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PART ONE Educational Production

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The Ph.D. Production Process

INTRODUCTION

Microeconomic theory of nonprofit institutions is currently a relatively underdeveloped area of analysis. In an attempt to expand this body of theory, the present paper applies the economic model of rational behavior to the Ph.D. production process within the university. In particular, economic analysis is used to explain the marked disciplinary differences in mean time to degree and in student attrition that have been the subject of much recent discussion.[1] I think that the theory developed is broadly applicable, although the data have been drawn primarily from the University of California at Berkeley.

Section I contains data documenting departmental differences in Ph.D. production, Section II develops the theory of departmental behavior, and Section III presents evidence in support of that theory. It should be noted that the present paper has been distilled from a considerably larger study, and much of the empirical work has been deleted. The interested reader should refer to the author's dissertation[2] for more complete treatment of the topic.

I. DIFFERENCES IN DEPARTMENTAL PERFORMANCE

In a 1966 study[3] prepared for the Graduate Division of the University of California at Berkeley, sociologist Rodney Stark analyzed five cohorts of

graduate students beginning graduate work at three-year intervals in each of four Berkeley departments, English, History, Political Science, and Chemistry. The success rates for each group, as of 1966, are presented in Table 1. Note the sharp contrast between Chemistry and the

TABLE 1. The Outcome of Doctoral Studies by Department and Year of Admission, Berkeley

	Year of Admission				
	1951	1954	1957	1960	1963
Political Science Department					
Received Ph.D.	17%	14%	14%	4%	0%
Withdrew after M.A.	24	23	29	35	26
Withdrew—no degree	59	60	51	39	21
Still registered (1966)	0	3	6	14	53
On leave of absence	0	0	0	8	0
Number of students	29	35	49	49	42
Chemistry Department					
Received Ph.D.	86%	77%	76%	68%	0%
Withdrew after M.A.	7	6	10	8	0
Withdrew—no degree	7	17	12	16	2
Still registered (1966)	0	0	2	6	96
On leave of absence	0	0	0	2	2
Number of students	28	35	51	50	50
English Department					
Received Ph.D.	13%	16%	15%	6%	0%
Withdrew after M.A.	23	25	24	14	24
Withdrew—no degree	58	55	58	29	36
Still registered (1966)	3	0	3	37	34
On leave of absence	3	4	0	14	6
Number of students	31	38	53	49	50
History Department					
Received Ph.D.	27%	12%	29%	8%	0%
Withdrew after M.A.	15	27	13	18	14
Withdrew—no degree	52	54	52	31	46
Still registered (1966)	6	0	4	23	32
On leave of absence	0	7	2	20	8
Number of students	33	26	48	51	50

SOURCE: Unpublished study by Rodney Stark, prepared for the Dean of the Graduate Division, Berkeley, 1966.

other three departments with respect to the per cent of successful Ph.D. completions.

Table 2 contains the number of enrolled-graduate-student-years that must be charged against the degree output of the four departments in the Stark study. For the English, History, and Political Science departments, the figures represent the combined results of the 1951, 1954, and 1957 cohorts, while the 1960 cohort was also included for the Chemistry Department, since that group was virtually complete by 1966. Note the much shorter average time to degree in chemistry and the early occurrence of attrition in the program. By contrast, unsuccessful students in the other three departments were not terminated or did not drop out

TABLE 2 Enrolled Student Time per Degree, 1951-54-57 Cohorts,[a] Four Departments, Berkeley

	Number of Students	Enrolled Student-Years	Average Years per Outcome
Political Science Department			
Received Ph.D.	6	44	7.3
Received M.A.	26	85	3.3
Received no degree	50	183	3.6
Total	82	312	
Chemistry Department			
Received Ph.D.	94	358	3.8
Received M.A.	14	27	1.9
Received no degree	17	23	1.4
Total	125	408	
English Department			
Received Ph.D.	9	61	6.8
Received M.A.	27	80	3.0
Received no degree	45	114	2.5
Total	81	255	
History Department			
Received Ph.D.	16	108	6.8
Received M.A.	16	51	3.2
Received no degree	42	108	2.5
Total	74	267	

SOURCE: Stark study, Berkeley, 1966.
[a] Limited to students who enrolled with B.A. or B.S. only. Chemistry includes the 1960 cohort.

until an average of two to three years had been completed in the program.

Data limitations prohibited preparation of similar cohort studies for a larger number of Berkeley departments. However, degree-enrollment ratios for the seven-year period 1961–67, presented in Table 3, indicate the range of departmental variation.

Evidence that the differential pattern of attrition and time to degree observed in Berkeley departments is not unique to that campus is found in Joseph Mooney's recent study of attrition among Woodrow Wilson Fellows.[4] Mooney examined success rates as of 1966 for the 1958–60 entering cohorts of Woodrow Wilson Fellows, and found the same pattern that Berkeley displays—high success rates in the physical and biological sciences, followed by the social sciences, with the humanities a poor third.

Explanation of these differences found in the literature typically focus upon such factors as variation in financial support, intrinsic differences in fields, different traditions, and so forth. In particular, departments are implicitly viewed as passive organizations lacking objectives regarding the number of Ph.D.'s to award. No attempt has been made in previous work to analyze departmental objectives and the constraints under which departments operate, and to relate these factors to Ph.D. production. The following theory attempts to fill that gap.

II. A THEORY OF DEPARTMENTAL BEHAVIOR

The system that we wish to analyze is far from simple. The production of Ph.D.'s involves the joint and interacting behavior of two groups, faculty and students, whose objectives may be more in conflict than in agreement. Furthermore, individual faculty members have personal objectives, from which we must construct a description of departmental objectives. Thus, our theory must consider student and faculty motivation, and combine these into a theory of departmental behavior.

In Section A, a theory of graduate student behavior will be presented, followed in Section B by a theory of faculty motivation. The second section will also examine the relation of faculty objectives to departmental objectives. Section C will discuss the factors that enter into the department's objective function, and in Section D the elements of analysis will be synthesized into a theory that explains departmental differences in pattern and timing of graduate student attrition.

TABLE 3 Seven-Year Enrollment and Degree Totals, University of California, Berkeley, 1961–67

Department	Column A Ph.D. Degrees Awarded	Column B Ph.D. Student-Years[a]	Degrees per Student-Year (Col. A/Col. B)	Student-Years per Degree (Col. B/Col. A)
Entomology	79	397	.198	5.02
Chemistry	335	1,802	.185	5.38
Chemical Engineering	75	404	.185	5.39
Electrical Engineering	175	1,032	.169	5.90
Civil Engineering	129	763	.169	5.91
Physics	380	2,438	.155	6.42
Zoology	94	634	.148	6.74
Botany	52	352	.147	6.77
Geology	37	270	.137	7.30
Biochemistry	63	469	.134	7.44
Geography	21	158	.132	7.52
Mechanical Engineering	94	716	.131	7.62
Psychology	162	1,238	.130	7.64
Astronomy	32	246	.130	7.69
Spanish	18	150	.120	8.33
History	177	1,517	.116	8.57
Math	194	1,680	.115	8.66
Classics	13	118	.110	9.08
German	24	219	.109	9.12
Bacteriology	17	157	.108	9.24
Economics	137	1,316	.104	9.61
Anthropology	69	720	.095	10.43

TABLE 3 (concluded)

Department	Column A Ph.D. Degrees Awarded	Column B Ph.D. Student-Years[a]	Degrees per Student-Year (Col. A/Col. B)	Student-Years Per Degree (Col. B/Col. A)
Political Science	96	1,026	.093	10.69
Physiology	24	267	.089	11.12
English	105	1,374	.076	13.09
Sociology	57	753	.075	13.21
French	28	374	.074	13.36
Philosophy	27	507	.053	18.78

SOURCE: Office of Institutional Research, University of California, Berkeley.

