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**Ph. D.
Scientists and
Engineers in
Private Industry
1968-80**

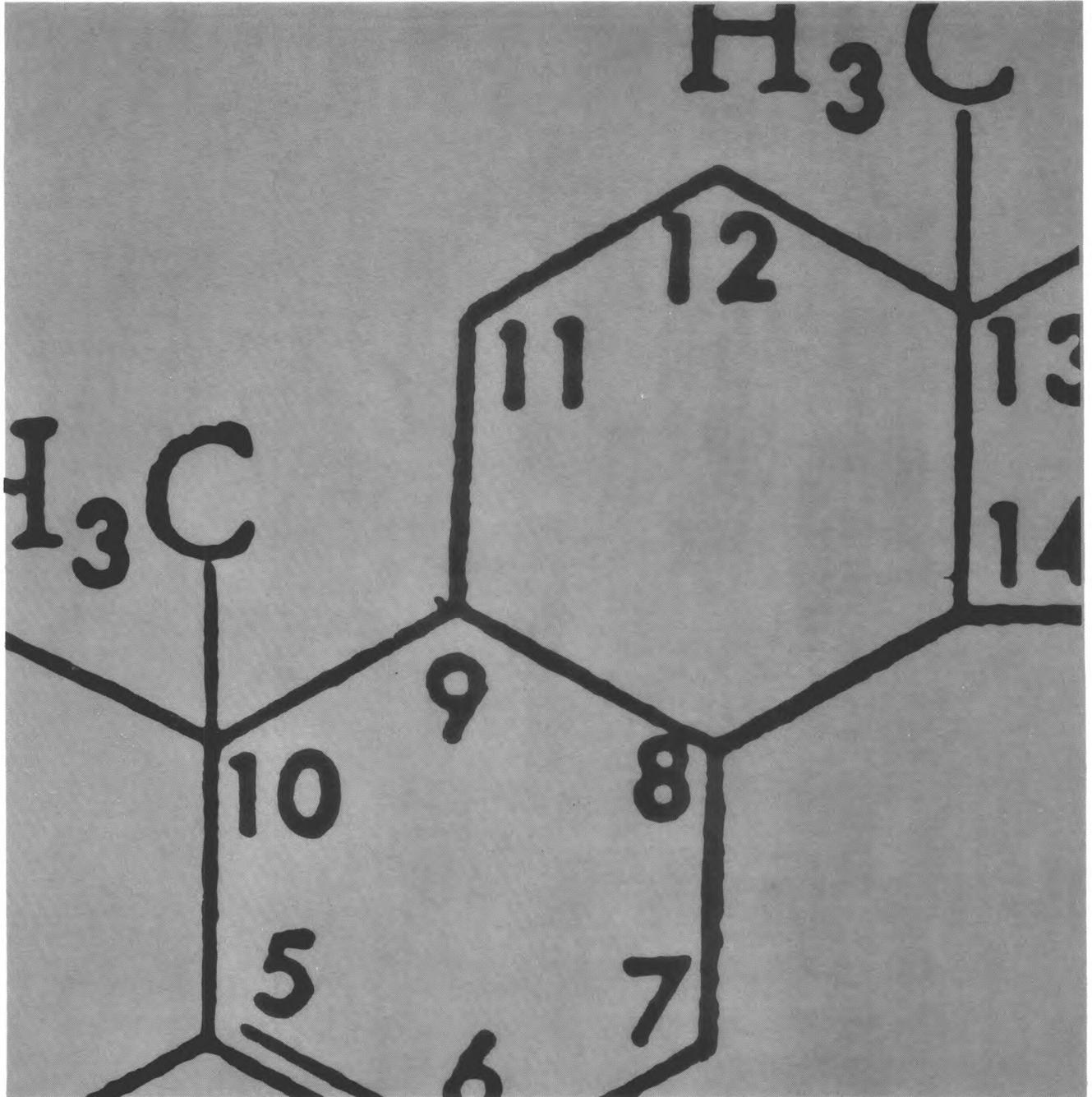
Bulletin 1648

U.S. DEPARTMENT OF LABOR
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Ph. D. Scientists and Engineers in Private Industry 1968-80

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1970

U.S. DEPARTMENT OF LABOR

George P. Shultz, Secretary

BUREAU OF LABOR STATISTICS

Geoffrey H. Moore, Commissioner



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PREFACE

This report presents the results of a study of the factors influencing manpower requirements in private industry for scientists and engineers holding doctoral degrees. It also presents illustrative projections of 1980 employment requirements for these workers. The study was conducted in 1968 by the Bureau of Labor Statistics with support from the National Science Foundation.

The report was prepared by Michael F. Crowley, with the assistance of Daniel Hecker in the Bureau's Division of Manpower and Occupational Outlook under the direction of Neal H. Rosenthal. Elinor Abramson, Maxine Both, Kevin Kasunic, Jerry Kursban, and Douglas Schmude participated in the interview phase of the study.

Assistance from the National Science Foundation was provided by Norman Seltzer and Joel Barries of the Foundation's Office of Economic and Manpower Studies.

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INTRODUCTION

Extensive analytical work has been conducted to estimate private industry's manpower requirements for all scientists and engineers, but little research has been done on the factors influencing the industry need for one segment of this professional group—scientists and engineers holding a doctoral degree. Only limited research has been conducted on the hiring and recruitment practices of employers of Ph. D. scientists and engineers. This report presents the results of research into Ph. D. manpower requirements, including illustrative projections of private industry's 1980 employment requirements for these highly trained workers. It is designed to aid officials responsible for developing national policies concerning the Federal Government's support of graduate science education, and others concerned with manpower and the training of Ph. D. scientists and engineers.

