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Volume Title: Education as an Industry

Volume Author/Editor: Joseph T. Froomkin, Dean T. Jamison and Roy Radner, eds.

Volume Publisher: NBER

Volume ISBN: 0-88410-476-1

Volume URL: http://www.nber.org/books/jami76-1

Publication Date: 1976

Chapter Title: Faculty-Student Ratios in U.S. Higher Education

Chapter Author: Roy Radner, Dean T. Jamison, Roy Radner

Chapter URL: http://www.nber.org/chapters/c4497

Chapter pages in book: (p. 415 - 452)

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Faculty-Student Ratios in U.S. Higher Education

1. INTRODUCTION

It usually requires no special effort to interest academics in the subject of faculty-student ratios, at least at the level of faculty club or cocktail party conversation. We feel threatened by any decrease in the faculty-student ratio, and we consider any increase to be a sign of increasing quality. On the other hand, if the ratio is low, we can boast to the legislature of our "efficiency."

An interest in forecasting the demand for teachers leads naturally to an interest in the patterns of variation of student-teacher ratios among institutions and through time. More generally, it leads to an interest in the relations among inputs and outputs in higher education, or, as the production economist might put it, in the "technological possibilities" that have been observed within the education sector. Of course, there are many nonhuman inputs into the educational process, but the human ones are probably still the most important. In any case, the everyday

NOTE: This paper is based on research supported by the Carnegie Commission on the Future of Higher Education and also by the National Science Foundation. The material presented here forms part of a more extensive report that Leonard S. Miller and I have prepared for the Carnegie Commission: *Demand and Supply in U.S. Higher Education* (New York: McGraw-Hill, 1975). The data processing and regression analyses for Section 4 were done by Sunny Yoder, whose contribution to this research has been considerable.

mythology of education suggests that the relations among the human inputs and outputs have remained at the heart of the educational process since at least the time of Socrates and may even have changed very little from his day to ours!

On the other hand, the measurement of "quality" of inputs and outputs may not have advanced much either during the past twenty-five hundred years, nor shall we in this paper contribute to the solution of this important problem. I, like most other educators, cling to the hypothesis that an educational institution *can* do more to increase the quality of its output than merely select students with higher initial "ability." But quantitative confirmation of this hypothesis still seems to elude those who have studied the question carefully.[1]

Relative to the magnitude of the various problems to which I have referred, the goal of the present study is quite modest. We shall try to "explain" the variation in numbers of faculty, both among institutions of higher education and through time, as a function of numbers of students enrolled, and in terms of several other institutional variables, such as ratings of graduate schools, faculty salaries, size, type of control, and so forth.

Although our data are crude and subject to considerable error, some conclusions may be ventured. First, during the period 1950–67, there seems to have been a downward trend in faculty-student ratios, except in private universities. This trend appears both in aggregate data and in individual data for a sample of institutions (Section 2).

However, the variation in faculty-student ratios among institutions, even within standard categories (classified by control and level), is striking. A major part of this report (Sections 3 and 4) is devoted to trying to relate this variation to variation in other institutional variables by a cross-section analysis of a 1966 sample of institutions. This cross-section analysis reveals the presence of "increasing returns to scale" in the relation between faculty "inputs" and student enrollment, except in the universities and in public master's-degree-level institutions, and (curiously enough) the public four-year institutions. The other groups all show some evidence of fitting the "economizing model," in which institutions substitute higher salaries, or a greater percentage of Ph.D.'s on the faculty, for higher faculty-student ratios.

Finally, we have had some success, in the case of the universities, in estimating separate "faculty input coefficients" for undergraduate and graduate education and in showing how these coefficients depend on other institutional variables. If our estimates are not unduly inaccurate, the university faculty input coefficients for undergraduate education are somewhat lower than those for private master's degree level institutions and private four-year institutions with high faculty salaries, but are

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above those for other types of institutions. Furthermore, the university faculty input coefficients for graduate education appear to be from two to four times as large as those for undergraduate education (in the universities).

2. RECENT HISTORICAL TRENDS IN FACULTY-STUDENT RATIOS

2.1. Summary

We present here evidence from two sources on trends in faculty-student ratios during the period 1950–67. Roughly speaking, during this period, faculty-student ratios declined in public universities and in institutions other than universities, and increased somewhat in private universities. However, there was considerable variation within each major category of institution. This variability declined somewhat in the undergraduate categories but remained relatively stable in the universities. In Sections 3 and 4, we try to relate this variation among institutions to variations in institutional variables.

2.2. Evidence from the Office of Education Statistics

We first consider estimates of faculty-student ratios calculated from statistics on numbers of faculty and students published by the Office of Education. For these estimates, institutions have been grouped in six categories, based on a two-way classification: (a) public, private; and (b) universities, "other four-year colleges," two-year colleges. For each of the years 1957, 1963, and 1967, and for each of the six categories, we have estimated the ratio of total full-time-equivalent faculty to total full-time-equivalent students. The results are presented in Table 2.1. It should be emphasized that these estimates may be subject to considerable error because of the noncomparability of statistics in different years and the difficulties of estimating full-time equivalents.

Table 2.1 indicates that faculty-student ratios fell in all categories except that of private universities. In this last category, the ratio increased from 1957 to 1963 and then fell between 1963 and 1967.

In interpreting Table 2.1 and subsequent tables, it may be useful to have in mind some sample numbers relating faculty-student ratios to student-faculty ratios:

Faculty-student ratio	.04	.05	.06	.07	.08	.09
Student-faculty ratio	25.0	20.0	16.7	14.3	12.5	11.1

TABLE 2.1 Total Faculty-Student Ratios

	—Universities—		Other Four-Year —Colleges—		Two-Year —Colleges—	
	Public	Private	Public	Private	Public	Private
1957	.078	.085	.065	.078	.053	.080
1963	.066	.099	.058	.074	.051	.067
1967	.060	.089	.056	.069	.046	.056
Per cent change 1957–67	−23	+5	−14	−12	−13	−30

SOURCE: Estimated from Office of Education Statistics. See the appendixes to Chapter 6 of Roy Radner and Leonard S. Miller, *Demand and Supply in U.S. Higher Education* (New York: McGraw-Hill, 1975).

2.3. Evidence from the "ACE Sample"

We consider next a sample of 372 colleges and universities taken from a larger set of more than 900 institutions for which data were available[2] on numbers of faculty and students for the years 1950, 1954, 1958, and 1962. These 372 institutions included all those in the larger set that either (a) were purely undergraduate institutions or (b) had substantial graduate enrollment in each of the four years mentioned above but were neither purely graduate schools nor primarily religious or professional schools. In this paper, these two groups will be called "undergraduate schools" and "universities," respectively; there are 259 "undergraduate schools" and 113 "universities." With a few exceptions, we had data on numbers of faculty and students for each of the 372 schools for each of the four years. Thus, we were able to avoid the problems of possible changes in numbers and classification of institutions. On the other hand, our sample is not random, and it may well not be "representative."

After further subdividing the undergraduate schools and universities into public, private nonsectarian (hereafter called "private"), and private sectarian (hereafter called "sectarian"), we calculated the average and the standard deviation of each of the faculty-student ratios for the resulting six groups for each of the four years in our observation period (1950–62). The results are presented in Table 2.2.

The mean faculty-student ratio clearly fell in each of the undergraduate groups, with the greatest decline (28 per cent) in the public schools and the smallest decline (14 per cent) in the private schools. The

TABLE 2.2 Averages and Standard Deviations of Faculty-Student Ratios

	Undergraduate			Universities		
	Public	Private Nonsectarian	Private Sectarian	Public	Private Nonsectarian	Private Sectarian
Mean of faculty-student ratio						
1950	.0939	.1016	.1031	.0833	.1111	.0782
1954	.0859	.0963	.0973	.0785	.1244	.0868
1958	.0742	.0934	.0859	.0777	.1263	.0845
1962	.0674	.0875	.0809	.0766	.1266	.0956
Standard deviation of faculty-student ratio						
1950	.036	.031	.033	.030	.062	.039
1954	.039	.028	.030	.029	.072	.037
1958	.028	.031	.023	.029	.074	.037
1962	.027	.022	.018	.030	.066	.041
Number of institutions in group						
1950	45	51	162	51	46	13
1954	45	51	162	54	46	14
1958	44	51	162	54	46	14
1962	45	51	162	55	45	14

mean faculty-student ratio also fell slightly in the public universities, but rose in the other universities. In both undergraduate schools and universities the private schools ended the period with the highest ratios; and the public schools, with the lowest. Of course, one suspects that the increases in the universities are due to the increased fraction of the total enrollment represented by graduate students.

The variability of the faculty-student ratios, as well as their means, declined in the undergraduate-school groups, but remained relatively stable in the university groups. On the whole, there was considerable variation in the ratios, with the means roughly only two to four times the standard deviations. In 1962, the private universities had the lowest ratio of mean to standard deviation (1.9), whereas the sectarian undergraduate schools had the highest (4.5).

All in all, we have a picture of declining faculty-student ratios in undergraduate schools and in public universities, and of increasing ratios in private sectarian and nonsectarian universities. The downward pressure on the faculty-student ratios seems most pronounced in the case of the public schools, both undergraduate and universities. Within each of the groups there is considerable variation in the faculty-student ratio. Our task in the subsequent sections will be to try to relate this variation—over time and within groups—to variation in institutional variables, and in the case of the universities, to changes in the undergraduate-graduate student mix.