[a] Enrollment figures are understated for those departments that require doctoral students first to earn the M.A. degree; those student-years are not recorded. Enrollments include both degree winners and nondegree students.

A. The Graduate Student

I assume that the vast majority of graduate students view the decision to enter graduate school as an investment, much as the human capital literature suggests. However, in the case of the Ph.D., for those people intent upon an academic career the relevant variable is not necessarily the rate of return calculated in money terms, but the investment in a life-style. Inasmuch as the Ph.D. is the required "union card" of the college professor, one might view the investment decision from the student's point of view as a step function (see Figure 1). The student may study for several years, but if he fails to earn the degree, his payoff is effectively zero, thereby making his investment extremely costly to him.[5]

In considering this model of the student's view of the value of incomplete degree work, it is important to remember the reason for the discontinuity in the function; apart from income considerations, the step signifies that the degree winner is properly certified and acceptable for types of employment not open to individuals without the degree. We shall assume this factor to be of primary importance to students and shall continue to represent the investment as having a sharp discontinuity.

Given the investment model of student behavior, economic theory would suggest that students as potential investors will gather information regarding the costs of investment, the anticipated benefits (pecuniary and nonpecuniary), and the risks surrounding successful completion of the program, and will embark upon graduate study only if the present value of the benefits, adjusted for risk, exceeds the present value of the costs. Certain costs can be determined with some precision; these include the opportunity cost of forgone earnings, tuition, and out-of-pocket costs. Other elements in the cost-benefit analysis however, are subject to considerable uncertainty. In evaluating factors such as the length of time required to earn a degree, sources of financial support, and the probability of successful completion, the student must rely upon information he can gain from the department and other sources such as friends already in the program. One of the most important items of information needed for an informed decision is the probability of successful completion. This is unknown for any individual student, but a reasonable proxy would be the historical experience of students in the department; if y students have enrolled over the past several years and x students have earned the doctorate, then a reasonable probability estimate of successful completion would be x/y. Unfortunately, this rudimentary piece of information is not generally available, leaving the student unable to make an informed estimate of the risk involved.

Knowledge of the demand for one's services upon successful completion of the doctorate would be an additional piece of information needed

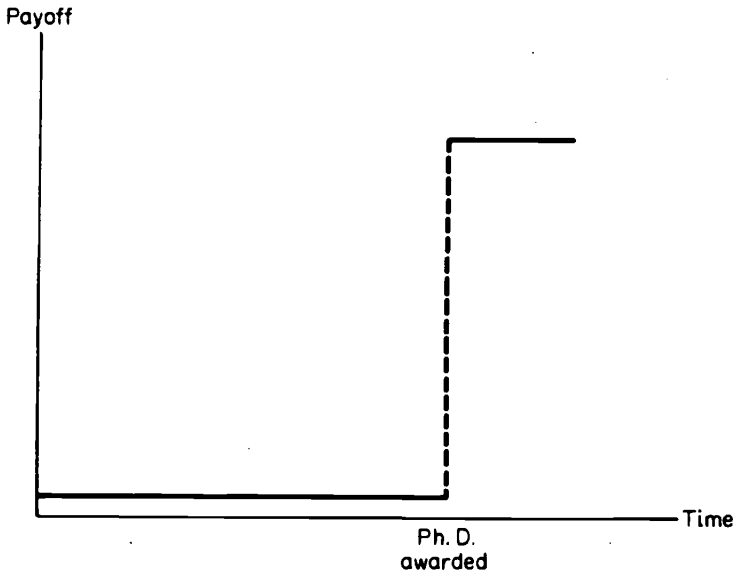


FIGURE 1

for an informed investment decision. Hard information on this item is essentially unavailable to the student for at least two reasons. First, studies of the academic markets[6] have all commented on the limited information available to participants in these markets. Most universities do not publicly advertise their openings, and no central clearinghouse exists to provide complete job coverage. Second, the length of the production cycle (approximately five years) means that a student would need a forecast of demand five years hence, a difficult prospect at best. Demand in governmental and industrial markets may be better advertised, but the need to forecast years ahead again clouds the picture.

The lack of specific information regarding market demand for Ph. D.'s has probably not been a deterrent to students during the 1950s and 1960s, because of a general belief that the country was desperately short of Ph. D.'s. The baby boom, the tremendous expansion of college enrollments, and the increasing proportion of the 18 to 21 age group going on to college during this period resulted in a series of crisis forecasts, sparked by the National Education Association biennial surveys,[7] which appear to have been widely circulated and believed. Hence, it is reasonable to assume that during the period under study, students believed that many employers would demand their services, regardless of their field.

The following implications for rational student behavior can be deduced from the investment model of student motivation coupled with the discontinuity in the payoff function. (We assume that students can control within limits the speed with which they progress through the program and are free to withdraw at any point.) From the standpoint of the cost of earning the doctorate, of which much is borne by the student, we might conclude that all students will proceed through the program as rapidly as possible, i.e. students will take full course loads, prepare for examinations as rapidly as possible, and not waste time getting started and finishing the dissertation. However, given the nature of the payoff function, rational behavior may result in a decision to proceed more slowly in order to maintain higher grades, improve class standing, earn or keep fellowships, and so forth. To the extent that these factors operate in all fields, we should not expect any departmental differences in the time to degree to arise from this source. However, because opportunity costs do differ between fields, we might expect, ceteris paribus, that students in disciplines with high starting Ph.D. salaries would be less willing to slow their own progress than would students in less well-paying fields. For example, a chemistry student planning to enter industry sees the cost of an additional year in the program as $15,000, while the philosophy student may see a cost of $9,000 for an additional year's work. Furthermore, the philosophy student is presumably aiming at an academic position, and he may rationally calculate that an additional year's work on his thesis may result in an offer from a more prestigious university, thereby increasing the psychic return on the investment.

The preceding analysis suggests that students acting rationally may stretch out their degree programs, and argues that this decision may be related to the type of employment sought by the Ph.D. candidate and to the opportunity costs related to that employment. However, regardless of field, this analysis does not explain the differences in attrition between departments as a function of student decisions. Thus, we must look elsewhere for our theoretical explanation of the large differences in attrition among the disciplines.

The proposed model of student behavior is summarized as follows:

1. The student, regardless of field or sex, is viewed as an investor rather than a consumer of graduate education.
2. The investment requires the earning of the Ph.D. degree for its successful completion, i.e. the student attaches little if any value to incomplete degree work.
3. The investment is not properly evaluated in money terms alone, but is viewed by the student as an investment necessary for entry into certain occupations requiring the doctorate.

4. The potential graduate student has very limited information regarding his probability of successfully completing the degree and regarding the demand for his services upon completion of the program. He undertakes the investment in the face of this uncertainty, because he assumes that the department will treat him justly and that satisfactory employment will be available, i.e. he assumes that the demand for Ph.D.'s in his field will be strong when he graduates.
5. The rational student may have sound reasons for lengthening his time to degree, and departmental differences in average time to degree may be partly explained by the differences in opportunity costs seen by students in different fields. However, analysis of student behavior does not provide an explanation for departmental differences in attrition.

B. The Individual Faculty Member and the Department

My ultimate aim is to propose a theory of departmental behavior, but I must first explain my use of the term "the department." For present purposes, the members of the department are defined to include all faculty members, tenured and nontenured, who are employed full time by the university. I exclude from this definition students, teaching assistants, associate lecturers, and other nonregular faculty ranks. Thus, in seeking a theory of departmental behavior, I must propose a theory of faculty behavior and determine whether goals of individual professors blend consistently into a unified set of goals for the department.

