THE SUPPLY AND DEMAND OF COLLEGE TEACHERS

A. M. Cartter, American Council on Education

Considering the importance of the problem to higher education, and the many hundreds of millions of dollars appropriated by the Federal government for the expansion of graduate education over the last few years, it is rather astonishing that we know so little about the present and probable supply and demand of college teachers. The general consensus today as expressed by several Federal agencies, the National Education Association, and many college and university Presidents and graduate deans, seems to be summed up in the following three propositions: (a) persons trained at the doctoral level are in increasingly short supply; (b) the quality of faculty (as measured by highest degree attained) in the nation's colleges and universities is deteriorating; and (c) the situation will worsen over the coming decade as a consequence of burgeoning undergraduate enrollments. Over the last few years various distinguished educational spokesmen have used such terms as "disastrous shortage", "serious crisis", the nation standing virtually paralyzed", "frightening figures", "a major national scandal" to describe the supply of college teachers, and have called for "heroic efforts", "crash programs", and new degrees short of the doctorate to stem the tide.

At the risk of flying in the face of commonly held opinion, I wish to argue the reverse of the above propositions; namely that: (a) the "sellers market" in academic personnel is likely to disappear over the coming decade, (b) the quality of faculty in the nation's colleges and universities has improved, not deteriorated, over the last ten years, and (c) the situation is moderately well in hand now, and will improve dramatically in the 1970's. In attempting to support these views the paper will first summarize events of the last ten years, then present a growth model helpful in projecting supply and demand conditions ahead to 1985.

The Last Decade

The belief that things are getting worse rather than better is largely attributable to the biennial research bulletins issued since 1955 by the National Education Association on "Teacher Supply and Demand in Universities, Colleges and Junior Colleges."[1/] The first report presented a distribution of total staff by highest degree for 637 reporting institutions in 1953-54. Successive reports, however, have only inquired as to highest degree of new teachers. The figures shown in Table I, taken from the various NEA reports, have led some readers to believe that a rapid deterioration in faculty quality was in fact occurring.

A few critics of these reports have noted that it is an improper procedure to compare average and incremental ratios, but no attempt has been made to estimate the magnitude of this distortion. Table II is an attempt to correct this procedure, using additional data from the NEA reports. Columns 1 and 2 are the data used by Maul to obtain the percentages in Table I. In addition, however, the biennial reports give the number of new doctorates each year who "continue in teaching", and thus do not show up in the "new teacher" series.[2/] These are shown in column 3 of Table II, and a ratio of new doctorates in teaching to new teachers is computed in column 4. Now a meaningful comparison can be made between the average ratio for 1953-54 and the incremental changes in both the number and degree level of college teachers. This series suggests a slight improvement in the proportion of senior college faculty with the doctorate.

One further factor should be considered which is also favorable to the view that the quality of faculty (as measured by highest degrees attained) has not deteriorated. A priori one would assume that teachers with the doctorate are more likely to make a lifetime career out of teaching than those without a doctorate. It would be reasonable to assume that there is a differential net transfer rate for the two groups. A recent Office of Education study, to be published later this year,[3/] indicates that for 1962-63 the rate of those leaving college teaching for reasons other than death or retirement was 3.1% for doctorates and 7.1% for non-doctorates. Other data, discussed below, further indicate that the net transfer rate of doctorates into and out of teaching has been approximately zero in recent years--that is, that the in-transfer rate of doctorates from other employment was also about 3%. To illustrate the effect of a difference in the net transfer rate, assume that the rate is zero for Ph.D.'s and a 5% annual net loss for non-doctorates. For the 1963/64 class of new teachers, with an initial ratio of .484, five years later the ratio of doctorates to total continuing teachers would rise to .548. Unfortunately we have only one fragment of data from the COLFACS study to judge by, so this example is suggestive only; presumably the separations rate for non-doctorates is positive but not greater than seven percent.

If the data in Table II and its accompanying speculations, were the entire basis of the thesis that the percentage of college faculty with doctorate has been rising over the last decade, it would rest on a weak reed indeed. But this view is now supported by two new studies. One was recently presented by this author, drawn from data collected quadriennially by the American Council on Education.[4/] The findings are summarized in the first two columns of Table III. The other is a soon-to-be published study (COLFACS) by the Office of Education, whose findings are summarized in column 4 of Table III. Whether one views the comparison between total or full-time instructional staff, it seems clear that the percentage of doctorates has been rising for each type of institution. This conclusion is consistent with the N.E.A. data as presented in Table II above, although it is just the opposite of the conclusion which N.E.A. drew from its own material.

