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## APPENDIX D

### PROJECTIONS OF THE NUMBER OF ENGINEERING DEGREES TO 1970

IN THIS appendix we develop several projections of the number of engineering graduates for the period to 1970. Our purpose is not to provide precise quantitative estimates of the numbers of such graduates that we expect in the next decade and a half. To obtain such estimates would require a close study of the factors determining the number of students specializing in engineering and the future strength of these factors. Rather we merely wish to indicate the rough orders of magnitude of graduates if past trends persist.

The number of engineering graduates is a function of the number of persons of college age, the proportion of this number who are graduated from college, and the proportion of the latter who obtain engineering degrees. The number of persons reaching college graduation age through 1970 can be forecast with reasonable accuracy on the basis of past birth data and current age-specific death rates. The proportion of those who will attend college can be projected with somewhat less accuracy, although the historic rising trend in this proportion is quite clear and rather well defined. Projection of the proportion of college students specializing in engineering is subject to much uncertainty, however, because the trend in this proportion is less clearly defined and has fluctuated markedly.

In Table D-1 we use data on population aged 22,<sup>1</sup> number of bachelor's and first professional degrees granted, and number of engineering degrees granted, 1910-1950, to provide one set of estimates of engineering degrees through 1970.

The population data and the number of first degrees for the next fifteen years are taken from data prepared by the staff of the Commission on Human Resources. The population data are based on corrected birth registrations and age-specific death rates. The number of first degrees is derived by the Commission staff by

<sup>1</sup> Throughout, we use changes in the population aged 22 as an index of the movement of the population group from which new college graduates derive. This is the age group employed by the staff of the Commission on Human Resources, whose forecasts on first degrees are used in Table D-1. A more refined measure in which we would employ the movement of, say, the age classes 20-24, weighting each age class by the proportion of persons in that class who are new graduates in some current year, might yield slightly lower estimates in the next decade (see Chapter V).

TABLE D-1

An Estimate of the Future Number of Engineering Graduates

	Total Population Age 22 (1)	Total First Degrees (2)	Total First Degrees as Percentage of Popula- tion Aged 22 (3)	Total Engineering Degrees (4)	Engineering Degrees as Percentage of Total First Degrees (5)		
1910	n.a.	37,200	n.a.	1,709	4.6		
1920	1,887,000	48,500	2.6	4,716	9.7		
1930	2,203,000	122,500	5.6	7,395	6.0		
1940	2,292,000	186,500	8.1	13,808	7.4		
1950 <sup>a</sup>	2,399,000	272,340	11.4	26,893	9.9		
				A	B	A	B
1960	2,309,000	326,000	14.1	32,600	38,800	10.0	11.9
1965	2,909,000	454,000	15.6	45,900	58,600	10.1	12.9
1970	3,455,000	591,000	17.1	60,300	81,600	10.2	13.8

n.a. = not available.

<sup>a</sup> The degree data exclude veterans on the assumption that few veterans were as young as 22 in 1950 and therefore that the population aged 22 against which the recipients of degrees are measured was essentially a nonveteran universe. To the extent that any veterans receiving degrees in 1950 were 22 years old, the percentage in column 3 is understated.

## Column

## Source

- 1 Toby Oxtoby, Robert Mugge, and Dael Wolfe, "Enrollment and Graduation Trends: From Grade School to Ph.D.," *School and Society*, October 1952. 1920-1940, taken from census data. 1950-1970, projected on the basis of corrected birth data.
- 2 1910, *Biennial Survey of Education*, Office of Education, Chapter 1, 1950, p. 39. 1920-1940, Oxtoby, Mugge, and Wolfe, *op. cit.* 1950, derived by subtracting the estimated number of first degrees awarded to veterans in 1950 from the total number of first degrees in that year. 1960-1970, *ibid.* Derived by applying the percentages in col. 3 to the population estimates in col. 1.
- 3 1920-1950, col. 2 divided by col. 1. 1960-1970, *ibid.* Derived by projecting the 1920-1940 trend in the ratio of first degrees to population aged 22.
- 4 1910, *Annual Report of the Commissioner of Education*, 1909-1910. 1920-1940, *Biennial Surveys of Education*, Office of Education. 1950, estimated total of degrees awarded to nonveterans. Derived by assuming that nonveterans accounted for 51 per cent of all engineering degrees in 1950, or a slightly higher proportion than in 1947 and 1948 (see *Journal of Engineering Education*, January 1948 and February 1949). This percentage was applied to the total number of first degrees awarded in engineering in 1950 (from *Biennial Survey of Education*, Chapter 1, 1950, p. 36). 1960-1970, percentages A and B in col. 5 applied to total projected degrees in col. 2.
- 5 1910-1950, col. 4 divided by col. 2. 1960-1970, two projections of the ratio of engineering degrees to total degrees. The first assumes a slight rise from 1950 levels; the second, a continuance of the 1930-1950 trend.

