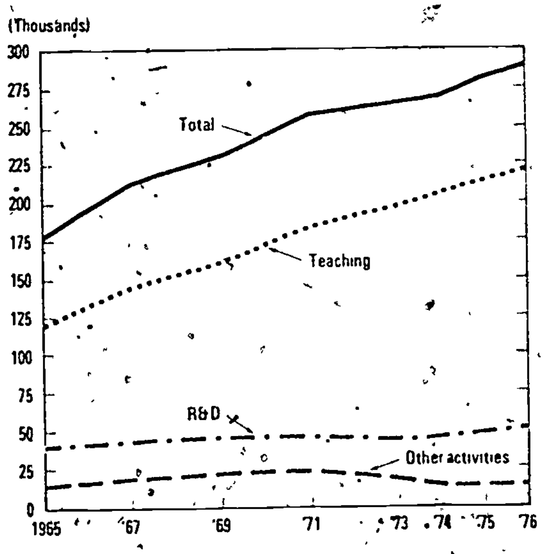


Fig. 11

In 1976, the number of academic scientists and engineers employed primarily in R & D activities increased two percent from 1975, to 51,000. However, less than 18% of academic scientists and engineers are primarily engaged in R & D in 1976, and during the longer period 1965-76, NSF found evidence of a significant shift toward teaching (Fig. 12). Academic scientists and engineers include some persons below the doctorate level.[31]

The 1976 budget for federal R & D obligations was up 15% from 1975, reflecting for the first time in five years a real dollar gain in R & D activities funded by the federal government. Funding, or course, means jobs. The number of scientists and engineers employed in industrial R & D in January 1975, was 357,500, down a few hundred from a year earlier, and down more than 25,000 from the peak employment of 1969. Although the 1977 federal budget for R & D rose another 8.6% in constant dollars, the estimated total for 1977 is 20% below that of 1967. Nonetheless, the rising direction in R & D spending indicates improving employment opportunities for scientists and engineers. The projections we have examined, however, indicate that supply is rising faster than demand.

SUMMARY AND CONCLUSIONS

Some trends in scientific and engineering manpower supply and demand seem fairly sure. The supply of new scientists and engineers appears to have caught up with, and in some instances exceeded the number of job opportunities requiring the level of training being achieved. Nonetheless, actual unemployment continues to be low among scientists and engineers relative to unemployment of other groups with similar amounts of education and training.

Opportunities for scientists and engineers depend significantly on the decisions of federal (and to a lesser extent, state and local) government as to funding for those kinds of activities that require large numbers of technologically-trained persons.

Congressional decisions for funding energy programs are and will be important in determining the demand for certain kinds of scientists and engineers; as will decisions regarding funding for environmental activities, food technologies, health care, and a host of other national enterprises.

One of the major reasons why dependable forecasts of supply and demand are not always available for a period of ten years or so is the inability to forecast what these governmental decisions will be. We also cannot predict the unexpected discovery or happening that will change the forecast, although we can be quite sure that something unexpected will occur. Nonetheless, forecasts are made, and we have examined some of them because they are a useful part of the information needed to make informed decisions.

One important thing to remember in examining projections is the difference between need and demand. It is not difficult to carry out a study of manpower needs for any given objective such as energy independence, environmental cleanup, or better national health, provided we can state the objective and set the time by which we wish to have accomplished it. One other factor, however, must be added, if we are to translate manpower needs into manpower demand. That factor is money. Only when funding is added can people be hired, no matter how many may be needed. If we could forecast accurately the state of the economy over the next ten years, our manpower projections also would be more accurate.

There are now, and will continue to be for the foreseeable future some imbalances in supply and demand among scientists and engineers. At the moment, some segments of the engineering profession below the doctorate level show potential imbalance on the low side of supply. The life and social sciences appear to be slated for the largest over-supply, both at the doctorate and lower degree levels. The physical sciences are somewhere in between, with chemistry offering more promise of opportunity than physics, geology offering more than chemistry, barring unforeseen changes in either supply or demand trends.

Increasingly, job opportunities will have to be sought in industry and not in academic settings where relatively fewer job opportunities will be available than in the past, either in elementary or secondary education or in higher education.

The alert scientist or engineer, including those still in school, will keep an eye on the changing marketplace, be aware when funds are drying up for one kind of activity and enlarging for others, and be prepared, if necessary, to consider some cross-field mobility.