Faculty Forecasting Models

Projections of the demand for college teachers made over the last decade have varied widely, and most have been such poor predictors of actual developments that the basis on which the projections were made needs careful scrutiny. The best known model is that developed by Ray Maul in the 1959 NEA report,[5] and now used by the Office of Education.[6] The model consists of three ingredients: (a) an independent projection of future enrollment, (b) an assumed student/staff ratio, and (c) an assumed replacement rate for faculty deaths, retirements and shifts to other employment sectors. In the most recent presentation by the Office of Education the student/staff ratio is estimated to average 14:1 for the next decade,[7] and the replacement rate is assumed to be 6%. The choice of the latter percentage apparently derives from the earlier Maul model.[8] The result of this model when applied to Office of Education enrollment projections is to predict an aggregate need for some 556,000 new college teachers over the next ten years. Assuming constant quality of faculty, the Office of Education predicts a probable "deficit" of more than 120,000 doctorates by 1973/74.[9]

There are a number of aspects of the current OE model which I believe lead to a considerable exaggeration of future faculty needs. First, the projected student/staff ratio (18:1, based on total instructional staff) is lower than the experience of the last decade would indicate. Table IV, using Office of Education data, shows the increment of enrollment and increment in total instructional staff since 1953/54.[10] It has averaged 19.3:1 and there is no clear trend upward or downward. On reflection this does not seem an unusually high marginal ratio for a number of reasons. First, junior colleges, where the average ratio is 20:1 or greater, represent a larger portion of increments in enrollment than they do of the current total (nearly 30% of the annual increases as compared to less than 15% of the total). Second, enrollment in public institutions, where the ratio is moderately high, is expanding more rapidly than in private colleges and universities. Third, much of the expansion is occurring in already existing institutions, and one would expect there to be some manpower economies of scale associated with such growth. Finally, modest changes in technology (language laboratories, educational television, independent study, etc.) presumably work to increase the ratio despite enrollment expansion. A continuing marginal ratio of nearly 20:1 would mean that the average ratio will rise from 15.3:1 today to 17.3:1 by 1985. The Office of Education choice of an 18:1 ratio, therefore, appears to overstate the expansion needs by nearly 10%.

A second, and more major, criticism is the use of a 6% replacement rate for faculty, for I believe it overstates replacement needs by a factor of three. The reason for believing that this is such a major error is the following. If one applied this model to the last decade, beginning with 1953/54, then we should have experienced a decline in the percentage of doctorates on teaching faculties from about 40% to 30%; instead, as Table III indicated, it has risen by seven to ten percentage points for four year institutions. As I have indicated in another paper, the actual experience of the last ten years is consistent with a replacement rate of slightly less than 2%. Judging by the age distribution of present faculty (1962/63), and applying appropriate mortality rates and estimating retirements, my estimate of the actual replacement rate for the coming decade is shown in Table V.[11]

A third objection to the OE model is that included in full-time equivalent staff are personnel for administrative services (few of whom, below the level of academic deans, would be expected to have the doctorate), junior instructional staff (who by definition are teaching assistants without the doctorate) and a large number for "research." Since research personnel needs are determined by factors largely independent of the purely educational function, and doctorates are probably not a large fraction of the other two categories, it seems much more appropriate to concentrate just on the needs for teaching faculty. As a corollary, this requires counting only new doctorates who enter teaching as a component of supply, rather than the number who enter higher education in all of its various facets.

So much for the Office of Education forecasts; as a stone-thrower I should at least create my own glass house as a target for others. The starting point is a projection of college enrollments (E) and doctoral degrees (P) to 1985 in Table VI. The enrollment projection is similar to that of the Office of Education through 1974, and assumes that the ratio of undergraduate enrollment to the 18-21 age group rises to .55 by 1985.[12] (It is now approximately .40). The doctoral projection is that of the author, and while it is moderately higher than the most recent Office of Education projection, it is below that of the National Science Foundation.[13] Assuming that the projections turn out to be accurate--I believe they are about as good a guess as can be made--one can then attempt to analyze the staffing implications of such a future growth path.