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projecting forward the 1940 ratio of new graduates to population aged 22 at the average annual rate by which this ratio rose between 1920 and 1930. The population projections show a decline from 2.4 million persons aged 22 in 1950 to 2.3 million in 1960 (when the children born in 1938 reach 22 years of age) and then a sharp rise to 2.9 million in 1965 and 3.5 million in 1970. The magnitude of this twenty-year rise of 1.1 million (or 44 per cent) in graduation-age population between 1950 and 1970 is even more striking when we compare it with that experienced during the preceding 30 years. From 1920 to 1950 the population aged 22 rose only 0.5 million or 27 per cent.

The number of degrees may be expected to rise from the 270,000 received by nonveterans in 1950 to 330,000 in 1960, 450,000 in 1965 and 590,000 in 1970. The last figure is more than double the number of nonveteran degree recipients in 1950. The rise between 1950 and 1960 is a function of the expected increase in the propensity to attend college, while the rise between 1960 and 1970 is a result of both this increasing propensity and the roughly 50 per cent rise in graduation-age population.

This forecast may be a conservative one, even though it is based on a growth rate experienced during the prosperous 1920's and disregards the depressing effect of the depression on college attendance.<sup>2</sup> According to this projection, 266,000 first degrees would have been granted in 1950 under "normal" trend conditions. This estimate was presented by the Commission staff in the original table, and is 6,000 less than the actual number of degrees granted to nonveterans in 1950 (see Table D-1).<sup>3</sup> That is, the projection implies that 11.1 per cent of the population aged 22 would have received first degrees in 1950, while the actual proportion was 11.4 per cent. And even this latter percentage makes no allowance for the difficulties nonveterans encountered in entering college during the flood of veteran students. The predicted number of college graduates was slightly too low.

We accept these forecasts, however, for the present analysis and apply to them alternative estimates of the proportion of all first degrees accounted for by degrees in engineering.<sup>4</sup> The first set of

<sup>2</sup> Between 1920 and 1930 the proportion of the population aged 22 who received first degrees rose at an average annual rate of 0.3 per cent; the corresponding rate for 1930-1940 was 0.25.

<sup>3</sup> We exclude veterans from the 1950 degree data in Tables D-1 and D-2 not only because they had special inducements to attend college but also because nearly all were older than 22.

<sup>4</sup> For a discussion of past trends in this ratio, see Chapter IV.

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estimates (A) in Table D-1 assumes merely a slight growth over 1950 levels in the ratio of engineering first degrees to total first degrees. The second (B) and more liberal set presupposes a continuation after 1950 of the 1930-1950 growth rate in the engineering ratio. According to these projections the number of engineering graduates should rise to between 33,000 and 39,000 in 1960, as compared to 27,000 nonveterans in 1950.

By 1970, the projections indicate a volume of graduates of between 60,000 and 82,000. The low figures in each case are based essentially on post-1950 ratios of engineering to total degrees, while the high figures imply a growth in the attractiveness of the engineering profession in the minds of college students at about the same rate as in the last several decades.

We can refine these projections somewhat by employing a related technique. This technique is based on the fact that almost all engineering graduates are men.<sup>5</sup> By restricting our attention to the changing proportion of males who graduate from college and the changing proportion of male graduates who have been trained in engineering, we are able to focus more precisely on the group from which engineers are obtained and to make more explicit the behavior of the male population with respect to college training and specialization in engineering. In the first set of projections, assumptions about this behavior are concealed within more general assumptions about the trends in total population size and propensity to attend college and specialize in engineering.