The fundamental assumption of the analysis is that behavior of the faculty members may be explained by the theory of utility maximization. Let us assume that the representative faculty member at a university such as Berkeley, regardless of field and rank, seeks to maximize his own prestige. Using Merton's distinction, faculty members at a large university such as Berkeley are "cosmopolitans" rather than "locals," i.e. primary loyalty is to the discipline rather than to the employing institution. Prestige, therefore, is understood to mean a professor's professional reputation within the discipline as judged by peers in the same field in other universities. Reputation is enhanced by the quality of a person's research publications and by the quality of the graduate students who serve as apprentices to the professor.

It seems reasonable to assume that nearly all faculty members at Berkeley accept this value system or behave as if they do. Initially, a considerable self-selection process operates to minimize the number of

faculty members on the staff not interested in research. Furthermore, the university discards those members who fail to produce by refusing tenure offers. Thus, survival on the faculty requires adherence to the values of research, or an uncanny ability to disguise one's true interests and still produce the minimum acceptable amount of research work.

In addition to these negative considerations, however, faculty members have many positive reasons for prestige maximizing. As a professor's prestige increases, his value to the institution also increases. Thus his bargaining power increases and he can command a higher income, faster promotion, a reduced teaching load, and other perquisites. In addition, increased prestige renders him potentially more valuable to a number of competing universities, who will bid for his services, thereby increasing his independence and mobility. In those fields where external funding of research projects is common, increased prestige will result in easier access to these funds. Increased prestige also enhances self-esteem, which is of no small value to people in intellectual occupations. In short, most of the objects that philosophers have recognized as desired by people—power, income, independence, self-esteem—accrue to the academic who successfully maximizes prestige.

If we assume that the prestige of an academic department is simply the sum of the prestige levels of its faculty members, then prestige-maximizing behavior on the part of each professor is consistent with the maximization of departmental prestige. The following passage from Caplow and McGee's *The Academic Marketplace* describes the symbiotic relationship between professor and department:

> The relationship between departmental prestige and the personal prestige of department members is reciprocal. Over a period of time, each man's personal prestige in his discipline is a partial function of his department's prestige, and vice versa. It becomes vitally important, then, to maintain the prestige of the department by hiring only individuals who seem likely to enhance it, since a decline in departmental prestige will be experienced by each individual member as a decline in his own prestige.[8]

Thus, in the remaining analysis, we shall speak of the department's goal of prestige maximization, grounded in the rational, self-regarding behavior of individual professors.

Departmental prestige is not, of course, an absolute measure but is determined on a relative scale by comparison with departments in the same discipline in other universities. Surveys, such as the 1966 Cartter Report,[9] are published periodically, ranking departments by the quality of faculty, thereby establishing relative prestige ratings. To the extent that ratings are reported by simple numerical orderings, departments are forced into a competitive zero sum game, i.e. in order for one

department to rise in the ratings, another department must fall. Thus, in order to maximize departmental prestige, a department must compete successfully for prestigious faculty, and this requires resources. From the department's perspective, the Dean is the primary supplier of resources, and the competitors are the other academic departments under the Dean's jurisdiction. Therefore, it seems certain that each department will discover the basis for resource acquisition within the university, and will behave in accordance with the incentive system in order to maximize command over resources.

Specification of resources is reasonably straightforward, and includes the number of full time equivalent (FTE) faculty, teaching and research assistantship (T.A. and R.A.) positions, salary money, funds for research, space, computer time, funds for library acquisitions, and so forth. In particular, it is assumed that departments are highly motivated to maintain or increase their number of faculty FTE positions, for in this way new people can be brought into the department periodically, thereby insuring against stagnation. A desire for increased faculty can be understood as allowing increased specialization, broader coverage of the discipline, reduced teaching loads, and increased prestige.

The connection between graduate students and prestige must now be introduced. Unlike undergraduates and M.A. candidates, doctoral students are part of the prestige system, since many new Ph.D.'s remain in academia. The apprentice system, whereby a Ph.D. candidate completes his research under the guidance of a faculty adviser, tends to link the two individuals so that the work produced will reflect credit or discredit upon them jointly, if not equally. Thus, the prestige-maximizing professor has a definite incentive to seek out the best graduate students and to avoid the worst, hoping that some other professor will be foolish enough to adopt that burden. If a professor is successful in this strategy for several years, his reputation as an effective and desirable adviser will result in the better students seeking him out. Similarly, a professor who has consistently been willing to work with the poorer students, may find himself unable to attract any of the better students. Thus, the quality of student research with which the latter man is associated will decline, and his prestige in the field will suffer correspondingly.[10]

Note that the major visible test of the quality of the student and his work is the job placement which he achieves. The student's thesis is actually read by very few people, and thus judgment must be made in a derivative manner by assuming that the "best" students will be hired by the "best" universities. Thus, within the profession, the quality of job placement reflects credit or discredit on the student, his adviser, and

the department. Given this analysis, we can conclude that a number of less able graduate students who manage to reach the dissertation stage each year may experience difficulty in securing a thesis adviser.[11] Nor will it be in the interest of the department to insure that such students complete the degree, for the department rationally seeks to attract the best students, award the Ph.D. degree to those students who can be placed well in other universities, and discourage those students who could only be placed in low-prestige positions. A department that successfully pursues this policy will enhance its own prestige and will be able to attract better students than those departments foolish enough to produce Ph.D.'s for low-prestige institutions.

Consideration of the quality of placement of new Ph.D.'s directs our attention to the job market faced by graduates in each field. In certain disciplines, such as the humanities, virtually the only acceptable employment available is college or university teaching, whereas graduates in the sciences may enter industrial or governmental employment as well. Ph.D.'s who accept employment in government or industry are outside the academic prestige system entirely, meaning that the majority of these placements will have a neutral impact on the department's prestige. The implication for our model of departmental behavior is to make the optimal output of the prestige-maximizing department a function of the demand conditions in the job market for each discipline. The department can regulate the supply of new Ph.D.'s produced by controlling variables such as admission and performance standards, the number and type of requirements included in the curriculum, the use of teaching and research assistantships, and the allocation of fellowships. Because control over the process is lodged within the department, we must look at departmental objectives and the institutional constraints in order to develop a plausible theory of the determinants of Ph.D. production.

Before summarizing this section, a more specific discussion of the control variables available to the department may be in order. These variables can be organized under four headings: admissions, curriculum, information, and use of resources.

Admissions

Until very recently, each academic department at Berkeley set its own graduate admissions standards and determined the number of Ph.D. candidates to admit. Thus, the number of Ph.D. students was a variable largely under departmental control.

Curriculum

The department exercises virtually complete control over the curriculum, including the number of required courses, their sequence, grades and grade requirements, standards exacted on screening and qualifying examinations, and the nature of the dissertation required. The curriculum will affect attrition in two ways. First, the timing of examinations and the standards set will directly affect attrition patterns in the obvious way. The decision on standards determines rather precisely the number allowed to continue, and the timing obviously affects the number of years a student spends before being rejected. Second, in a clumsier and less controllable manner, the longer, the less precise and less articulated the curriculum, the higher the likelihood of attrition. A student who feels that he is making no clear progress toward the degree may experience frustration and discouragement, and will reduce his estimate of the probability of success, possibly reaching a point where the expected present value of the benefits does not exceed the present value of the costs.

Information

The department can exert a strong influence on the individual student's estimate of the probability of success by controlling information needed by the student in making that estimate. Periodic evaluations of the student's progress, interpretation of test results, even chance comments, are the data points which the student uses in constantly revising his estimate of the risk factor. A department that wants to keep a student in the program must provide feedback designed to maintain the student's estimate of the probability of success at a high level.