If we are to assess the quality of instructional staff by highest degree obtained (a rough, but useful measure), we need to know the total size of faculty required and the likely number of teachers who will have the doctoral degree. Given the enrollment projection, the total faculty will expand as follows:

$$(1) \quad F_t = F_{t-1} + f(E_t - E_{t-1})$$

where F is faculty, E enrollment, and f the faculty coefficient (the inverse of the student/staff ratio). As indicated in Table IV, f has averaged .0517 over the last decade, and for the moment I will continue to assume that it remains constant.

Given the present number of doctorates on instructional staffs and the doctoral projection in Table V, the number of doctorates in teaching will grow in the following manner:

Table I

Percentage of Total Staff in 1953/54 and New Teachers in Successive Years Who Had the Doctorate

Total Staff in 1953/54	40.5%
New Teachers in 1953/54	31.4
1954/55	28.4
1955/56	26.7
1956/57	23.5
1957/58	25.3
1958/59	23.8
1959/60	25.9
1960/61	25.8
1961/62	27.3
1962/63	25.4
1963/64	28.3
1964/65	27.2

Source: "Teacher Supply and Demand in Universities, Colleges and Junior Colleges, 1963/64 and 1964/65, NEA Research Report 1965 R-4, Table 2.

Table II

Additions to College Teaching Staff and to Doctorates in Teaching 1953-1965

Year	New Teachers (1)	New Teachers With Doctorate (2)	Continuing Teachers Receiving Doctorate (3)	Ratio of New Doctorates in Teaching to New Teachers (4)
(Total Staff in 1953/54)	(58,719)	(23,768)	--	(.405)
1953/54	4,232	1,329	na	na
1954/55	4,694	1,333	822	.460
1955/56	6,337	1,695	856	.403
1956/57	8,308	1,953	1,528	.419
1957/58	9,293	2,354	1,529	.418
1958/59	9,100	2,254	1,825	.448
1959/60	10,221	2,650	1,894	.447
1960/61	11,184	2,886	1,987	.436
1961/62	10,439	2,851	2,115	.476
1962/63	12,186	3,092	2,334	.445
1963/64	13,562	3,833	2,732	.484
1964/65	16,059	4,361	3,084 est.	.463 est.

Source: Columns 1 and 2 from NEA Research Report 1965-R-4. Column 3 computed from Table Y of 1965 Report and comparable tables in earlier reports in the series. Column 4 is Col. 2+3 ÷ Col. 1.

(2) $D_t = [1-(c+m+r-a)]D_t + bP_{t-1}$

where the following new forms are introduced:
a = the accretion, or in-transfer, rate of persons with the doctorate who enter teaching from other employment;
c = the loss, or out-transfer, rate of doctorates leaving teaching for other employment;
m = mortality rate of the present teachers;
r = retirement rate of the present teachers;
b = the percentage of new doctorates who enter teaching; and
P = the number of doctoral degrees awarded.
(Using academic years as periods, the number of new Ph.D.'s entering teaching in year t depends upon doctoral output in year t-1.)

Given the values of the respective coefficients, equations (1) and (2) indicate how total faculty and doctorates in teaching will grow. In order to see the effect of various values for the coefficients, it may be useful to construct a supply and demand equation, as indicated in (3). Here one new coefficient, q, is added, defined as the percentage of new teachers with the doctorate.