In Table D-2 we present data on total male population aged 22 and on bachelor's and first professional degrees received by males at decennial dates between 1910 and 1950,<sup>6</sup> and two projections of these data to 1970. The population data are forecast on the basis of corrected male birth registrations and rates of survival through age 22 as indicated in the footnotes to the table. The degree estimates are projected on the basis of alternative assumptions as to the rate of growth in the ratio of male first degree recipients to total male population aged 22. The first set of forecasts (A) assumes a rate of growth in this ratio after 1950 equal to that experienced in 1920-1930. The second (B) assumes that the 1930-1950 rate of

<sup>5</sup> The percentage of students enrolled in engineering schools who were women did not rise above 0.6 per cent between 1934 and 1952, except for the war years 1944-1946. *Biennial Survey of Education*, Office of Education, 1934 to 1950, and *Engineering Enrollments and Degrees, 1952*, Office of Education, Circular 364, January 21, 1953. See Appendix C.

<sup>6</sup> We again exclude veterans from the degree data for 1950 for reasons described earlier.

TABLE D-2

## A Second Estimate of the Future Number of Engineering Graduates

Year	Total Male Population Age 22	Total First Degrees Received by Males	Total Male First Degrees as Percentage of Male Population Age 22		Total Engineering Degrees	Engineering Degrees as Percentage of Total Male First Degrees	
	(1)	(2)	(3)	(3)	(4)	(5)	(5)
1900	730,104	22,173	3.0		840	3.8	
1910	925,234	28,762	3.1		1,709	5.9	
1920	918,849	31,980	3.5		4,716	14.8	
1930	1,078,834	73,615	6.8		7,395	10.1	
1940	1,123,714	109,546	9.7		13,808	12.6	
1950 <sup>a</sup>	1,114,265	169,123	15.2		26,893	15.9	
		A B	A B	A B	A B	A B	A B
1960	1,206,000	223,000 234,000	18.5 19.4	35,700 44,000	16.0 18.8		
1965	1,501,000	303,000 323,000	20.2 21.5	48,800 65,600	15.1 20.3		
1970	1,758,000	383,000 415,000	21.8 23.6	62,000 90,100	16.2 21.7		

<sup>a</sup> The degree data for 1950 again exclude veterans.

## Column

## Source

- 1910-1950, *Census of Population*, Bureau of the Census. 1960-1970, derived by applying a survival rate through age 22 to corrected male birth registrations. Birth registrations from *Statistical Abstract of the United States*, Dept. of Commerce, 1953, p. 64 and *Statistical Abstract*, 1954, p. 66. Survival rate through age 22 derived by successively applying male age-specific death rates to survivors of initial cohort and obtaining ratio of final survivors to initial cohort. Male age-specific death rates obtained by deriving weighted average of male white and nonwhite age-specific death rates for 1950. The latter from *Statistical Abstract*, 1954, p. 72. Weights were 86 for white death rates and 14 for nonwhite death rates, computed on basis of per cent of total white male births and nonwhite male births in recent years. The latter fluctuated between 13.6 per cent and 14.4 per cent of total male births for benchmark dates between 1935 and 1953, *Statistical Abstract*, 1954, p. 65.
- 1900-1940, *Biennial Survey of Education, in the United States, 1949-50*, Office of Education, 1953, Chap. 4, sec. 1, p. 40. 1950, estimate of non-veteran degrees derived by applying to total male degrees the percentage of nonveteran enrollments in prior years. 1960-1970, derived by applying percentages A and B in col. 3 to male population in col. 1.
- 1900-1950, col. 2 divided by col. 1. 1960-1970, two projections of the ratio of male first degree recipients to total male population aged 22. The first assumes a growth in the ratio after 1950 at the rate experienced in 1920-1930; the second, a continuance after 1950 of the 1930-1950 growth rate.
- 1900-1950, see Table D-1. 1960-1970, figures in col. 2 multiplied by percentages A and B in col. 5.
- 1900-1950, figures in col. 4 divided by those in col. 2. 1960-1970, two projections of the ratio of first degrees in engineering to total male first degrees. The first assumes a ratio in 1960 about equal to the ratio of new engineering students to total male freshmen in the fall of 1952 and a slight growth thereafter. The second implies a growth rate after 1950 equivalent to that experienced in 1930-1950.

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growth in the ratio will continue. The projections for the ratio of male first degrees to male population aged 22 rise from 19 per cent for 1960 to 22-24 per cent for 1970, as contrasted with a rise from 7 to 15 per cent between 1930 and 1950.

