This PDF is a selection from an out-of-print volume from the National Bureau of Economic Research

Volume Title: The Demand and Supply of Scientific Personnel

Volume Author/Editor: David M. Blank and George J. Stigler

Volume Publisher: NBER

Volume ISBN: 0-87014-061-2

Volume URL: http://www.nber.org/books/blan57-1

Publication Date: 1957

Chapter Title: Front matter, The Demand and Supply of Scientific Personnel

Chapter Author: David M. Blank, George J. Stigler

Chapter URL: http://www.nber.org/chapters/c2660

Chapter pages in book: (p. -20 - 0)

# THE DEMAND AND SUPPLY OF SCIENTIFIC PERSONNEL

## NATIONAL BUREAU OF ECONOMIC RESEARCH NUMBER 62, GENERAL SERIES

,

# The Demand and Supply of Scientific Personnel

DAVID M. BLANK

GEORGE J. STICLER



NATIONAL BUREAU OF ECONOMIC RESEARCH, INC.

NEW YORK

1957

Copyright ©, 1957, by National Bureau of Economic Research, Inc. 261 Madison Avenue New York 16, N.Y. All rights reserved

L.C. CARD 57-8395

Printed in the United States of America by the Vail-Ballou Press, Inc., Binghamton, N.Y.

e.

#### NATIONAL BUREAU OF ECONOMIC RESEARCH

1957

OFFICERS Gottfried Haberler, Chairman Arthur F. Burns, President George B. Roberts, Vice-President and Treasurer Solomon Fabricant, Director of Research Geoffrey H. Moore, Associate Director of Research William J. Carson, Executive Director DIRECTORS AT LARGE Wallace J. Campbell, Director, Cooperative League of the USA Solomon Fabricant, New York University Albert J. Hettinger, Jr., Lazard Frères and Company Oswald W. Knauth, Beaufort, South Carolina H. W. Laidler, Executive Director, League for Industrial Democracy Shepard Morgan, Norfolk, Connecticut George B. Roberts, Vice-President, The First National City Bank of New York Beardsley Ruml, New York City Harry Scherman, Chairman, Book-of-the-Month Club Boris Shishkin, American Federation of Labor and Congress of Industrial Organizations George Soule, Bennington College N. I. Stone, Consulting Economist I. Raymond Walsh, New York City Joseph H. Willits, Director, The Educational Survey, University of Pennsylvania Leo Wolman, Columbia University Donald B. Woodward, Vick Chemical Company Theodore O. Yntema, Vice-President-Finance, Ford Motor Company DIRECTORS BY UNIVERSITY APPOINTMENT E. Wight Bakke, Yale Gottfried Haberler, Harvard Arthur F. Burns, Columbia Clarence Heer, North Carolina Melvin G. de Chazeau, Cornell R. L. Kozelka, Minnesota G. A. Elliott, Toronto C. Arthur Kulp, Pennsylvania Frank W. Fetter, Northwestern T. W. Schultz, Chicago H. M. Groves, Wisconsin Jacob Viner, Princeton DIRECTORS APPOINTED BY OTHER ORGANIZATIONS Percival F. Brundage, American Institute of Accountants Harold G. Halcrow, American Farm Economic Association Stanley H. Ruttenberg, American Federation of Labor and Congress of Industrial Organizations Murray Shields, American Management Association Willard L. Thorp, American Economic Association W. Allen Wallis, American Statistical Association Harold F. Williamson, Economic History Association RESEARCH STAFF Moses Abramovitz Thor Hultgren John W. Kendrick Arthur F. Burns Morris A. Copeland Simon Kuznets David Durand Clarence D. Long Richard A. Easterlin Ruth P. Mack Solomon Fabricant Ilse Mintz Geoffrey H. Moore Milton Friedman Raymond W. Goldsmith G. Warren Nutter Millard Hastay Lawrence H. Seltzer W. Braddock Hickman George J. Stigler Daniel M. Holland Leo Wolman Herbert B. Woolley

, .