This study is based primarily on information gathered from interviews with officials of approximately 70 companies. The companies interviewed were located in all areas of the United States and represented all major industries employing scientists and engineers, including those with large research and development programs. They employed approximately 35 to 40 percent of all Ph. D. scientists and engineers working in private industry. However, the visited companies do not represent a scientific sample of employers of Ph. D.'s in private industry. It would not have been possible to conduct interviews with the companies by following strict sampling procedures without significantly greater expenditures over a longer period of time.

HIGHLIGHTS

Almost 36,000 scientists and engineers holding a doctoral degree were employed in private industry in 1968. About 8 out of every 10 were engaged in research and development (R&D) activities. Of these, most were engaged in research.

Only a small number of job openings for Ph. D. scientists and engineers were not filled in mid-1968. The few firms experiencing hiring problems did not feel the problem was acute to the extent that operational or planned programs suffered.

New Ph. D. recipients were the primary source of Ph. D. scientists and engineers entering private industry in 1968. Only a limited number were being hired directly from positions in colleges and universities, Government, or nonprofit organizations.

Nearly all firms that employ a large number of Ph. D.'s (50 or more) had a well planned program for Ph. D. recruiting in 1968. In some cases a staff member had full-time responsibility for recruiting Ph. D.'s.

Interesting and challenging work in the area of an individual's particular field was given by employers as the major criterion determining a Ph. D.'s choice of employer. Salary was a factor only when it was below average. A common problem reported by many of the firms interviewed was that recent Ph. D. recipient's had to be convinced that private industry offers opportunities for good research.

Company officials indicated that industrial firms think in terms of Ph. D. manpower needs, and that the concept of requirements for Ph. D.'s can be discussed meaningfully in quantitative terms. Private industry's job requirements do not, however, correspond exactly to levels of academic training—bachelor's degree, master's degree, and doctoral degree—mainly because work experience and personal qualities also are important considerations.

The level of research and development activities and the mix between research and development are the key factors determining private industry's requirements for Ph. D. scientists and engineers. For work outside of R&D, most companies did not identify a specific need for Ph. D.'s.

Between 1968 and 1980, requirements for scientists and engineers holding the Ph. D. degree in private industry are projected to increase by more than 50 percent, from 35,800 in 1968 to 55,000 in 1980.

Chapter I

CURRENT EMPLOYMENT

In 1968, about 36,000 scientists and engineers holding the doctorate were employed in private industry in the United States. A little more than half were physical scientists, but less than 1,000 were mathematicians. (See table 1.)

Table 1. Estimated employment of Ph. D. scientists and engineers in private industry, by occupational group and research and development activities, 1968

Occupational group	Total	R&D activities
Total	35,800	28,300
Engineers	12,800	9,600
Mathematicians	800	600
Physical scientists	19,500	15,900
Life scientists	2,800	2,200

NOTE: Because of rounding, sums of individual items may not equal totals.

Scientists and engineers holding a doctorate and employed in private industry accounted for roughly one-third of the Nation's total employment of scientists and engineers with a doctorate.¹ More than half of the total were employed by colleges and universities. The remainder were employed by Federal, State, and local government or by nonprofit organizations.

Among engineering and the various science occupations, the proportions employed in the private sector varies considerably. For example, according to the National Science Foundation's *National Register of Scientific and Technical Personnel*, about 10 percent of all life scientists,

¹ This estimate is based primarily on data in *American Science Manpower, 1966* (National Science Foundation, Washington, D.C.); *The Backgrounds and Early Careers of Engineering Doctorate Recipients* (National Academy of Sciences—National Academy of Engineering, Washington, D.C.); *Profiles of Ph. D.'s In The Sciences* (National Academy of Sciences, Washington, D.C., Publication 1293); and *Doctorate Recipients From United States Universities, 1958-66* (National Academy of Sciences, Washington, D.C.).

15 percent of all mathematicians, and 40 percent of all physical scientists with Ph. D. degrees were employed in private industry in 1968. It is also estimated that between 40 percent and 50 percent of all engineers having Ph. D. degrees were employed in private industry.

The great majority of Ph. D. scientists and engineers, about 80 percent, were engaged in the performance or management of research and development (R&D) activities, according to a special survey of Ph. D. scientists and engineers employed in private industry in 1968 conducted by the Bureau of Labor Statistics. The proportion in R&D, however, was even greater among the companies interviewed, except in the chemicals industry where company officials indicated a significant proportion were in activities other than R&D such as technical sales and administration. Ph. D. scientists and engineers were concentrated more heavily in R&D than other scientists and engineers. Only an estimated 35 to 40 percent of all scientists and engineers in private industry were in R&D activities.

Within the broad area of research and development, most of these highly trained workers were engaged in research rather than development activities, according to information collected during interviews with company officials. This is buttressed by data from the National Science Foundation's *National Register of Scientific and Technical Personnel* which indicates that about 80 percent of all Ph. D. scientists in R&D were performing research; and a recent study conducted by the American Society for Engineering Education which shows that a greater number of Ph. D. engineers work in research rather than development.²

Of those Ph. D. scientists and engineers not engaged in research and development, some were involved with general management and administration. Most company officials interviewed felt that the possession of a doctorate in science or engineering did not preclude an individual from being a candidate for promotion to managerial positions. Ph. D. scientists and engineers, however, were not sought for top level management jobs to any greater extent than workers with less education in the companies interviewed. For the most part, companies indicated that Ph. D.'s were hired to do research not administration. In companies deeply involved in advanced technology, however, the extensive technical background of the Ph. D. was considered to be valuable in management positions, and in some companies interviewed top management positions were filled by scientists or engineers holding a doctorate.