Despite the gloomy prognostications we have examined, the picture for natural scientists and engineers generally is pretty good, particularly when compared to opportunities for new graduates, and even experienced ones in the humanities and in some segments of the social sciences. "Full employment" is not anticipated at the appropriate level for all the scientists and engineers in the country, either next year or over the next decade. There does not appear to be much likelihood of large scale unemployment either. The tragedy, if indeed there is any, will be for those individuals who have cut down on their opportunities for field switching by staying in too narrow a channel, or by not having kept up with developments outside a narrow specialty; and for those whose vision of successful employment is so limited that what might otherwise be seen as interesting options are viewed only as representing failure.

Barring that unforeseen development which is bound to occur, there does not appear to be any forthcoming crisis in science and engineering employment, either because of shortages or surpluses, although full utilization of science and engineering manpower resources does not look probable. Some individuals in this technological pool may face a crisis of unmet expectations, and the nation may not be able to take full advantage of its trained scientists and engineers, at least over the next decade.

By about 1990, however, significant shortages may again be evident in some areas of science and engineering because of declining birth rates and because in the light of projections of surplus graduates in the 1975-85 period, significant numbers of young people in the larger post-war generation may choose not to prepare for careers in science or engineering. If this drop does not occur, those scientists & engineers trained during the seventies who do not find employment in their fields of training also will be lost to the science and engineering workforce. A decade later when they might be needed in those fields, both their skills and their knowledge base will have become obsolescent.

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- *SCIENTIFIC, ENGINEERING, TECHNICAL MANPOWER COMMENTS*, periodical, 10/yr. $20.00 per year; 2 yrs., $35.00; 3 yrs., $50.00

A monthly digest of current developments affecting the recruitment, training and utilization of scientific, engineering, and technical manpower. Special sections include current information on supply and demand, women and minorities in science, education, pending legislation, federal agency activities, salaries, and new publications of interest to producers and users of technical manpower.

- *PROFESSIONAL WOMEN AND MINORITIES, A Manpower Data Resource Service*, June 1975, $40.00. Continuing update - supplement service, $25.00 per year.

This comprehensive 320-page study published in 1975 for use by educational institutions, industry and government brought together for the first time virtually all available data on manpower at professional levels with special emphasis on women and minorities in the natural and social sciences, engineering, arts, humanities, education and the professions.

Published in loose-leaf format with appropriate subject divider tabs, the four-part reference book includes basic information on affirmative action; manpower data in all fields from more than 140 sources; annotated recruitment resources; a bibliography, and a comprehensive cross incex. Approximately 400 tables and charts with breakouts by sex and/or minority status provide data on enrollments; degrees; and on general, academic and federal workforce participation of women and minorities by field and subfield. Each data resource section, arranged by field, is supplemented with textual highlights of the data and lists of specialized recruitment resources for women and minorities in that field.

A continuing subscription service updates and supplements the statistics as new data become available. 1976 supplements were published in February and October, 1976.

- *SALARIES OF SCIENTISTS, ENGINEERS AND TECHNICIANS, A Summary of Salary Surveys*, Seventh Edition, December 1975. $15.00 per copy.

A 112-page report presenting detailed information on starting and advanced salaries in industry, government and educational institutions with breakouts by field, highest degree, sex, years since first degree, age group, category of employment, work activity, type of employer, geographic area, academic rank, Civil Service grade and grade distribution, and level of responsibility, with some comparative salary data in non-technical fields. Includes both published and previously unpublished data on salaries for the period 1972-1975, with some trend data beginning in 1961.

The seventh edition of *SALARIES OF SCIENTISTS, ENGINEERS AND TECHNICIANS - A Summary of Salary Surveys* (December 1975, 106 +vi) includes 128 tables and 11 charts.

For comparing data back through 1971, copies of the Fifth (June 1971) and Sixth Editions (August 1973) are available, at reduced rates.

TEST YOURSELF FOR SCIENCE, April 1971. Single copy, $1.00; 25 or more copies, 50¢ each.

A novel career booklet to "test" a student's interests in various fields of science - chemistry, biology, mathematics, geology, physics - and engineering.

This 48 page program booklet guides students as they search for their science career interest. Sources of additional information are included.

- *SCIENCE AND ENGINEERING CAREERS - A BIBLIOGRAPHY*, April 1974. Single copy, $2.00; 25 or more, $1.00 each.

An extensive bibliography of career guidance information in science and engineering, with complete source address, cost, etc. It is designed to help young people, their parents and their guidance counselors to obtain accurate and up-to-date information about careers in science and engineering, including details on necessary training and professional employment opportunities. Sections on additional sources for obtaining career information, and a listing of sources of information on financial aid complete this comprehensive bibliography.