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David Breneman

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THE STABILITY OF FACULTY INPUT COEFFICIENTS IN LINEAR WORKLOAD MODELS OF THE UNIVERSITY OF CALIFORNIA

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1. Introduction

In recent years, economists and operations research specialists have suggested and occasionally developed linear economic models to aid college and university administrators in such diverse areas as cost simulation, departmental reorganization, forecasting enrollment, and forecasting demand for faculty. [See: Davis (1966); Judy (1967); Koulourianos (1967); Koza (1968); Nordell (1967); and Weathersby (1967)]. The purpose of the present investigation was twofold:

(1) To explore the computational feasibility of developing a linear workload model to predict the University of California's demand for faculty by departments rather than by more aggregated subject matter groups.

(2) To determine whether faculty input coefficients employed in such a model are sufficiently stable over time to provide meaningful forecasts.

These two issues are not unrelated, since the value of a departmental workload model has often been questioned on the grounds that stability in the coefficients is directly proportional to the level of aggregation. This terminology will be made more precise in following sections of this report.

2. Feasibility of Disaggregating the Workload Model

Two linear workload models of the University of California have been developed which can be used to forecast the University's demand for faculty [Nordell (1967) and Weathersby (1967)]. Both utilize a matrix of faculty input coefficients to transform a vector of student enrollment projections into a forecast of required faculty members. However, neither model is applicable at the departmental level since both use subject matter groups as the unit of analysis. (By a subject matter group we mean a collection of departments of roughly similar disciplines; for example, the Physical Sciences group combines the departments of Astronomy, Chemical Engineering, Chemistry, Geology, Geophysics, and Physics.) In this manner, the two models condense 85 departments on the Berkeley campus into twelve subject matter groups.

Consideration of the course workloads generated by students in different departments raises immediate questions about the appropriateness of subject matter grouping for a workload model. For example, within the Physical Sciences group, physics majors certainly take more mathematics courses than do geology majors. Faculty input coefficients calculated for subject matter groups may yield inaccurate predictions if the departmental proportions of the group do not remain constant. Pursuing the above example, if the University enrolls an increased number of geology majors, with the number of physics majors unchanged, the model will indicate an increased need for professors of the Mathematics subject matter group, when in fact no additional professors from this group are needed. Furthermore, the University hires departmental faculty, not faculty for subject matter groups. These two considerations suggest that a workload model

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focusing attention on the departmental rather than subject matter group level would be more valuable to administrators.

The workload model to which we refer can be described in vector notation as follows:

$$y(t+1) = A\, x(t+1)$$

$$z(t+1) = M\, y(t)$$

where:

- t is an index denoting the time period, $t=0,1,2,3, \ldots$,
- $y(t)$ is an m-dimensional column vector of full time equivalent faculty in period t,
- $x(t)$ is an n-dimensional column vector of projected student enrollments by major department and grade level in period t,
- A is an $m \times n$ matrix of faculty input coefficients,
- M is a diagonal $m \times m$ "survival matrix" for faculty,
- $z(t)$ is an m-dimensional column vector of remaining faculty in period t .

Given a vector $x(t+1)$ of anticipated student enrollments in period $t+1$, the matrix A transforms these enrollments into required faculty inputs. The survival matrix M operates on the current faculty stock to yield $z(t+1)$, the stock remaining in period $t+1$. Comparison of $y(t+1)$ and $z(t+1)$, the faculty required and the faculty available in period $t+1$, yields the net deficiency or excess of faculty projected for each department in the next period. This information should be helpful to administrators in planning faculty recruiting efforts. In addition, if a discrepancy between existing and required faculty in certain fields is too great, the projected enrollment pattern may have to be altered.

