Ph.D. Manpower: Employment Demand, and Supply 1972-85

U.S. Department of Labor
Bureau of Labor Statistics
1975

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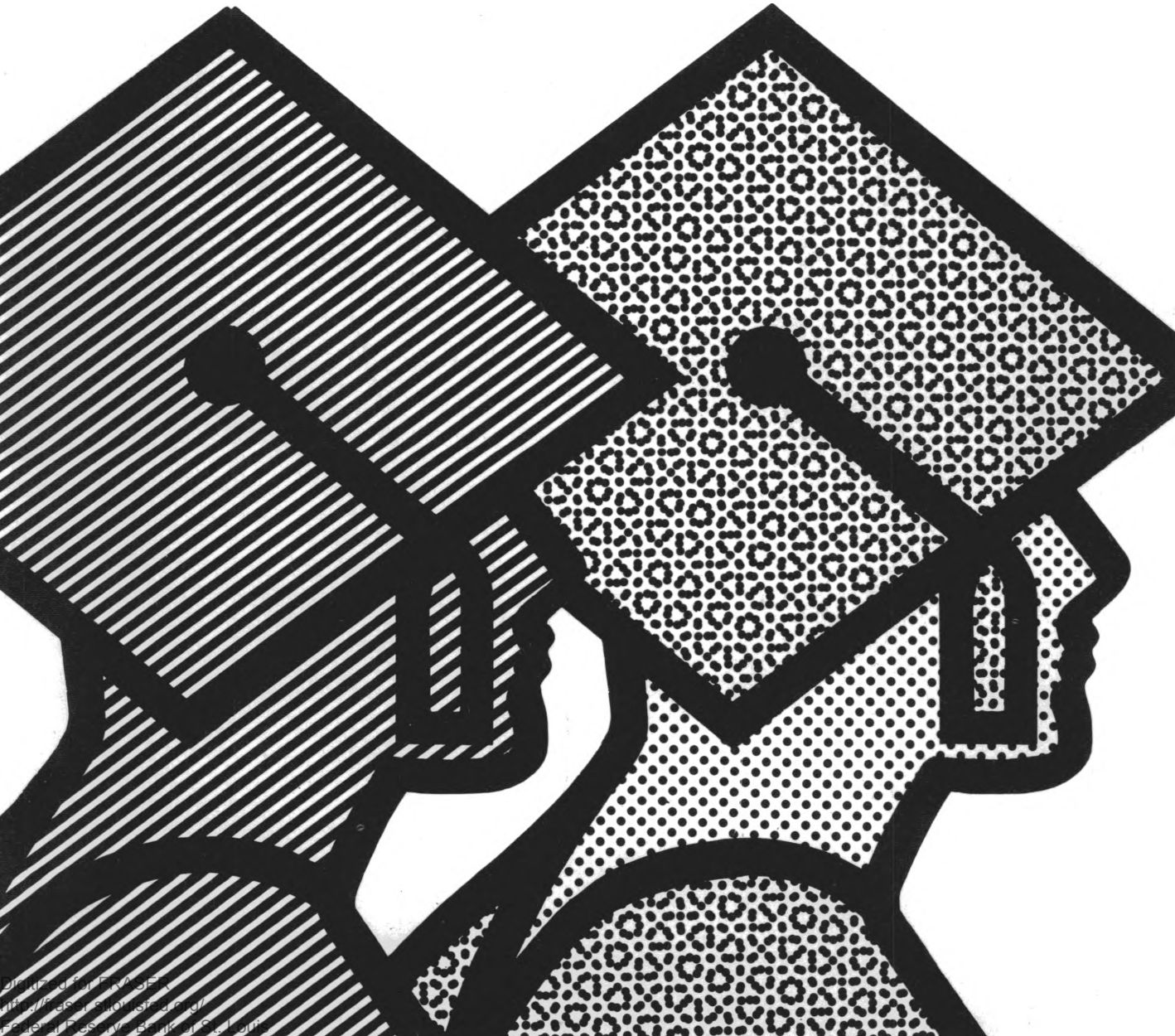

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John T. Dunlop, Secretary
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1975

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Preface

The Bureau of Labor Statistics has as one of its major tasks the development and dissemination of information on future manpower requirements and supply. This bulletin is part of a series relating to the Bureau's projections of economic and manpower data to 1985. Other publications include:

The Structure of the U.S. Economy in 1980 and 1985, BLS Bulletin 1831 (1975).

Occupational Manpower and Training Needs, Revised 1974, BLS Bulletin 1824 (1975).

"Detours: The Road Ahead for College Graduates," **Occupational Outlook Quarterly,** Summer 1974, Vol. 18, No. 2.

The U.S. Economy in 1985: A Summary of BLS Projections, BLS Bulletin 1809 (1974). Reprint of 4 articles from the **Monthly Labor Review** of December 1973.

"Education of Workers: Projections to 1990," **Monthly Labor Review,** November 1973.

This bulletin was prepared in the Bureau's Division of Manpower and Occupational Outlook by Elinor W. Abramson under the general direction of Michael F. Crowley.

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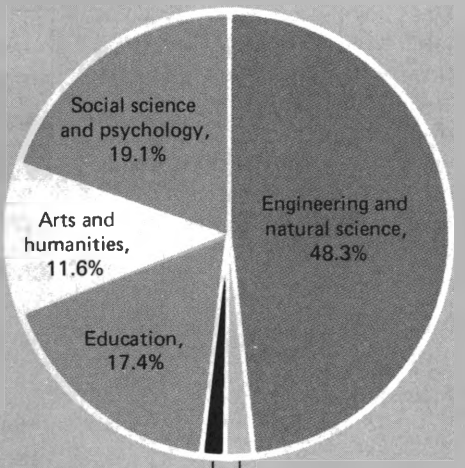
HIGHLIGHTS

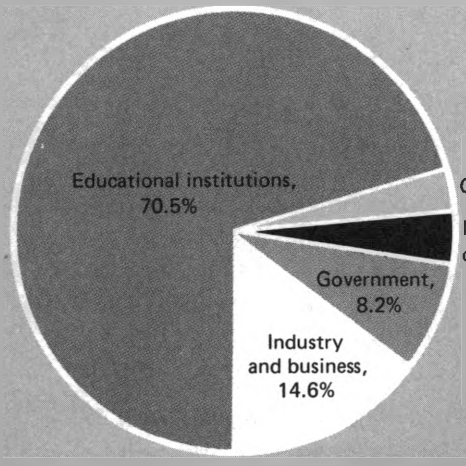
Ph.D. employment in 1972

An estimated 335,000 Ph.D.'s were employed in 1972.

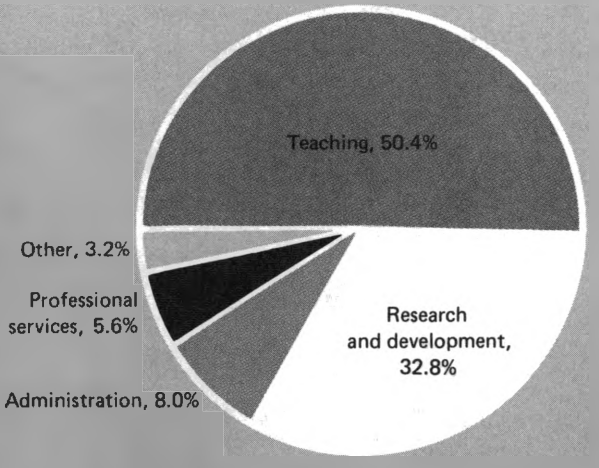
About one-half were in engineering and natural science.



About seven-tenths worked in educational institutions.



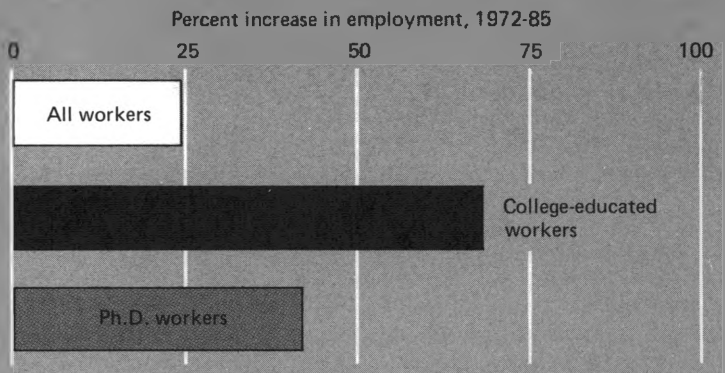
About one-half taught most of the time.