3. UNDERGRADUATES AND GRADUATES: THE FIXED-COEFFICIENT MODEL AND ITS DIFFICULTIES

3.1. A Simple Fixed-Coefficient Model

It is generally believed that graduate students take up more faculty time, per student enrolled, than do undergraduates. In the language of activity analysis, we might say that the training of undergraduates and graduate students are two different "activities," with different (faculty) input coefficients. This suggests the simple linear relationship

(3.1) $$F = a_u U + a_g G$$

where, for a given institution, at a given date

F is the number of (full-time equivalent) faculty;

U, G are the numbers of enrolled (full-time equivalent) undergraduate

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a_u, a_g are the faculty input coefficients for undergraduate and graduate teaching, respectively.

If observations were available on a given school for several points of time, during a period in which the input coefficients remained constant but the ratio of undergraduate to graduate students was changing, then the input coefficients could be estimated from, say, a regression of F on U and G. Which particular regression would be appropriate would depend on the particular stochastic specification of the relationship (3.1). Alternatively, if observations were available at a given point of time on each of a set of schools believed to have common input coefficients, then the coefficients could be estimated from a "cross-section" regression.

The situation we are considering is illustrated in Figure 3.1, which is based on a simple transformation of equation 3.1 into a relationship involving student-faculty ratios. Define

$$U^* = \frac{U}{F} \qquad G^* = \frac{G}{F}$$

Then, dividing both sides of equation 3.1 by F gives

$$1 = a_u U^* + a_g G^* \tag{3.2}$$

All (nonnegative) pairs (U^*, G^*) satisfying (3.2) would lie on a single line, as in Figure 3.1. The line might be thought of as the "output transformation locus" per unit of teacher input. The slope of that line would equal the negative of the ratio (a_u/a_g), and the intercepts on the U^* and G^* axes would be $1/a_u$ and $1/a_g$, respectively. The figure represents a situation in which a_g is greater than a_u.

3.2. Problems in the Use of Time Series Data

Observations on a single school at different points of time would yield (U^*, G^*) pairs all lying on the same line, if the input coefficients remained constant during the period, and if there were neither "disturbances" in the input-output relationship nor errors in the measurement of the variables. However, suppose there were a time trend in the input coefficients. A smooth trend would produce a situation such as that illustrated in Figure 3.2. Successive solid lines in the figure represent different transformation loci, and correspond to successive pairs (a_u, a_g), but we have only one observation on each line (one observation for each point of time). In the situation depicted by the figure, the ratio of graduates to undergraduates (equal to G^*/U^*) is also increasing smoothly. The result is that observed (U^*, G^*) pairs appear to fall on a single (dotted) line, which corresponds to a (a_u, a_g) pair that is a very

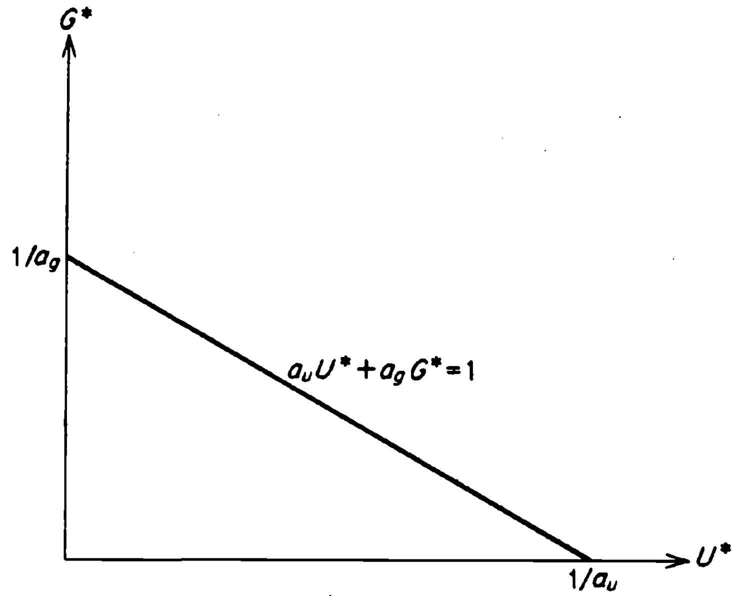

FIGURE 3.1 Locus of (U^*, G^*) Pairs for Constant Input Coefficients

poor (indeed biased) estimate of the true average (a_u, a_g) pair over the period of the observation.

Even if the input coefficients remain constant during the observation period, random disturbances (or errors of measurement) may obscure the underlying relationship. It is clear that for a given variability of the disturbances, the greater the variation in the undergraduate/graduate ratio, the easier it will be to estimate the input coefficients. This is illustrated in Figures 3.3a and 3.3b. In Figure 3.3a, the undergraduate/graduate ratio is practically constant over the observation period, and it is impossible to get a good estimate of the input coefficients (i.e. it is impossible to estimate the relationship 3.2). In Figure 3.3b, there is a great variation in the undergraduate/graduate ratio, so that the relationship can be reliably estimated in spite of the random disturbances.

Unfortunately, a school that is experiencing large changes in its undergraduate/graduate ratio is also likely to be experiencing "structural" or quality changes that will affect its input coefficients. Therefore, in the presence of random disturbances, we are likely to face a dilemma in which either the input coefficients are stable but we cannot estimate them, or they are not stable but we cannot identify the pattern of change.

FIGURE 3.2

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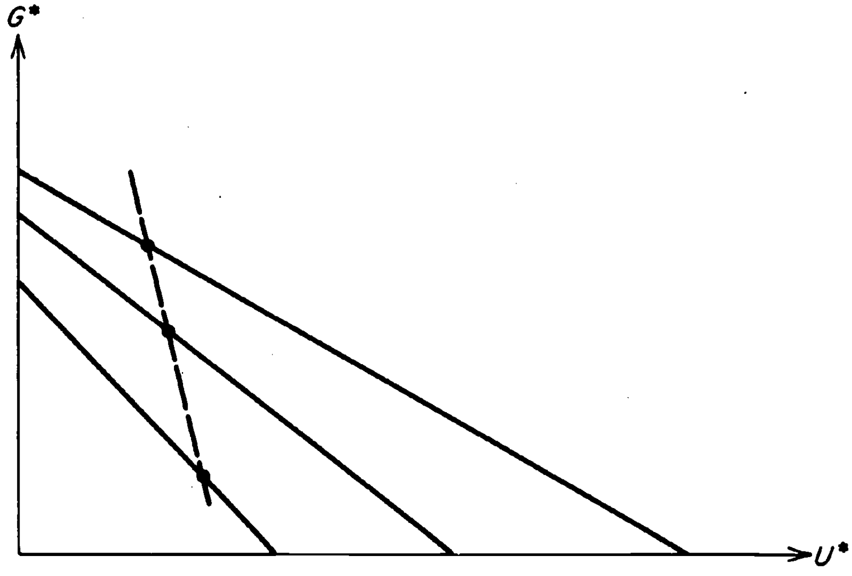


FIGURE 3.2 The Case of a Smooth Trend in the Input Coefficients

Examination of the data reveals that we are indeed faced with this dilemma, as I shall now show. First, note that for a least-squares fit of relation 3.2, the appropriate measure of stability (i.e. lack of variation) of the undergraduate/graduate ratio in a set of observations $[U^*(t), G^*(t)]$ is the coefficient

$$r = \frac{\Sigma U^*(t)G^*(t)}{[\Sigma U^*(t)^2 \Sigma G^*(t)^2]^{1/2}}$$

Note that r has the form of a correlation coefficient, except that the moments are around zero instead of around the means of the variables. if $r = 1$, then all of the pairs $[U^*(t), G^*(t)]$ lie on a common ray through the origin; the greater the variation of the undergraduate/graduate ratio in the sample, the closer will r be to zero.

In our sample of 113 universities, r ranged from 1.0 to .80, and was at least .88 in all but five cases. Figure 3.4 shows the scatter diagram of (U^*, G^*) observations for five selected universities, with r ranging from .88 to .999. In all but one of these cases (South Carolina State College), there is clearly no possibility of estimating the individual input coefficients from the observations. Even in the case of South Carolina State College, a line fitted to the four points would imply that the undergraduate faculty input coefficient is larger than the graduate

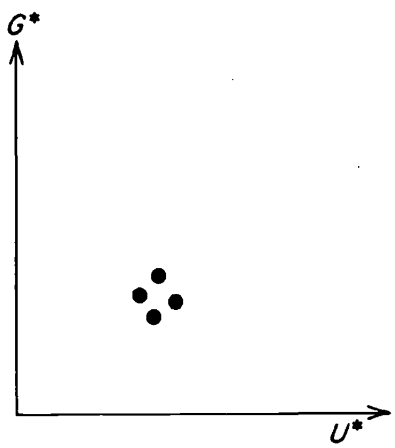


FIGURE 3.3a Small Variation in *U/G*

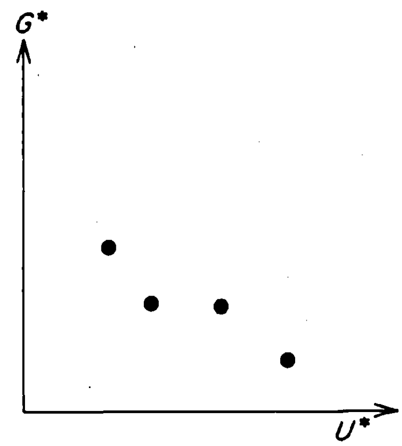


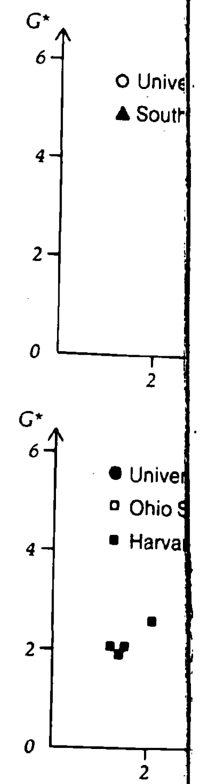
FIGURE 3.3b Large Variation in *U/G*

coefficient. These selected schools are typical, and an examination of the observations for the entire set of schools shows that in most of the cases there is no clear basis for estimating the input coefficients, either because the variation of the random disturbances is too large, or because there have been changes in the coefficients, or both. We are, of course, handicapped by the smallness of the sample, but even with more observations during this twelve-year period, it seems unlikely that reliable estimation would be feasible.