An important element in the model is the matrix A , which describes the faculty workload created by a student, not only in his major department, but also in the numerous other departments with which he interacts. Fortunately, workload coefficients measuring student-department interactions on the Berkeley campus have been collected for several years by the Berkeley Office of Institutional Research. A typical element in the matrix, a_{ij}, represents the input of regular faculty from department i per student in activity j. (Note: "activity j" identifies the student as to major and grade level.) It is given by the following formula, adapted from [Nordell (1967), p. 74]:

$$a_{ij} = \sum_{k=1}^{3} \frac{\ell_{ijk} \cdot r_{ik} \cdot d_{ik}}{c_{ik1} \cdot t_{i1}}$$

where:

- k = level of instruction (i.e., lower division, upper division, and graduate).
- ℓ_{ijk} = workload in units per student in activity j in courses in department i at level k.
- r_{ik} = ratio of total student weekly contact hours in class to total student credit hours in department i at level k.
- d_{ik} = proportion of student class time taught by regular faculty in department i at level k.
- c_{ik1} = average class size taught by regular faculty in department i at level k. (c_{ik2} would be average class size taught by teaching assistants.)
- t_{i1} = teaching load (in contact hours per week) of regular faculty in department i. (t_{i2} would be teaching load of teaching assistants.)

The factor r_{ik} is required since student workloads are measured in course units, while faculty workloads are measured in classroom contact hours per week. The factor d_{ik} refers to regular faculty (the professorial ranks, instructors, lecturers, and associates), as opposed to teaching assistants. Note that four of the five elements in the calculation (all but ℓ_{ijk}) refer only to the department with which the faculty member is associated. The ℓ_{ijk} entries, however, refer to the students from all fields taking course work in department i .

This model has the following dimensions when implemented for the University of California, Berkeley campus:*

Symbol	Dimensions
y(t)	85 x 1
A	85 x 260
x(t)	260 x 1

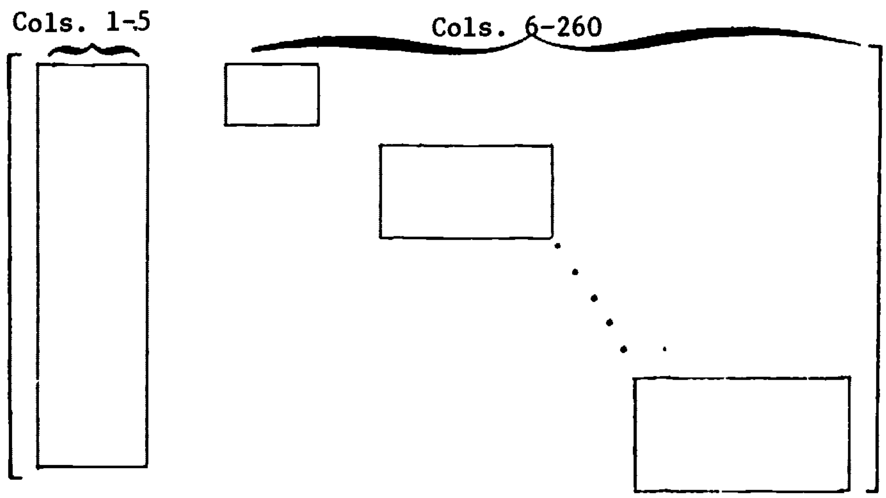
The number 85 corresponds to the departments at Berkeley, while the number 260 refers to student activities. Students are classified into four grade levels: lower division (freshmen and sophomores), upper division (juniors and seniors), other graduate (Master's candidates and first year Ph.D. students), and advanced doctoral (Ph.D. candidates who have completed at least 36 quarter units). Lower division students enroll in one of five colleges, while all other students major in one of the 85 departments.

Should we want to obtain projected demands for teaching assistants, a similar matrix A would be used. Three changes would be required: the proportion of class time taught by regular faculty, (d_{ik}), would be replaced by $(1 - d_{ik})$; the workload factor, t_{j1} , for regular faculty would be replaced by the workload factor for teaching assistants, t_{j2}; and average class size (c_{ik1}) would be replaced by (c_{ik2}) , average class size taught by teaching assistants. [Nordell (1967) , p. 75].

*For an estimate of the cost of producing a university simulation model as a function of its dimensions, see [Hopkins (1969)].