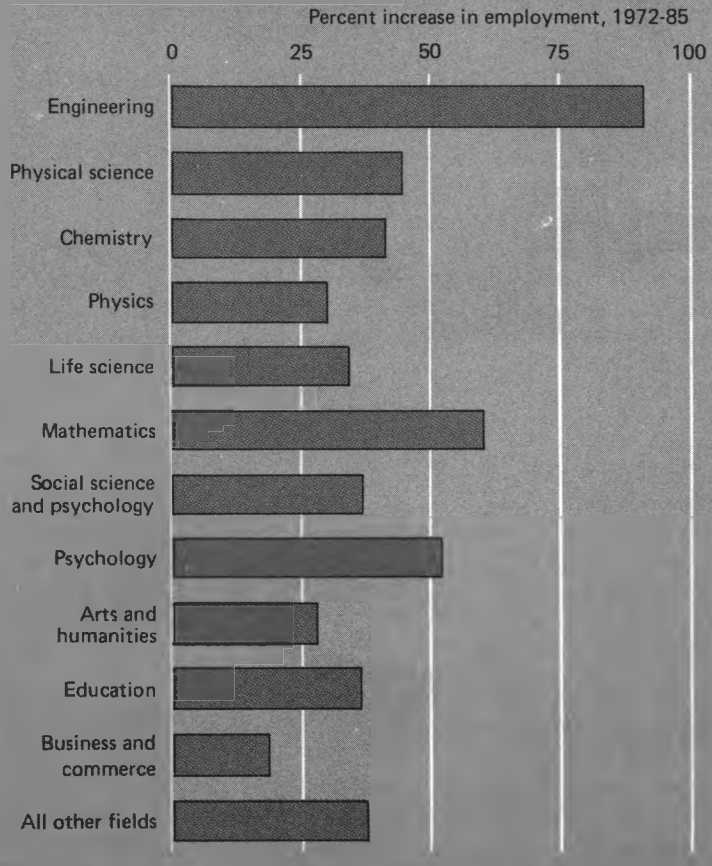
HIGHLIGHTS—Continued

Ph.D. employment growth

From 1972 to 1985, demand for Ph.D.'s will grow nearly twice as fast as for all workers, but more slowly than for college graduates as a whole. By 1985, employment requirements for Ph.D.'s will increase to 475,000, if trends continue in the use of Ph.D.'s relative to other workers in the same occupation.



Field of Ph.D.

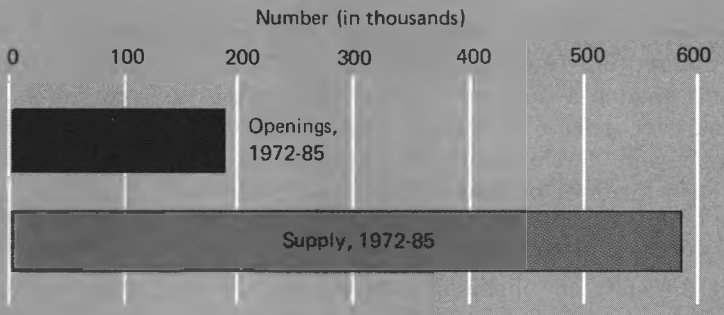


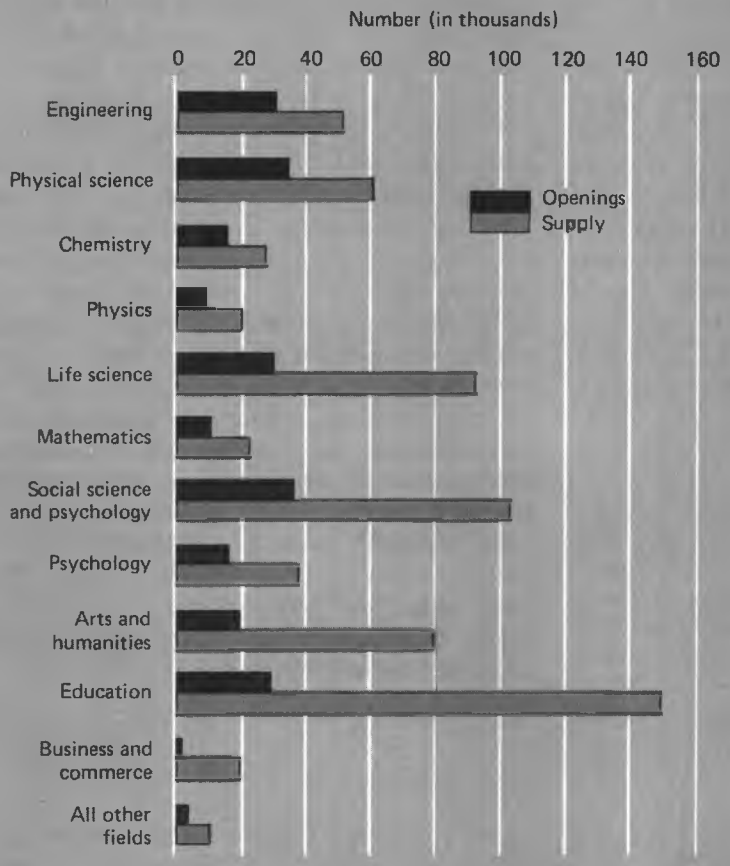
Business and commerce, the slowest growing field, will be up 18 percent; engineering, the fastest growing, 80 percent.

HIGHLIGHTS—Continued

Ph.D. openings and supply, 1972-85

Total openings over the 1972-85 period for growth and for replacement will number about 187,000. On the other hand, if trends in the awarding of Ph.D. degrees continue as in the past decade, the supply of new doctorates will number 580,000.





The outlook for Ph.D.'s during the 1970's and early 1980's probably will not be as bright as in the past. Increasing numbers may work in jobs not formerly held by Ph.D.'s. In some fields Ph.D.'s will feel the effects more strongly than in other fields.

Introduction

Beginning in the late 1960's, great concern developed about the future employment prospects for persons holding a doctoral degree. Federal cutbacks of funds for defense and space-related activities and research and development (R&D) combined with weakened financial positions of colleges and universities to produce a poor job market for doctorate holders. Individuals having doctoral degrees experienced difficulty in obtaining jobs of their choice. Nevertheless, the number of students enrolled in graduate programs continued to increase to record levels.

Publicity about manpower surpluses highlighted the troubled job market for Ph. D.'s during the late 1960's and early 1970's. Numerous stories were told of doctorate holders preparing income tax forms, pumping gasoline, or parking cars. Unemployment data for selected groups of Ph. D.'s indicated that although their unemployment rate was much lower than the average for all workers, it had increased significantly during the 1968-71 period.[1]

When the employment situation for doctorate holders is assessed, however, the consequences of underutilized Ph. D. manpower must be considered for individuals, employers, and society. Additional questions also arise. What is the long term supply-demand outlook for Ph. D. manpower? Should graduate education be changed from its traditional research orientation? What information should be given to young people who are considering graduate education as a road to their career goals?

This report attempts to shed light on some of the major factors that should be considered in answering these questions for policymaking and vocational guidance by providing basic manpower data on Ph. D.'s. The data cover persons holding a doctoral degree in engineering, mathematics, natural science, social science, the arts and humanities, education, business and commerce, and other fields. These degrees may be conferred as Doctor of Philosophy (Ph. D.). Doctor of Science (Sc. D.), Doctor of Education (Ed. D.), Doctor of Business Administration (D.B.A.), Doctor of Arts, or other similar awards. First professional doctor's degrees such as M.D., D.D.S., and J.D. are not included.

Underlying the projections in this report are the assumptions that changes in relative wages, the desire for education, and other factors will have little effect on the educational patterns and career choices of young persons, and that conditions will not arise whereby employers will significantly change the trend in the utilization patterns for Ph. D. manpower. If supply and demand are not in balance, however, such changes are likely to occur to some extent. Therefore, the requirements and supply projections in this report are not forecasts of actual conditions in 1985. However, by illustrating what could be expected if the past decade's trends and patterns continue, valuable insight can be obtained for planning careers, education, and training. It also would be very useful to identify the extent to which adjustments to supply and requirements will occur because of supply-demand imbalances.

[1] For example, the National Science Foundation reported a 0.9 percent unemployment rate for Ph. D. scientists in 1970, rising to 1.4 percent in 1971, compared with a 1970 unemployment rate of 4.9 percent for all workers, rising to 5.9 percent in 1971. See **Unemployment Rates and Employment Characteristics for Scientists and Engineers, 1971**, NSF 72-30 (National Science Foundation, 1972).

Chapter I. Current Employment

About 335,000 persons having a doctoral degree were employed in 1972. Nearly half—about 162,000—had doctorates in engineering or natural science (table 1). Only a small proportion had earned their doctorates in business and commerce.[2]

[2] These estimates are consistent with those published by the National Academy of Sciences, although they differ somewhat because of coverage. The current study encompasses doctorate holders in all fields, including fields not included by the Academy. See appendix to this report and **Doctoral Scientists and Engineers in the United States, 1973 Profile** (National Academy of Sciences, March 1974).