3.3. Problems with the Use of Cross-Section Data

As already noted in Section 3.1, one could estimate equation 3.1 or 3.2 from a cross section of universities at a given point of time, provided one had a set of institutions that were approximately homogeneous with respect to input coefficients.

For this purpose, we looked at the Higher Education General Information Survey (HEGIS) data for the year 1966. Our sample included 55 public universities and 38 private universities. (A number of universities covered by HEGIS were eliminated from our sample because they did not have substantial "standard" graduate programs or because data on other variables, used in the analysis discussed in Section 4, were not available. For definitions of the data and sources, see Chapter 7, *Demand and Supply in U.S. Higher Education.*)



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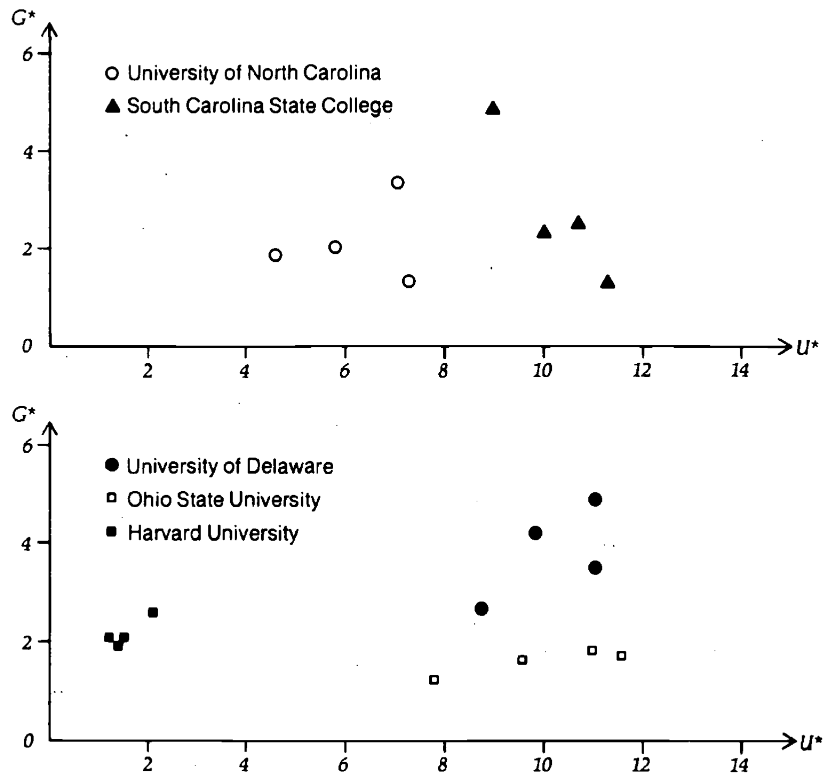


FIGURE 3.4 Scatter Diagrams of ($U^*(t), G^*(t)$) Pairs for Five Selected Universities, for t = 1950, 1954, 1958, 1962

To see how well the data might fit equation 3.2, we plotted a scatter diagram of (U^*, G^*) pairs for each of the two groups of universities, public and private. (Recall that $U^* = U/F$ and $G^* = G/F$.) The two scatter diagrams are shown in Figures 3.5a and 3.5b, respectively. Figure 3.4 reveals tremendous variation in the pairs (U^*, G^*), even among institutions with the same undergraduate/graduate student ratio. (Recall that institutions with the same U/G ratio will lie on the same ray through the origin.) It is clear that equation 3.2 does not fit either of the scatter diagrams (with a line like that of Figure 3.1).

Of course, one expects the input coefficients to vary among institutions and to be related more or less to various institutional characteristics. This is confirmed in a rough and informal way by an examination of Figure 3.4. In each half of the figure, if we compare those institutions at

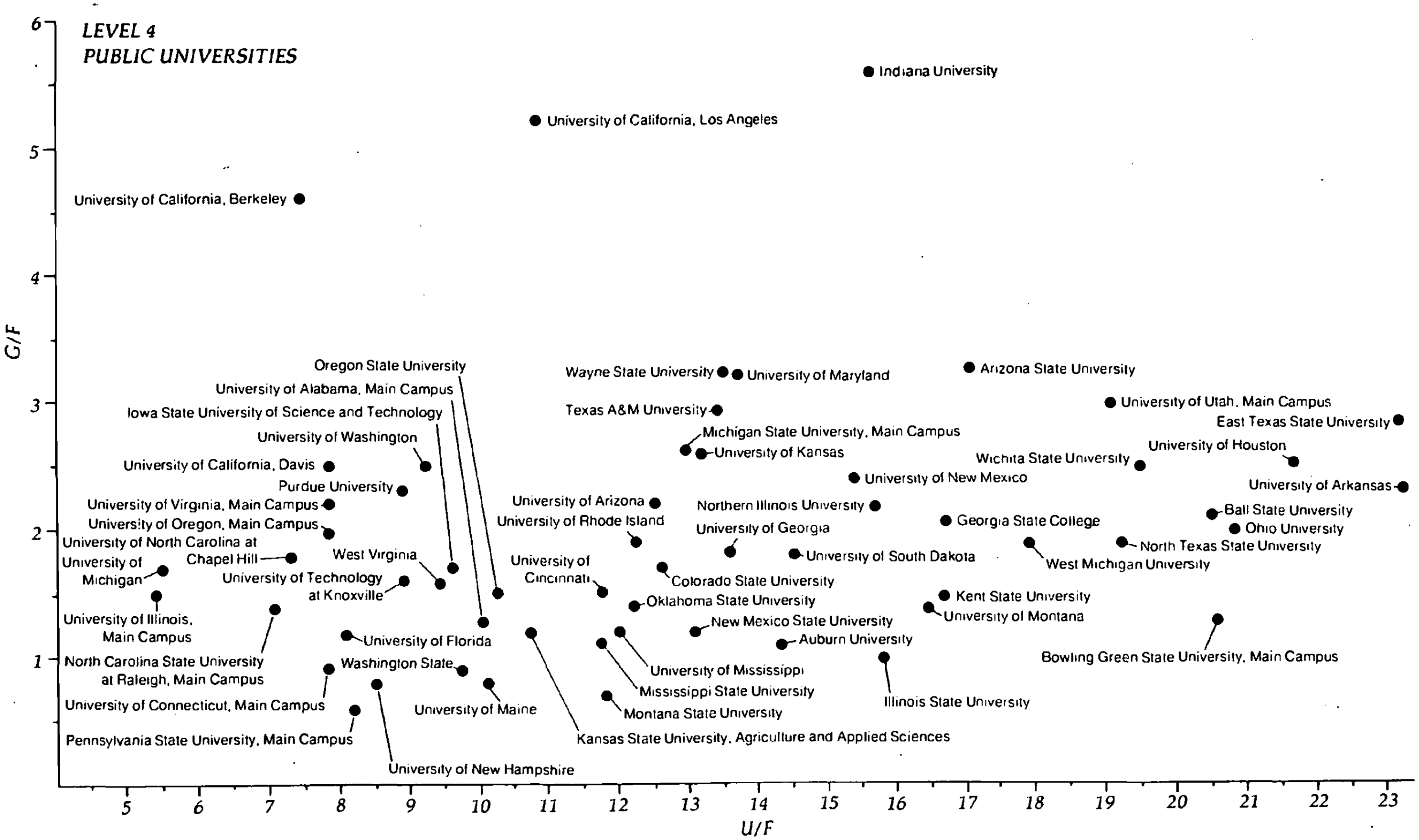
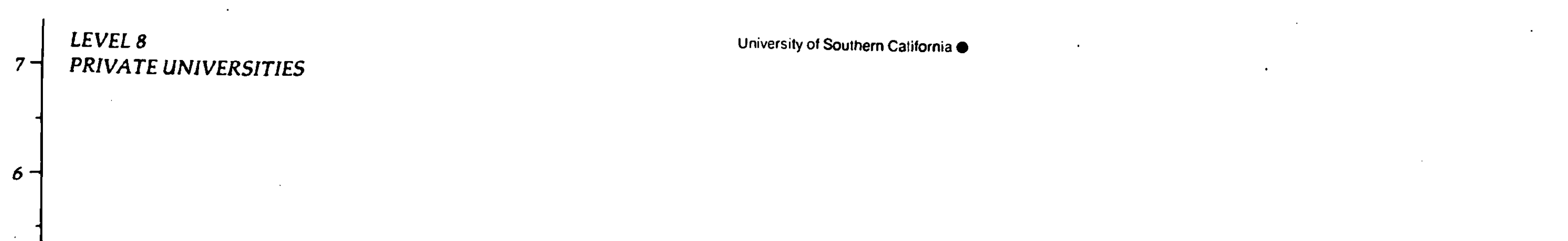