This specification of the model considers only two faculty types, regular faculty and teaching assistants, based on the assumption that regular faculty members, regardless of rank, are substitutes for each other in the instructional process, while teaching assistants are qualified to teach only certain courses in each department. The Weathersby Cost Simulation Model [Weathersby (1967)] separates faculty into seven ranks, since salary differentials are important from a cost standpoint. To extend the present model in this manner would require a matrix A of dimensions 595 x 260, and vectors x(t) and y(t) of dimension 595 x 1.

Should we want to reduce the dimensions of the model, a more meaningful method for aggregating coefficients than following subject matter groups is available. We want aggregate coefficients that correspond to departments that interact strongly with each other. That is, departments should be grouped so that an increase in students in one department will increase the workload mainly in the other departments in the aggregated group. It is conjectured that the matrix A could be partitioned into blocks by a suitable permutation of its rows and columns. Then it would resemble:



where the entries not included in any block are close to zero. Having isolated interacting departments in this manner, we would then aggregate departments into the groups suggested by the blocks in columns 6 to 260 of this permuted A matrix. The principle suggested here appears in the theoretical literature on Leontief input-output models. [See: Dorfman, Samuelson, and Solow (1958), pp. 240-3.]

3. Stability of Faculty Input Coefficients

The literature on Leontief input-output models suggests that a practical way to improve the accuracy of prediction i‹ ‹. ‹eriodic updating of those coefficients which have been shown to change over time. [Stone (1963) and Sevaldson (1963)]. To the author's knowledge, no one has studied the stability of faculty input coefficients; rather, model builders have measured input-output relationships at one point in time and then have assumed these relationships to be constant over time. Although the requisite data is available at Berkeley in comparable categories for the years 1963-1967, there is some question regarding the influence of the change from semester to ' ‹ter system in September, 1966, on this data. Since the purpose of a change from semesters to quarters was not to increase or decrease the amount of faculty contact a student enjoys, one might expect the input coefficients to be unaffected. As will be shown, certain changes in the data that occur between 1965 and 1966 do offset each other, thus not altering the values of the coefficients.

For the purpose of this study, the Mathematics Department at Berkeley was chosen as the unit for analysis, since it is a large department serving students from many disciplines. Departments that draw heavily on Mathematics are: Physics, Statistics, Economics, Business Administration, Chemistry and, of course, Mathematics itself. In addition, two more aggregate student categories drawing heavily on Mathematics were studied--the five lower division colleges and the College of Engineering, a subject matter group.

The coefficients were analyzed in two parts. First, the institutional characteristics of the Mathematics Department (hours/unit ratio, proportion of student class time taught by regular faculty at each level, average class size, and faculty workload) were traced over a period of five years. Secondly, the induced course load created in the Mathematics Department by students from the various disciplines was studied.

Table I shows the ratio of classroom hours per unit of credit, (r_{ik}), for the three course levels in the years 1963-1967.

TABLE I: HOURS/UNIT RATIOS*

	Lower Division		Upper Division		Graduate	
	Ratio	% Change	Ratio	% Change	Ratio	% Change
Fall term, 1963	1.032		1.030		.864	
		- 3.1		- 3.3		+ 0.8
" " 1964	1.000		.996		.871	
		+ 1.3		+ 0.3		- 4.9
" " 1965	1.013		.999		.828	
		+ 1.6		- 23.0		- 26.2
" " 1966	1.029		.769		.611	
		- 1.5		- 0.5		- 2.5
" " 1967	1.004		.765		.596	

*Source: See Appendix II. Ratios were derived by dividing total weekly contact hours (WCH) by total student credit hours (SCH).

The major change in these figures is the decline of approximately 25% in the ratio for upper division and graduate courses following the change from semester to quarter system in 1966.

Table II reports the proportion of total student class time taught by regular faculty in the three course levels, (d_{ik}).