Employers

Of the doctorate holders employed in 1972, about 70 percent worked in educational institutions. Another 15 percent worked in private industry and business or were self-employed. Smaller proportions worked in government and in nonprofit organizations. This distribution is virtually the same as 10 years earlier.

In all fields except engineering and chemistry, educational institutions were the major employer of

Table 1. Employment of Ph. D.'s, by field and employer, 1972

Field	Total	Educational institutions	Industry and business	Government	Nonprofit organizations	Other[1]
	Number (in thousands)					
All fields	334.6	235.9	48.7	27.6	12.7	9.7
Engineering and natural science	161.7	91.1	44.6	15.4	4.8	5.9
Engineering	31.0	12.7	14.0	2.0	1.0	1.3
Physical science	63.8	30.6	24.3	4.9	1.7	2.3
Chemistry	35.9	14.6	17.6	1.9	.7	1.0
Physics	22.6	12.5	5.6	2.5	1.0	1.0
Life science	54.5	38.1	4.6	7.9	1.7	2.1
Mathematics	12.4	9.7	1.7	.5	.3	.2
Social science and psychology	63.8	47.2	2.6	8.1	3.8	2.1
Psychology	22.7	13.2	1.3	4.9	2.3	1.0
Arts and humanities	38.8	36.8	.4	.4	.7	.5
Education	58.3	51.6	.6	3.3	1.9	.9
Business and commerce	5.4	4.5	.4	.1	.1	.2
Other fields	6.7	4.8	.1	.2	1.4	(2)
	Percent distribution					
All fields	100.0	70.5	14.6	8.2	3.8	2.9
Engineering and natural science	100.0	56.3	27.6	9.5	3.0	3.6
Engineering	100.0	41.0	45.0	6.6	3.2	4.2
Physical science	100.0	48.0	38.0	7.7	2.9	3.4
Chemistry	100.0	40.8	49.1	5.3	1.9	2.9
Physics	100.0	55.3	24.6	11.0	4.6	4.5
Life science	100.0	69.9	8.5	14.5	3.2	3.9
Mathematics	100.0	77.8	13.9	4.0	2.5	1.8
Social science and psychology	100.0	73.9	4.1	12.7	6.0	3.3
Psychology	100.0	58.4	5.7	21.7	10.0	4.2
Arts and humanities	100.0	94.8	1.0	1.1	1.8	1.3
Education	100.0	88.5	1.0	5.7	3.2	1.6
Business and commerce	100.0	84.0	8.3	2.7	2.0	3.0
Other fields	100.0	72.3	1.8	3.6	21.7	.6

[1] In the prime source data, the National Academy of Sciences shows an "other" category, which may be used by respondents to the NAS doctoral report. However, it is not clear what this category includes.

[2] Fewer than 50 persons.

NOTE: Details may not add to totals due to rounding.

Table 2. Percent distribution of Ph. D.'s, for each employer by field, 1972

Field	Total	Educational institutions	Industry and business	Government	Nonprofit organizations	Other [1]
All fields	100.0	100.0	100.0	100.0	100.0	100.0
Engineering and natural science	48.3	38.6	91.5	55.6	38.0	61.0
Engineering	9.3	5.4	28.7	7.4	7.7	13.6
Physical science	19.1	13.0	49.8	17.8	14.2	22.9
Chemistry	10.7	6.2	36.2	6.9	5.3	10.9
Physics	6.8	5.3	11.4	9.0	8.1	10.6
Life science	16.3	16.1	9.5	28.6	13.6	22.1
Mathematics	3.7	4.1	3.5	1.8	2.4	2.3
Social science and psychology	19.1	20.0	5.4	29.4	29.9	22.0
Psychology	6.8	5.6	2.6	17.8	17.7	9.9
Arts and humanities	11.6	15.6	.8	1.5	5.4	5.3
Education	17.4	21.9	1.2	12.0	14.6	9.7
Business and commerce	1.6	1.9	.9	.5	.8	1.7
Other fields	2.0	2.0	.2	.9	11.3	.4

[1] In the prime source data, the National Academy of Sciences shows an "other" category, which may be used by respondents to the NAS doctoral report. However, it is not clear what this category includes.

NOTE: Details may not add to totals due to rounding.

Ph. D.'s. Because of the great involvement of engineers and chemists in industrial research and development, private industry utilizes proportionately more doctoral workers in these two fields than in other fields. In many fields, few doctorate holders work outside of educational institutions. For example, only 5 percent of the Ph. D's in the arts and humanities work outside of educational institutions.

As an indication of the importance of R&D in industry and business, more than nine-tenths of the Ph. D.'s working for these employers hold degrees in engineering and natural science (table 2). In government, slightly more than one-half of the Ph. D.'s are in engineering and natural science. The government's strong interest in social welfare and health programs also can be seen clearly—more than one-fourth of government Ph. D.'s are in social science and psychology and another one-fourth are in life science. On the other hand, in both educational institutions and nonprofit organizations, three-fifths of all Ph. D.'s are in fields other than engineering and natural science.

Table 3. Employment of Ph. D.'s, by employer and primary work activity, 1972

Employer	Total	Teaching	Research and development	Administration	Professional services to individuals	Other activities
	Number (in thousands)					
All employers	334.6	168.6	109.8	26.8	18.9	10.6
Educational institutions	235.9	166.6	38.6	21.7	6.9	2.1
Industry and business	48.7	.2	40.5	1.1	3.1	3.7
Government	27.6	.7	18.1	2.3	4.8	1.6
Nonprofit organizations	12.7	.6	6.9	1.0	3.3	.9
Other [1]	9.7	.4	5.7	.6	.7	2.3
	Percent distribution					
All employers	100.0	50.4	32.8	8.0	5.6	3.2
Educational institutions	100.0	70.6	16.4	9.2	2.9	.9
Industry and business	100.0	.5	83.1	2.3	6.4	7.7
Government	100.0	2.7	65.6	8.4	17.5	5.8
Nonprofit organizations	100.0	4.9	54.1	7.7	26.3	7.0
Other [1]	100.0	4.5	58.7	5.8	7.7	23.3

[1] In the prime source data, the National Academy of Sciences shows an "other" category, which may be used by respondents to the NAS doctoral report. However, it is not clear what this category includes.

NOTE: Details may not add to totals due to rounding.

Primary work activity

Ph. D.'s work primarily in teaching, research and development, administration, and professional services to individuals. The single most important work activity is teaching—employing about one-half of them most of the time (table 3).[3]

Next to teaching, the most important work activity of Ph. D.'s—33 percent—is R&D. In all sectors except education, more Ph. D's were engaged in R&D than any other activity. R&D activities involved 83 percent of the Ph. D.'s employed in industry and business, 66 percent in government, and 54 percent in nonprofit organizations compared with only 16 percent in educational institutions.

About 8 percent or 26,800 of all Ph. D.'s were in administration in 1972. Approximately 21,700 of

[3] These data are based on what the Ph. D. did most of the time although the individual also may have worked in another activity.

Table 4. Percent distribution of Ph. D.'s, for each work activity by employer, 1972

Employer	Total	Teaching	Research and development	Administration	Professional services to individuals	Other activities
All employers	100.0	100.0	100.0	100.0	100.0	100.0
Educational institutions	70.5	98.8	35.2	80.3	36.7	19.8
Industry and business	14.6	.1	36.9	4.1	16.5	34.9
Government	8.3	.4	16.5	8.6	25.5	15.1
Nonprofit organizations	3.8	.4	6.3	3.8	17.6	8.5
Other [1]	2.9	.2	5.2	2.3	3.7	21.7

[1] In the prime source data, the National Academy of Sciences shows an "other" category, which may be used by respondents to the NAS doctoral report.

NOTE: Details may not add to totals due to rounding.