#### Relation of the Directors to the Work and Publications of the National Bureau of Economic Research

1. The object of the National Bureau of Economic Research is to ascertain and to present to the public important economic facts and their interpretation in a scientific and impartial manner. The Board of Directors is charged with the responsibility of ensuring that the work of the National Bureau is carried on in strict conformity with this object.

2. To this end the Board of Directors shall appoint one or more Directors of Research.

3. The Director or Directors of Research shall submit to the members of the Board, or to its Executive Committee, for their formal adoption, all specific proposals concerning researches to be instituted.

4. No report shall be published until the Director or Directors of Research shall have submitted to the Board a summary drawing attention to the character of the data and their utilization in the report, the nature and treatment of the problems involved, the main conclusions and such other information as in their opinion would serve to determine the suitability of the report for publication in accordance with the principles of the National Bureau.

5. A copy of any manuscript proposed for publication shall also be submitted to each member of the Board. For each manuscript to be so submitted a special committee shall be appointed by the President, or at his designation by the Executive Director, consisting of three Directors selected as nearly as may be one from each general division of the Board. The names of the special manuscript committee shall be stated to each Director when the summary and report described in paragraph (4) are sent to him. It shall be the duty of each member of the committee to read the manuscript. If each member of the special committee signifies his approval within thirty days, the manuscript may be published. If each member of the special committee has not signified his approval within thirty days of the transmittal of the report and manuscript, the Director of Research shall then notify each member of the Board, requesting approval or disapproval of publication, and thirty additional days shall be granted for this purpose. The manuscript shall then not be published unless at least a majority of the entire Board and a two-thirds majority of those members of the Board who shall have voted on the proposal within the time fixed for the receipt of votes on the publication proposed shall have approved.

6. No manuscript may be published, though approved by each member of the special committee, until forty-five days have elapsed from the transmittal of the summary and report. The interval is allowed for the receipt of any memorandum of dissent or reservation, together with a brief statement of his reasons, that any member may wish to express; and such memorandum of dissent or reservation shall be published with the manuscript if he so desires. Publication does not, however, imply that each member of the Board has read the manuscript, or that either members of the Board in general, or of the special committee, have passed upon its validity in every detail.

7. A copy of this resolution shall, unless otherwise determined by the Board, be printed in each copy of every National Bureau book.

(Resolution adopted October 25, 1926 and revised February 6, 1933 and February 24, 1941) · · ·

•

#### PREFACE

THE present monograph is primarily a study of the methods by which one can explain movements in the supply and demand for scientific personnel. Rather than discuss the problem in abstract terms, however, we have deemed it more fruitful to apply the methods under examination to the recent situation in the technological professions in the United States, that is, up to 1955. We wish to forewarn the reader that these applications have been handicapped by limitations of data on salaries and fringe benefits, types of activities of engineers, sources of non-graduate engineers, and several other aspects of the problem. One of our chief products is a considerable list of further data collection and research which will be necessary to progress in the understanding of the rapidly growing professions under review.

The study was conducted under a grant by the National Science Foundation. The Foundation did not participate in the formulation or execution of the study, however, and the grant should not be interpreted as carrying any judgment on the methods or substantive findings.

We wish to express our gratitude to Dr. H. S. Conrad of the U.S. Office of Education, Harold Goldstein of the Bureau of Labor Statistics, and Thomas J. Mills of the National Science Foundation for invaluable assistance. We have profited from the suggestions of Solomon Fabricant, Daniel Holland, Albert Rees, and Leo Wolman. Jack Farkas assisted us throughout the investigation and Vera Eliasberg participated in the earlier stages.

> DAVID M. BLANK George J. Stigler

; • 0

.