FIGURE 3.5a Scatter Diagram of (*U/F*, *G/F*) for Public Universities



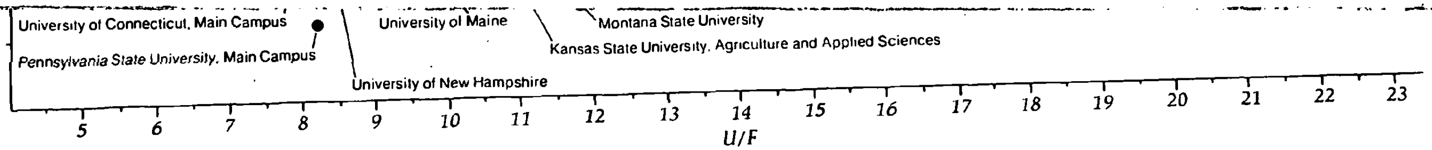


FIGURE 3.5a Scatter Diagram of (*U/F*, *G/F*) for Public Universities

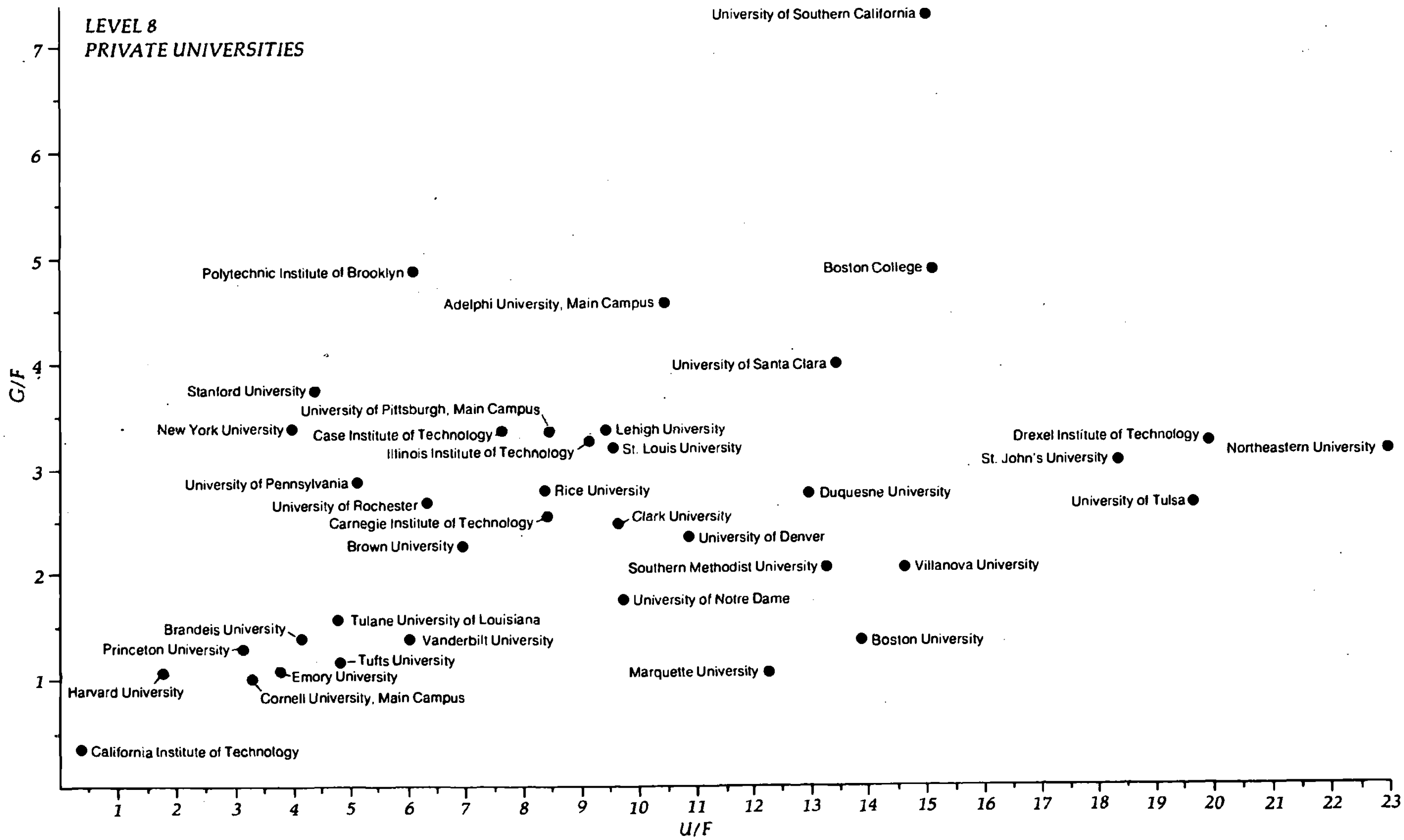


FIGURE 3.5b Scatter Diagram of (*U/F*, *G/F*) for Private Universities

or near the "southwest" boundary of the scatter diagram with those near the "northeast" boundary, we find that the first set has a higher concentration of "prestige" institutions than the second. An attempt to relate the input coefficients to other institutional variables will be described in the next section.

4. THE RELATIONSHIP BETWEEN INPUT COEFFICIENTS AND OTHER VARIABLES: A CROSS-SECTION ANALYSIS

4.1. A Variable Input Coefficient Model

In the previous section, we saw that variations in student-faculty ratios were far from explained by variations in the undergraduate–graduate-student mix, but that for schools with the same mix the ratios appeared to be related to other school characteristics. In the context of the activity analysis model, this could be expressed by saying that the "crude" numerical input-output coefficients, in terms of numbers of faculty, undergraduates, and graduates, depend on the "quality" of the inputs and outputs, and possibly on other school characteristics as well. Why not try to relate these input-output coefficients directly to these other variables?

Unfortunately, there are few, if any, accepted measures of the quality of inputs and outputs, nor do we have available data on many of the more promising measures. However, many people have found it reasonable to suppose that institutions with the same average faculty salaries, the same per cent of faculty with the Ph.D. degree, and so on, tend to have the same quality of inputs and outputs, or at least that the variation in quality among institutions that are similar in these characteristics is less than among the set of all institutions.

Consider again the linear relationship 3.1,

$$F = a_u U + a_g G$$

where F, U, and G represent the full-time-equivalent numbers of faculty, undergraduate students, and graduate students, respectively. For each institution, let W and Z be two vectors of measurements of institutional characteristics (there may be some characteristics common to both vectors), and assume that the input coefficients are related to these characteristics, as follows:

(4.1) $$a_u = h_0 + h \cdot W, \qquad a_g = k_0 + k \cdot Z$$

where h_0 and

(4.2) $h \cdot W = \sum_j h$

(4.3) $k \cdot Z = \sum_j k_j$

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where h_0 and k_0 are parameters, h and k are vectors of parameters, and

$$h \cdot W = \sum_j h_j W_j, \qquad (4.2)$$

$$k \cdot Z = \sum_j k_j Z_j \qquad (4.3)$$

Combining equations 4.1 and 4.2, and adding a constant term c, yields the equation:

$$F = c + (h_0 + h \cdot W)U + (k_0 + k \cdot Z)G \qquad (4.4)$$

The constant term, c, if different from zero, could reflect the presence of increasing or decreasing returns to scale (if c is positive or negative, respectively). An alternative measure of returns to scale could be obtained by setting $c = 0$ but including a measure of "size" in the vectors W and Z.

Finally, it should be noted that equation 4.4 could be applied to purely undergraduate institutions to examine how variation in faculty student ratio (a_u) is related to institutional characteristics.

Equation 4.4 can easily be fitted by least squares, since the equation is linear in the parameters to be estimated. However, if the vectors W and Z contain measurements in common, problems of multicollinearity may arise (they may, and do, arise in any case, for other reasons!).

For the components of the vector W we have taken the variables

PHD = fraction of the faculty holding a Ph.D. degree
SAL = average faculty salary
U = undergraduate

For the components of the vector Z we have taken

$QUAL$ = measure of the quality of the graduate program (see below)
SAL = average faculty salary
G = graduate

The variable $QUAL$ is an index derived from two measures: (1) an overall index derived from the departmental ratings in the 1966 American Council on Education report on quality of graduate education in the United States, the so-called Cartter Report,[3] and (2) the numbers of Woodrow Wilson and National Science Foundation Fellows electing to go to a given institution. Unfortunately, we were not able to obtain a comparable measure of quality of undergraduate programs.

With these "explanatory variables," equation 4.4 takes the form

$$F = c + h_0U + h_1(SAL)(U) + h_2(PHD)(U) + h_3U^2 + k_0G + k_1(SAL)(G) + k_2(QUAL)(G) + k_3G^2 \qquad (4.5)$$

In the regressions that we shall report, two restrictions were imposed. First, we did not include both the constant term, c, and the size variables, U^2 and G^2, in the same regression. Second, we found that the two variables $(SAL)(U)$ and $(SAL)(G)$ were too highly correlated to permit reliable estimation of their coefficients separately; therefore, we imposed the restriction that $h_1 = k_1$, which is equivalent to replacing the two above variables by the single variable $(SAL)(STUD)$, where $STUD = U + G$.

4.2. The Sample

For our cross-section analysis, we used a sample of institutions for which HEGIS data were available for the year 1966. These institutions were grouped in a two-way classification, by "control" (public or private) and by "highest degree granted" (two year, bachelor's, master's, Ph.D.). Actually, for the second classification we use the following corresponding terms: two year, four year, M.A., Ph.D. (or university). For all institutions except the universities, "private" means "private nonsectarian." The "private universities" include both nonsectarian universities and those sectarian universities that did not have primarily religious programs of education. We did not include all institutions of higher education covered by the HEGIS data. In particular, we did not include: (1) institutions with less than 300 undergraduates, (2) institutions beyond the two-year level that were very specialized or were primarily vocational, (3) institutions for which the data on some of our variables were missing or were obviously in error. In some cases we supplemented our main body of data with material from other sources. Finally, the category "private four year" was divided into two groups, according to whether the average faculty salary was above or below $8,000 per year.

Table 4.1 shows the classification of institutions and the number of institutions in each category.

The variables used were those described in Section 4.1. They are listed here again, together with the corresponding scaling factors, where applicable. (See Chapter 7, *Demand and Supply in U.S. Higher Education*.)