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TABLE II: PROPORTION OF INSTRUCTION BY REGULAR FACULTY*

	Lower Division		Upper Division		Graduate	
	Proportion	% Change	Proportion	% Change	Proportion	% Change
Fall term, 1963	.51[illegible]		1.000		1.000	
		+ 5.2		- 3.2		0.0
" ", 1964	.54[illegible]		.968		1.000	
		+ 8.4		+ 1.4		0.0
" ", 1965	.592		.982		1.000	
		+ 5.7		- 2.0		- 4.5
" ", 1966	.626		.962		.955	
		+ 5.3		- 0.5		+ 4.7
" ", 1967	.659		.957		1.000	

*Source: See Appendix II. Proportions were derived by dividing the number of weekly student hours (WSH) taught by regular faculty by total WSH.

Virtually all upper division and graduate courses were taught by regular faculty, while the lower division courses show an increasing proportion taught by regular faculty. Our records indicate that the increases in lower division were partially the result of increased use of associates in later years.

Table III contains the average class size taught by regular faculty at the three course levels, (c_{ikl}).

TABLE III: AVERAGE CLASS SIZE*

	Lower Division		Upper Division		Graduate	
	Students	% Change	Students	% Change	Students	% Change
Fall term, 1963	140.39		23.76		11.11	
		- 7.8		- 14.7		- 17.1
" ", 1964	129.44		20.26		9.21	
		- 4.2		+ 16.3		- 21.8
" ", 1965	123.95		23.57		7.20	
		- 9.2		- 0.6		- 11.7
" ", 1966	112.52		23.43		6.36	
		- 35.0		- 11.4		+ 2.5
" ", 1967	73.16		20.76		6.52	

*Source: See Appendix II. Averages were derived by dividing total enrollments by number of class sections.

We see that the average class size declined in lower division and graduate courses, while the upper division class size was relatively stable. The declining lower division and graduate class size was primarily caused by an increase in the number of sections offered to approximately the same number of students.

TABLE IV reports the average regular faculty workload in terms of classroom contact hours per week, (t_{il}) .

TABLE IV: REGULAR FACULTY CONTACT HOURS PER WEEK*

	Hours	% Change
Fall term, 1963	6.52	
		+ 3.4
" " , 1964	6.74	
		+ 15.1
" " , 1965	7.76	
		- 9.3
" " , 1966	7.04	
		- 9.8
" " , 1967	6.35	

*Source: See Appendix II. Contact hour workloads were derived by dividing total weekly contact hours for regular faculty by the number of full time equivalent faculty members.

The four sets of data components studied above contain certain elements of instability when considered separately. However, it was postulated that their combination into a single figure for each course level and each year would be stable due to the interaction of offsetting factors. TABLE V displays the values of the composites $(\frac{r_{ik}}{c_{ikl}} \cdot \frac{d_{ik}}{t_{il}})$, which have the dimensions faculty per student credit hour:

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TABLE V: MATHEMATICS FACULTY PER STUDENT CREDIT HOUR

	Lower Division		Upper Division		Graduate	
	Faculty/SCH	% Change	Faculty/SCH	% Change	Faculty/SCH	% Change
Fall term, 1963	.00058		.00664		.01192	
		+ 6.8		+ 6.3		+ 17.7
" " , 1964	.00062		.00706		.01403	
		0.0		- 24.0		+ 5.5
" " , 1965	.00062		.00536		.01481	
		+ 30.6		- 16.4		- 12.0
" " , 1966	.00081		.00448		.01303	
		+ 82.7		+ 23.8		+ 10.4
" " , 1967	.00148		.00555		.01439	

The lower division figures demonstrate remarkable stability for the period 1963-1965, the years of the semester system, and marked increases in 1966 and 1967. The increases in the latter two years resulted from an increase in the proportion of class time taught by regular faculty, (d_{ik}) , and the decline in average class size and faculty workloads. Considering this column alone, one might conclude that faculty per SCH figures for a well established system are stable, and that the instability of the data can be attributed to the change from semesters to quarters. However, examination of the upper division and graduate faculty per SCH figures casts doubt on any such facile explanation. The upper division figure drops substantially from 1964 to 1965 - both semester system years - caused almost entirely by an increase in the regular faculty workload from 6.74 to 7.76 contact hours per week. The further decline in 1966 was the result of a 23 per cent decline in the hours/unit ratio that was not completely offset by the decrease in faculty workload. To further complicate matters, the figure for 1967 very nearly returns to its 1965 level, largely as the result of a further decline in faculty workload.