Table 5. Employment of Ph. D.'s, by field and primary work activity, 1972

Field	Total	Teaching	Research and development	Administration	Professional services to individuals	Other activities
	Number (in thousands)					
All fields	334.6	168.6	109.8	26.8	18.9	10.6
Engineering and natural science	161.7	59.4	90.1	3.0	2.9	6.2
Engineering	31.0	9.2	18.8	.7	.6	1.6
Physical science	63.8	20.2	40.0	.8	.6	2.1
Chemistry	35.9	11.0	23.4	.4	.2	.9
Physics	22.6	6.2	15.5	.3	.2	.5
Life science	54.5	22.2	27.3	1.4	1.5	2.1
Mathematics	12.4	7.8	3.9	.1	.2	.4
Social science and psychology	63.8	36.3	13.5	2.8	9.3	1.9
Psychology	22.7	7.9	6.5	.7	7.0	.5
Arts and humanities	38.8	35.4	1.1	1.1	.5	.7
Education	58.3	29.0	4.1	18.9	5.0	1.2
Business and commerce	5.4	4.1	.4	.4	.3	.2
Other fields	6.7	4.4	.5	.5	.9	.3
	Percent distribution					
All fields	100.0	50.4	32.8	8.0	5.6	3.2
Engineering and natural science	100.0	36.8	55.7	1.8	1.8	3.9
Engineering	100.0	29.8	60.6	2.3	2.0	5.3
Physical science	100.0	31.7	62.7	1.3	1.0	3.3
Chemistry	100.0	30.6	65.2	1.1	.6	2.5
Physics	100.0	27.3	68.6	1.3	.7	2.1
Life science	100.0	40.7	50.2	2.5	2.8	3.8
Mathematics	100.0	62.8	31.8	.7	1.3	3.4
Social science and psychology	100.0	56.9	21.2	4.4	14.5	3.0
Psychology	100.0	35.0	28.8	2.9	31.0	2.3
Arts and humanities	100.0	91.1	2.9	2.9	1.2	1.9
Education	100.0	49.8	7.1	32.4	8.6	2.1
Business and commerce	100.0	75.8	7.4	7.9	5.1	3.8
Other fields	100.0	66.6	7.5	7.8	13.8	4.3

NOTE: Details may not add to totals due to rounding.

these worked in educational institutions, 2,300 in government, 1,000 in nonprofit organizations, and 1,100 in industry and business.

In the fourth activity, professional services to individuals,[4] less than 6 percent of all Ph. D's are employed. Of these, 37 percent worked in educational institutions, 26 percent in nonprofit organizations, and 18 percent in government (table 4).

Primary work activity varies considerably by field (table 5). For example, over three-fifths of Ph. D. mathematicians primarily teach, but no other group of engineering and natural science Ph. D.'s is engaged in teaching to that extent. In engineering and natural science specialties, between one-half and two-thirds of the doctorate holders participate in R&D most of the time. Arts and humanities doctorate holders, on the other hand, have little employment outside of teaching. Psychology is the only field shown in which Ph. D.'s are very nearly evenly divided among three activities.

[4] Included are consultation, guidance, and advisory activities.

Chapter II. Projected Requirements and Supply

Requirements

A basic question exists about the nature of the demand for Ph. D. manpower. Is there an identifiable need in a specific occupation for doctoral workers that can be distinguished from a general need for college educated workers? If it cannot be separately identified, projections of demand for Ph. D.'s would not be meaningful. The need exists if (1) specific jobs can be identified that require Ph. D.'s and (2) employers have special activities designed to recruit Ph. D.'s.

Although a decision to hire a specific individual depends on that person's qualifications and on current economic conditions, the demand for Ph. D.'s can be identified separately from the more general demand for college graduates. This conclusion is based largely on a 1968 BLS study of doctoral scientists and engineers in private industry.[5] However, a doctoral degree increasingly is required for academic employment, although private industry may be less rigid than higher education or government in substituting non-Ph. D.'s for Ph. D.'s. Nonprofit organizations have hiring practices similar to policies in higher education.

In some instances, employment of doctorate holders is related to the prestige factor of the degree itself. If an organization is willing to pay a higher rate for a Ph. D. than for a less qualified worker, then an effective demand exists. Whatever the reason, the result is the same—an economic demand for Ph. D's.

The projections of requirements in this report assume a continuation through 1985 of past use patterns for Ph. D.'s relative to total workers in a specific occupation. For example, historical data indicated that the proportion of psychologists employed by nonprofit organizations who have had a doctorate has remained at about 25 percent over the past several years. In the 1985 projections, this rate is, therefore, the same.

Most ratios, however, did change between 1966 and 1972, as a result of changes in the nature of the work requiring higher degrees of skill and education, institutional changes affecting occupational qualifications, and supply-demand conditions stemming from the rapid growth in the number of Ph. D. degrees that were awarded. Projected 1985 ratios developed for each field by sector of the economy were applied to the Bureau's 1985 occupational projections to obtain the projections of Ph. D. requirements.[6]

In the analysis of Ph. D. manpower, therefore, the interaction of a greater (or lesser) supply than in the past of Ph. D.'s relative to demand could change employers' use patterns. For example, if in a specific field many more Ph. D.'s became available than were being hired at the going wage rate for Ph. D.'s, theoretically some might accept jobs at lower wages which in turn could induce employers to hire even more Ph. D.'s. Also, a changing supply-demand situation of Ph. D.'s could change employers' perceptions of what constitutes Ph. D.-type work. To the extent that these perceptions change over time, Ph. D.'s could be employed in a wide variety of jobs not now currently filled by those holding the Ph. D.

General assumptions that underlie the Bureau's occupational projections are as follows:

The institutional framework of the American economy will not change radically.

Economic, social, technological, and scientific trends will continue, including values placed on work, education, income, and leisure.

Efforts to solve major domestic problems, such as air and water pollution, solid waste disposal, urban congestion, inadequate industrial safety, and energy shortages, may consume more productive resources.

Fiscal, monetary, and manpower training and educational programs will achieve a satisfactory balance between unemployment and price stability, permitting achievement of the long-term economic growth rate. (The projections assume a 4-percent unemployment rate and a 3-percent annual increase in the implicit price deflator for gross national product.)

[5] **Ph. D. Scientists and Engineers in Private Industry, 1968-80,** Bulletin 1648 (Bureau of Labor Statistics, 1970).

[6] See appendix for detailed explanation.

The projections also assume that U.S. energy requirements will be roughly in line with those projected by the U.S. Department of the Interior in **U.S. Energy Through the Year 2000**, December 1970. This means major reliance on oil imports to close the energy supply-demand gap. However, curtailment of oil supplies from the Mideast in late 1973 raised questions regarding the use of imports to close the supply-demand gap over the next few years. It remains to be seen what implications higher oil prices may have for the long-term growth rate and for structural changes in the economy. The Bureau is studying the employment effects of alternative assumptions on energy; the results are expected to be available in late 1975.

Factors affecting requirements

The earlier discussion indicated the basic parameters for projections of Ph. D.'s in this report. However, several factors in specific occupations affect the demand for Ph. D.'s. The two most important work activities of Ph. D.'s are teaching and research and development. Although teaching is done primarily by college and university faculty, R&D activities take place in different sectors of the economy—colleges and universities, private industry, government, and nonprofit organizations. Some of the specific factors that affect the demand for faculty Ph. D.'s and research Ph. D.'s are discussed in the following paragraphs.

Faculty. In educational institutions, doctorate holders teach and advise students; conduct research; and administer schools, departments, or programs.

In statistical terms, college and university demand for Ph. D.'s is a function of the number of young persons in the population, the proportion attending college, pupil-faculty ratios, and doctorate-faculty ratios. The Office of Education's projections of total faculty, which were used to develop the doctorate-faculty ratios in this report, indicate that pupil-teacher ratios will continue to decline gradually.[7]

In 1972, about 57 percent of all faculty members in 4-year colleges and universities held a doctorate. If present trends continue, the proportion of faculty having doctorates by 1985 could be expected to rise to about 65 percent. Based on trends between 1966 and 1972, the comparable ratios for community colleges would be 5 percent in 1972 and 9 percent in 1985.

If 65 percent of college and university faculty have doctorates by 1985, projections in this report imply that about 71 percent of new hires in 4-year colleges and universities and about 10 percent of new hires in community colleges will have such degrees.[8]

Doctorate holders working in elementary and secondary schools are primarily Ed. D.'s, although the exact proportion of such workers is not known. The projections, therefore, reflect trends for the period 1957-72 in the proportion of doctorate holders to all teachers employed in elementary and secondary schools.

Research and development. The key demand factor for doctorate holders in sectors other than educational institutions is R&D activity, which is largely performed by scientists and engineers.

Two aspects are involved in estimating demand for Ph. D.'s in R&D: (1) The level of R&D activity (dollars expended), and (2) the nature of R&D activity (the mix between research and development). Doctorate holders are more likely to do research than development. The Ph. D. projections in this report are consistent with the level of R&D activity implied in the Bureau's economic projections to 1985.

Other factors. Most Ph. D.'s work in either teaching or R&D positions. A rapidly growing number of doctorate holders, however, work in jobs that probably could be performed as well by non-Ph. D.'s. Even when demand generally has been high, some Ph. D.'s have worked by choice in jobs that traditionally have not been held by Ph. D.'s; others, for personal reasons, could only find such jobs. It is likely that this type of nontraditional employment and underemployment will continue. Employment of Ph. D.'s in these kinds of jobs does not represent true demand for doctoral manpower, but it does draw on the supply of Ph. D's. These patterns must be accounted for in projections of future demand if the picture is to be complete.