(3) $bP_t = (c+m+r-a)D_t + qf(E_t - E_{t-1})$

This equation represents a supply-demand identity, the left hand term representing the quantity of new doctorates supplied, and the two right hand terms the replacement and expansion demand components.[14] From various studies we can estimate the approximate values of each of these variables for recent years.
b = .50 (the N.E.A. reports indicate an average of about .48 over the decade, closer to .50 for the last four years).
m = .0069 (calculated from the age distribution of faculty in the COLFACS study).
r = .0112 (calculated from COLFACS data, see note 11 above).
a = .0310 (the rate at which doctorates intended to leave higher education, from COLFACS data).
c = .0321 (estimated on the basis of Table V, above, which indicates that the net transfer rate (c-a) has been approximately .0011).
q = .33 (the estimated value over the past decade).
f = .0517 (from Table IV, above).
D = approximately 90,000 in 1963/64.
The combined factors which go to make up the replacement rate are equal to .0192, as indicated in Table V. These factors are small in magnitude and appear to have been relatively stable in recent years--although (c-a) obviously responds to changes in the relative salary level of academic personnel. The three significant coefficients are b, q, and f. Of these, f has remained relatively constant since 1958 at about .05, and is stable in the sense that it is the result of conscious decisions on the part of college and university administrators in determining the staff/sudent ratio. The percentage of new teachers hired with the doctorate, q, reflects the aspirations of the institutions, for most institutions equate a high q with excellence and a low q with deterioration of faculty quality. The percentage of doctorates who enter college teaching reflects the aspirations of graduate students for a majority enter graduate school with the intention of entering college teaching.[15] Both b and q are highly variable, depending upon yearly market conditions for new Ph.D.'s.

Using the projections for E and P for the next twenty years, assuming a constant faculty coefficient (f = .0517) and a constant replacement rate (rounded off at $[c+m+r-a]$=.02), what behavior might we predict for b and q? Column 1 of Table VII gives the predicted values for b if q remains constant--that is, the percentage of new Ph.D.'s who would have to enter college teaching in order to maintain a constant ratio of doctorates in teaching to total faculty. We might call this the "constant faculty quality" model.[16] Over the coming three years the required value of b is higher than we have experienced or can reasonably expect; therefore the quality of faculty is unlikely to be maintained. However, after 1968 b will steadily decline (to a low of less than 12% for the 1980-85 period), and will probably be lower than it has ever been in history.

Alternatively, column 2 of Table VII projects an "absorption" model, assuming that the percentage of new doctorates entering teaching (b) remains constant at 50%, and that all such available doctorates become employed in college teaching. The ratio of new teachers with the doctorate to annual additions to the instructional staff ($q = \frac{\Delta D}{\Delta F}$) dips for the 1965/66-1967/68 period, then steadily rises to new historical highs. Assuming a constant b, by 1977/78 every new college teacher would possess the doctorate; after that year the absolute number of non-doctorates would fall rapidly as doctorate-teachers displaced non-doctorates faster than the latter were reaching retirement age. Figure I illustrates dramatically the relationship between the available supply if b remains constant quality. After a temporary deficit in the 1965-68 years, the available supply begins to exceed demand by a rapidly growing amount, sharply altering the market conditions for college teachers.

The "absorption" and "constant quality" versions of the model seem to me to represent the outside limits; actual experience will probably lie somewhere between. Figure II shows the outer boundaries, and illustrates an intermediate case similar to the experience of the last decade discussed in the first section of the paper. In this example it is assumed that the overall ratio of doctorates to faculty continues to rise by one-half of one percentage point each year. The two intermediate lines indicate the values for both b and q (given the projections of E and P) for a steadily rising quality model. In this case q rises to about unity (its logical maximum) and b gradually declines to one-fifth.

Table III

Percentage of Doctorates Among 4-Year College and University Faculty

Type of Institution	All Instructional Staff 1950-51 (ACE)[1/] (1)	All Instructional Staff 1962-63 (ACE)[1/] (2)	Full-time Instr. Staff 1953-54 (NEA)[2/] (3)	Full-time Instr. Staff 1962-63 (OE)[3/] (4)
Public Universities	36.0	44.9	44.0	58.4
Private Universities	37.3	43.8	51.9	59.6
Public Colleges	28.2	33.5	30.7	42.6
Private Colleges	29.7	35.4	35.2	42.7
All Institutions	32.3	39.4	40.5	50.6

Sources: 1/ A.M. Cartter, "A New Look . . .", op. cit. p.270.
2/ "Teacher Supply and Demand in Degree Granting Institutions," NEA Research Bulletin XXXIII, 4 (December 1955), p. 138.
3/ "Doctorates Among Teaching Faculty," op. cit., Table III