•

## CONTENTS

Pref	ace	ix
I.	<ul><li>A General View of the Technological Professions</li><li>1. The Growth of the Technological Professions</li><li>2. What is an Engineer?</li><li>3. The Growth of Organized Research</li></ul>	3 3 8 12
II.	Demand and Supply: Methods of Analysis	19
	<ol> <li>Has There Been a Shortage? A Survey of Earn- ings</li> <li>The Bureau of Labor Statistics Mathed of Predic</li> </ol>	22
	tion of Demand	33
	3. The Engineers Joint Council Method of Prediction of Demand	37
III.	Factors Influencing the Demand for Engineers and Chemists	47
	1. Industrial Patterns in the Use of Engineers and	
	Chemists	48
	2. The Role of Government 3. The Unward Trend of Demand	57
	4 Short-Bun Changes in Demand	66
	5. The Gross vs. Net Demand for Engineers	68
IV.	The Supply of Engineers	73
	1. College-Trained Engineers	74
	2. Graduate Degrees in Engineering	77
	3. The Distribution of Bachelor's Degrees by Field	79
	4. Other College-I rained Entrants into the Engineer-	00
	5. Limitations on the Supply of College-Trained En-	00
	gineers	85
	6. Nongraduate Engineers	86
V.	Supply and Demand for Mathematicians and Physi-	
	cists	93
	1. Demand Factors	93
	a) Faculty-student ratios	94
	b) The trend of college enrollments	98
	2. The Supply of Mathematicians and Physicists	103

ŀ

#### CONTENTS

Appendix

А.	Engineering Earnings	107
В.	Census Data on Number of Engineers and Chemists, 1890–1950	143
C.	Tables on Engineering Enrollments and Degrees	156
D.	Projections of the Number of Engineering Degrees to 1970	166
E.	Reconciliation of 1940 and 1950 Census Counts of Engineers	174
F.	Tables on Years of School Completed for Engineers, 1940, and Age and Years of School Completed for Engineers and Scientists, 1950	179
G.	Analysis of Rates of Transfer Out of the Engineering Profession for Engineers with Varying Years of Ex-	
	perience	189
H.	The Engineers Joint Council Surveys	192
I.	Advertisements for Engineers	197
Index		199

ļ

É

ĥ

1.	The Growth of Engineering and Chemical Professions, 1870–1950	5
2.	Bachelor's and First Professional Degrees in Natural Sciences since 1901 ,	6
3.	Doctoral Degrees in Natural Sciences and Engineering since 1901	7
4.	Comparison of Numbers of Male Engineers and Chem- ists of Given Age in 1940 and 1950	9
5.	Educational Background of Employed Male Engineers and Chemists and Experienced Male Engineers and Chemists Seeking Work, 1940	11
6.	Source of Research and Development Funds, 1941–1952	14
7.	Performance of Research and Development, Measured by Expenditures, 1941-1952	14
8.	Number and Percentage Distribution of Research Engineers and Scientists, 1941–1952	15
9.	Federal Government Expenditures for Research and Development	16
10.	Industrial Research Activities, 1952–1955	18
11.	Index of Ratio of Median Engineering Salary to Aver- age Wage and Salary or Net Income of Selected Occu- pations, Benchmark Dates, 1929–1954	25
12.	Percentage Increase in Average Wage or Salary In- come, Full-Time Male Wage or Salary Workers in Selected Professional and Technical Occupations, 1939–1949	26
13.	Annual Percentage Changes in Salaries of Engineers and Scientists at Selected Experience Levels, 1947– 1956	5 27
14.	Percentage Increases in Salaries and Earnings of Se- lected Occupations, Various Periods, 1950–1956	28
15.	Total Engineers and the Labor Force in Five Industry Groups, 1890–1960	34