Projected requirements

Over the 1972-85 period, requirements for Ph. D.'s are projected to rise about 42 percent or 1¾ times as fast as total employment. By comparison, demand for workers having 4 years or more of college is

[7] During the 1972-85 period covered by this study, the Office of Education projects that enrollment in institutions of higher education will increase by 5.6 percent.

[8] See alternative projections on page 13.

Table 6. Projected requirements for Ph. D.'s, by employer, 1985

Employer	Requirements, 1985	Percent change, 1972-85
All employers	474,900	41.9
Educational institutions	312,000	32.3
Industry and business	97,400	100.0
Government	42,700	54.7
Nonprofit organizations	22,800	79.1

NOTE: Details may not add to totals due to rounding.

projected to rise by about 68 percent because of expected rapid increases in sales and managerial jobs—areas not expected to have a significant demand for Ph. D.'s.

The projected rate of growth for Ph. D.'s varies among different employers. Requirements for Ph. D.'s in educational institutions are expected to increase only 32 percent; in government, almost 55 percent; in nonprofit organizations 79 percent; and in industry and business, 100 percent (table 6). As a result of these different growth rates, the distribution of Ph. D.'s by sector of the economy is expected to change over the 1972-85 period as follows:

	Distribution of Ph. D.'s, by employer	
	1972	1985
Total	100.0	100.0
Educational institutions	72.6	65.7
Industry and business	15.0	20.5
Government	8.5	9.0
Nonprofit organizations	3.9	4.8

The projections also show great variety in growth rates by occupation (tables 7 and 8).

Demand for **engineering** Ph. D.'s is expected to rise to 59,100, an increase of more than 90 percent—the largest relative increase of all the fields. More than three-fifths of these jobs in 1985 are projected for industry and business. Nearly another one-third are expected to be in educational institutions.

Demand for **physical science** Ph. D.'s is projected to increase by about 44 percent to 91,700. Nearly one-half of the jobs are expected to be in industry and business, with another two-fifths in educational institutions.

Some variation exists for the two major subfields, chemistry and physics. Demand for **chemistry** Ph. D.'s is expected to grow to 50,000, nearly 41 percent above 1972 levels. Nearly three-fifths of the projected 1985 requirements are expected to be in industry and business and almost one-third in educational institutions. On the other hand, nearly one-half of the projected jobs for **physics** Ph. D.'s in 1985 are expected to be for work in educational institutions and more than one-third in industry and business, with demand for all Ph. D.'s in physics rising by 30 percent to 29,400.

Demand for **life science** Ph. D.'s is projected to grow by 34 percent to 73,100. More than two-thirds of these are expected to be employed by educational institutions in 1985.

Mathematics Ph. D. requirements are projected to increase by nearly 59 percent to 19,800, with three-fourths of all mathematics doctoral degree holders working for educational institutions.

Social science and psychology Ph. D. requirements are projected to rise by about 37 percent to 87,100. Three-fourths of the jobs for these workers are expected to be in educational institutions.

Table 7. Projected requirements for Ph. D.'s, by field, 1985

Field	Employment, 1972	Requirements, 1985	Percent change, 1972-85
All fields	334,600	474,900	41.9
Engineering and natural science	161,700	243,700	50.7
Engineering	31,000	59,100	90.5
Physical science	63,800	91,700	43.8
Chemistry	35,900	50,500	40.7
Physics	22,600	29,400	30.0
Life science	54,500	73,100	34.2
Mathematics	12,400	19,800	59.3
Social science and psychology	63,800	87,100	36.5
Psychology	22,700	34,400	51.7
Arts and humanities	38,800	49,400	27.3
Education	58,300	79,200	35.9
Business and commerce	5,400	6,300	18.2
Other fields	6,700	9,100	37.2

NOTE: Details may not add to totals due to rounding.

Table 8. Projected requirements for Ph. D.'s, by field and employer, 1985

Field	Total	Educational institutions	Industry and business	Government	Nonprofit organizations
	Number (in thousands)				
All fields	474.9	312.0	97.4	42.7	22.8
Engineering and natural science	243.7	120.2	90.8	25.2	7.5
Engineering	59.1	18.0	35.6	3.5	2.0
Physical science	91.7	37.0	44.0	8.3	2.5
Chemistry	50.5	16.1	29.9	3.6	.9
Physics	29.4	13.7	10.6	3.6	1.4
Life science	73.1	50.1	7.9	12.6	2.5
Mathematics	19.8	15.1	3.3	.8	.5
Social science and psychology	87.1	65.4	3.6	12.1	6.0
Psychology	34.4	20.2	1.0	9.7	3.5
Arts and humanities	49.4	46.7	.8	.7	1.2
Education	79.2	68.3	1.2	4.1	5.6
Business and commerce	6.3	5.2	.7	.2	.2
Other fields	9.1	6.1	.3	.4	2.3
	Percent distribution				
All fields	100.0	65.7	20.5	9.0	4.8
Engineering and natural science	100.0	49.3	37.3	10.4	3.1
Engineering	100.0	30.5	60.3	5.9	3.3
Physical science	100.0	40.3	48.0	9.0	2.7
Chemistry	100.0	31.9	59.2	7.1	1.8
Physics	100.0	46.8	36.2	12.2	4.8
Life science	100.0	68.5	10.7	17.3	3.4
Mathematics	100.0	76.2	16.8	4.2	2.7
Social science and psychology	100.0	75.1	4.2	13.9	6.8
Psychology	100.0	58.6	2.9	28.2	10.3
Arts and humanities	100.0	94.6	1.6	1.3	2.5
Education	100.0	86.2	1.5	5.2	7.1
Business and commerce	100.0	82.8	11.0	3.1	3.1
Other fields	100.0	67.2	3.1	4.3	25.3

NOTE: Details may not add to totals due to rounding.

Psychology Ph. D. requirements, which are expected to increase nearly 52 percent, will rise most rapidly in government where more than one-fourth of the jobs in 1985 are projected to be found. Growing nearly as rapidly, psychology degree holders employed by educational institutions may constitute nearly three-fifths of the 1985 requirements.

Demand for **arts and humanities** Ph. D.'s, nearly all of whom are expected to be employed by educational institutions, is projected to increase by 27 percent to 49,400.

Demand for **education** Ph. D.'s is expected to increase by 36 percent to 79,200. Although requirements in industry and business and in nonprofit organizations are projected to double and triple, respectively, nearly 9 of every 10 are expected to be working for educational institutions.

Demand for **business and commerce** Ph. D.'s is projected to grow to 6,300, an increase of only 18 percent. Although industry's demand for these is expected to grow, only about 1 of every 10 is expected to work for industry and business. Most are projected still to be in educational institutions.

Demand for doctorate holders in **all other fields** is projected to increase by 37 percent to 9,100. About two-thirds of these probably will be needed by educational institutions. One-fourth are expected to be working for nonprofit organizations.

Owing to the variation in the projected growth rates among individual fields, the distribution of Ph. D.'s in 1985, by broad field, is expected to change somewhat from the distribution in 1972, as shown in the following tabulation:

	Distribution of Ph. D.'s, by field	
	1972	1985
Total, all fields	100.0	100.0
Engineering and natural science	48.3	51.3
Social science and psychology	19.1	18.4
Arts and humanities	11.6	10.4
Education	17.4	16.7
Business and commerce	1.6	1.3
Other fields	2.0	1.9

Table 9. Source of demand for Ph. D.'s, 1972-85

Field	Total demand	Growth			Replacement needs
		Total	Educational upgrading	Employment expansion	
All fields	187,400	140,300	30,800	109,500	47,100
Engineering and natural science	100,100	82,000	19,900	62,100	18,100
Engineering	29,300	28,100	5,500	22,600	1,200
Physical science	33,400	28,000	8,900	19,100	5,400
Chemistry	14,800	14,600	7,100	7,500	200
Physics	7,700	6,700	1,100	5,600	1,000
Life science	27,600	18,600	3,400	15,200	9,000
Mathematics	10,000	7,400	2,100	5,300	2,600
Social science and psychology	35,200	23,300	4,900	18,400	11,900
Psychology	15,000	11,700	4,100	7,600	3,300
Arts and humanities	19,700	10,600	200	10,400	9,100
Education	26,800	20,900	4,000	16,900	5,900
Business and commerce	2,000	1,000	300	900	1,000
Other fields	3,600	2,500	1,700	800	1,100

NOTE: Details may not add to totals due to rounding.

Job openings

Job openings for Ph. D.'s are created by either occupational growth or the need to replace Ph. D.'s who will retire, die, or otherwise leave the labor force. The projections in this report indicate a need for about 187,000 doctorate holders over the 1972-85 period, 140,000 for growth and 47,000 for replacements (table 9).

Openings resulting from growth are based on an analysis of trends in the proportion of workers in each occupational field holding a doctorate. (See appendix for a discussion of the projection method.) About four-fifths of these job openings stem from growth in the number of workers in each occupation. The remainder result from the educational upgrading of jobs and reflect the projected 1972-85 increase in the proportion of workers in each field holding a doctorate.