A few Ph. D. scientists and engineers were engaged in sales, production activities, recruitment, and liaison work below the management level.

Current shortages

Only a small number of openings for Ph. D. scientists and engineers in private industry were unfilled in mid-1968. These positions were primarily in narrow specialties; for example, electrochemistry and metallurgical physics. Most respondents felt that a relative balance of supply and demand existed at the time of the interviews. Among the company officials interviewed who did feel there was an overall shortage of Ph. D.'s, more than half represented companies that were not experiencing any hiring problems. The few that were experiencing hiring difficulties did not feel that the problem was acute to the extent that planned programs were suffering. In contrast, a few

² See "Characteristics of Engineers With Advanced Degrees," *Journal of Engineering Education*, Volume 58, Number 5, January 1968, American Society for Engineering Education, Washington, D.C.

firms hinted at an overall surplus of Ph. D. scientists and engineers; several firms mentioned that more than enough Ph. D. chemists were available.

Based on their recruiting experience, several firms indicated that Ph. D.'s have been more available relative to demand during the last few years than during the late 1950's and 1960's. Among the major reasons given for this situation were: (1) A decline in the rate of growth of R&D activities in industry, (2) a rapid increase in Ph. D. degrees awarded, and (3) a cutback in Federal funds for R&D at colleges and universities.

Sources of Ph. D. scientists and engineers

New Ph. D. recipients and those completing a post doctoral program are the primary source of Ph. D. scientists and engineers entering private industry. Firms indicated that only a limited number of Ph. D.'s were hired directly from positions in colleges and universities, Government, or nonprofit organizations. Persons receiving degrees abroad are another source of Ph. D. scientists and engineers. According to the National Register of Scientific and Technical Personnel, however, only about 8 percent of the doctorate holders in private industry received their degrees abroad, including immigrants and U.S. citizens who studied overseas.

New Ph. D. recipients. The primary factor that determines the level of new Ph. D. scientists and engineers available to private industry is the number of doctoral degrees awarded in these fields. In addition to the overall number of doctoral degrees awarded, the distribution of these degrees among the various specialties is also important to the available supply. Many firms indicated Ph. D.'s were hired because the company wanted experts in specialized fields. Some firms indicated that no particular value would arise from hiring a Ph. D. if he were to work outside the area of his specialty. Very few firms indicated they employ individuals in science and engineering jobs who hold doctorates in fields other than science or engineering.

In some cases company officials indicated an overlapping of fields, such as between chemistry and chemical engineering. Thus, even though the work is of a specialized nature, individuals from one or more disciplines might be hired to fill a particular job. Despite the desire for specialists, some firms, when an individual with the proper specialization is not found, consider it advantageous to employ a Ph. D. whose training is in another discipline. Furthermore, an individual already employed by a firm gradually might cross over from one field to another because of changing interests. To determine how much crossover actually occurred, firms were asked whether they had Ph. D.'s working in an occupational group (engineering, physical science, life science, mathematics) other than the one in which they were trained. Most firms indicated that the number actually working outside the occupational group of their degree was small, even if a narrow definition of the field (that is, chemistry and physics within physical science) was used. The small amount of shifting was attributed basically to the highly specialized nature of the Ph. D.'s work which requires long years of training. Ph. D.'s, therefore, are reluctant to leave a field after investing years of study in it.

Private industry must compete for the available supply of Ph. D.'s with colleges and universities, Government, and nonprofit organizations. In 1966, only about one-fourth of all new science and engineering Ph. D.'s entered private industry for their first job after receiving their

doctorate.³ About twice as many, or about half of the Ph. D. recipients entered employment in colleges and universities. About 15 percent entered Government service or worked for nonprofit organizations. The first job of about 10 percent of those receiving Ph. D. degrees in natural science and engineering was with a foreign employer. Most of these were probably foreign nationals who returned to their home countries.

Some trends in the proportion of new doctorate recipients entering various employment sectors were apparent over the 1958-66 period. From 1958 to 1966, the proportion whose first employment was in private industry declined, despite employer indications that supply-demand conditions for Ph. D. scientists and engineers in private industry has become more favorable in recent years. In contrast, the proportion whose first post-doctoral employment was with a college or university increased over the period, in large part because an increasing proportion of doctorate recipients have taken postdoctoral fellowships and because research contracts awarded to universities increased rapidly in the 1958-66 period. However, some firms indicated that during the few months preceding the interviews (early 1968), an increasing number of new Ph. D. scientists and engineers were seeking employment in private industry, a situation which was attributed directly to a cutback in Federal Government research funds available to universities.

The decline in the proportion of Ph. D. science graduates entering employment in private industry is reflected in the data in the *National Register of Scientific and Technical Personnel*. Between 1958 and 1966, the proportion of all Ph. D.'s, listed in the register as employed in private industry declined from about 33 percent to slightly more than 29 percent. The proportion employed in colleges and universities increased during this period.

Many firms interviewed felt that recent Ph. D. graduates were more inclined to teach or do research at a college or university than to work in private industry. According to company officials, new graduates feel that research conducted in private industry is not as "scientific" or "challenging" as university research. Although firms felt that research in industry is on a plane with that conducted in academic institutions, it is often difficult to convince new graduates of this. However, since most firms indicated that they are meeting their needs, it appears that they have been successful in convincing graduates of the merits of private industry research.