TABLE 4.1 Classification and Numbers of Institutions

	Two Year	Four Year		M.A.	Ph.D.
Public	185	51		134	55
Private	34	44[a]	47[b]	62	38

[a] Average salary less than $8,000.
[b] Average salary greater than or equal to $8,000.

F Full-tim
U Full-tim
G Full-tim
$STUD$ $U + G$
PHD Fraction
$QUAL$ An inde
SAL Average

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F	Full-time-equivalent number of faculty, $\times 10^{-2}$
U	Full-time-equivalent number of undergraduates, $\times 10^{-3}$
G	Full-time-equivalent number of graduate students, $\times 10^{-3}$
$STUD$	$U + G$ ($STUD = U$ for levels 1, 5, 2, and 6)
PHD	Fraction of the faculty who hold Ph.D. degrees
$QUAL$	An index of quality of the graduate program (see Section 4.1)
SAL	Average nine-month (or nine-month equivalent) faculty salary, $\times 10^{-4}$

Tables 4.2 and 4.3 show the means and standard deviations, respectively, of the variables for each level. The statistics for the mean faculty-student ratios are also shown. In interpreting these statistics, the reader must keep in mind the scaling factors. In addition, in comparing the mean faculty-student ratios with those reported in Table 2.1, one must keep in mind that Table 4.2 gives the means of faculty-student ratios for individual institutions, whereas the ratios reported in Table 2.1 are ratios of total faculty to total students in a given category of institution. We see that the mean faculty-student ratios for 1966 in Table 4.2 are generally lower than the *corresponding* ratios for 1962 reported in Table 2.2, thus suggesting an extension of the downward trend. On the other hand, the fact that the mean ratios for 1966 are generally higher than the (total) ratios for 1967 reported in Table 2.1 is probably more a reflection of the difference in the method of averaging than a reflection of any trend (although other information suggests that the downward trend has indeed continued beyond 1966).

4.3. Results of the Regression Analyses for the Undergraduate and Master's Level Institutions

For each of the categories other than the two Ph.D. levels (public and private universities), we fitted by least squares the following two regression equations:

$$F = h_0 STUD + h_1(SAL)(STUD) + h_2(PHD)(STUD) + h_3(STUD)^2 \quad (4.6)$$

$$F = c + h_0 STUD + h_1(SAL)(STUD) + h_2(PHD)(STUD) \quad (4.7)$$

Generally, we found that the specification without the constant term (4.6) gave a slightly better fit, although the differences in fit were not very great. In each category, the fit was quite good; in the set of seven categories the multiple correlation (R^2) ranged between .904 and .986.

In Table 4.4 the estimates of the regression coefficients are given for specification 4.6. In order to conserve space, we have reported only one set of estimates for each category of institution. In selecting the set of estimates to present for each particular category, we restricted ourselves to specifications that included only "explanatory" variables yielding

TABLE 4.2 Sample Means

	Level	*F* ($\times 10^{-2}$)	*U* ($\times 10^{-3}$)	*G* ($\times 10^{-3}$)	*STUD* ($\times 10^{-3}$)	*F/STUD* ($\times 10$)	*PHD*	*QUAL*	*SAL* ($\times 10^{-4}$)
1.	Public two year	0.935	2.213	0.	2.213	0.489	.041	–	0.835
5.	Private two year	0.464	0.842	0.	0.842	0.661	.039	–	0.715
2.	Public four year	0.963	1.849	0.	1.849	0.556	.243	–	0.815
6L.	Private four year	0.566	0.972	0.	0.972	0.634	.263	–	0.705
6H.	Private four year	0.747	1.091	0.	1.091	0.783	.447	–	0.951
3.	Public M.A.	2.382	3.891	0.359	4.249	0.588	.356	–	0.924
7.	Private M.A.	1.379	1.872	0.166	2.038	0.753	.457	–	0.937
4.	Public Ph.D.	10.085	11.290	1.909	13.200	0.742	.513	.581	1.048
8.	Private Ph.D.	9.027	5.869	1.998	7.869	1.492	.589	.896	1.121

NOTE: Figures in parentheses under variable names indicate the scaling factors.
SOURCE: Higher Education General Information Survey, 1966.

TABLE 4.3 Sample Standard Deviations

Level	F ($\times 10^{-2}$)	U ($\times 10^{-3}$)	G ($\times 10^{-3}$)	STUD ($\times 10^{-3}$)	F/STUD ($\times 10$)	PHD	QUAL	SAL ($\times 10^{-4}$)
1. Public two year	0.864	2.549	0.000	2.549	0.131	0.055	–	.154
5. Private two year	0.265	0.601	0.000	0.601	0.294	0.063	–	.096
2. Public four year	0.591	1.355	0.000	1.355	0.115	0.102	–	.134
6L. Private four year	0.264	0.578	0.000	0.578	0.146	0.106	–	.086
6H. Private four year	0.336	0.883	0.000	0.883	0.192	0.182	–	.170
3. Public M.A.	1.752	2.548	0.607	2.989	0.193	0.126	–	.128
7. Private M.A.	0.842	1.286	0.281	1.455	0.287	0.173	–	.138
4. Public Ph.D.	7.370	5.161	1.610	6.583	0.253	0.079	.602	.075
8. Private Ph.D.	9.340	3.965	1.974	5.334	2.669	0.146	.662	.175

NOTE: Figures in parentheses under variable names indicate the scaling factors.
SOURCE: Higher Education General Information Survey, 1966.

TABLE 4.4 Regressions for Nonuniversity Groups

Level	*STUD* times[a]: 1	*STUD* times[a]: *SAL*	*STUD* times[a]: *PHD*	*STUD* times[a]: *STUD*	n	R^2	a^*_{STUD}[b]
1. Public two year	.667	−.197		−.013	185	.956	.446
	(.00)	(.00)		(.00)			
5. Private two year		1.062	−1.443	−0.126	34	.904	.491
		(.00)	(.04)	(.00)			
2. Public four year	.291	.279	.336	−0.028	51	.986	.496
	(.00)	(.05)	(.02)	(.00)			
6L. Private four year, *SAL* < $8,000	.760			−0.137	44	.967	.496
	(.00)			(.00)			
6H. Private four year, *SAL* > $8,000	1.075	−.495	.657	−.101	47	.979	.677
	(.00)	(.00)	(.00)	(.00)			
3. Public M.A.	.174	.435		−.006	134	.969	.525
	(.03)	(.00)		(.04)			
7. Private M.A.		.394	.852	−.022	62	.947	.668
		(.00)	(.00)	(.03)			

[a] For items where two numbers appear, the upper number is the regression coefficient for the corresponding variable in the regression equation

$$F = h_0 STUD + h_1(SAL)(STUD) + h_2(PHD)(STUD) + h_3(STUD^2)$$

The number in parentheses is the significance level of the coefficient. For two-year and four-year colleges, "*STUD*" means undergraduates only. For M.A.-granting colleges, $STUD = U + G$. All variables are scaled as in Table 4.2.

[b] a^*_{STUD} is the derivative of the regression equation with respect to *STUD*, evaluated at the sample means of the explanatory variables.

statistically significant coefficients, and among such specifications we chose the one that gave the best fit. Since the correlations between some of the explanatory variables were rather high, we had in some instances problems of multicollinearity; these problems are discussed in Section 4.5, where we also present some examples of regressions with coefficients that are statistically not significant. In any case, in none of the specifications reported in Table 4.4 could the fit be significantly improved by adding more variables.

Table 4.4 also shows the corresponding estimates a^*_{STUD} of the derivative of the regression equations with respect to the variable *STUD*, i.e. $a^*_{STUD} = dF/dSTUD$; this derivative has been evaluated at the sample means of the explanatory variables. Thus a^*_{STUD} is the "marginal input coefficient." Notice that a^*_{STUD} is not in general equal to the input coefficient, a_{STUD}, since the input coefficient itself depends on the variable *STUD*. Indeed, since (by Section 4.1)

$$\begin{aligned} a_{STUD} &= h_0 + h_1 SAL + h_2 PHD + h_3 STUD \\ a^*_{STUD} &= h_0 + h_1 SAL + h_2 PHD + 2h_3 STUD \end{aligned} \tag{4.8}$$

the two coefficients are related by

$$a^*_{STUD} = a_{STUD} + h_3 STUD$$

We see from Table 4.4 that h_3, the coefficient of $STUD^2$, is significant in every case, and negative. This indicates that in each of the nonuniversity categories there was a measurable effect of *increasing returns to scale* to the faculty input. We see, too, that this effect was more pronounced in the case of the private institutions than in the case of the public ones. This is no doubt related to the fact that the average enrollments in the public groups were consistently higher than those in the corresponding private groups (see Table 4.2).

If we compare the marginal input coefficients of Table 4.4 with the mean faculty-student ratios of Table 4.2, we see that the marginal coefficients are consistently lower than the average coefficients. This is, of course, consistent with the effect of increasing returns to scale. The ranking of the 7 nonuniversity groups is roughly the same by the marginal as by the average coefficients, but the exceptions to this are revealing. Table 4.5 gives the two rankings, with the number "1" corresponding to the largest coefficient. The most obvious discrepancies in the two rankings occur in the case of the private two-year and the public M.A. groups. Table 4.2 shows, however, that these two groups have the lowest and highest mean enrollments, respectively, of the seven groups. Thus it would appear that, although the private two-year institutions have relatively low marginal input coefficients, their average coefficient is high because of their small average size. An analogous, but reverse, argument would seem to apply to the public M.A. group.

[a] For items where two numbers appear, the upper number is the regression coefficient for the corresponding variable in the regression equation

$F = h_0 STUD + h_1(SAL)(STUD) + h_2(PHD)(STUD) + h_3(STUD^2)$

The number in parentheses is the significance level of the coefficient. For two-year and four-year colleges, "*STUD*" means undergraduates only. For M.A.-granting colleges, $STUD = U + G$. All variables are scaled as in Table 4.2.