Replacement needs are estimated by applying an average annual separation rate to the projected average annual employment between 1972 and 1985. The separation rate for Ph. D.'s, 0.89 percent,[9] was computed as a part of this study. (See appendix.)

Growth and replacement needs also may be expressed as annual openings for Ph. D. workers. Approximately 14,000 doctorate holders will be required on the average each year between 1972 and 1985, of which one-fourth will replace Ph. D. workers who retire, die, or leave the labor force for other reasons.

[9] This rate is somewhat lower than comparable rates for all college and university teachers (2.68 percent) or for all physicists (1.07 percent) because the age distributions of Ph. D.'s in both 1972 and 1985 are skewed toward workers under the age of 40.

Alternative projections

The job projections described earlier are based on continuation of past trends and certain assumptions about the ratio of Ph. D.'s to all workers for each occupation in each major economic sector. However, many factors, including changing wage differentials and changing technology, could alter these patterns. It is desirable to know, therefore, the effect of changes in these ratios on manpower needs for Ph. D.'s.

Alternative projections were developed for 4-year college and university faculties, the sector of the economy employing the most Ph. D.'s. The basic projections imply that about 71 percent of annual faculty openings would be job openings for Ph. D.'s. Thus, of the estimated 8,250 annual openings for faculty over the 1972-85 period, 5,900 would be for Ph. D.'s. However, the proportion could rise if greater numbers of doctorate workers were available at lower relative salaries, and, consequently, colleges and universities hired more Ph. D.'s. Increases of 5 percentage points to 76 percent and 10 percentage points to 81 percent would raise annual openings as shown in the following tabulation. Over the 13-year period, job openings for an additional 5,200 Ph. D.'s on college and university faculties would result from each 5-percentage point increase in the proportion of new hires with a doctoral degree.

Percent of new hires with doctorates	Annual faculty openings	Annual Ph. D. requirements
71	8,250	5,900
76	8,250	6,300
81	8,250	6,700

If 81 percent of all new faculty hires for colleges and universities between 1972 and 1985 have doctorates, by 1985 the percentage of total faculty with doctoral degrees would rise to about 67 percent. As may be seen from the following tabulation, large increases in the proportion of new hires with doctorates would produce small changes in the percentage of the faculty with doctorates because the ratio of annual openings to total faculty averages only 2 percent between 1972 and 1985. Even if 100 percent of all new hires have doctorates, the percentage of total faculty with doctorates would rise to only 73 percent in 1985.

Percent of annual new hires with doctorates (1972-85)	Percent of total faculty with doctorates (1985)
71	65
81	67
85	68
100	73

Increasing the proportion of Ph. D.'s employed by community colleges probably will not have much effect either. The projections developed in this report indicate that 10 percent of the projected 11,000 annual new hires by junior colleges will have doctorates. For each increase of 5 percentage points, only 550 additional doctorates would be needed each year. Thus, these institutions probably will have little effect on the supply-demand balance of Ph. D.'s.

Supply

The supply estimates in this report are based on the U.S. Office of Education's projections of doctorate degrees. Projections for the first 5 years, by field, are based primarily on enrollments for advanced degrees the previous fall and the proportion of these enrollments that historically have resulted in doctorates.[10] This method is valid since anyone who will earn a doctorate in the next 5 years probably is enrolled in graduate school.[11] Projections of Ph. D. degrees beyond 5 years are based on more general demographic characteristics, and assume that the percent of the age group getting a doctorate will continue to increase, but at a slower rate than in the past.

In the past, population growth, increased sources of student financial support, and other factors combined to produce a rapidly growing number of new doctorate degree recipients each year. In the future, even though the school age population will not continue to grow at past rates, the impact of rising educational aspirations, as measured by the trend of rising proportions of the college age population who complete college and attend graduate school, indicates a 3-percent annual increase in the number of new doctorates between 1972 and 1985.

Not all new Ph. D. recipients, however, enter the U.S. labor force. Some foreign nationals return to their homelands and some U.S. citizens choose to work overseas. On the other hand, some persons who earn Ph. D.'s overseas (or who originally were trained in the U.S. and returned to their homelands) may immigrate. Estimates of the first group were subtracted, and of the second group were added to the Office of Education projections. After these adjustments, about 580,000 Ph. D.'s would be seeking to enter the U.S. labor force between 1972 and

[10] This procedure was first initiated in 1971.

[11] **Report on the CGS Doctorate Production Survey** (Washington: Council of Graduate Schools, May 3, 1972).

Table 10. Estimated supply of new Ph. D.'s, 1972-85

Field	Number	Percent
All fields	583,400	100.0
Engineering and natural science	224,400	38.5
Engineering	50,300	8.6
Physical science	60,300	10.3
Chemistry	25,800	4.4
Physics	19,900	3.4
Life science	92,200	15.8
Mathematics	21,600	3.7
Social science and psychology	101,800	17.5
Psychology	37,700	6.5
Arts and humanities	79,600	13.6
Education	148,800	25.5
Business and commerce	19,200	3.3
Other fields	9,700	1.7

NOTE: Details may not add to totals due to rounding.

Table 11. supply and demand, 1985
(in thousands)

Field	New supply, 1972-85	Openings, 1972-85	Difference
All fields	583.4	187.4	396.0
Engineering and natural science	224.4	100.1	124.3
Engineering	50.3	29.3	21.0
Physical science	60.3	33.4	26.9
Chemistry	25.8	14.8	11.0
Physics	19.9	7.7	12.2
Life science	92.2	27.6	64.6
Mathematics	21.6	10.0	11.6
Social science and psychology	101.8	35.2	66.6
Psychology	37.7	15.0	22.7
Arts and humanities	79.6	19.7	59.9
Education	148.8	26.8	122.0
Business and commerce	19.2	2.0	17.2
Other fields	9.7	3.6	6.1

NOTE: Details may not add to totals due to rounding.

1985. About 70 percent of them will have earned degrees during that period (table 10).

Based on these projections, nearly two-fifths of new doctoral workers over the 1972-85 period would be in engineering and natural science; one-fourth in education; one-sixth in social science and psychology; one-eighth in arts and humanities; and small proportions in business and commerce and other fields.

Supply-Demand Balance

According to the projections of requirements presented earlier, job openings for doctoral degree workers between 1972 and 1985 would total about 187,000. The available supply of new Ph. D.'s during the same period, however, is estimated at about 580,000 persons. Therefore, **if present trends continue in patterns of use of Ph. D.'s relative to other workers and in the proportion of persons obtaining doctoral degrees,** by 1985 more than twice as many Ph. D.'s would be available for work in Ph. D.-type jobs as there are jobs (table 11).

The gap between the prospective supply and requirements for new Ph. D.'s varies by field. For example, in physics, the supply would be about half again more than requirements while in mathematics, only about one-eighth more. In contrast, projected supply may be twice as high in life science or social science and psychology; 3 times in arts and humanities; 4½ times in education; and 8½ times in business and commerce. However, in many cases the magnitude of numerical differences is more noteworthy.

Chapter III. Implications

For many years, society seemed to have an insatiable demand for new doctoral degree holders. Beginning in the mid-1960's, however, observers began cautioning that perhaps the situation would change.[12] This report supports the conclusions reached by those anticipating a changing supply-demand relationship in the 1970's through the mid-1980's. Even under the most extreme alternative projections, supply would greatly exceed demand. This chapter focuses on some of the implications of the imbalance in this relationship and of the groups primarily affected: (1) individuals, (2) universities, (3) other employers, and (4) society.

Individuals. Even with the oversupply projected, it is unlikely that unemployment of Ph. D.'s will be high relative to other groups in the labor force. Instead, underemployment—defined as employment in a job requiring less skill than the worker has acquired—with its inherent job dissatisfaction, may be widespread.

When persons with more education take jobs previously held by individuals with less education, bumping—a chain reaction felt most on the low end—is set off through the economy from the highest level. In the future, workers without a college degree will have less chance than in the past of advancing to professional positions and to higher level positions in sales, managerial, and some clerical and service occupations. Competition for entry jobs may be limited and few jobs may be available.

As a result, salary differentials paid to Ph. D. holders may narrow, although preliminary evidence is mixed. For the years 1967-68 through 1972-73, information from the College Placement Council's survey of salary offers to new degree recipients shows no clear trend toward either widening or narrowing of the differentials between bachelor's degree salaries and doctorate degree salaries. For example, between 1967-68 and 1972-73, salary offers to new physics graduates increased by about 16 percent for those with the bachelor's degree; for those with the Ph. D., the increase was about 14 percent. For mathematics graduates, comparable figures were 14 percent and 20 percent.