16.	Response to the Engineers Joint Council Surveys, 1952–1954	38
17.	Comparison of Expected Net Accessions of Engineers and Realized Net Accessions, 1952, Total EJC Sample	39
18.	Comparison of Expected and Realized Net Accessions of Engineers, 1952, Constant Group Sample	40
19.	Comparison of Expected and Realized Net Accessions of Engineers, 1953, Total EJC Sample	41
20.	Comparison of Expected and Realized Net Accessions of Engineers, 1953, Constant Group Sample	41
21.	Comparison of Expected and Actual Net Accessions for Three Groups of Firms, 1953	43
22.	Comparison of Expected and Realized Gross Accessions (by Components) and Losses of Engineers, 1953	44
23.	Chemists and Technical Engineers as a Percentage of Total Employment, Selected Industries, 1930–1950	49
<b>24.</b>	Hypothetical Ratio of Engineers and Chemists to Total Labor Force, Assuming Industry Ratios Constant at the Average of Their 1930, 1940 and 1950 Levels, 1890– 1950	55
25.	Decade Increments in the Ratio of Engineers and Chemists to the Labor Force, 1890–1950	56
26.	Average Ratio of Engineers and Scientists Engaged in Private Research to Total Employment in Manufactur- ing Firms, by Industry, January 1952	59
27.	Average Ratios of Engineers and Scientists Engaged in Government-Supported Research and Private Research to Total Employment in Manufacturing Firms Engag- ing in Both Types of Research, by Industry, January	01
28.	Engineers and Scientists on Private Research as Per	61
29.	Distribution of Number of Companies and Employ- ment in Companies Carrying on Research, by Ratio of Research Engineers and Scientists to Total Employ- ment, in Four Industries, January 1952	65
		00

xiv

30.	Number of Bachelor's and First Professional Degrees in Engineering and Ratio to Total Bachelor's and First Professional Degrees, 1901–1955	75
31.	Number of Doctor's Degrees in Engineering, 1911–1955	78
32.	Ranking of Engineering Fields by Percentage Increase in Base Salary of Engineers with 9 to 11 Years' Ex- perience, and by Percentage Increase in Share of First Degrees, Various Periods, 1929–1948	81
33.	Percentage Distribution of Employed Engineers by Age and Years of Schooling, 1950	88
34.	Per Cent of Employed Engineers under 25 and under 35 Who Had Completed No Years of College and less than 4 Years of College, by Field of Specialization, 1950	89
35.	Percentage Distribution of Employed Engineers by Field of Specialization and Years of Schooling, 1950	90
36.	Distribution of Mathematicians and Physicists with Ph.D.'s among Fields of Employment, 1951	94
37.	Faculty per 1,000 Students in 35 Colleges and Universities, Selected Years	95
38.	College Enrollments, 1900–1954	99
39.	Estimated Population of College Age (18–21), 1940 to 1965	99
40.	Percentage of Mathematics and Physics Teachers with Doctorates in 21 Institutions, 1900–1954	102
41.	Percentage of Mathematics and Physics Teachers with Doctorates, 1930, 1940 and 1950	102
<b>A</b> -	1. Median and Quartile Base Monthly Salary Rates of All Engineers, 1929–1946	114
<b>A</b> -:	2. Median and Quartile Base Monthly Salary Rates of Graduate Engineers, 1946 and 1953	116
<b>A</b> -3	3. Median and Quartile Base Monthly Salary Rates, by Years of Experience, for All Engineers, 1929–1946	117

A-4.	Annual Earnings of Engineering Graduates, Classi- fied by Years since Graduation, 1894–1924	124
<b>A-</b> 5.	Indexes of Annual Earnings of Engineering Gradu- ates, Classified by Years since Graduation, 1894–1924	125
A-6.	Median and Quartile Base Monthly Salary Rates of Graduate Engineers, by Years of Experience, 1894– 1924	126
A-7.	Base Monthly Salary Rates of Privately Employed Graduate Engineers, by Years of Experience, 1946– 1953	127
A-8.	Indexes of Median Salary for All Engineers and for Engineers at Stated Experience Levels, Selected Years, 1929–1953	130
A-9.	Base Monthly Salary Rates of All Engineers by Spe- cialization, 1929–1946	133
A-10.	Median Base Monthly Salary Rates and Indexes of Salary Rates of Graduate Engineers with Bachelor's Degree, by Professional Field and Years of Experi- ence, 1929–1946	135
A-11.	Median Base Monthly Salary Rates and Indexes of Salary Rates of All Engineers, by Professional Field and Years of Experience, 1939–1946	136
A-12.	Ranking of Engineering Fields by Percentage In- crease in Salary Rates, 1929–1946 and 1939–1946	137
<b>A-</b> 13.	Median Monthly Incomes and Salaries of All Engi- neers, 1939 and 1949	138
A-14.	Average Starting Monthly Salaries for College Gradu- ates in Various Specialties, 1947–1956	140
A-15.	Annual Percentage Changes in Average Monthly Sal- aries of Research Engineers and Scientists with B.S. Degree, by Years of Experience, 1948–1955	141
B-1.	Growth of Labor Force and Engineering and Chem- ical Professions	144
<b>B-2</b> .	Engineers and Chemists as a Percentage of the Labor Force	147