The graduate faculty per SCH figures show the smallest percentage changes of the three sets. The 17.7% increase between 1963 and 1964 was largely the result of the reduced class size in 1964. The 1964, 1965, and 1967 numbers are of similar magnitude; the 1966 figure, 12.0% below the preceding year's, declined primarily because of the 26% reduction in the hours/unit ratio. The changes observed in the upper division and graduate faculty per SCH figures suggest that the interactions within the system are more complicated than was originally postulated. Clearly, there are some factors involved which do not offset each other. Also, the close numerical values of the 1965-1967 figures for upper division and graduate courses respectively seems to indicate that the change from semester to quarter system need not radically alter the departmental component of the faculty input coefficients.

TABLE VI shows student credit hour per student figures (ℓ_{ijk}) for seven student categories taken from the larger sample studied. The entries in the table represent the average number of student credit hours per student in the categories indicated. A cursory glance at these figures indicates that they vary considerably within each category. The shift from semester to quarter system definitely had an effect on these figures due to the fact that the average unit credit per course was increased from three to four units for upper division and graduate courses. It is interesting to note that this increase just offsets the 25 per cent decline in the hours/units ratios for upper division and graduate courses mentioned earlier. The hours/units ratio did not change for lower division courses, and the average lower division course credit remained constant at approximately four units.

To complete the computation of faculty input coefficients, the SCH per student entries in TABLE VI were multiplied by the corresponding faculty per SCH entries in TABLE V to produce the faculty input per student at each instructional level.

TABLE VI: STUDENT CREDIT HOURS PER STUDENT*

	Mathematics (Upper Division)			Mathematics (Other Graduate)			Economics (Other Graduate)		
	Lower Division	Upper Division	Graduate	Lower Division	Upper Division	Graduate	Lower Division	Upper Division	Graduate
Fall Term, 1963	.547	4.716	.283	.000	1.641	5.096	.072	.709	.000
" " , 1964	.630	4.937	.131	.000	2.063	5.312	.028	.422	.000
" " , 1965	.494	5.081	.309	.020	1.425	5.567	.051	.448	.019
" " , 1966	.659	5.647	.505	.000	1.898	6.968	.187	.656	.125
" " , 1967	.401	4.233	.737	.027	1.371	6.810	.054	.864	.000

	Physics (Upper Division)			Physics (Advanced Doctoral)			Statistics (Advanced Doctoral)		
Fall Term, 1963	.555	1.529	.033	.000	.034	.149	.000	.153	.615
" " , 1964	.420	1.579	.012	.000	.011	.138	.000	.209	.418
" " , 1965	.489	1.424	.038	.000	.000	.146	.000	.166	.444
" " , 1966	.356	2.183	.125	.000	.000	.088	.000	.230	.384
" " , 1967	.408	1.846	.081	.016	.016	.236	.000	.000	.461

	Engineering (Lower Division)		
	Lower Division	Upper Division	Graduate
Fall term, 1963	3.360	.047	.000
" " , 1964	3.564	.022	.000
" " , 1965	3.568	.065	.000
" " , 1966	3.603	.137	.000
" " , 1967	3.687	.130	.000

*Source: See Appendix II. SCH per student were derived by dividing total student credit hours earned by students in activity j in courses in department i at level k by the total number of students in activity j .

Summing over the three levels gives the appropriate a_{ij} entry in the matrix A . The coefficients reported in TABLE VII were chosen as representative of the range of extremes found in the full sample. (The complete set of faculty input coefficients is contained in Appendix I.)