Table IV

Average and Marginal Faculty Coefficients

1953/54 - 1963/64

	E	ΔE	F	ΔF	F/E	ΔF/ΔE	ΔE:ΔF
1953/54	2,236		182.0	--	.084		
1955/56	2,660	424	197.8	15.8	.076	.037	26.8:1
1957/58	3,047	387	226.5	28.7	.074	.074	13.5:1
1959/60	3,377	330	244.5	18.0	.072	.055	18.2:1
1961/62	3,861	484	266.6	22.1	.069	.046	21.7:1
1963/64	4,495	634	298.9	32.3	.066	.051	19.6:1
1953/54 to 1963/64	2,259			116.9		.0517	19.3:1

Source: "Projections of Educational Statistics to 1973/74" (OE-10030, 1964), pp. 8 and 24. Faculty considered here are members of the Instructional Staff at the level of Instructor or above. The extremely high and low ratios, for 1955/56 and 1957/58 may result from errors in reporting by institutions.

Table V

Estimated Annual Replacement Rate for College Faculty

Losses annually due to:	
Deaths	.69%
Retirement	1.12%
Net Transfer to Other Employment	.11%
Total Annual Losses	1.92%

Table VI

Total College Enrollment (E) and Doctoral Production (P)
Actual 1953-64, and Projected to 1985 (000's)

	E	ΔE	P
1953-54	2,207	--	9.0
1954-55	2,421	214	8.8
1955-56	2,627	206	8.9
1956-57	2,891	264	8.8
1957-58	3,009	118	8.9
1958-59	3,195	186	9.4
1959-60	3,344	149	9.8
1960-61	3,536	192	10.6
1961-62	3,804	268	11.6
1962-63	4,124	320	12.6
1963-64	4,433	309	14.5
1964-65	4,744	311	15.0
1965-66	5,185	441	16.1
1966-67	5,641	456	16.8
1967-68	6,064	423	18.0
1968-69	6,382	318	19.5
1969-70	6,676	294	21.4
1970-71	6,982	306	23.2
1971-72	7,315	333	26.0
1972-73	7,671	356	28.9
1973-74	8,027	356	31.5
1974-75	8,401	374	33.6
1975-76	8,750	349	35.7
1976-77	9,082	332	37.9
1977-78	9,369	287	40.4
1978-79	9,644	275	43.1
1979-80	9,936	292	46.0
1980-81	10,148	212	47.9
1981-82	10,288	140	49.7
1982-83	10,428	140	51.6
1983-84	10,487	59	53.2
1984-85	10,598	111	54.7

Source: Actual figures from Office of Education data; Projections by the author (See A. M. Cartter and R. Farrell, "Higher Education in the Last Third of the Century," The Educational Record, Spring 1965, pp. 119-128)

Table VII

Projected Percentages of New Doctorates Entering Teaching (b), and New Teachers with the Doctorate (q) for "Constant Quality" and "Absorption" Growth Medals: 1965-85

	Values of: b (q=.33)	Values of: q (b=.50)
1965-66	60%	24%
1966-67	62	26
1967-68	54	28
1968-69	41	41
1969-70	36	48
1970-71	34	51
1971-72	33	52
1972-73	31	55
1973-74	29	61
1974-75	28	64
1975-76	26	73
1976-77	24	81
1977-78	21	100
1978-79	19	111
1979-80	19	110
1980-81	15	163
1981-82	13	255
1982-83	12	264
1983-84	9	639
1984-85	11	340

Note: Based on assumed continuing values: f = .0517 and (c+m+r-a) = .02

Figure I

Doctorates Available, and Doctorates Required to Maintain Constant Quality of Faculty at 1963/64 Level