B-3.	Total Employment and Employment of Chemists and Technical Engineers in Selected Industries, 1930, 1940, and 1950	148
C-1.	Enrollments in Engineering Courses in Universities, Colleges, and Technological Schools, 1904–1915	156
C <u>-</u> 2.	Total Enrollments of Students in Engineering in the United States, 1920–1953	157
C-3.	Undergraduate Enrollments in Engineering Schools, in the United States, by Class, 1926–1953	158
C-4.	Male Enrollments in Engineering as Per Cent of To- tal Enrollments, 1934–1952	159
C-5.	Total U.S. Enrollments in Engineering, by Field, 1920–1953, Percentage Distribution	160
C-6.	Total Degrees Awarded in Engineering in the United States, 1920–1953	162
C-7.	First Degrees in Engineering, by Field, 1920–1952, Percentage Distribution	164
C-8.	Graduate Degrees in Engineering by Field, 1920– 1952, Percentage Distribution	165
D-1.	An Estimate of the Future Number of Engineering Graduates	167
D-2.	A Second Estimate of the Future Number of Engi- neering Graduates	1 <b>7</b> 0
E-1.	Reconciliation of 1940 and 1950 Census Data on En- gineers	176
F-1.	Years of School Completed by Employed Engineers and Experienced Engineers Seeking Work, by Field of Specialization, 1940	180
<b>F-2 t</b> h	rough F-18.	
	Age and Years of Schooling:	
F-2.	For All Employed Engineers, 1950	180
F-3.	For Employed Aeronautical Engineers, 1950	181

## Age and Years of Schooling:

<b>F-4</b> .	For Employed Chemical Engineers, 1950	181
<b>F</b> -5.	For Employed Civil Engineers, 1950	182
<b>F-6</b> .	For Employed Electrical Engineers, 1950	182
F-7.	For Employed Industrial Engineers, 1950	183
F-8.	For Employed Mechanical Engineers, 1950	183
F-9.	For Employed Metallurgical Engineers and Metallur- gists, 1950	184
F-10.	For Employed Mining Engineers, 1950	184
F-11.	For Employed Engineers Not Elsewhere Classified, 1950	185
F-12.	For Employed Agricultural Scientists, 1950	185
F-13.	For Employed Biological Scientists, 1950	186
F-14.	For Employed Chemists, 1950	186
F-15.	For Employed Geologists and Geophysicists, 1950	187
F-16.	For Employed Mathematicians, 1950	187
F-17.	For Employed Physicists, 1950	188
F-18.	For Employed Miscellaneous Natural Scientists, 1950	188
G-1.	Percentage of Stevens Alumni Who Are Currently Engaged in Engineering Work, Classified by Year of Graduation	189
G-2.	Annual Rates of Transfer Out of the Engineering Profession, Estimated on Basis of Alternative As- sumptions as to Proportion of Graduates Never En- tering the Profession	191
H-1.	Comparison of Expected, Required, and Realized Net Accessions of Engineers, 1952–1954	194
I-1.	Advertisements for Engineers, New York Times	197

## CHARTS

1.	College Enrollments as Percentage of Population 18–21 Inclusive, 1900–1954	101
A-1.	Indexes of Median Salaries for All Engineers and for Engineers at Stated Experience Levels, Selected Years, 1929–1953	119
A-2.	Indexes of Base Monthly Salary Rates of All Engi- neers by Specialization, 1929–1946	132

•