A note of caution regarding the interpretation of the percentage change figures must be inserted prior to our analysis of the input coefficients. In addition to the percentage change from year to year, one must also examine the magnitude of the particular coefficient under consideration in order to assess properly the resource implications of a change in the coefficient. For example, the coefficient for advanced doctoral physics students was .00114 in 1966, and was .00349 in 1967, a 206.1 per cent increase, while the coefficient for other graduate mathematics students experienced only a 6.4 per cent increase during the same two years, changing from .09929 in 1966 to .10562 in 1967. However, if there were 100 students in each category, the 206 per cent increase in the coefficient for physics students would require an increase of .235 full time faculty (.349 - .114) , while the 6 per cent increase in the mathematics students coefficient would require an increase of .633 full time faculty (10.562 - 9.929) , a figure over two and one half times as large.

The category "upper division mathematics students", had the most stable set of input coefficients found in the sample, with a maximum percentage change of 13.4 per cent, and a 1967 coefficient only 0.8% below the 1963 coefficient. Stability in this category is particularly interesting since the magnitude of these coefficients is large relative to the

TABLE VII: MATHEMATICS FACULTY INPUT COEFFICIENTS

	Student Category					
	Mathematics (Upper Division)		Mathematics (Other Graduate)		Economics (Other Graduate)	
	Coeficient	% Change	Coefficient	% Change	Coefficient	% Change
1963	.03499		.07163		.00474	
		+ 5.9		+ 24.4		- 37.1
1964	.03707		.08908		.00298	
		- 13.4		+ 1.1		- 9.1
1965	.03210		.09008		.00271	
		+ 0.9		+ 10.2		+ 73.4
1966	.03240		.09929		.00[illegible]70	
		+ 7.0		+ 6.4		+ 3.4
1967	.03468		.10562		.00486	

	Physics (Upper Division)		Physics (Advanced Doctoral)		Statistics (Advanced Doctoral)	
1963	.01086		.00199		.00834	
		+ [illegible].4		+ 0.5		- 12.1
1964	.01156		.00200		.00733	
		- 26.6		+ 8.0		+ 1.6
1965	.00849		.00216		.00745	
		+ 37.5		- 47.2		- 19.1
1966	.01167		.00114		.00603	
		+ 2.8		+ 206.1		+ 10.0
1967	.01200		.00349		.00663	

	Engineering (Lower Division)	
1963	.00225	
		+ 4.4
1964	.00235	
		+ 8.5
1965	.00255	
		+ 38.0
1966	.00352	
		+ 75.3
1967	.00617	

other sets of coefficients in the sample. Another set of relatively large coefficients, those for other graduate mathematics students, does not display similar stability, increasing steadily throughout the period under study. Apparently, enrollment trends for upper division mathematics students have moved in concert with the departmental faculty per SCH figures to produce a stable faculty input per student, while the other graduate mathematics students have steadily increased their demands on regular faculty.

The input coefficients for other graduate economics students are interesting, for they demonstrate the ambiguity of the semester-quarter relationship. The 1963, 1966, and 1967 coefficients are very similar in magnitude while the 1964 and 1965 figures show a sizeable reduction from the 1963 level. The decline from 1963 to 1964 (both semester years), suggests that instability cannot be explained simply by the change of instructional systems.

The coefficients for upper division physics students are reasonably stable with the exception of 1965, when there was a reduction in the percentage of these students taking upper division mathematics courses. Figures for advanced doctoral physics students are included to indicate the large percentage changes that can be found even in the coefficients of logically interacting departments; the coefficient declined by 47.2 per cent from 1965 to 1966, and increased by 206.1 per cent from 1966 to 1967. The coefficient's decline in 1966 was due to the fact that half the "normal" number of advanced doctoral physics students enrolled in graduate mathematics courses in 1966, followed by a return to the earlier level in 1967. The initial decline might be attributed to the switch from semesters to quarters, but the subsequent return to the earlier level in

1967 is not easily explained on that basis.

Finally, it is instructive to consider simultaneously the last two sets of coefficients--advanced doctoral statistics students and lower division engineering students. Coefficients for the statistics students follow a cyclical pattern, with a maximum percentage change between years of 19.1 per cent, while coefficients for the engineering students show percentage increases between years as large as 75.3 per cent and 38.0 per cent. During this five year period, there were an average of 48 students in the advanced doctoral statistics category and an average of 637 students in the lower division engineering category. Apparently, a large number of students in an activity does not automatically assure stability, nor does a small number of students necessarily produce extreme instability. (The average number of students in each category in the sample may be found in Appendix J.)