[b] a^*_{STUD} is the derivative of the regression equation with respect to *STUD*, evaluated at the sample means of the explanatory variables.

TABLE 4.5 Rankings of Nonuniversity Groups by Marginal and Average Input Coefficients

Level	Ranking by Marginal Input Coefficient	Ranking by Average Input Coefficient
Public two year	7	7
Private two year	6	3
Public four year	4–5	6
Private four year: low salary	4–5	4
Private four year: high salary	1	1
Public M.A.	3	5
Private M.A.	2	2

Before studying the "effects" of salary and per cent of faculty with the Ph.D., it might be useful to speculate on some a priori models. The first, which might be called the "prestige model," postulates that high faculty-student ratios, high salaries, and high percentage of faculty with the Ph.D. are all trappings of a high-prestige institution, so that one would expect the coefficients h_1 and h_2 to be positive. The second model, which might be called the "substitution model," postulates that salary and per cent Ph.D. are measures of "quality," and that quality of faculty inputs can be substituted for quantity, so that one would expect h_1 and h_2 to be negative. Of course, in the "substitution model" one would want to control for the quality of output, which we have not been able to do here.

Table 4.4 does not show any consistency among the groups in the signs of h_1 and h_2. Public four-year, private M.A., and (in part) public M.A. institutions seem to follow the "prestige model," whereas the two-year and the high-salary private four-year institutions show evidence of "substitution," with respect to one of the variables. It should be pointed out that most of the so-called high-prestige liberal arts colleges fall into the private M.A. group, since they typically give some beginning graduate work. The low-salary private four-year institutions do not show a significant effect of either salary or per cent Ph.D. on the input coefficient.

4.4. Results of the Regression Analyses for the Universities

For each of the two university categories we fitted by least squares the following two regression equations:

$$(4.9) \quad F = h_1(SAL)(U + G) + h_0U + h_2(PHD)(U) + h_3U^2 + k_0G + k_2(QUAL)(G) + k_3G^2$$

$$(4.10) \quad F = c + h_1(SAL)(U + G) + h_0U + (PHD)(U) + k_0G + k_2(QUAL)(G)$$

Again, we found in general that the specification without the constant term (4.9) gave a slightly better fit. The fits for the universities were not quite as good as those for the other groups, but were still quite good.

In Table 4.6 the estimates of the regression coefficients are given for specification 4.9. For each group, we have given more than one set of estimates in order to illustrate some of the problems that we face.

Recall that for the case of the universities, one of the tasks we set ourselves was to estimate the separate effects of U and G on the numbers of faculty. Thus we aim not only to get a good "fit," but also to get reasonable estimates of the marginal input coefficients a^*_u and a^*_g. (See Sections 3 and 4.1. The marginal input coefficients are defined just as in equation 4.8.)

Examination of Table 4.6 shows that, although each regression equation shown gives a reasonably good fit, not all the specifications lead to sensible values for the marginal input coefficients. For example, the second specification for each of the two groups is the same as equation 3.1, i.e.

$$(4.11) \quad F = a_uU + a_gG$$

The resulting estimates of a_u and a_g are reasonable for the public universities, but not for the private universities. The first specification for each of the two groups does lead to reasonable estimates of the marginal input coefficients:

	a^*_u	a^*_g
Public universities	.596	1.166
Private universities	.575	1.983

However, one would have expected a^*_u to be larger for the private than for the public universities; it is generally believed that classes are smaller and teaching loads are lighter in private universities than in public universities. These faculty input coefficients for undergraduate education are somewhat smaller than the coefficients for the private M.A. and high-salary private four-year groups, but larger than those for the other groups. It should be emphasized that the data on "faculty" did not include teaching assistants, teaching associates, or teaching fellows; to that extent the input coefficients underestimate the instructional inputs. On the other hand, the data for "faculty" include faculty in organized research units.[4]

We do not find evidence of significantly increasing returns to scale in either undergraduate or graduate education at the mean values of the

TABLE 4.6 Regressions for the Universities

Level	U times: 1	U times: SAL	U times: PHD	U times: U	G times: 1	G times: SAL	G times: QUAL	G	n	R^2	a^*_u	a^*_p
4. Public Ph.D.		.569 (.00)				.569 (.00)	.982 (.00)		55	.907	.596	1.166
	.497 (.00)				2.330 (.00)				55	.887	.497	2.330
8. Private Ph.D.		.513 (.00)				.513 (.00)	1.572 (.00)		38	.782	.575	1.983
	.217 (.45)				3.416 (.00)				38	.702	.217	3.416
		2.395 (.00)	−3.358 (.01)	−0.039 (.09)		2.395 (.00)			38	.808	.249	2.685

NOTE: The regression equation is given by 4.9. Numbers in parentheses are significance levels. See Table 4.4 for other explanatory notes.

explanatory variables (except in the case of the third regression for the private universities, which does not in any case yield sensible values of the input coefficients). The universities, of course, have much larger enrollments, on the average, than do the other groups (see Table 4.2).

If we accept the first regression in each of the two university groups as valid, then the universities appear to fit the "prestige model" quite well. The variable *QUAL* represents the combined judgments of faculty peers and prospective graduate students concerning the "quality of the faculty in graduate programs," and therefore would seem to be a measure of the quality of faculty input. (It should not be necessary to insist here on the uncertainties surrounding the meaning of this measure!)

4.5. An Analysis of Elasticities

Although the regression coefficients discussed in Sections 4.3 and 4.4 give a fairly good qualitative idea of the relationships between the input coefficients and the "explanatory" variables, it is difficult to interpret their numerical magnitudes. For this reason we calculated the *elasticities* of the input coefficients with respect to each explanatory variable in the appropriate regression equation. Recall that the elasticity of an input coefficient, say a, with respect to a variable, say X, is defined by:

$$\text{elasticity} = \frac{d\log a}{d\log X} = \frac{X}{a} \cdot \frac{da}{dX} \tag{4.12}$$

Thus, for small changes, the elasticity equals the percentage change in the input coefficient associated with a 1 per cent change in the explanatory variable.

Table 4.7 shows the elasticities of a^*_{STUD} with respect to the explanatory variables *SAL*, *PHD*, and *STUD* in the regression equations determined by the coefficients in Table 4.4, taking the estimates of a^*_{STUD} from the same table, and taking the variables at their sample means. Table 4.8 shows the corresponding elasticities for the two university groups, using the first regression for each group in Table 4.6.

In the nonuniversity groups, the elasticities of the input coefficients with respect to *STUD* are largest (in magnitude) for the private two- and four-year institutions, and lowest for the public M.A. and two-year institutions. Indeed, although the regression coefficient for *STUD* is statistically significant in the case of the public M.A. group, the corresponding elasticity is rather small in magnitude. It is interesting that with regard to the variable *PHD*, the private two-year group has the largest regression coefficient but the smallest elasticity (in magnitude). Generally, the elasticities with respect to *SAL* are larger in magnitude than those with respect to *PHD*.

TABLE 4.7 Elasticity, Coefficient of Variation, and Probable Per Cent Variation: Nonuniversity Groups

	Elasticity of a^*_{STUD} with Respect to:			Coefficient of Variation			Probable Per Cent Variation of a^*_{STUD} with Respect to:		
Level	*SAL*	*PHD*	*STUD*	*SAL*	*PHD*	*STUD*	*SAL*	*PHD*	*STUD*
1. Public two year	−0.368		−.129	.184		1.152	−.068		−.149
5. Private two year	1.546	−.114	−.432	.134	1.598	0.715	.207	−.182	−.309
2. Public four year	0.458	.165	−.209	.164	0.419	0.733	.075	.069	−.153
6L. Private four year			−.537			0.594			−.319
6H. Private four year	−0.695	.434	−.325	.178	0.408	0.809	−.124	.177	−.263
3. Public M.A.	0.766		−.097	.138		0.703	.106		−.068
7. Private M.A.	0.553	.583	−.134	.147	0.379	0.714	.081	.221	−.096

TABLE 4.8 Elasticity, Coefficient of Variation, and Probable Per Cent Variation: Universities

	Elasticity of:					Probable Per Cent Variation		
	a^*_u with Respect to	a^*_g with Respect to		Coefficient of Variation		a_u	a_g	
Level	*SAL*	*SAL*	*QUAL*	*SAL*	*QUAL*	*SAL*	*SAL*	*QUAL*
4. Public Ph.D.	1.000	.511	.489	.072	1.036	.072	.037	.507
8. Private Ph.D.	1.000	.290	.710	.156	0.739	.156	.045	.525

In the two university groups, the graduate input coefficient is about equally elastic with respect to *SAL* and *QUAL* in the public universities, but almost two and one-half times as elastic with respect to *QUAL* than *SAL* in the private universities.

Further insight into the relative importance of the explanatory variables can be obtained by taking account of the dispersion of the explanatory variables in the sample. To measure the relative dispersion of a variable we used the *coefficient of variation*, equal to the ratio of the standard deviation to the mean. For the nonuniversity groups (see Table 4.7), the overall picture is that *STUD* has the largest coefficients of variation, and *SAL* the smallest. In the universities, the coefficient of variation was considerably larger for *QUAL* than for *SAL*.

To "correct" the elasticities for differences in relative dispersion, we measure the "probable per cent variation," defined by

(4.13) probable per cent variation = (elasticity) × (coefficient of variation)

This last measure can be interpreted as an approximation to the per cent change in the input coefficient associated with a change in the explanatory variable equal to 1 per cent of its standard deviation. The figures for probable per cent variation are also given in Tables 4.7 and 4.8. It is interesting to note in Table 4.8 that, when measured by the probable per cent variation, the association of *QUAL* with the graduate input coefficient is considerably more "important" than that of *SAL*. Also, the probable per cent variation of the undergraduate input coefficient with respect to *SAL* is larger than that of the graduate input coefficient.