Resources

Given the resources available for student support in each field, we assume that departments may organize their fellowships, teaching assistantships, and research assistantships in a variety of ways, and some ways may be better than others, judged by the criterion of Ph.D. production. One would expect the more productive departments to have a policy of financial support designed to provide funds in the most useful way to a student at each phase of the program.

Our analysis of the faculty member and the department can be summarized:

1. The faculty member is assumed to be rationally attempting to maximize his own prestige, and this behavior on the part of all

members of a department is consistent with maximization of departmental prestige.

2. Departmental prestige is a function of resources and the quality of placement of its Ph.D. students within the prestige system. Individuals who accept industrial or governmental jobs are outside the academic prestige system and this type of placement is viewed as neutral, or in some cases, positively prestigious.
3. Considerations of the quality of placement forces the analysis to include the nature of demand for new Ph.D.'s in each field as a determinant of the prestige-maximizing level of doctoral output.
4. The department was shown to have control over the factors assumed to affect the rate and timing of attrition. These include admissions policy, curriculum design, information, and organization of resources for financial support.

C. Analysis of the Department's Objective Function

In the previous section it was argued that departmental prestige is a function of two variables: (1) resources; (2) quality of Ph.D. placement. We must now examine these two variables in order to understand how they are determined.

In California, the following formula has been developed with the State Department of Finance to determine the numbers of FTE faculty positions that the state will fund:[12]

$$\text{FTE Faculty} = \frac{1.0\,LD + 1.5\,UD + 2.5\,OG + 3.5\,AD}{28}$$

where

LD = number of FTE lower-division students enrolled;
UD = number of FTE upper-division students enrolled;
OG = number of FTE Master's candidates and first-year doctoral students enrolled; and
AD = number of FTE advanced doctoral students enrolled.

In other words, the state is committed in principle to a weighted 28 to 1 student-faculty ratio. Note that each advanced doctoral student enrolled brings the campus ⅛ FTE faculty position.

Internally, there is considerable evidence indicating that allocation of FTE positions to departments closely follows the same weighted enrollment formula. Interviews with Budget Office personnel revealed that departmental requests for new positions are often bolstered by enrollment figures, and cross-section regression analysis indicated that weight-

ed enrollments "explain" approximately 82 per cent of the variation in departmental staffing. Therefore, although the formula expressed in equation 1 is not followed mechanically at the departmental level, it seems reasonably clear that departments are awarded faculty positions on the basis of weighted student enrollments. Once the number of faculty positions for each department has been determined, other resources such as office space and nonacademic personnel can be functionally related to the faculty numbers. Thus, the resource allocation process can be viewed as a two-stage process (see Figure 2).

The second element of the department's prestige function is the quality of placement achieved by the department's doctoral students. Quality of placement for each year's group of students will be a function of the number produced and the demand for Ph.D.'s in a field. The following simple model may clarify the process of placement.

We begin with the following assumptions:

1. Assume that at any point in time a department can rank its graduate students from best to worst.
2. Assume also that a department and its graduate students would generally agree on a ranking of university, college, and junior-college departments according to prestige. (We might think of a clustering of colleges and universities into five broad groups, rated along the scale from high, positive prestige to low, negative prestige.)
3. Assume that regardless of the rate of attrition, the department will view those students who complete the Ph.D. as its best students. In other words, assume that the awarding of Ph.D.'s follows the student rank ordering, so that if 3 students out of 10 receive the doctorate, the department will view the successful candidates as the 3 best students.
4. Considering just the academic market, assume a strong positive correlation between the prestige ordering of job offers and the department's rank ordering of its successful Ph.D. candidates.
5. Assume that a student with multiple offers will accept the most prestigious position.

Given these assumptions, our model of the market's functioning as viewed by the department is depicted as in Figure 3.

Since it has been argued that the department controls the number of Ph.D.'s it produces, the decision problem facing the department is to determine where in the rank ordering of students it should draw the line. The actual number cannot be precisely controlled because of random factors, but one can assume that a department knows approximately how much attrition a particular curriculum, set of standards, and level of financial support will produce. In other words, the department is pre-

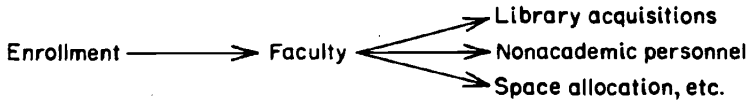


FIGURE 2

sumed to have considerable knowledge of its production function. The fundamental hypothesis is that the decision on where to draw the line is a function of the department's perceived demand curve for its graduates. In Figure 3, a department wishing to maximize prestige by avoiding placement in schools with negative prestige would only award Ph.D. degrees to the six "best" students, resulting in an attrition rate of 50 per cent.

The introduction of another large employing sector, such as industry, provides the department with an escape hatch from the prestige system. In the previous example, all the department's products were forced into the academic market; thus, to avoid poor placement, a department must create a certain amount of attrition. However, a department such as Chemistry enjoys a large, nonacademic demand for its Ph.D.'s, and is therefore not under pressure to create attrition as is a department lacking that outlet.

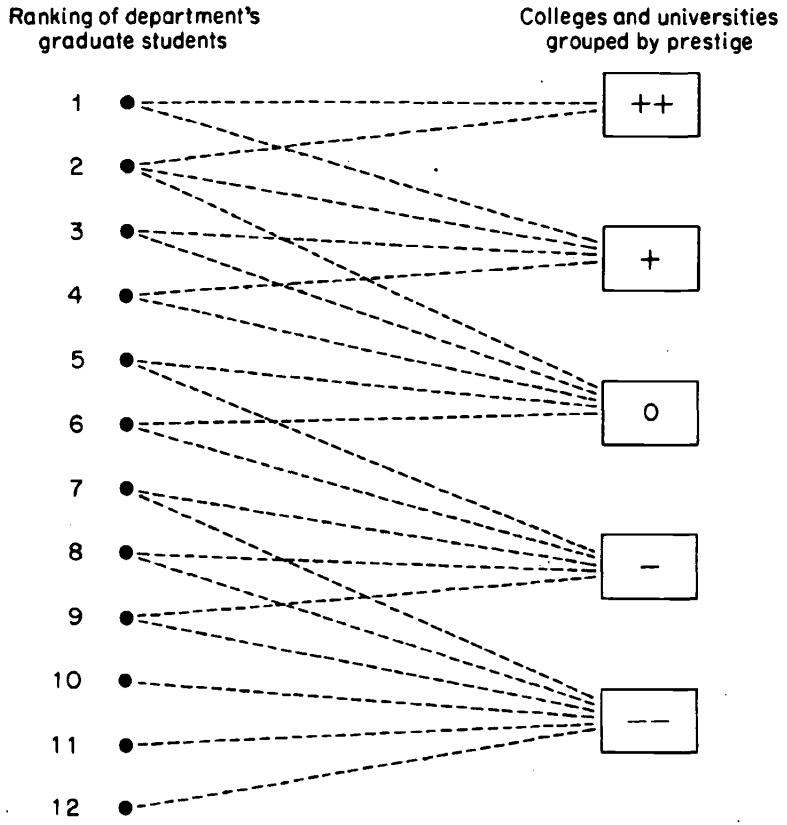
The elements of a theory explaining differences in attrition rates by department are now complete.

D. The Theory of Departmental Attrition

The theory of departmental attrition follows in a direct and simple way from the previous discussion. In this section, a simple analytic model will be developed to explain the differences in departmental success rates. In the following section, comments on the differences in timing of attrition will be made.

The Theory of Different Success Rates

It should be stressed that this theory describes the long-run adjustment of a department. Academic departments are relatively slow in their ability to react to changing circumstances; the loose form of organization and the collegial system insures this. Furthermore, we know that much uncertainty and many random factors affect the system under discussion, while the theory describes a department operating with full information and considerable foresight. Nonetheless, the following simple model captures the essence of the optimization problem facing the department.