4. Summary and Conclusions

(1) Our analysis of Berkeley input-output data indicates that certain coefficients were reasonably stable during the five year period with maximum fluctuations between 13 and 20 per cent, that other coefficients displayed definite trends such as the steady increase in the figures for other graduate and advanced doctoral mathematics students, but that the majority fluctuated in positive and negative directions with annual changes as high as 200 per cent.

(2) A comparison of the stability of coefficients for engineering students (a subject matter group) and those for students of a small department, such as Statistics, suggests that aggregate

figures are not necessarily more stable than departmental figures. The largest percentage change observed in each student category for the two groups, together with the average number of students in each group, are listed below:

	Engineering		Statistics	
	Largest Percentage Change	Average Number of Students	Largest Percentage Change	Average Number of Students
Lower Division	75.3	637	N/A	N/A
Upper Division	22.6	1063	37.1	17
Other Graduates	47.1	682	45.2	37
Advanced Doctoral	24.8	456	19.1	48

Although additional research would be necessary to establish this result firmly, the sample studied and reported in Appendix I does not support the assumption that a large number of students in a category produces stable coefficients, while a small number causes instability. It appears that the existence of a logical reason for interaction between departments-- such as, Statistics and Mathematics-- will produce a degree of stability even though the number of students involved is small. This result, should it be confirmed by further research, represents one of the most significant findings of this study, since it contradicts the belief of many practitioners in this field. In particular, we cannot conclude that a workload model disaggregated to the department level would necessarily involve more instability than a model designed for subject matter groups.

(3) Annual updating of the larger coefficients suggests itself as a relatively simple way to eliminate gross inaccuracies in a workload model. For example, the 1963 coefficient for other graduate

mathematics students was .07163, while the 1967 figure was .10562. If there were 100 students in this category, the first figure would yield a demand for approximately seven faculty members, while the latter figure would produce a demand for ten and one half faculty members, a substantial difference.

(4) Finally, examination of the fluctuations in the individual components which make up the faculty input coefficients clearly indicates a need for a better understanding of why these elements vary. Future study of the departmental decision-making process might allow us to explain the changes we have observed as responses to such economic factors as relative input costs, shifts in enrollment, and budgetary changes.

APPENDIX I: Faculty Input Coefficients

(Coefficients represent the input of regular Mathematics faculty per student in the activity listed at the top of each column. All figures refer to the Fall term).

Key:
- LD : Lower Division
- UD : Upper Division
- OG : Other Graduate
- AD : Advanced Doctoral
- Ave. No.: Average number of students in the activity for five year period.

	LD Letters & Science		LD Agriculture		LD Chemistry	
	Coefficient	% Change	Coefficient	% Change	Coefficient	% Change
1963	.00060		.00037		.00212	
		+ 8.3		+ 45.9		+ 18.9
1964	.00065		.00054		.00252	
		+ 6.2		- 13.0		- 16.3
1965	.00069		.00047		.00211	
		+ 34.8		+ 14.9		+ 27.5
1966	.00093		.00054		.00269	
		+ 61.3		+ 107.4		+ 76.6
1967	.00150		.00112		.00475	
	Ave. No.: 6101		Ave. No. 112		Ave. No. 193	

	LD Engineering		UD Engineering		OG Engineering	
1963	.00225		.00220		.00382	
		+ 4.4		+ 16.8		+ 4.71
1964	.00235		.00257		.00562	
		+ 8.5		+ 22.6		- 12.6
1965	.00255		.00315		.00491	
		+ 38.0		- 7.3		+ 6.5
1966	.00352		.00292		.00523	
		+ 75.3		+ 22.6		+ 3.6
1967	.00617		.00358		.00542	
	Ave. No.: 647		Ave. No. 1063		Ave. No. 682	