Experienced Ph. D.'s. Most experienced Ph. D.'s who were hired by the firms interviewed had been employed by other companies in the private sector of the economy. The number of Ph. D. scientists and engineers employed in academe who shift to private industry employment is relatively small, according to the interview data. In the opinion of industry officials, most Ph. D.'s find academic life attractive and are not interested in seeking a job in private industry. This fact, combined with the reluctance of firms to actively recruit faculty members for fear of creating ill will at the university that could seriously damage their overall recruiting efforts, has led to relatively few hirings from academe. However, the same factors that make academic life attractive to those already on university faculties also causes some Ph. D.'s in private industry to shift to academic employment. On net balance, therefore, whatever flow exists of experienced Ph. D. scientists and engineers is believed to be from industry toward college and university faculties.⁴

³ Based on data in *Doctorate Recipients from United States Universities, 1958-66* (National Academy of Sciences, Washington, D.C.), 1967.

⁴ See, for example, *The Mobile Professor* by David G. Brown, American Council on Education, Washington, D.C., 1967.

Little information was obtained on employment shifts between private industry and Government and nonprofit organizations. However, the net number of shifts is believed to be relatively small and probably has little effect on the overall supply-demand conditions for Ph. D. scientists and engineers in private industry.

A few firms indicated that some experienced Ph. D.'s were hired to work in fields other than those in which they were trained. Some of these shifts were due to the overlap of certain fields; therefore, a move from one field to another did not involve a major shift in the type of work performed. The few firms that did employ Ph. D.'s in work quite different from that in which they were trained felt that Ph. D.'s could assimilate new knowledge rapidly, and that their research skills were applicable over a wide range of fields. However, firms with this feeling were the exception rather than the rule.

Experienced Ph. D.'s vs. new graduates. Many firms felt that experienced Ph. D.'s were more productive in a shorter period after being hired than new graduates. Also, in research projects with specific objectives, an experienced Ph. D. would be more likely to achieve results within a shorter time span. Some firms indicated that when the firm entered a new area of research, it was particularly desirable to hire a Ph. D. with experience in that area.

Firms with a preference for new graduates indicated that recent graduates are more inclined to be familiar with the most recent thinking and discoveries in a particular field. In addition experienced Ph. D. holders may have little or no experience in some new areas of work.

Most firms hired both new graduates and experienced workers, the majority of hirings being new Ph. D. graduates. Individual firm responses ranged from hiring only new graduates to hiring only experienced workers. The only identifiable difference in hiring patterns of experienced workers vs. new graduates by industry, size of firms, or number of Ph. D.'s employed was in firms engaged in defense and aerospace work. In these firms many new workers were experienced Ph. D.'s. This did not indicate a preference among defense contractors for experienced Ph. D.'s, but rather an apparently large turnover rate resulting from shifting defense contracts.

How Ph. D.'s are recruited

Nearly all firms that employ a large number of Ph. D.'s (50 or more) have a well planned program for Ph. D. recruiting. Several firms employed a staff member whose full-time responsibility is recruiting Ph. D.'s. Some firms combine Ph. D. recruiting with that for other advanced degree personnel or senior staff. Nearly all firms conducted their recruiting for Ph. D.'s and senior level staff separately from other recruiting activities.

Ph. D. recruiting generally is a year-round operation. For many firms successful recruiting was noted to be generally dependent on developing ties and lines of communication between company staff and university faculty, graduate students, and Ph. D.'s employed in other firms. Staff members in most firms are encouraged to attend conferences, participate in seminars, publish articles, and present papers which, in addition to promoting professional development and enhancing the firm's reputation in the scientific community, promotes the development of personal relationships that prove valuable in locating and attracting high level staff members. For example, these activities provide staff members with an opportunity to inform faculty members and graduate students about the types of work the firm is performing so that interested persons can be recruited. Also, through these activities, the firm can determine which universities are training Ph. D.'s in areas of interest to them.

Recruitment of new graduates is conducted primarily through visits to the universities by staff Ph. D. scientists or engineers, or non-Ph. D. senior project leaders. In some cases the companies obtain the names of prospective employees through faculty members; in other cases they obtain them through referral of graduate students by present staff members. Some firms have a program of hiring graduate students during summer vacations. In cases where graduate students have worked for the firm during summer vacation, a hiring commitment may be made before the degree is obtained.

Companies generally use a combination of methods for recruiting experienced Ph. D.'s; for example, advertising in professional journals or newspapers, employment agencies and referrals by currently employed scientists and engineers, and by referral services operated by professional associations. The effectiveness of each type of recruiting varied. Some companies indicated that each was an effective method, and others indicated that each was virtually useless. Most respondents also indicated that companies receive unsolicited applications but generally hire only a small percent of those who apply in this manner.

Hiring inducements. The most effective inducements for attracting Ph. D. scientists and engineers to a specific firm revolves around the overall "image" of the particular firm or its research laboratory, especially its reputation for good research and its ability to provide an opportunity for professional development. Specifically, the most effective inducement for attracting Ph. D. scientists and engineers, according to the firms interviewed, is the opportunity to perform work of an advanced theoretical nature in the area of the individual's particular field of interest. An integral component of this inducement is the opportunity of working in association with authorities in a particular field in the proper scientific environment. A common problem among private firms seemed to be to convince recent Ph. D. recipients that opportunities for good research and professional development exist in the firm as well as at a university.

Location also appears to play a significant role in a Ph. D.'s employment decision. Most Ph. D. scientists and engineers want a location near a metropolitan area with its cultural activities, and near a reputable university so that they can maintain academic ties and "consult" with university colleagues. Like other workers, Ph. D.'s have preferences for living in certain areas of the country and often are unwilling to move. A number of firms located on the East Coast indicated difficulties in attracting Ph. D.'s from schools in the South and West, and some firms in areas with severe winters considered their location a liability.