Universities. For universities, the availability of funds to support graduate students is a major factor underlying the Ph. D. manpower situation. During the peak academic year of 1967-68, for example, about 51,000 graduate students held federally supported fellowships or traineeships, many for 3 years of study. By the 1972-73 academic year, the number of students funded in this manner had fallen to fewer than 25,000. By early 1974, the estimate was 6,600 for the 1974-75 academic year, mostly for only 1 year of graduate education.

Between 1974 and 1978, a similar drop is expected in the number of graduate students supported by the current G.I. Bill, even though the number increased 6 percent from fiscal 1972 to fiscal 1973. However, because fewer persons have been discharged since 1970 and because veterans have only 10 years in which to use their educational benefits, a turning point in graduate enrollments may occur in the late 1970's or early 1980's.

The effect of this situation on Ph. D. training and employment in colleges and universities is difficult to predict. On one hand, if government funds for graduate education do not become more readily available, universities may find it economically inefficient to operate as many doctoral programs as at present. Neighboring institutions may consolidate duplicate programs and eliminate others with limited appeal.

On the other hand, the overall effect of Federal support on graduate enrollments is not clearly known. Possibly, students may obtain funds from other sources, such as employment or family, and reductions in enrollment could be slight. Some students, however, may decide not to go on to graduate school as the marginal advantage of having a doctoral degree declines. New baccalaureate graduates may decide that the income lost while in graduate

[12] Allan M. Cartter, "A New Look at the Supply of College Teachers," **Educational Record,** Vol. 44, Summer 1965; Allan M. Cartter, "Scientific Manpower for 1970-1985," **Science, 172,** Apr. 9, 1971; Dael Wolfe and Charles V. Kidd, "The Future Market for Ph. D.'s," **Science, 172,** Aug. 27, 1971; and the Carnegie Commission's **College Graduates and Jobs** (New York: McGraw-Hill, 1973).

school is greater than the possible additional lifetime earnings with a doctorate.

Doctoral study programs may need to be restructured. With about one-half of all Ph. D.'s teaching in classrooms, more emphasis may be given to developing teaching skills. At present, nearly all doctorates are research oriented with relatively few doctoral candidates pursuing the Doctor of Arts degree.

Other employers. Employers may be more selective in hiring and advancement practices. They also may find they must be selective in hiring Ph. D.'s for work other than what has traditionally been done by Ph. D.'s lest morale problems develop. Job dissatisfaction may increase among workers at all levels if educational requirements get upgraded without coincident upgrading of job responsibilities. Employers, therefore, may have to consider ways to restructure jobs to make use of Ph. D.'s.

Employers may be encouraged to restructure jobs if salary differentials do narrow between Ph. D.'s and other college graduates. Relatively lower Ph. D. salaries might make it more attractive to hire increased numbers of Ph. D.'s.[13]

Society. Finally, society—the Nation—must evaluate and weigh the purpose of graduate education against other national priorities, before deciding how much to spend in support of graduate education.[14] Also, the relationship between national input for graduate education and the supply of and demand for Ph. D.'s must be determined. During the 1950's and early 1960's, when the Nation faced a shortage of doctoral manpower, support was forthcoming. Now when an oversupply of doctoral manpower is perceived, should support for graduate education be cut back?

Before the Nation can decide these questions, it must determine what happens if the continued rapid growth of the manpower pool of Ph. D.'s is actively discouraged. Will trained manpower be available to carry on the progress of this Nation? Will Ph. D.'s be trained in fields and specialties needed? What if a national emergency requires manpower that is not available?

This report has attempted to provide data that can serve as a basis for the policymakers and planners who will be concerned with these problems.

[13]Some researchers believe that the classical price system reaction to manpower surpluses has already begun in the Ph. D. labor market. Freeman and Breneman, for example, estimate that relative starting salaries of Ph. D. scientists and engineers fell during the 1969-73 period. They feel that a continuation of this trend would reestablish equilibrium between Ph. D. supply and demand. See Richard B. Freeman and David W. Breneman, **Forecasting the Ph. D. Labor Market: Pitfalls for Policy**, Technical Report No. Two (Washington: National Board on Graduate Education, April 1974).

[14]A comprehensive discussion of this is contained in **Graduate Education: Purposes, Problems, and Potential,** Technical Report No. One (Washington: National Board on Graduate Education, November 1972).

Appendix: Data Sources and Statistical Methods

Data sources

The Doctorate Records Files of the National Academy of Sciences provided most of the data for the 1972 employment estimate. These records, which begin with 1920, have become progressively more detailed with the passage of time. Information is supplied by all doctoral candidates in all fields shortly before graduation. Also helpful was **Careers of Ph. D.'s, Academic Versus Nonacademic** (NAS Publication 1577).

To augment these data, other sources of information were used. Principal among these were two National Science Foundation Reports, **American Science Manpower, 1970** (NSF 71-45), and **Scientists and Engineers from Abroad, 1962-64** (NSF 67-3).

Variables used to project requirements levels are from the Bureau's economic model for 1985 as published in the **Monthly Labor Review,** December 1973, Vol. 96, No. 12, reprinted as **The U.S. Economy in 1985: A Summary of BLS Projections,** Bulletin 1809 (1974). Additional independent variables were taken from the U.S. Office of Education projections of earned degrees and faculty size.

Insight into the proportion of faculty members having the doctorate and working in elementary and secondary schools, junior colleges, or 4-year colleges and universities was gained from two Office of Education studies, both titled **Numbers and Characteristics of Employees of Institutions of Higher Education**—for 1966 and 1967. Alan E. Bayer's **College and University Faculty: A Statistical Description** and **Teaching Faculty in Academe: 1972-73** helped to further delineate the faculty information.

Estimated new supply of doctorate holders for the 1972-85 period was based on the Office of Education's 1973 doctoral degree projections by field. For the first 5 years of this period, the Office of Education relates its projections directly to enrollments for advanced degrees the previous fall. For the second half of the period, projections are related to more general demographic characteristics.

Statistical methods

A. Current employment, 1972

For purposes of this study, it has been assumed that Ph. D.'s employed in 1972 earned doctorates

Table A-1. Current employment of Ph. D.'s, 1972

(in thousands)

Field	Gross doctorates awarded, 1932-72	Losses to foreign employers, 1932-72	Losses from deaths and retirements, 1932-72	Additions from immigration (net), 1932-72	Employment of doctorate holders, 1972
All fields	390.1	26.3	40.2	11.0	334.6
Engineering and natural science	187.4	15.3	19.0	8.6	161.7
Engineering	37.3	2.8	3.8	.3	31.0
Physical science	70.1	5.3	7.2	6.1	63.8
Chemistry	39.9	2.0	4.2	2.2	35.9
Physics	22.4	1.3	2.3	3.9	22.6
Life science	66.0	6.4	6.6	1.4	54.5
Mathematics	13.9	.9	1.4	.8	12.4
Social science and psychology	75.0	4.7	7.8	1.3	63.8
Psychology	25.7	.8	2.7	.6	22.7
Arts and humanities	44.9	1.9	4.8	.6	38.8
Education	68.0	2.6	7.2	(1)	58.3
Business and commerce	6.3	.5	.6	.2	5.4
Other fields	8.5	1.4	.8	.3	6.7

NOTE: Details may not add to totals due to rounding.

[1] Fewer than 50 persons.

between 1932 and 1972. Thus, a 30-year old doctorate recipient in 1932 would be 70 years old in 1972.

The Doctorate Records Files provided data for estimates of the total number of doctorates awarded by field. Persons involved in post doctoral study or training in 1971 and 1972 were considered employed in colleges and universities. From these gross figures, estimates were subtracted of new doctorates who leave this country to work for foreign employers or to return to their native lands. For the years 1958 through 1972, these data are available from the Doctorate Records Files. Estimates of these losses for earlier years were developed on the basis of the reported trend (table A-1).

Losses due to deaths, retirements, and other factors were then calculated in 5-year specific age group cohorts. The cohorts were advanced in 5-year periods through the 41 years. Since several researchers have noted that the working life patterns of female Ph. D.'s closely resemble the career patterns of their male peers,[1] male separation rates[2] were used for the whole group.

A final adjustment was made for net immigration of persons with doctorates from foreign universities. A National Science Foundation (NSF) report on foreign scientists and engineers was the basis of these estimates.[3]

No adjustments were made for unemployment since such data are available for doctorate holders for only 2 years, 1970 and 1971.[4]

Information on employer and primary work activity of new doctorate recipients is available from the Doctorate Records Files beginning in 1957. Since about 70 percent of the doctorates employed in 1972 received degrees after 1960, a distribution of activity by employer based on data for this group is a good indication of the characteristics of the whole group. Averages which were computed by field for the 15-year period became the basis for distributing the 1972 Ph. D. pool among the several employer types and primary work activities. The final distributions compared favorably with the 1970 NSF National Register.