	AD Engineering		UD Mathematics		OG Mathematics	
1963	.00806		.03499		.07163	
		+ 6.6		+ 5.9		+ 24.4
1964	.00859		.03707		.08908	
		+ 9.4		-13.4		+ 1.1
1965	.00940		.03210		.09008	
		+ 15.9		+ 0.9		+ 10.2
1966	.01089		.03240		.09929	
		- 24.8		+ 7.0		+ 6.4
1967	.00819		.03468		.10562	
	Ave. No.: 546		Ave. No. 276		Ave. No. 147	

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	AD Mathematics Coefficient	% Change	UD Statistics Coefficient	% Change	OG Statistics Coefficient	% Change
1963	.06165		.01379		.01110	
		+ 30.0		- 20.2		+ 1.1
1964	.08013		.01101		.01123	
		+ 6.3		+ 35.0		- 29.9
1965	.08519		.01486		.00787	
		+ 9.0		+ 29.8		+ 45.2
1966	.09289		.01929		.01143	
		+ 0.2		- 37.1		+ 44.2
1967	.09310		.01213		.01648	
	Ave. No.: 167		Ave. No.: 17		Ave. No.: 37	

	AD Statistics		UD Economics		OG Economics	
1963	.00834		.00084		.00474	
		- 12.1		+ 45.2		- 37.1
1964	.00733		.00122		.00298	
		+ 1.6		+ 28.7		- 9.1
1965	.00745		.00157		.00271	
		- 19.1		- 23.6		+ 73.4
1966	.00603		.00120		.00470	
		+ 10.0		+ 81.7		+ 3.4
1967	.00663		.00218		.00486	
	Ave. No.: 48		Ave. No. 298		Ave. No.: 133	

	AD Economics		UD Physics		OG Physics	
1963	.00092		.01086		.01638	
		+ 42.4		+ 6.4		+ 19.0
1964	.00131		.01156		.01950	
		- 17.6		- 26.6		- 5.6
1965	.00108		.00849		.01840	
		- 14.8		+ 37.5		+ 18.7
1966	.00092		.01167		.02184	
		+ 181.5		+ 2.8		+ 9.1
1967	.00259		.01200		.02382	
	Ave. No.: 151		Ave. No.: 225		Ave. No.: 121	

	AD Physics		UD Bus. Admin.		OG Bus. Admin.	
1963	.00199		.00055		.00055	
		+ 0.5		- 50.9		+ 18.2
1964	.00200		.00027		.00065	
		+ 8.0		- 11.1		- 15.4
1965	.00216		.00024		.00055	
		- 47.2		+ 87.5		+ 25.4
1966	.00114		.00045		.00069	
		+ 206.1		+ 53.3		+ 92.8
1967	.00349		.00069		.00133	
	Ave. No.: 252		Ave. No.: 588		Ave. No.: 415	

AD Bus. Admin.

	Coefficient	% Change
1963	.00225	
		- 98.6
1964	.00003	
		+ 3633.3
1965	.00112	
		+ 69.6
1966	.00190	
		+ 38.9
1967	.00264	

Ave. No.: 63

APPENDIX II: Sources of Data*

TABLE I: Office of Analytic Studies, 247 University Hall, Berkeley, California; Report Form IS 720.

TABLE II: Office of Analytic Studies, 247 University Hall, Berkeley, California; Report Form IS 540A.

TABLE III: Office of Institutional Research, Building T-8, University of California, Berkeley, California; Class Enrollments.

TABLE IV : Office of Analytic Studies, 247 University Hall, Berkeley, California; Report Form IS 540B (for total weekly class hours taught by regular faculty), and Office of Institutional Research, Building T-8, University of California, Berkeley, California; Staff, Budgeted and Actual (for total FTE regular faculty).

TABLE VI : Office of Instutional Research, Building T-8, University of California; Table A, Workload Analysis Tables (for total student credit hours of students in the various activities in the three levels of mathematics courses); Summary of Students (for total number of undergraduates in the activities studied); and Graduates by Degree Code (for total number of graduate students in the activities studied).

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