Salaries were considered to have an effect on recruitment only if they were below average. On the other hand, they felt that there would be no significant difference in recruiting Ph. D.'s if they offered higher than average salaries. Many firms indicated that they rely on private or published surveys and determine salaries according to them. A few firms indicated that in unusual circumstances, if they feel a particular individual's skills were essential to the firm, they may try to "buy" him with a higher salary offer. In general experienced Ph. D.'s tended to be somewhat more concerned about salary and long term promotional opportunities than recent graduates, according to officials of companies interviewed.

Chapter II

REQUIREMENTS

In approaching an analyses of employment requirements for Ph. D. scientists and engineers in private industry, a fundamental question arose: Can needs for these workers be separated from requirements for all scientists and engineers, or do companies generally consider that jobs are open equally to Ph. D.'s or other highly educated and experienced scientists and engineers? If requirements for Ph. D. scientists and engineers cannot be separately identified, meaningful projections cannot be developed.

To determine if an identifiable requirement for Ph. D.'s exists, the following two questions were posed: (1) Can firms identify specific jobs for which a Ph. D. scientist or engineer is needed? (2) Do firms have specific recruiting requirements for Ph. D.'s in their hiring goals? Answers to the first question would indicate whether scientists and engineers with Ph. D. degrees are separately identifiable from "high level" scientists and engineers without the degrees; answers to the second question would indicate whether an "economic demand" or "market" existed for Ph. D.'s that is separate from that for other scientists and engineers.

The responses to these questions led to the general conclusion that requirements for Ph. D. scientists and engineers can be separately identified for the purpose of making illustrative manpower projections. However, the results did indicate that there is some overlapping of requirements for Ph. D. holders with other high level workers.

In response to question 1 above, only a minority of firms indicated they were able to identify jobs filled by Ph. D.'s that could only be filled by a scientist or engineer holding a Ph. D. degree. These jobs generally involved the performance of independent basic research in specialized fields or the management of R&D activities, and firms felt that the specialized knowledge, theoretical background, and research skills necessary to perform the work could only be obtained through a formal Ph. D. program. Many company officials identified positions in which the job requirements called for a scientist or engineer holding the Ph. D. or the equivalent in experience and education. Nevertheless, these firms generally recruited for a worker holding a Ph. D. for these positions. The common deviation from this procedure—when recruiting was not done—was when a qualified individual without a Ph. D. already employed in the firm was promoted to a "Ph. D. position." A few firms identified positions that might be filled by a Ph. D., but where the degree was not specifically recruited. Qualifications for these jobs included various combinations of education, experience, and demonstrated ability. Even in these jobs, however, the companies indicated that the best qualified person for such jobs often held a Ph. D. degree.

Nearly all firms interviewed were able to discuss their requirements for Ph. D. scientists and engineers quantitatively, despite some of the differences in identifying jobs specifically requiring a Ph. D. Most firms had specific hiring goals for Ph. D.'s and set hiring quotas. Also, in discussing shortages firms were very clear as to whether their Ph. D. positions were filled.

Most firms had some general idea of future Ph. D. scientist and engineer requirements; several firms had a specific hiring objective such as (1) hiring a specific number each year, (2) increasing Ph. D. scientists and engineers at a specified annual rate, or (3) having a specified proportion of Ph. D.'s on the R&D staff. One comment made by nearly all firms, however, was that they would hire a really good Ph. D. even if their goals already were met.

Factors affecting requirements

Research and development. Research and development activity is the key factor that determines private industry's requirements for scientists and engineers holding the Ph. D. degree. The vast majority of firms interviewed clearly indicated that they hired Ph. D. scientists and engineers to perform or manage research and development work. For work outside of research and development, most companies had little *specific need* for scientists and engineers holding the Ph. D. However, this does not preclude scientists and engineers who hold the Ph. D. from going into other areas of work.

Two major aspects of R&D activity are involved in determining requirements for Ph. D. scientists and engineers: (1) The level of R&D activity (dollars expended); and (2) the nature of the R&D activity involved, generally the mix between research activity and development activity. Most firms felt that changes in these aspects had been and in the future would be significant in determining Ph. D. requirements in their firms. Some company officials attributed significant changes in their firm requirements primarily to changes in only one of the above factors.

Level of R&D activity. In discussing past trends in the employment of Ph. D. scientists and engineers, most firms indicated that such employment had increased over the past 5 years, primarily because of an expansion in research and development programs. Most firms anticipated a continued increase in requirements for Ph. D. scientists and engineers during the 1970's because of an expansion of their R&D programs. In 1968, scientists and engineers holding the Ph. D. represented roughly 10 percent of private industry's scientists and engineers engaged in research and development activities.

Nature of R&D activity. Officials interviewed indicated that even within R&D, Ph. D. scientists and engineers are not needed or needs are quite limited in certain types of work, particularly in some areas of development. Many firms indicated that the proportion of R&D scientists and engineers who hold Ph. D.'s is considerably greater in research than in development. Therefore, a shift between research and development requiring different degrees of intensity of Ph. D. utilization would result in a shift of Ph. D. requirements. A few firms attributed some or all of their increased Ph. D. employment in the past to a shift in R&D emphasis from development to research, or felt that future growth of their Ph. D. employment requirements would be due to such a shift. Several others that indicated a decline in the proportion of their R&D scientists and engineers who held Ph. D. degrees over the past few years attributed the decline to a shift in emphasis from research to development activities.