NOTE: Dotted lines indicate job offers.

FIGURE 3

We have assumed the department's objective to be prestige maximization. Prestige was discussed in terms of the department's ability to attract and hold good people, and its ability to place its doctoral students well. Following the logic of the last section, this reduced operationally to command over resources and the number of Ph.D.'s produced. The functional relationships implied can be expressed as follows:

(1) Prestige = f (resources, number of Ph.D.'s produced)

(2) Resources = g (enrollments)

(3) Number of Ph.D.'s produced = h (enrollments).

Our interest focuses on relation 3 which defines the attrition rate. I have argued that this function is not technologically determined, but is subject to departmental control. The model provides one plausible hypothesis to explain why departments differ with regard to relationship 3.

Graphically, the functions might be expressed as they are in Figures 4 through 7.

Figure 4 depicts a linear relationship between enrollments and resources over a range from X_0 to X_1, with a kink at X_1 and a leveling of the function. The kink at X_1 recognizes the fact that departments are not free to expand enrollments indefinitely, that limits are imposed by scarce resources and administrative control.

Figure 5 sketches one possible relation between doctoral enrollment and Ph.D.'s produced. Of particular interest is the angle θ, which can range over values from 0° to 45°, with 0° representing 100 per cent attrition and 45° representing no attrition.

Figure 6 depicts the relation between resources and prestige. The function may or may not be linear; the only restriction is that it be monotopically increasing.

Figure 7 represents one possible relationship between the number of Ph.D.'s produced and departmental prestige. This particular graph might represent a field serving only the academic market, with the shape of the function following directly from the analysis of the previous section. This particular function is also properly interpreted as the department's perceived demand curve for its Ph.D. products. The shape of the function will vary according to the nature of the market served.

These functions are now linked together as a system to show how the department's prestige-maximizing behavior determines the optimal attrition rate. The French and Chemistry departments, representing the extremes of departmental behavior, will be examined.

The French Department is a typical humanities department whose Ph.D.'s only enter academia. For the past twenty-one years, the department at Berkeley has awarded between one and five Ph.D.'s a year despite a rising enrollment. Our theory suggests that this behavior would be consistent with a perceived demand curve of the type sketched in quadrant III of Figure 8. Given a stable market without large fluctuations in demand, the department's prestige-maximizing long-run equilibrium output would be three Ph.D.'s per year, with small expected variance caused by random factors. This output rate will insure P_2 units of prestige from placement.

The combination of quadrants I and II indicate that the department will enroll the maximum allowable, E_1, in order to receive R_1 resources, producing P_1 units of prestige.

The angle θ_1 in quadrant IV, the department's optimal attrition rate,

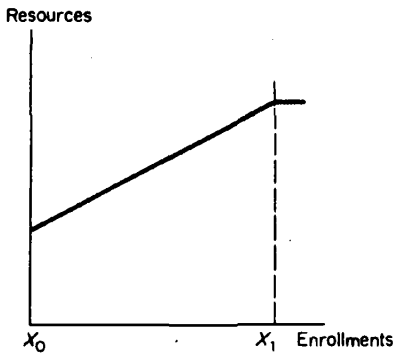


FIGURE 4

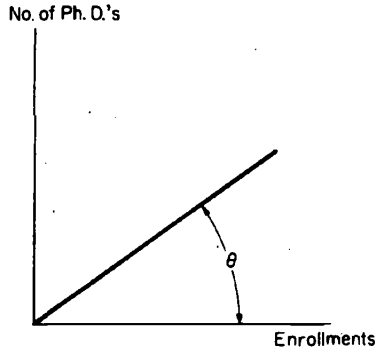


FIGURE 5

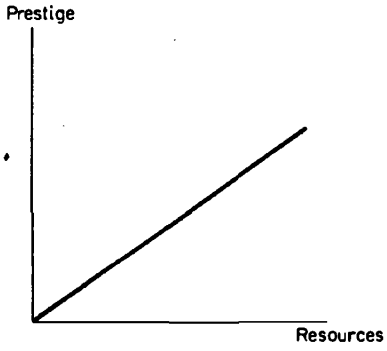


FIGURE 6

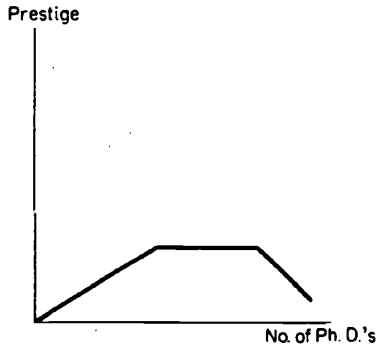


FIGURE 7

is now completely determined by the intersection of the prestige-maximizing enrollment and output decisions from quadrants I and III. Maximum prestige possible, $P_1 + P_2$, is attained with the department not having to trade off one determinant of prestige against the other.

Regardless of department, quadrants I and II remain essentially unchanged, i.e., departments have incentive to maintain enrollments at a maximum. Thus, the market will determine the angle θ for each department.

Relative to a field such as French, the market during the 1950s and 1960s for Ph.D. chemists was very strong and diversified. Fewer than 50 per cent of the chemists produced by graduate departments accepted academic positions,[13] as industrial firms sought to hire these individuals. In this circumstance, one might assume that the Chemistry Department would view the demand for their Ph.D.'s as unlimited, with each stu-

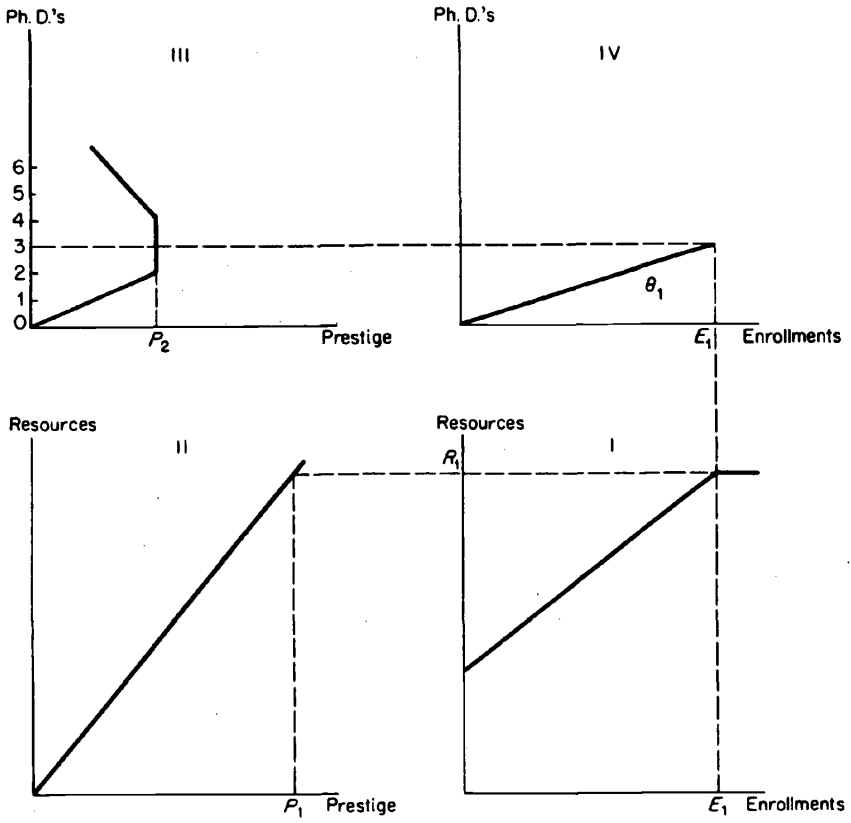


FIGURE 8 Case 1, French Department

dent receiving multiple offers, all of them satisfactory placements. A discipline in this fortunate position would have no need to organize the program to insure a certain level of attrition; in fact, every effort would be made to produce as many Ph.D.'s as possible, resulting in an angle θ_2 very near to 45°. This field would be graphed as follows in Figure 9.