Total male population aged 22 rose only about 200,000 between 1910 and 1950 (or 23 per cent). The effects of the recent rise in births can be seen in the fact that this male age class will increase almost 650,000 (or 58 per cent) in only two decades after 1950. The bulk of this increase will take place between 1960 and 1970 when the full impact of the war and early postwar baby boom will be felt.

Total first degrees received by men are expected to rise from the 169,000 received by nonveterans in 1950 to around 220,000 to 230,000 in 1960. By 1970, male first degree recipients are expected to reach levels between 380,000 to 415,000. Thus, the number of such recipients in 1970 will be almost two and a half times as large as the number of male nonveterans receiving first degrees in 1950.

From these data we develop a second set of projections of the future volume of engineering degrees. The ratio of engineering degrees to total male first degrees has risen over time (Table D-2) from slightly less than 4 per cent in 1900 to almost 16 per cent (for nonveterans) in 1950, with the ratios for the years before World War II running around 12 to 13 per cent. The highest ratios were experienced after each World War, with some decline thereafter. Wolfe reports that the ratio of all engineering first degrees (including those received by veterans) to all first degrees received by males (including veterans) declined continuously between 1947 and 1953—from 18.0 per cent to 12.0 per cent.<sup>7</sup> A portion of this decline was due to the decrease in this period in the proportion of male college students who were veterans; male veterans concentrated slightly more heavily in engineering than did nonveterans. Another portion of the decline in the later years was due to the general concern in 1948 and 1949 about the possibility of a surplus of engineers after the graduation of the large classes of 1949 and 1950.

There has been a shift back toward engineering since the low degree ratio of 1953. In the fall of 1952, engineering enrollments accounted for 12.7 per cent of all male college enrollments and

<sup>7</sup> The annual ratios are: 1947, 18.0 per cent; 1948, 17.7; 1949, 16.5; 1950, 15.9; 1951, 14.9; 1952, 13.5; 1953, 12.0 (Dael Wolfe, *America's Resources of Specialized Talent*, Harper, 1954, p. 97).

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new engineering students represented almost 16 per cent of all male students entering college for the first time.<sup>8</sup>

In Table D-2, the two projections of the proportion of male graduates specializing in engineering are derived in the same manner as in Table D-1. The first (A) assumes a level in this proportion in 1960 only slightly higher than in 1950 and a very small increase to 1970. The second (B) assumes a continuance after 1950 of the 1930-1950 growth in this ratio. We apply the low projection of the ratio of engineering degrees to male degrees to the low projection of the ratio of male degrees to male population aged 22, and the high engineering degree projection to the high total male degree projection. The resulting projections of the number of engineering degrees range from 36,000 to 44,000 in 1960 and from 62,000 to 90,000 in 1970. These projections run slightly higher than those derived earlier on the basis of total population aged 22 and of graduation trends (both total and engineering) in relation to this population group.

In summary, then, if there is only a moderate rate of increase in the proportion of persons aged 22 graduating from college and maintenance of approximately the current degree of concentration on engineering among such graduates, engineering schools will graduate roughly 33,000 to 36,000 engineers in 1960 and 60,000 or more engineers in 1970. If the proportion of men aged 22 graduating from college rises in the next decade and a half as it has since 1930, and if the degree of specialization in engineering increases as it has since 1930, the number of engineering graduates in 1960 will be over 40,000 and the number in 1970 will reach the staggering total of 90,000. In all likelihood, with a rising level of demand for engineering services, the lower estimates will be exceeded. But it is at least doubtful whether the higher estimates will be realized in view of the increasing difficulty which is likely to be encountered in diverting students from other academic programs.

The most conservative estimates yield an indicated total of college-trained engineers in 1965 of about 720,000, contrasted with a 1950 total of about 300,000. The high estimates lead to an indicated 1965 total of about 820,000 college-trained engineers. These projections allow for deaths and retirements but take no account of prospective losses to the profession and prospective inflows of new college graduates from other disciplines. If we make allowance for these changes at rates experienced in the early fifties, we obtain

<sup>8</sup> *Engineering Enrollments and Degrees, 1952*, p. 1.

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totals about 50,000 lower, the net result of anticipated losses of both new engineering graduates and of older graduates of over 100,000 during the fifteen year period and anticipated accessions of graduates of other disciplines of over 50,000.