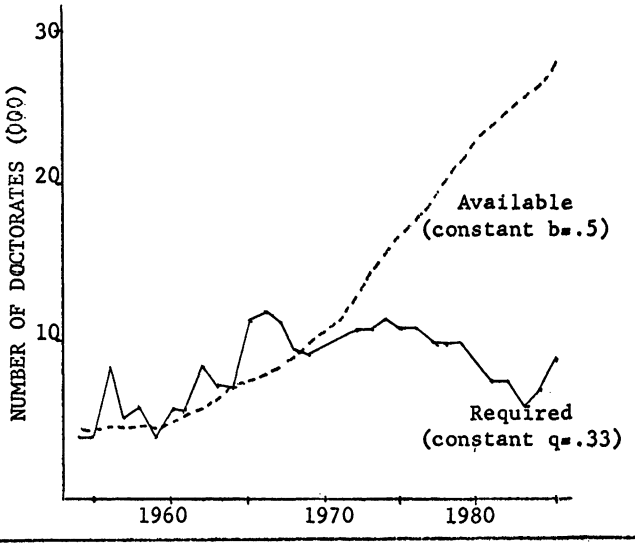
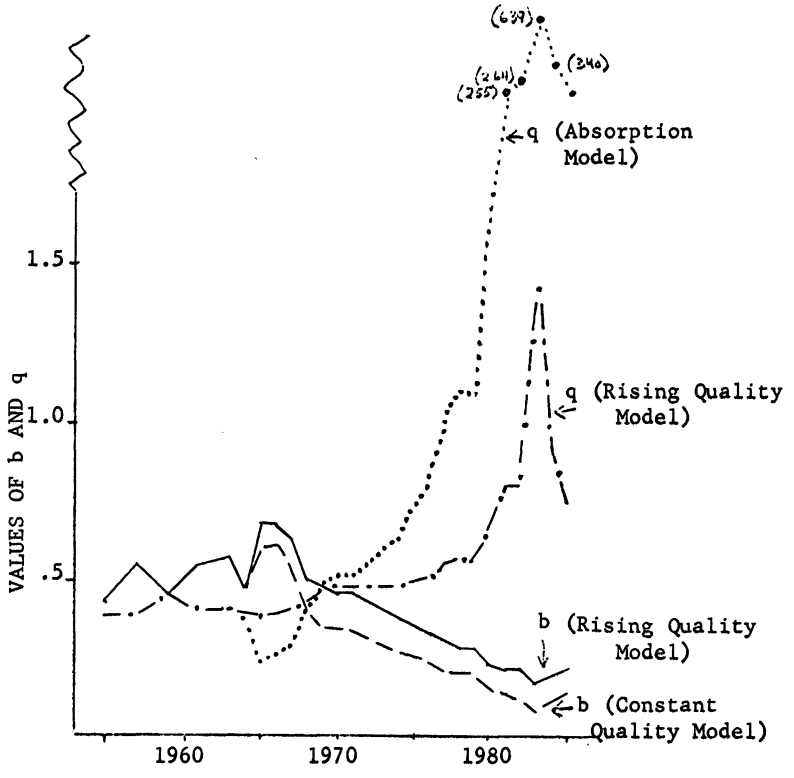


Figure II

Values of b and q for Absorption, Constant Quality, and Rising Quality Models



Conclusions

The preceding analysis suggests that educators have been much too pessimistic about the adequacy of both the present and future supply of college teachers. We seem to have learned little from the experience of the 1950's when the National Education Association and most public school officials were maintaining that there was a critical shortage of school teachers, only to find by the end of the decade that both the number and quality (as measured by formal preparation) of teachers had been steadily rising. Similarly, the despairing cries about the rapidly deteriorating situation on the college level have now proved to be in error, and the future looks bright beyond the next three to five years.

If the projections of total college enrollment and of doctorates to be awarded are even approximately correct, the sellers' market for college faculty will quickly disappear in the early 1970's. This has many implications for public policy and for the nation's colleges.

Given the time lag between entrance to graduate school and completion of doctorate, it is conceivable that graduate education facilities might be expanded too rapidly by basing decisions on degrees awarded in the recent past. The present faculty and facilities, at their current level of utilization, would turn out about 20,000 doctorates a year in a stable system. That is to say, because we are rapidly expanding we occasionally forget that the fifteen thousand doctorates awarded this year reflect the teaching capacity of the graduate schools about 1960. If, as the model suggests, the demand for new doctorates in teaching will stabilize or even decline after 1968, as a consequence of the declining rate of growth of the total system, then a serious question of public policy may be whether or not it is desirable to encourage many new institutions to enter the doctoral field. Four-fifths of the present nearly 250 universities awarding the Ph.D. are too small to be educationally or economically efficient. We might well ask whether public policy would be better served by consolidating and strengthening our existing graduate schools, rather than encouraging another ten or twelve new doctoral granting institutions to join the university ranks each year as is now occurring.[17/]