The two polar cases demonstrate how market forces operate upon prestige maximizing departments to produce different rates of attrition. We must now turn our attention to the differences in timing of attrition observed among departments.

The Theory of Differences in Attrition Patterns

As mentioned earlier, Stark's study[14] revealed two disturbing aspects of attrition at Berkeley, the differences in departmental success rates and

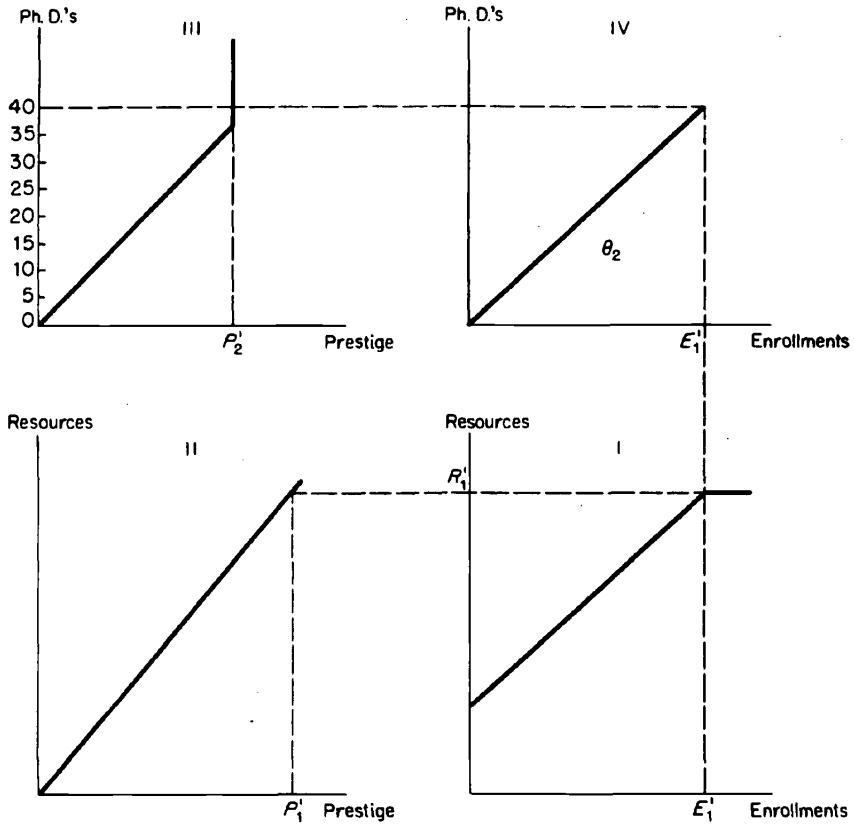


FIGURE 9 Case 2, Chemistry Department

the differences in timing of attrition. Thus, not only did the Chemistry Department have a high success rate, but the attrition occurred almost entirely within the first year. By contrast, the other three fields had numerous students enrolled for two, three, or even four years before leaving without a degree. The theory presented in the first part of this section explained differences in success rates; the purpose of this section will be to present a theory to explain the differences in timing of attrition.

As in the first part, the theory will concentrate upon the department's role, with emphasis placed upon the production functions in each field and the internal economy of departments. The nature of faculty input and the role of physical capital in the production process will be relevant factors, as well as the graduate student's role in the department's economy.

Consider first the economy of the French Department. Previously it was suggested that the demand for Ph.D.'s in French is not great and has been reasonably stable during the last several years, relative to many other disciplines. It was argued that this fact explains the low success rate in French. Weakness in the market also explains the lack of financial support available to graduate students in French. The department, however, has a demand for graduate students based on its need to produce student credit hours to maintain its claim over university resources. Furthermore, the presence of numerous graduate students generates demand for advanced courses in highly specialized areas of French literature, the type of courses that faculty members like to teach. The department's demand for graduate students coupled with the minimal demand for French Ph.D.'s would pose a serious problem were it not for the presence of Letters and Science undergraduates who are required to complete four quarters of a foreign language.[15] This requirement generates a large demand for teaching assistants and solves the department's problem of providing financial support for graduate students. Thus, the economy of this department rests, somewhat perilously, on the demand for undergraduate instruction artificially created by breadth requirements.

The technology of Ph.D. production in this field is reasonably simple, and from the department's point of view, inexpensive. Faculty input is limited to course offerings, testing, and thesis advising; capital requirements are classroom space and library facilities, provided by university funds. The department has no incentive to economize on the use of resources required to produce Ph.D.'s; in fact, there is every incentive to maximize use and control over such resources.

From the perspective of the French faculty, then, the graduate student must be viewed as a very valuable member of the department's economy. Not only does the graduate student teach the dull introductory courses, but he is a source of student credit hours and demand for advanced instruction. Departmental technology is such that having graduate students in residence for several years is costless to the faculty, and not without certain advantages. First, the experienced teaching assistant requires minimal supervision; if graduate turnover were high, faculty would be forced to spend more time working with the fledgling teachers. In addition, second- and third-year graduates can be expected to enroll in more advanced courses, thereby allowing increased faculty specialization. Consequently, in this type of department, faculty members have no incentives to make rapid decisions to terminate Ph.D. aspirants. Graduate students are particularly valuable assets to such departments and will be kept in residence as long as possible. Eventually, fatigue, financial pressures, or the dissertation will produce the necessary attrition.

Linking the analysis of the first part with the above, we have a picture of a humanities department desiring a high attrition rate, but not wanting this to occur within the early years of the student's graduate career. If this is an accurate description of the department's objectives, we would expect to find the following features of the graduate program:

1. Critical hurdles designed to eliminate candidates in the late rather than in the early stages of the program.
2. A curriculum sufficiently ambiguous and fuzzy to keep students mildly confused about their rate of progress toward the degree.
3. Conscious minimization of the student's feeling that he is a member of a particular graduate class or cohort. A student should have a minimum of checkpoints by which to measure his progress.
4. Feedback from the department designed to keep the student's estimate of success high.
5. Extremely demanding requirements for the dissertation, this being the final hurdle for the degree.
6. Use of the same individuals as teaching assistants for several years.
7. Absence of discussion or information related to the job market for Ph.D.'s.
8. A general lack of information about the historical success rates of graduate students, attrition patterns, and so forth. The best policy for the department would be to minimize information flows to the students.
9. A tendency for the department not to keep detailed records on the experiences of past graduate students.
10. Little evidence of major curriculum revisions.

By way of contrast, let us now consider a natural science department such as Chemistry. Stark's study demonstrated that virtually all of the attrition in this field occurs in the first year. Why might this be?

First, our earlier analysis suggested that this department, having faced an excellent market during the 1950s and through most of the 1960s, would have had little reason to want any particular level of attrition; in fact, market factors alone may have dictated a zero attrition rate as optimal. Under these circumstances, the department would have no incentive to delay a decision on a student until the second or third year. Students who appear short on intelligence or motivation should be spotted quickly and removed to make room for others who will be successful.