4.6. Multicollinearity and Other Specification Problems

The pattern of correlations among the variables is such that in many instances it is not evident which selection of explanatory variables is "best." Examples of this are shown in Table 4.9.

In the first example (private Ph. D.), the coefficient of (*STUD*)(*SAL*) is not very significant (statistically) when introduced in addition to (*G*)(*QUAL*); but if the variable (*U*)(*PHD*) is then introduced, the coefficient of (*STUD*)(*SAL*) becomes more significant, and the coefficient of (*G*)(*QUAL*) loses its significance. Similar problems arise in the other examples.

For each group of institutions, quite a few different regression specifications were tried. In choosing the ones we have presented here, we considered not only the criterion of goodness of fit, but also the plausi-

TABLE 4.9 Examples of the Effects of Multicollinearity

	U times:				G times:					
Level	1	SAL	PHD	U	1	SAL	QUAL	G	Constant Term	R^2
							2.574 (.00)		3.898 (.00)	

TABLE 4.9 Examples of the Effects of Multicollinearity

Level	*U* times: 1	*U* times: *SAL*	*U* times: *PHD*	*U* times: *U*	*G* times: 1	*G* times: *SAL*	*G* times: *QUAL*	*G* times: *G*	Constant Term	R^2
							2.574		3.898	
							(.00)		(.00)	
8. Private Ph.D. [a] (with constant term)		.372				.372	1.989		1.770	
		(.07)				(.07)	(.00)		(.29)	
		1.623	−3.199			1.623	.978		2.893	
		(.02)	(.06)			(.02)	(.17)		(.10)	.819
		.529				.529	1.891			
		(.00)				(.00)	(.00)			
8. Private Ph.D. [b] (without constant term)		1.459	−2.206			1.459	1.151			
		(.04)	(.17)			(.04)	(.11)			
		1.790	−2.319	−.028		1.790	.727			.811
		(.02)	(.16)	(.26)		(.02)	(.36)			
	.406								.171	
	(.00)								(.00)	
6L. Private B.A. [c]	.189	.283							.183	
	(.32)	(.25)							(.00)	
	.203	.241	.107						.173	.965
	(.44)	(.34)	(.49)						(.00)	
		1.004			−4.432	1.004	2.375			
4. Public Ph.D. [d]		(.00)			(.00)	(.00)	(.00)			
	1.149	−.094			−3.441	−.094	2.809			.928
	(.06)	(.87)			(.02)	(.87)	(.00)			

NOTE: See Table 4.4 for other explanatory notes.
[a] Correlation between (*G*)(*QUAL*) and (*U*)(*PHD*) is .398.
[b] Correlation between (*STUD*)(*SAL*) and (*U*)(*PHD*) is .913, and between U^2 and (*G*)(*QUAL*) is .202.
[c] Correlation between *U* and (*U*)(*SAL*) is .986.
[d] Correlation between *U* and (*STUD*)(*SAL*) is .976.

bility of the resulting estimates of the input coefficients. We have already alluded to this in the discussion of the regression estimate of equation 4.11.

One may wonder how it is that the regression estimate of 4.11 for the public universities could give plausible results, whereas the scatter diagram in Fig. 3.5a is so diffuse. Related to this is the fact that regressions of *F/STUD* on the other variables invariably gave poor fits (for all groups of institutions). This suggests that, in the regressions in which *F* is the independent variable, those institutions in each group that have relatively large numbers of faculty and students may have a "disproportionate" influence on the results. However, we have not yet sufficiently explored this problem to come to a conclusion.

Finally, we should mention that treating undergraduate and graduate students separately in the M.A.-level institutions did not give good results. It would appear that in this group of institutions, it is not possible, with these data, to obtain reliable estimates of a_u and a_g separately.

NOTES

1. Alexander W. Astin, "Undergraduate Achievement and Institutional 'Excellence,'" *Science* 161 (Aug. 16, 1968): 661–667.
2. *American Universities and Colleges* (Washington, D.C.: American Council on Education, 1952, 1956, 1960, 1964). Numbers for faculty and students are "head counts," and not full-time equivalents.
3. Allan M. Cartter, *An Assessment of Quality in Graduate Education* (Washington, D.C.: American Council on Education, 1966).
4. Variations in reporting practice prevented us from excluding research faculty in any consistent manner. Thus our faculty figures reflect the "research style" of each institution.

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10 COMMENTS

Gus Haggstrom

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Roy Radner's paper provides an admirable study of faculty-student ratios over the period 1950–67, together with an enlightening cross-sectional analysis of the 1966 institutional data in which he attempts to explain the variation in these ratios among institutions in terms of other variables.

In reporting the behavior of faculty-student ratios over time, Radner begins by presenting Table 2.1, which contains his estimates of faculty-student ratios by institutional category for the years 1957, 1963, and 1967. The table suggests that faculty-student ratios have been dropping rather consistently between 1957 and 1967 in all categories except the private universities.

This table is of particular interest to me because of its relevance to projecting the future demand for college teachers and because of the uncertainties involved in estimating the ratios from the available data. As Radner points out, the data published by the Office of Education both on enrollments and on numbers of faculty lack year-to-year comparability, so that his estimates may be subject to considerable error. Having recently attempted to construct a similar table from the same sources, I understand his misgivings about the reliability of the estimates. The 1966 and 1967 Office of Education surveys on numbers of faculty seem almost to have been designed to frustrate attempts to compare them with the notably consistent biennial surveys up to 1963. My estimates of faculty-student ratios for the period 1957–67 are given in Table 1. The estimates in parentheses in Table 1 were derived independently by June O'Neill and were published in her book *Resource Use in Higher Education* (Berkeley, Calif.: Carnegie Commission on Higher Education, 1971).

Although the sets of estimates are not strictly comparable because of differences in our definitions (in particular, June O'Neill's estimates of FTE faculty include junior faculty), the time trends for my estimates tend to confirm Radner's calculations for the four-year colleges. On the other hand, whereas Radner's estimates show a steep decline in the faculty-student ratios for the two-year colleges between 1963 and 1967, my estimates show a slight increase, and June O'Neill's estimates show a substantial increase in faculty-student ratios for the public two-year institutions between 1963 and 1966.

Tables 2 through 4 provide some background information for analyzing the behavior of the faculty-student ratios over time. From Table 2, which shows the number of institutions within each category, we note that the number of public two-year institutions increased by 73 per cent between 1957 and 1967, despite the fact that many two-year colleges became four-year institutions during this period. Thus, the category of public two-year institutions

TABLE 1 Faculty-Student Ratios by Institutional Category, Aggregate U.S., 1957–67

	Universities		Other Four-year Colleges		Two-Year Colleges	
	Public	Private	Public	Private	Public	Private
1957	.083 (.086)	.095 (.101)	.067 (.067)	.079 (.081)	.049 (.048)	.066 (.075)
1959	.078	.096	.063	.078	.049	.058
1961	.074 (.083)	.100 (.111)	.059 (.061)	.074 (.077)	.049 (.045)	.053 (.059)
1963	.070 (.080)	.105 (.114)	.058 (.060)	.074 (.078)	.048 (.045)	.054 (.060)
1966	.063 (.079)	.091 (.118)	.057 (.060)	.070 (.076)	.048 (.050)	.058 (.058)
1967	.064	.089	.056	.069	.049	.058
Per cent change 1957–67	−23	−6	−16	−13	0	−12

included a high proportion of new campuses which had not yet had an opportunity to achieve a degree of efficiency through experience in faculty utilization and economies of scale. Incidentally, the counts of the two-year colleges do not include the many two-year branch campuses of universities. The faculty and students in the two-year branches are included in the calculation of the faculty-student ratios for the universities.

Table 3 suggests one reason why the faculty-student ratios for the private universities have behaved differently from those of the other categories. The private institutions had a much higher proportion of graduate students in 1957, and in absolute terms they have shown the largest increase in the proportion of graduate students between 1957 and 1967.

On the other hand, Table 4 shows that the private universities have shown

TABLE 2 Number of Institutions within Each Institutional Category, Aggregate U.S., 1957–67

	Universities		Other Four-Year Colleges		Two-Year Colleges	
	Public	Private	Public	Private	Public	Private
1957	82	59	286	969	302	241
1959	82	59	290	1,009	332	243
1961	83	60	293	1,022	348	238
1963	88	58	299	1,058	377	260
1966	92	65	313	1,112	479	276
1967	93	64	323	1,113	522	267
Per cent change 1957–67	13	8	13	15	73	11

TABLE 3 Ratio Enroll Enroll 1957-

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TABLE 3 Ratio of Full-Time Equivalent Graduate Resident Enrollment to Total Opening Fall Full-Time Equivalent Enrollment by Institutional Category, Aggregate U.S., 1957–67

	Universities		Other Four-Year Colleges		Two-Year Colleges	
	Public	Private	Public	Private	Public	Private
1957	.099	.152	.038	.029	–	–
1959	.114	.170	.042	.033	–	–
1961	.120	.175	.047	.034	–	–
1963	.118	.194	.052	.036	–	–
1966	.140	.222	.052	.042	–	–
1967	.148	.221	.057	.044	–	–
Per cent change 1957–67	49	45	50	52	–	–

the smallest rate of increase in average total enrollment per institution between 1957 and 1967. According to my estimates, among the private universities almost 40 per cent of the increase in full-time equivalent enrollment per institution was at the graduate level.