The type of research performed determines, in large part, the particular occupational specialty required. Most firms indicated that they were able to define their hiring needs for Ph. D.'s in a more narrow classification than in the broad occupational groupings of engineers, mathematician, life scientist, and physical scientist. Although the responses as to the degree

of identifiable specialization varied for engineers, they were generally defined in terms of the the major branches of engineering; for example, electrical engineering or chemical engineering. For physical sciences and life sciences, needs were generally defined in terms of the subfields of the major fields in these sciences; for example, organic, analytical, or physical chemistry; optics, solid-state physics, or thermal physics; pharmacology, pathology, or microbiology. In some cases firms indicated needs as specific as one of the specializations of these subfields; for example, polymer chemistry, thermodynamics, or drug metabolism.

Another significant factor affecting requirements for Ph. D.'s in research was a fairly widespread feeling that the longrun trend towards increased sophistication and complexity of science and technology has and will continue to create a need for a generally advanced level of education. In terms of Ph. D. requirements this may mean that over the longrun, even with a constant mix between research and development, an increasing proportion of the total requirements for scientists and engineers in R&D will be for those holding the Ph. D.

Other factors. Although persons with Ph. D. degrees are employed in non-R&D functions, individual firms indicated they generally were not required for these positions. Among the companies interviewed, only in the chemicals industry were officials able to identify significant numbers or proportions of Ph. D. scientists and engineers outside of R&D activities; in that industry about one-fourth of the Ph. D.'s work in non-R&D activities such as technical sales and general administration and management. For the most part, experienced Ph. D. scientists and engineers left R&D positions because of changing interest or to accept a promotion. As such, Ph. D.'s in non-R&D positions do not necessarily represent a "demand" for the degree since the job could be performed equally well by a non-Ph. D. However, some firms, which in the past had a policy of not using Ph. D. scientists and engineers outside of R&D activities, recently have revised their thinking (according to officials interviewed) and are starting to utilize them in other areas.

In some instances the utilization of Ph. D. scientists and engineers is related to the "prestige" factor of the Ph. D. degree itself. For example, in several firms Ph. D. hiring goals were set by the company's top management and carried out by the operating divisions. In some of these cases the number hired at the operating level was less than management goals because it was felt that the goals were unrealistic in relation to "actual needs." It was felt that a B.S. recipient who commands half the salary of the Ph. D. was all that was needed. However, if a firm is willing to pay the going rate for a Ph. D. recipient, an effective demand exists for that individual. Whether a company wants a Ph. D. because of the nature of the work or the "prestige" involved, the net result is the same—an economic demand for a Ph. D.

Estimates of 1980 requirements

Illustrative projections of requirements for scientists and engineers holding the Ph. D. degree were developed using the general methodology employed by the Bureau of Labor Statistics to project future manpower requirements for scientists, engineers, and technicians.⁵

⁵ See, for example, *Technician Manpower: Requirements, Resources, and Training Needs* (U.S. Department of Labor, BLS, Bulletin 1512) and *Scientists, Engineers, and Technicians in the 1960's* (National Science Foundation, NSF 63-34), prepared for the National Science Foundation by the Bureau of Labor Statistics.

The basic assumption made regarding the question of an identifiable demand for Ph. D.'s—an assumption that is probably oversimplified in the light of the foregoing discussion—was that their employment in 1968 reflected the requirements at that time. This assumption does not appear unreasonable since there appeared to be no general shortage or surplus of Ph. D. scientists and engineers in private industry in 1968. In general, the methodology followed includes the development of a statistical relationship between employment and the key factors affecting employment requirements, and between employment requirements for Ph. D. scientists and engineers and overall employment requirements for the economy. For Ph. D. scientists and engineers, one parameter reflected both of these characteristics—projections of requirements for all scientists and engineers in research and development. These projections were developed within the framework of manpower projections for all industries and occupations in the economy in 1980. They reflect the growth of research and development expenditures, although at a slower rate than shown in the late 1950's and early 1960's. They also reflected other major assumptions underlying the Bureau's overall projections, including: A national unemployment rate of 3 percent; continuation of high rates of economic growth; a level of defense and space activities in the target year approximating those of 1963, somewhat higher than the levels prior to the Viet Nam buildup; and a continuation of scientific and technological advances at about the same rate as in the recent past.

First approximations of Ph. D. scientist and engineer requirements in 1980 were developed by calculating ratios of Ph. D. scientists and engineers to an estimate of all scientists and engineers in private industry engaged in R&D in 1968, and then applying these ratios to projected 1980 requirements for all R&D scientists and engineers in private industry. Analytical adjustments then were made based on information received during the interviews with company officials and on employment data of Ph. D. scientists and engineers by industry available from the BLS survey.

In developing the projections it would have been helpful to analyze the past effects of factors such as changing levels of R&D expenditures on employment of Ph. D. scientists and engineers for years prior to 1968. Since these data had not been collected, information previously discussed that was obtained from officials of firms interviewed about the past growth of their Ph. D. scientists and engineers in relation to R&D expenditures, employment levels of scientists and engineers, and levels of research and development were analyzed. This analysis provided some idea of how these factors could be expected to influence the employment of scientists and engineers holding the Ph. D.

Although the firms interviewed were able to provide some general information about the relative rates of growth for each occupational group in the past and/or expected rates of growth, individual firm responses were so varied that no consistent pattern could be developed. Thus, projected 1980 requirements of total scientists and engineers holding the Ph. D. were distributed into one of four major occupational groups—engineers, mathematicians, physical scientists, life scientists—based on the estimated distribution for each industry in 1968 as developed from data collected in the 1968 survey. The different rates of growth projected for each occupational group reflect primarily different industry rates of growth for all scientists and engineers and requirements for scientists and engineers in research and development activities because the relative importance of each occupational group in various industries differ.