The model also has serious implications for the future level of academic salaries. For the next three years the market will remain fairly tight, and the succeeding several years may be needed to regain temporarily lost ground. The 1970's, however, may usher in a "buyers' market," and academicians may experience again a decline in their relative income position. The model above assumed that the replacement rate remained constant over the next twenty years, but this is unlikely in a market where supply is relatively abundant. There may develop a trend for colleges to lower mandatory retirement ages (thus raising r), and the transfer rate of senior staff (c-a) will probably rise a few percentage points. For example, a tendency for b to fall as a result of a decrease in demand would tend to depress beginning academic salaries. As the upward pressure on salaries of new Ph.D.'s diminishes, colleges may let out-transfers increase and reduce in-transfers of older doctorates (i.e. c-a would rise) partly stemming the decline in b. Junior and senior faculty are relatively good substitutes from the point of view of performing the teaching function. Alternatively, the slack might be taken up by a rising faculty coefficient (a reduced marginal student/staff ratio).

If I were to hazard a guess fifteen or so years ahead, I would predict a fairly constant marginal faculty coefficient (f), a gradually diminishing percentage of new Ph.D.'s entering teaching (b) after 1970, a continuing modest improvement in the percentage of faculty with the doctorate ($q \rangle \frac{D}{F}$), a positive net out-transfer rate ($c \rangle a$ and gradually rising), and a slowing down in the upward drift of academic salaries becoming noticeable in the early 1970's. It may well be that the real challenge to Committee Z of AAUP will come in the 1970's when in all probability market forces will be an opponent rather than an ally in efforts to improve the relative income position of college teachers.

The discussion above has ignored field-by-field differences partly in the interests of brevity and partly because the aggregate data are better than that for individual disciplines. There are wide variations in the values of each of the coefficients from field to field,[18/] but the demarcations between fields are too fuzzy to permit the application of such a model with any degree of precision to individual disciplines. Certainly shortages in many fields will continue beyond 1970, but the general outlook appears to be favorable for the continued expansion and improved quality of higher education in the United States.

Footnotes

1/The first report in the series had a slightly different title; see "Teacher Supply and Demand in Degree Granting Institutions, 1954-55", NEA Research Bulletin XXXIII, 4 (December 1955). The Series has been under the directorship of Ray C. Maul, and the most recent is NEA Research Report 1965-R4.

2/These data are not precisely comparable, but should be sufficient to illustrate the principle. Maul's data on new teachers is drawn from questionnaires to the colleges hiring new teachers, while his data on the employment of new doctorates is drawn from questionnaires to the graduate schools granting the doctorates.

3/"Teaching Faculty in Universities and 4-Year Colleges, Spring, 1962" by Dunham, R.E., Wright, P.S., and Chandler, N.O. (OE-53022-65). Preliminary data were presented in a paper "Doctorates Among Teaching Faculty" at the annual meeting of the American Educational Research Association, February 11, 1965. This study is commonly referred to as COLFACS.

4/See "A New Look at the Supply of College Teachers," The Educational Record, (Summer 1965), pp. 267-277.

5/Teacher Supply and Demand . . .", NEA Research Report 1959-R10, pp. 50-54. The same model was used also in the 1961 Report, but did not appear in the later reports.

6/"Projections of Educational Statistics to 1973-74" (OE-10030, 1964), p. 26.

7/The ratio, in terms of full-time staff equivalents, ranges from a low of 10:1 to a high of 16:1 in somewhat random fashion, but averages 14 for the decade to 1973-74. In terms of total instructional staff at the rank of Instructor or above, the OE projection ranges from 14:1 to 27:1, averaging 18:1. As Table IV indicates, this is lower than the average of the last decade. See "Projections of Educational Statistics . . ." op. cit., pp. 8 and 24.

8/The choice of the appropriate replacement rate is so critical to the model that it is surprising that no very serious attempts have been made to verify it. A difference of one percentage point makes a difference of about 40,000 teachers over a decade. Various assumptions have been used by different model builders -- e.g. 5% by the Fund for the Advancement of Education in Teachers for Tomorrow (1955) 5% by Brown in The Market for College Teachers (1965), 4% by Berelson in Graduate Education in the United States (1960), 3% by Wolozin in "How Serious Is the Faculty Shortage?", Challenge (June 1965).

9/Memoranda on "Estimates of Demand for and Supply of Higher Educational Staff," Higher Education Personnel Staff, Office of Education, October 26, 1964 and January 4, 1965.