Since the behavior of faculty-student ratios derived from aggregate totals for institutional categories may be distorted by the inclusion of new institutions and changes in institutional classification (say, from two-year to four-

TABLE 4 Average Full-Time Equivalent Enrollment per Institution (Ratio of Aggregate Full-Time Equivalent Enrollment to Number of Institutions in the Category), Aggregate U.S., 1957–67

	Universities		Other Four-Year Colleges		Two-Year Colleges	
	Public	Private	Public	Private	Public	Private
1957	8,600	6,330	1,720	620	930	270
1959	9,310	6,600	2,020	660	950	300
1961	10,570	7,000	2,310	740	1,080	350
1963	12,400	7,500	2,710	790	1,260	360
1966	16,020	8,300	3,660	920	1,680	440
1967	17,050	8,690	3,950	950	1,770	470
Per cent change 1957–67	98	37	130	53	90	74

year or from private to public control), it is important to supplement them by longitudinal studies of individual institutions. Radner has done this for 372 institutions for which he has relatively complete data for the years 1950 to 1962. (See Table 2.2.) The institutions in his sample constituted only about one-sixth of all institutions listed in the *Higher Education Directory* of the Office of Education in 1962 and, as Radner points out, they surely do not constitute a representative sample. Nevertheless, the conclusions seem clear. There was a sharp reduction in the aggregate faculty-student ratios at the primarily undergraduate institutions throughout the period. There was a smaller but consistent drop in these ratios for the public universities, and there was a relatively consistent increase in the ratios for the private universities.

It is regrettable that the time period covered by Table 2.2 ends in 1962, and I hope that Radner will attempt to update his study soon to include data for the late 1960s. A comparison of this table with my Table 4 on the average FTE enrollment per institution suggests that the decreases in the faculty-student ratios between 1950 and 1962 are approximately proportional to the increases in average enrollment per institution. Thus, Table 2.2 seemingly presents very strong evidence of sizable returns to scale, but Radner is apparently unwilling to draw this conclusion from his study. For reasons to be discussed below, I share Radner's caution in ascribing the drops in faculty-student ratios to economies of scale.

As an indication of more recent trends in faculty-student ratios, Hans Jenny and Richard Wynn in a new book *The Golden Years* report the results of a longitudinal study of 48 small private four-year liberal arts colleges over the period 1960–68, during which time the aggregate enrollment for this group of colleges increased 29 per cent. The aggregate faculty-student ratios for the group barely changed at all during the eight-year period. On the other hand, the faculty-student ratios for the individual institutions fluctuated widely over time with some showing large increases between 1960 and 1968 and others showing large decreases. Jenny and Wynn provide a plot of percentage growth in FTE faculty between 1960 and 1968 versus percentage growth in FTE enrollment for the 48 colleges which shows almost no relationship between these two variables. This study suggests that the reduction of faculty-student ratios may be unrelated to economies of scale.

How then can one explain the behavior of the faculty-student ratios by institutional category over the period 1957–67? One approach is suggested by the following identity:

$$C/S = (C/C_F)(C_F/F)(F/S)$$

Here

C = instructional costs;
S = number of students;
C_F = total cost for faculty salaries; and
F = number of faculty.

I contend that the individual institutions operate under certain constraints that limit increases in instructional costs per student over time. Indeed, some governors and boards of trustees are not above fixing (or at least assessing) next year's budget for instructional costs by combining an enrollment projection with a modest increase in the present instructional cost per student. I believe that, in general, the budgetary constraints upon the public institutions were much more restrictive than those for the private institutions during the period 1957–67. For one thing, the public institutions had to accommodate much larger increases in enrollment during this period. (See Table 4.) Between 1957 and 1966, according to estimates by June O'Neill, instructional costs per credit hour rose by 34 per cent in the public institutions and by 57 per cent in the private institutions.

On the right-hand side of the identity are three factors: (1) the ratio of instructional costs to the expenditure for faculty salaries (this ratio should be relatively constant over time); (2) the average faculty salary; and (3) the faculty-student ratio. Since faculty salaries are not as directly subject to the same budgetary constraints that affect instructional costs per student, they are more susceptible to external factors such as the state of the labor market for highly trained manpower. In fact, faculty salaries did rise very rapidly between 1957 and 1967 (at an annual rate of close of 6 per cent per year), partly as a result of the extreme shortage of college teachers during a period of rapid enrollment growth. It follows from the above identity that faculty-student ratios had to decrease in those institutions where the increases in faculty salaries were far in excess of increases in instructional costs per student. Given the recent change in the job market for college teachers, we may very well see a change in the behavior of faculty-student ratios over time.

The last part of Radner's paper deals with the cross-sectional analysis of the institutional data for 1966. He provides an insightful discussion leading up to the linear model specified by equations 4.1–4.4. First, I have some reservations about his basic equation

$$F = a_u U + a_g G$$

since this relationship attributes increases in faculty entirely to enrollment increases, ignoring the role of research activity in creating new faculty positions. I should have preferred to see either a third term on the right side of the equation measuring the institution's research activity or a reduction in the number of faculty on the left side of the equation to account for differences in average teaching load among the institutions. However, perhaps neither of these preferences are realizable due to the unavailability of suitable data.

The results of his regressions as summarized in Tables 4.4 and 4.6 lack a consistency across categories that suggests a lack of fit (despite the high values of R^2) perhaps due to the inappropriateness of the model. In Table 4.4 there seems to be a general consistency among the nonuniversity groups in the regression coefficients that indicates increasing returns to scale for faculty inputs. However, the strength of the relationship may be exaggerated by the omission of a key variable (e.g. the age of the institution or a measure of the degree of budgetary constraint that has affected the institution in the past).

It is interesting that the corresponding regressions for the universities summarized in Table 4.6 do not provide evidence of returns to scale. However, here the multicollinearity among the independent variables may be preventing a cogent analysis. To skirt this difficulty, Radner might have based his analysis on an equation of a slightly modified form:

$$F = a_s(STUD) + a_g[G - c(STUD)]$$

with c equal to the overall proportion of graduate students for institutions of the same type.

In summary, I think the paper sheds a lot of light on the subject of faculty-student ratios, but I am hopeful that Radner will attempt to update his work with more recent data and provide more insight into some of the many questions that remain unanswered in this area.

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Student-faculty ratios in higher education are worthy of study and analysis. For one thing, the data, although subject to considerable measurement and definitional error are generally available across the levels and variety of higher education. For another, the ratios, themselves, can be interpreted as proxy measures of such factors as efficiency, financial insufficiency, and prestige. For still another, they supply evidence of the wide diversity in the circumstances under which higher education is carried out.

What additional light, then, does Radner throw upon the input-output relationships of students and faculty in higher education? In general I think he would agree that his study tends to confirm what has already been thought to be true: faculty-student ratios declined during the period, 1950–67, with contrary trends for private universities during part of the period;[1] ratios vary considerably even within an institutional category; faculty input coefficients and consequently costs for graduate education appear to be from two to four times as large as those for undergraduate education in the universities. Undergraduate-graduate student ratios are poor predictors of faculty input coefficients; and prestige institutions have lower student-faculty ratios both at undergraduate and graduate levels than do other types of institutions.

Where Radner tests relatively unexplored relationships such as increasing returns to scale through tradeoffs of rising salaries and growing numbers of Ph.D's for larger faculties, the numerical results, although often statistically significant, still tend to be suggestive only of possible relationships rather than conclusive or definitive. In a comparison of faculty input coefficients in public and private universities, however, he arrives at results that are inconsistent with what we already believe to be obvious relationships. Therefore he rejects his finding that the marginal input coefficient of faculty to undergraduate students in private universities is smaller than in public universities. Incidentally, as Radner points out, because of the ambiguities involved in the definition and measurement of student enrollments and faculty size, his data may be subject to considerable error. For this reason alone interpretation of the data must be qualified.

Beyond these observations about his specific findings, I consider the most interesting parts of the paper those that lead to further speculation about possible root causes of the present financial crisis in higher education. Surely the declining productivity in private higher education as well as the modestly rising productivity in public higher education, as revealed in these faculty-student ratios, must be instrumental in the growing financial bind. Moreover, the evidence on increasing returns to scale, particularly in the case of private institutions, clearly would appear to reflect underutilization of faculty. Since the student-faculty ratio is an obvious and reasonably objective measure of productivity trends, it is not surprising that public and private institutions as well are being forced to take a hard look at teaching loads, faculty size, courses offered, and so on.

Another point of considerable interest in this paper is Radner's evidence that quality or prestige considerations have such a positive impact on faculty costs. In the university syndrome, drives for salary and prestige, particularly prestige in the private universities, contribute markedly to growing costs and declining physical productivity.

This leads me to some final observations about quality of output and the influence of environment, especially the faculty, upon the quality of the output. As Radner rightly points out, the studies of undergraduate students by Alexander Astin and others have shown little relationship between institutional excellence and undergraduate achievement. If allowances are made for the ability of the student upon entering, then his performance upon graduation appears to be unrelated to the alleged quality or prestige of his institution. Since this thesis has not been seriously contradicted, then the moves to rationalize the use of educational resources by raising student-faculty ratios may not have deleterious or even perceptible effects on the quality of the output. Moreover, studies of class size have not demonstrated the superiority of the small class for the learning process. If, in addition to these considerations, more than lip service is paid to the desirability of building student independence and self-reliance, then serious questions must be raised about the dramatically higher costs associated with graduate education. If student ability is a powerful determinant of the educational outcome, if the student demand increasingly is for relatively more independent study, and if there are strong philosophical and educational arguments supporting this trend, then why must we have such high faculty-student ratios at the undergraduate level and accept ever-rising ratios at the graduate level?

NOTES

1. See William Baumol, *AAUP Bulletin* (American Association of University Professors), Spring 1968.

PART FOUR