Based on the methodology described above, requirements for workers covered in the survey are projected to increase by more than 50 percent, from 35,800 in 1968 to 55,000 by 1980. Requirements for Ph. D. scientists and engineers in each of the four occupational groups are not expected to increase at the same rate.

Table 2. Illustrative projections of 1980 requirements for Ph. D. scientists and engineers in private industry, by occupational group

Occupational group	Number		Percent increase, 1968-80
	1968	1980	
Total	35,800	55,000	53.5
Engineers	12,800	20,100	57.5
Mathematicians	800	1,300	56.6
Physical scientists	19,500	29,500	51.6
Life scientists	2,800	4,100	47.1

NOTE: Because of rounding, sums of individual items may not equal totals.

Company officials indicated that nearly all Ph. D. scientists and engineers are recruited to work in R&D activities. However, the data from the survey show that about 20 percent of all Ph. D. scientists and engineers employed in private industry worked in non-R&D activities in 1968. These workers included Ph. D. scientists and engineers engaged in research for several years who then shifted to non-R&D positions such as sales, production, or management. Company officials indicated that firms benefit by retaining a Ph. D. in non-R&D work rather than risk losing him. Although those Ph. D.'s employed in non-R&D activities may not represent a true demand for a Ph. D., they do reflect employment patterns of Ph. D. scientists and engineers and must be accounted for in the projections or the future employment requirements picture would be incomplete. Thus, the illustrative 1980 employment requirements projections presented here include all Ph. D. scientists and engineers in private industry, both those in R&D and in other activities. They assume that these scientists and engineers will continue to be employed in non-R&D activities in 1980 at approximately the same proportion (20 percent) as in 1968.

Appendix A

COVERAGE AND DEFINITIONS

The definition of engineers, mathematicians, physical scientists, and life scientists used in this report are those used in the survey of scientific and technical personnel in private industry conducted by the Bureau of Labor Statistics.⁶

Generally, scientists and engineers are all persons actually engaged in scientific or engineering work at a level that requires a knowledge of science or engineering equivalent at least to that acquired through completion of a 4-year college course with a major in science or engineering, regardless of whether they hold a college degree.

Additionally, each employee reported working as an engineer, mathematician, physical scientist, or life scientist who holds a doctoral degree was reported by the type of work he performed, regardless of the discipline or field of study in which the degree was earned. Thus, an employee holding a doctoral degree in mathematics but working as an engineer was reported as an engineer and not as a mathematician.

Excluded from coverage as doctoral degree holders were persons whose highest degree was an M.D., D.D.S., or D.V.M., other first professional degrees, or any honorary degree.

The scope of this report was limited to those doctoral degree holders who were employed in private industry. Excluded were doctoral degree holders employed by Federal, State, and local governments; colleges and universities; and nonprofit institutions.

⁶ See *Scientific and Technical Personnel in Industry, 1961-66, op. cit.*

Appendix B

INTERVIEWS

The following interview guide was prepared as an aid to Bureau staff members in conducting the interviews.

Of course, not all companies were able to answer all the questions suggested in the guide. However, its use assured the same questions being asked each company official. In addition, by following the format suggested in the guide, the written reports of each interview tended to follow a standard format that aided in the analysis of the interviews.

INTERVIEW GUIDE

Study of Employment Requirements for Engineers, Mathematicians, and Scientists with Doctoral Degrees in Private Industry

A. Introduction

1. Reason for the need to make projections of employment requirements for engineers, mathematicians, and scientists with doctoral degrees (Ph. D.).
 - (a) Planning educational programs
 - (b) Support of education
2. Study is being done by BLS for NSF.
3. All data and information obtained in the interview will be confidential.
4. Although information on 1968 employment of social scientists will be obtained in the Survey of Scientific and Technical Personnel in Industry, 1968, they are excluded from this study of requirements. Natural scientists and engineers who hold a M.D., D.D.S., or D.V.M. degree, other first professional degree, or an honorary degree are also excluded unless they also hold a Ph. D. degree.
5. This interview is being conducted primarily to obtain information on the factors that effect the company's demand for Ph. D. scientific and technical manpower. Some parts of the interview are designed to increase our basic knowledge of Ph. D. manpower in private industry.

B. Current employment

1. As part of the BLS study of Ph. D. engineers, mathematicians, and scientists, a survey is being conducted of current Ph. D. employment and your company recently has received a questionnaire requesting the following information. (Give attachment A to respondent.)

Number of employees working as	Number employed as of January 1968	
	Total	Performing or managing R&D activities
ENGINEERS who hold doctoral degrees in any field		
MATHEMATICIANS who hold doctoral degrees in any field		
PHYSICAL SCIENTISTS who hold doctoral degrees in any field		
LIFE SCIENTISTS who hold doctoral degrees in any field		

2. Can you provide me with this information now so that I can place your responses to my questions in the proper perspective? (Whenever possible, the respondent should be made aware of this request over the telephone while making the appointment for the interview.)

3. In what functions other than research and development are the company's Ph. D. scientists and engineers engaged, and approximately what proportion of the total are engaged in each activity?

- (a) Management and administration
 - (1) Research and development (should be included in R&D statistics on schedule)
 - (2) Other activities (specify)
- (b) Production
- (c) Other (specify)

4. Do any of the Ph. D. scientists and engineers reported in B 1 above have Ph. D. degrees in fields other than natural science, mathematics, or engineering? If yes, approximately what proportion?