Departmental technology also plays an important role in this type of field. Unlike the humanities, a doctoral student in chemistry may easily require thousands of dollars worth of expensive equipment for dissertation research. This equipment is often purchased from the funds of a

professor's research grant. The professor, having hired the student as a research assistant, cannot afford to have someone incompetent working with equipment purchased from his grant, since the funding agency expects satisfactory research results. Should a student in this situation fail to produce, the professor would bear a large part of the cost. Therefore, the department must do its screening early to protect against this type of embarrassment. Even if the Chemistry Department faced a poor job market, the above considerations suggest that attrition would occur early in the program. The inclusion of expensive capital equipment in the production function plus a heavier involvement of faculty time makes attrition in the third or fourth year too expensive for the department to bear.

Note the fundamental difference between the cost functions in French and Chemistry departments. An advanced doctoral student in French may need expensive library resources, funded through the university budget. This cost is not borne by any professor in the French Department, i.e., the cost is not included in the professor's or the department's cost function. If the student fails to complete the dissertation, the department will still benefit from the enlarged French collection in the library. By contrast, chemistry professors are directly accountable to the external funding agencies which support their research; thus, the performance of graduate students is incorporated into the individual professor's cost function, providing the professor with incentive to see that the work is done.

Although both departments have a demand for graduate students as an input in the production of student credit hours, the Chemistry Department primarily needs graduate students for research assistance, while the French Department's primary need is for teaching assistance. Given the research orientation of the Ph.D. degree, it is obvious that the needs of the Chemistry Department coincide with the degree requirements much more closely than do those of the French Department.

Our analysis of the Chemistry Department's technology suggests that the department will screen its students closely during the first year, eliminating from the program students who might be poor research risks. That done, one would expect a rationally organized curriculum designed to get students through quickly and into the market.

III. EVIDENCE SUPPORTING THE THEORY

A. The Demand for Ph.D.'s

Writing in 1966, Allan Cartter made the following observation:

> Considering the importance of the problem to higher education, and the many hundreds of millions of dollars appropriated by the federal government for the expansion of graduate education over the last few years, it is rather astonishing that we know so little about the present and probable supply and demand of college teachers.[16]

Cartter was referring to our ignorance regarding aggregate supply and demand for Ph.D.'s; he later comments that we know even less about supply and demand by field.[17] In particular, we lack reliable time series data on demand for Ph.D.'s by discipline.

In his 1965 study, *Academic Labor Markets*,[18] prepared for the U.S. Department of Labor, David Brown proposes several measures for comparing excess demand across fields:[19]

1. starting salaries of newly graduated Ph.D.'s;
2. extent of salary increase;
3. salaries paid to full professors in 1962–63;
4. academic rank of newly graduated Ph.D.'s;
5. unfilled positions as a percentage of all positions;
6. percentage of newly graduated Ph.D.'s entering college teaching; and
7. expansion demand as a percentage of all hiring.

Brown argues that none of the above measures taken separately adequately captures the relative supply-demand balance across fields; however, survey data Brown collected allowed him to rank 23 disciplines on each of the seven measures. These separate rankings were then combined into a single shortage index for 1964, reproduced as Table 4. In commenting on these rankings, Brown stresses that, "The individual discipline markets are tighter in the expanding fields and in those fields where the opportunities outside the academic community are greatest."[20]

In considering Brown's data, we merely note that those fields in high demand in 1964, the hard sciences and engineering, are the fields with minimal attrition and shorter time-to-degree at Berkeley, while the fields with lesser demand, the humanities, are the high attrition, lengthy time-to-degree programs at Berkeley. Thus, these data are consistent with the demand-oriented theory of Ph.D. production. Further reference to these data will be made as we turn to the supply side of the market.

TABLE 4 Brown's Ranking of 23 Disciplines by Excess Demand,[a] 1964

Discipline	Shortage Index
Electrical Engineering	1
Educational Services and Administration	2
Mechanical Engineering	3
Mathematics	4
Physics	5
Economics	6
Civil Engineering	7
Chemistry	8
Counseling and Guidance	9
Clinical Psychology	10
Sociology	11
Art	12
Secondary Education	13
Political Science	14
Earth Sciences and Geology	15
General Biology	16
Biochemistry	17
Physical Education and Health	18
Music	19
General Zoology	20
English and Literature	21
History	22
French	23

SOURCE: David Brown, *Academic Labor Markets*.
[a] Rank of 1 means excess demand greatest in that discipline.

B. The Supply of Ph.D.'s

Although we have no precise method for determining the demand schedule for Ph.D.'s by field over time, annual figures are available on the supply of new doctorates. In assessing departmental performance, a comparison of Berkeley's doctoral output with national production of Ph.D.'s adds to the plausibility of our market-oriented theory.

Data were collected on doctorates awarded annually by field for the 21-year period, 1947–48 to 1967–68. In addition to total production, degrees awarded by the top 20 quality ranked schools[21] in each discipline were recorded. Table 5 presents the 21-year totals for each field. Examination of the column headed "Berkeley % of Top 20" demonstrates that Berkeley is a significant producer in all subject areas. For example, Berkeley's forty-one Ph.D.'s in Spanish (an average of two per

TABLE 5 Total Ph.D. Degrees Produced by U.S. Universities, 28 Fields, 1947–48 to 1967–68 (21-year totals)

Field	No. of Ph.D.'s Awarded in U.S.	No. of Ph.D.'s Awarded by 20 Top Quality Schools[a]	No. of Ph.D.'s Awarded by Berkeley	% of Total Produced by 20 Top Quality Schools	Berkeley % of Total	Berkeley % of Top 20
Classics	775	638	25	82.3	3.2	3.9
English	9,161	5,349	209	58.4	2.3	3.9
French	1,399	1,074	53	76.8	3.8	4.9
German	1,021	696	53	68.2	5.2	7.6
Spanish	1,036	649	41	62.6	4.0	6.3
Philosophy	2,190	1,381	66	63.1	3.0	4.8
Anthropology	1,316	1,197	119	91.0	9.0	9.9
Economics	6,077	3,538	300	58.2	4.9	8.5
Geography	1,115	936	51	83.9	4.6	5.4
History	7,910	4,695	364	59.4	4.6	7.8
Political Science	4,472	2,839	194	63.5	4.3	6.8
Sociology	3,728	2,118	95	56.8	2.5	4.5
Bacteriology	3,247[b]	1,286[b]	85	39.6	2.6	6.6
Biochemistry	3,857[b]	1,655[b]	198	42.9	5.1	12.0
Botany	2,947	1,485	130	50.4	4.4	8.8
Entomology	1,710	1,408	188	82.3	11.0	13.4
Physiology	1,727[b]	721[b]	95	41.7	5.5	13.2
Psychology	14,157	5,448	351	38.5	2.5	6.4
Zoology	3,915[b]	1,989[b]	236	50.8	6.0	11.9

Astronomy	533	487	65	91.4	12.2	13.3
Chemistry	23,418	10,412	778	44.5	3.3	7.5
Geology	3,542	2,414	92	68.2	2.6	3.8
Mathematics	7,097	3,635	313	51.2	4.4	8.6
Physics	12,699	6,616	811	52.1	6.4	12.2
Chemical Engineering	4,142	2,236	103	54.0	2.5	4.6
Civil Engineering	2,405	1,684	142	70.0	5.9	8.4
Electrical Engineering	5,617	3,755	244	66.8	4.3	6.5
Mechanical Engineering	2,846	1,760	146	61.8	5.1	8.3
Total, 28 fields	134,059	72,101	5,547	53.8	4.1	7.7

SOURCE: U.S. Department of Health, Education and Welfare, Office of Education, *Earned Degrees Conferred*, 1947–48 to 1967–68.

[a] Ranked in *Assessment of Quality* (Cartter Report 1966).