10/Ideally one would like to use full-time equivalents for both measures, but national enrollment data is not available on this basis despite the fact that the Higher Education Facilities Bill of 1963 uses a full-time equivalent enrollment formula for the distribution of Title I funds.

11/Bolt, Kolton and Levine have recently published a model for scientific fields which is in close agreement with the above. Their estimate for scientists, based on a review of National Register data for recent years and an assumption that scientists retire at age 65, is:

Death rate	.009
Retirement	.006
Total	.015

See "Doctoral Feedback into Higher Education," Science (May 14, 1965), pp. 918-28. The retirement assumptions in my estimate are that 4% of faculty aged 60-64 voluntarily retire each year, and that from age 65 on teachers on the average retire from teaching one year after mandatory retirement age is reached. This is the equivalent of assuming that one-third retire at the mandatory age, one-third continue (probably at another college) for one year, and one-third for two years. An alternative assumption that 10% of teachers age 60 and above will retire each year would give a current rate of .0098.

12/See A. M. Cartter and R. Farrell, "Higher Education in the Last Third of the Century," The Educational Record, (Spring, 1965) for the development of this and alternative projections of enrollment.

13/See "Projections of Educational Statistics to 1973/74," op. cit., pp. 12-16 for OE Forecasts, and Comparisons of Earned Degrees Awarded 1901-62 -- With Projections to 2000 (NSF-1964), p. 54. The author's "A New Look at the Supply of College Teachers, " The Educational Record (Summer, 1965) compares these with other doctoral projections. For periods up to ten years ahead P may be taken as an exogenous variable, determined by the level of fellowship support, the capacity of graduate schools, etc. In projecting doctoral degrees, however, I have assumed after 1974 that P_t is a function of E_t-7, the value of the functional coefficient being .0058. From 1964 through 1974 the value of this coefficient is approximately (.0047 + .0001t). This model produced reliable estimates of doctorates for years before 1964, and a projection that falls reasonably between the low estimates of the Office of Education and the high estimates of the National Science Foundation. For the 1974-85 period it is very close to Lindsay Harmon's "Reference Series." See "Memorandum on Projected Doctorate Production", National Academy of Sciences (January 29, 1965).

[14] If one were collecting data from colleges and universities, it would be more appropriate to express the supply-demand identity as follows:
(3A) $bP_t+aD_t+sD_t=sD_t+(c+m+r)D_t+qf(E_t-E_{t-1})$
This differs from equation (3) in that aD_t is shifted to the left hand side, since it is technically part of the supply of doctorate-teachers, and a new term sD_t appears on both sides of the equation (s being defined as the percentage of teachers who shift teaching positions from one college to another in any year); when aggregating sD_t cancels out. According to COLFACS data, s = .114 in 1962/63.

[15] I would estimate that half of science students and at least 90% of non-science students would prefer--other things being equal--to enter college teaching. The fact that only about 20% of the former and 75% of the latter category do become teachers upon receiving their degrees is attributable to the economically attractive alternatives at the time of graduation. b is therefore assumed to be sensitive to relative salaries in academic and non-academic occupations. In the economist's terms I would assume that b is price (i.e. salary) elastic, and that q is relatively price inelastic.

[16] This might be compared with Brown's "Quality-constant supply" function, which uses different (and I believe unlikely) assumptions. See The Market for College Teachers, op. cit., pp. 18-27.

[17] One quick answer is that government and industry can absorb all the additional doctorates produced. This may turn out to be so, but if it does occur doctorates in non-educational employment will experience an increasing rate of growth. For example, if the educational system followed the path indicated by the constant-quality model, then doctorates entering non-teaching employment would grow from the present level of about 7,500 per year, to 26,000 in 1975 and to 54,000 by 1985. Over the last ten years the total number of employed non-teaching doctorates has grown about 4-5% per year; over the next twenty years it would expand at the rate of about 10% per year.

[18] Take the retirement rate (r) as an example; over the next five to ten years it will probably average from a low of only .47% in Biochemistry to a high of 3.71% in Classics. Judging from the present age distribution of teachers, the combined mortality and retirement rate for the next several years will be about 2.5% in the Humanities, 1.7% in the Biological and Physical Sciences, 1.6% in Engineering, and 1.9% in the Social Sciences.