[1] See, for example, John K. Folger, Helen S. Astin, and Alan E. Bayer, **Human Resources and Higher Education** (New York: Russell Sage Foundation, 1970), pp. 288-94.

[2] **Tomorrow's Manpower Needs, Supplement 4,** Bulletin 1606 (Bureau of Labor Statistics, 1974).

[3] **Scientists and Engineers from Abroad, 1962-64,** NSF 67-3 (National Science Foundation, 1967).

[4] **Unemployment Rates and Employment Characteristics for Scientists and Engineers, 1971,** NSF 72-307 (National Science Foundation, 1972).

Justification for using reports of "first post doctoral employer" data to represent lifetime career patterns is found in the National Research Council's (NRC) second report on a follow-up study of 10,000 doctorate holders from the classes of 1935, 1940, 1945, 1950, 1955, and 1960.[5] NRC found that one-half of the Ph. D.'s spent their careers in academic employment and one-fourth in nonacademic employment. The remaining one-fourth were divided about equally between those who switched from academic to nonacademic jobs and those who switched in the opposite direction.

After the total number of separations had been deducted, an age distribution remained for those employed in 1972 (table A-2). Based on this age array and 1-year specific age group male separation rates, an annual average separation rate of 0.8185 percent for doctorate holders during the 1932-72 period was computed.

B. Requirements, 1985

In order to have some basis for projecting trends and patterns of Ph. D. workers, employment patterns were developed for the 6 preceding years—1966, 1967, 1968, 1969, 1970, and 1971. The method used was exactly the same as explained earlier for the 1972 estimate. However, because employer data were not available until 1957 and because more new doctorates are included in the computed average at the end of the period than at any of its other points, estimates for 1966 are less reliable than those for 1972. This "time series," including 1972, is shown in table A-3.

The greatest numbers of Ph. D.'s are employed by educational institutions—a broad classification including 4-year colleges and universities, community colleges, and elementary and secondary schools. To project future demand in these three areas, it was first necessary to break them out of the time series estimates. The Doctorate Records Files distinguish only "colleges and universities" and "elementary and secondary schools." Distributions for all Ph. D.'s in educational institutions were based on estimates in two Office of Education reports.[6] Alan Bayer's study provided a basis for developing community college estimates.[7]

[5] **Careers of Ph. D.'s Academic Versus Nonacademic,** Publication 1577 (National Academy of Sciences, 1968).

[6] **Numbers and Characteristics of Employees of Institutions of Higher Education,** 1966 and 1967 editions (U.S. Department of Health, Education, and Welfare, Office of Education).

[7] Alan E. Bayer, **College and University Faculty: A Statistical Description,** Vol. 5, No. 5, (Washington: American Council on Education, 1970).

Table A-2. Estimated age distribution of Ph. D.'s, 1972

Age group	Number (in thousands)	Percent
Total	323.6	100.0
25-34	179.9	55.6
35-44	91.2	28.2
45-54	32.7	10.1
55-64	17.6	5.4
65 and over	2.2	.7

These ratios were converted to numerical estimates and applied to faculty data from the Office of Education to produce ratios of Ph. D.'s to total faculty. From these ratios, which were projected to 1985, numerical estimates were developed. Subsequently, these estimates were used as controls for the projections by field of Ph. D.'s in educational institutions.

The "time series" observations became the basis for developing trend lines and projections in each field for each employer. Generally, the independent variables were employment requirements projections developed in the Bureau's basic projection model for 1985 and published in **The U.S. Economy in 1985,** BLS Bulletin 1809. For example, Ph. D.'s in engineering and natural science were related to BLS projections of engineers and scientists, by field and industry. Other Ph. D.'s in industry, government, and nonprofit organizations were related to total workers in closely related occupational groups, e.g., social science was related to social scientists.

Table A-3. Estimated employment of Ph. D.'s, by field, 1966-72 (in thousands)

Field	1966	1967	1968	1969	1970	1971	1972
All fields	197.4	214.8	234.6	257.1	280.2	298.0	334.6
Engineering and natural science	97.5	106.5	116.1	127.1	138.1	145.6	161.7
Engineering	14.9	17.0	19.2	22.1	25.1	27.0	31.0
Physical science	42.0	45.3	48.9	52.7	56.1	58.5	63.8
Chemistry	26.0	27.7	29.7	31.6	32.2	33.1	35.9
Physics	12.4	13.5	14.8	16.2	19.4	20.6	22.6
Life science	34.1	36.8	39.7	43.3	46.6	49.0	54.5
Mathematics	6.6	7.4	8.3	9.1	10.2	11.1	12.4
Social science and psychology	39.4	42.6	46.2	50.7	54.8	57.6	63.8
Psychology	13.3	14.5	15.8	17.3	18.8	20.1	22.7
Arts and humanities	22.7	24.5	26.7	29.0	31.2	33.9	38.8
Education	31.2	34.1	37.6	41.5	46.5	50.4	58.3
Business and commerce	2.6	2.8	3.3	3.6	4.2	4.5	5.4
Other fields	4.0	4.4	4.5	5.2	5.5	6.1	6.7

NOTE: Details may not add to totals due to rounding.

Table A-4. Percent distribution of Ph. D.'s employed by educational institutions, 1966-72

Year	Total in all educational institutions	4-year colleges and universities	Community colleges	Elementary and secondary schools
1966	100.0	92.6	1.6	5.8
1967	100.0	92.0	1.8	6.2
1968	100.0	91.5	1.9	6.7
1969	100.0	90.9	2.0	7.1
1970	100.0	90.0	2.4	7.6
1971	100.0	90.1	2.9	7.1
1972	100.0	89.8	3.3	6.9

Projections of Ph. D.'s in colleges and universities were tied to degree projections for all levels in the same field and were controlled by the previously projected total faculty estimates. The resultant numerical estimates were aggregated.

C. Openings, 1972-85

Projected openings during the 1972-85 period arise from two components, growth and replacements. Growth was determined by subtracting 1972 employment from 1985 projected requirements:

1985 requirements	474,900
1972 employment	334,600
1972-85 growth	140,300
1972-85 annual average growth	10,800

The second component of openings—replacement needs—was estimated for the 1972-85 period in the same manner as earlier for the 1932-72 period. A 1985 age distribution was computed, along with a 1985 annual average separation rate of 0.9739 percent (table A-5).

Since replacement needs usually are computed on an average employment figure or time period midpoint estimate, the 1972 and 1985 annual average separation rates were averaged to produce an esti-

Table A-5. Estimated age distribution of Ph. D.'s, 1985

Age group	Number (in thousands)	Percent
Total	474.9	100.0
25-34	117.3	24.7
35-44	204.2	43.0
45-54	109.7	23.1
55-64	33.7	7.1
65 and over	10.0	2.1

Table A-6. Estimated supply of new Ph. D.'s, 1972-85

(in thousands)

Field	U.S. Office of Education projected degrees, 1972-73 to 1984-85	Losses to foreign employers	Additions from immigration	Estimated supply, 1985
All fields	609.1	38.7	13.0	583.4
Engineering and natural science	233.6	19.4	10.2	224.4
Engineering	53.9	4.0	.3	50.3
Physical science	57.4	4.4	7.3	60.3
Chemistry	24.4	1.2	2.6	25.8
Physics	16.3	1.0	4.6	19.9
Life science	100.2	9.6	1.6	92.2
Mathematics	22.0	1.4	1.0	21.6
Social science and psychology	106.9	6.6	1.5	101.8
Psychology	38.3	1.3	.7	37.7
Arts and humanities	82.4	3.4	.7	79.6
Education	154.5	5.8	.1	148.8
Business and commerce	20.6	1.6	.2	19.2
Other fields	11.1	1.8	.4	9.7

NOTE: Details may not add to totals due to rounding.

mated separation rate of 0.8962 percent for the 1972-85 period.[8] Thus:

1972-85 midpoint employment	404,750
1972-85 midpoint annual average separation rate	0.8962 percent
1972-85 annual average separations	3,600

D. Supply Estimates

The supply estimates are based on the Office of Education's projections of earned doctorates developed in 1973.[9] Based on historical data from the Doctorate Records Files, the projected number of new doctorate holders who are expected to leave the United States to work for foreign employers was subtracted. Increments, by field, have been added to represent immigration of doctorate holders from foreign universities. The distribution of immigrants for 1972-85 was assumed to be the same as for 1932-72 (table A-6).

[8]For a further discussion of separation rates, see **Tomorrow's Manpower Needs**.

[9]**Projections of Educational Statistics to 1982-83, 1973 Edition** (U.S. Department of Health, Education, and Welfare, Office of Education). Projections for 1983-84 and 1984-85 are from unpublished materials made available by the Office of Education.

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