5. What is the approximate proportion of the company's Ph. D. scientists and engineers that have degrees in scientific or engineering fields other than in the field in which they are working? For example: Man working as an engineer with a Ph. D. degree in physical science.

6. (Note to interviewer: Review concept that an individual with Ph. D. degree in science or engineering may be employed in another occupation.) Does your company employ any workers with a Ph. D. degree in the natural sciences, mathematics, or engineering who are not working as natural scientists, mathematicians, or engineers? If yes, approximately how many?

C. Shortages

1. Is your company's current staffing needs for Ph. D. scientists filled?

If not—

- (a) What is the approximate number of vacant positions?
- (b) Is the number of vacancies affected by seasonal factors? For example: Do you allot additional positions in May or June for new graduates?

2. Is the company actively recruiting Ph. D.'s?

(a) If yes—

- (1) In what occupational field?
- (2) What are the recruiting problems?
 - Salaries
 - General lack of supply
 - Lack of supply with specific fields of specialization

(b) If not recruiting, why isn't the company actively recruiting?

- (1) Feel the supply is not available.
- (2) Administrative restrictions, i.e., is to wait for applications

D. Hiring practices

1. Who decides that a Ph. D. worker is needed for a particular job (project leader, personnel department) and what criteria are used in making this determination?
2. Does your company have any "set" or "desired" staffing pattern for scientists and engineers by educational level? (Ph. D., Master's, Bachelor's.)
 - (a) In R&D
 - (b) Other activities
3. In determining the qualification needed for a specific job, is degree level the key measure or a combination of education and experience?
4. Do you have any work that you feel can be done only by a Ph. D.?
 - (a) How many such positions? (Relate to total reported in B 1.)
5. Is there established company policy on salary differentials between Ph. D.'s and those with less education?
6. How does the company recruit Ph. D.'s?
 - (a) Visit colleges
 - (1) New graduates
 - (2) Professors
 - (b) Wait for applications from employees of other firms or from new college graduates
 - (c) Contact professional associations
 - (d) Advertise in professional journals or newspapers
 - (e) Through professional employment agencies
 - (f) Referral by our employees
7. What inducements are most effective in recruiting employed Ph. D.'s to your firm?
 - (a) Salary increase
 - (b) More interesting challenging work
 - (c) Better long term promotional opportunities
 - (d) Promotion to a position of higher status than presently held
 - (e) Opportunities for professional development (sabbatical leave, paid travel to professional association meetings, etc.)
8. What has been the major sources of the Ph. D.'s hired in the past?
 - (a) New graduates
 - (b) Other private employers
 - (c) Government
 - (d) Educational institutions (employed professors)

9. What do you do if you can't get Ph. D.'s?

- (a) Hire persons with Master's or Bachelor's degrees
- (b) Use company training to upgrade skills of Master's and Bachelor's
- (c) Help Master's and Bachelor's to get additional education
- (d) Leave position vacant until Ph. D. becomes available

10. If you can't get a Ph. D. with the desired educational background, do you substitute a Ph. D. from another discipline?

11. Are there any specialties for which particular courses of graduate study or curricula are not offered, but for which the company feels training should be offered?

E. Past trends

1. Has the number of scientific and technical staff holding doctorate degrees in your company increased over the past 5 years?

- (a) Approximately what percent?
How does this compare with total science and engineering employment changes?
- (b) What has been the major factors contributing to this growth? (Rank)
 - (1) Growth of company
 - (2) Growth of R&D activities
 - (3) Greater utilization of Ph. D.'s
 - (a) Management
 - (b) R&D
 - (c) Other activities
 - (4) Greater availability of Ph. D. workers
 - (5) All, or combination of above

2. What occupational fields have shown the fastest growth? Why?

- (a) Engineering
- (b) Physical science
- (c) Life science
- (d) Mathematics

3. What type of supply-demand conditions for Ph. D.'s did the company experience during this period? Any differences in these conditions by occupational field?

- (a) Shortages throughout
- (b) No hiring difficulties

F. Future

1. Will the factors that affected your company's demand for Ph. D. scientists and engineers in the past have the same impact over the next 10 years? (Rank)
 - (a) Company expansion
 - (b) Growth of R&D
 - (c) Greater utilization of Ph. D.'s
 - (1) Management
 - (2) R&D
 - (3) Other (especially new activities in which Ph. D.'s are not currently utilized)
 - (d) Greater availability of Ph. D.'s

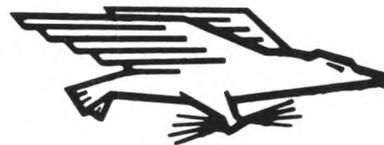
2. Follow-up of the R&D needs.
 - (a) You have about _____ Ph. D.'s working in research and development. (See B 1.) Assuming current supply-demand conditions and that you were to increase your R&D activities by about 25 percent in the next 10 years, would the number of Ph. D.'s hired for this work expand (1) faster, (2) slower, (3) the same rate? How much slower or faster?
Assume no scarcity (only if company currently is experiencing a shortage).
 - (b) Assuming no increase in R&D activities, would the company increase the number of Ph. D. scientists and engineers in this work? (Discuss magnitudes.)

3. Do you expect different rates of employment growth of Ph. D.'s among various scientific and engineering fields?
 - (a) Engineering
 - (b) Physical science
 - (c) Life science
 - (d) Mathematics

4. Does the firm have any active plans to increase the number of Ph. D. scientists and engineers in the future?
 - (a) Have projections of company's needs been made?
 - (1) Over what period
 - (2) Number desired

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