[b] Totals are understated because certain universities did not list their degrees under this category.

year) still represents 6.3 per cent of the production by the top 20 schools. In terms of sheer numbers, a recent publication of the National Research Council, *Report on Doctoral Programs*, shows that Berkeley ranked fifth out of 184 institutions in total doctorate production for the period 1958–62, and first out of 213 for the period 1963–67.[22] Of the fields considered in this study, Berkeley's lowest departmental ranking in terms of Ph.D. output for the period 1963–67 was thirteenth out of 102 in the English and American Language and Literature category.[23] In virtually every other field, Berkeley ranked within the top four producers. Forgetting departmental enrollments and looking just at output, there would seem to be little cause for concern.

Shifting to individual fields, consider the supply of French Ph.D.'s, reported in Table 6. Note that Berkeley's output of two to three Ph.D.'s per year generally accounted for 4 to 6 per cent of top 20 production. One realizes how thin the market for French Ph.D.'s is by recalling that Brown's shortage index ranked this field last in terms of excess demand during the middle 1960s; in fact, Brown referred to French as one of the surplus disciplines. And yet, during that period, total production averaged only seventy Ph.D.'s, per year with the top 20 schools averaging approximately fifty Ph.D.'s. If, during 1963–64, Berkeley's department, with a graduate enrollment of over ninety students, had produced a reasonable number of Ph.D.'s for that enrollment (say fourteen instead of four), Berkeley's per cent of the top 20 production would have risen from 6.0 per cent to 18.2 per cent. I submit that an increase of such magnitude would not have gone unnoticed in a very thin market. One can imagine the department facing a very difficult marketing operation; not only might the jobs not be there, but within the fraternity of French departments, such an increase might have been interpreted as a reduction in quality. The department might have found it very difficult to regain its reputation as a quality program.

Two additional representative tables are presented, covering the supply of Ph.D.'s in German (Table 7) and Political Science (Table 8). Since both fields are typified by high attrition rates at Berkeley, the reader is encouraged to consider the effect that tripling the department's output would have had upon the market in each field. I believe that these figures reveal a major determinant of each department's decision regarding the desirable number of Ph.D.'s to produce.

C. Placement of Berkeley Ph.D.'s

Earlier it was hypothesized that departments at Berkeley are not interested in producing Ph.D.'s for all segments of the academic market, but operate instead to produce a number that can be placed reasonably

TABLE 6 Annual U.S. Production of Ph.D. Degrees in French, 1947-48 to 1967-68

Year	No. of Ph.D.'s Awarded in U.S.	No. of Ph.D.'s Awarded by 20 Top Quality Schools[a]	No. of Ph.D.'s Awarded by Berkeley	% of Total Produced by Top 20 Schools	Berkeley % of Total	Berkeley % of Top 20
1967–68	159	119	5	74.8	3.1	4.2
1966–67	118	83	5	70.2	4.2	6.0
1965–66	94	69	6	73.4	6.4	8.7
1964–65	80	57	2	71.2	2.5	3.5
1963–64	88	67	4	76.1	4.5	6.0
1962–63	63	50	3	79.4	4.8	6.0
1961–62	63	48	3	76.2	4.8	6.2
1960–61	51	35	2	68.6	3.9	5.7
1959–60	63	51	3	81.0	4.8	5.9
1958–59	70	55	3	78.6	4.3	5.4
1957–58	41	35	2	85.4	4.9	5.7
1956–57	50	43	3	86.0	6.0	7.0
1955–56	59	48	2	81.4	3.4	4.2
1954–55	53	40	2	75.5	3.8	5.0
1953–54	58	35	1	60.4	1.7	2.9
1952–53	57	43	2	75.4	3.5	4.6
1951–52	52	46	2	88.5	3.8	4.3
1950–51	44	35	1	79.5	2.3	2.8
1949–50	58	51	1	87.9	1.7	2.0

TABLE 6 (concluded)

Year	No. of Ph.D.'s Awarded in U.S.	No. of Ph.D.'s Awarded by 20 Top Quality Schools[a]	No. of Ph.D.'s Awarded by Berkeley	% of Total Produced by Top 20 Schools	Berkeley % of Total	Berkeley % of Top 20
1948–49	48	39	0	81.2	0.0	0.0
1947–48	30	25	1	83.3	3.3	4.0
Total, 21 years	1,399	1,074	53	76.8	3.8	4.9

NOTE: Other statistics based upon 21-year totals:

	Total U.S. Universities	Berkeley
French degrees as % of total degrees awarded in all 28 fields	1.04	0.95
% of degrees in French awarded to men	64.8	81.1

SOURCE: H.E.W., *Earned Degrees Conferred*; Berkeley degrees gathered from dissertation records.
[a] Ranked by the Cartter Report.

TABLE 7 Annual U.S. Production of Ph.D. Degrees in German, 1947–48 to 1967–68

Year	No. of Ph.D.'s Awarded in U.S.	No. of Ph.D.'s Awarded by 20 Top Quality Schools[a]	No. of Ph.D.'s Awarded by Berkeley	% of Total Produced by Top 20 Schools	Berkeley % of Total	Berkeley % of Top 20
1967–68	122	69	4	56.6	3.3	5.8
1966–67	100	67	4	67.0	4.0	6.0
1965–66	95	49	4	51.6	4.2	8.2
1964–65	68	46	4	67.6	5.9	8.7
1963–64	78	51	2	65.4	2.6	3.9
1962–63	37	28	1	75.7	2.7	3.6
1961–62	46	34	5	73.9	10.9	14.7
1960–61	38	26	1	68.4	2.6	3.8
1959–60	24	17	0	70.8	0.0	0.0
1958–59	29	26	2	89.6	6.9	7.7
1957–58	35	27	5	77.1	14.3	18.5
1956–57	32	25	5	78.1	15.6	20.0
1955–56	33	17	3	51.5	9.1	17.6
1954–55	26	19	2	73.1	7.7	10.5
1953–54	46	35	4	76.1	8.7	11.4
1952–53	37	33	1	89.2	2.7	3.0
1951–52	56	43	0	76.8	0.0	0.0
1950–51	31	22	1	70.1	3.2	4.5
1949–50	40	30	3	75.0	7.5	10.0

TABLE 7 (concluded)

Year	No. of Ph.D.'s Awarded in U.S.	No. of Ph.D.'s Awarded by 20 Top Quality Schools[a]	No. of Ph.D.'s Awarded by Berkeley	% of Total Produced by Top 20 Schools	Berkeley % of Total	Berkeley % of Top 20
1948–49	27	14	0	51.8	0.0	0.0
1947–48	21	18	2	85.7	9.5	11.1
Total, 21 years	1,021	696	53	68.2	5.2	7.6

NOTE: Other statistics based upon 21-year totals:

	Total U.S. Universities	Berkeley
German degrees as % of total degrees awarded in all 28 fields	0.76	0.95
% of degrees in German awarded to men	78.6	86.8

SOURCE: H.E.W., *Earned Degrees Conferred.*

[a] Ranked by the Cartter Report.

TABLE 8 Annual U.S. Production of Ph.D. Degrees in Political Science, 1947–48 to 1967–68

Year	No. of Ph.D.'s Awarded in U.S.	No. of Ph.D.'s Awarded by 20 Top Quality Schools[a]	No. of Ph.D.'s Awarded by Berkeley	% of Total Produced by Top 20 Schools	Berkeley % of Total	Berkeley % of Top 20
1967–68	457	267	17	58.4	3.7	6.4
1966–67	390	213	20	54.6	5.1	9.4
1965–66	336	192	15	57.1	4.5	7.8
1964–65	304	181	16	59.5	5.3	8.8
1963–64	263	171	12	65.0	4.6	7.0
1962–63	228	134	9	59.2	3.9	6.7
1961–62	214	142	7	66.4	3.3	4.9
1960–61	217	153	10	70.5	4.6	6.5
1959–60	201	137	7	68.2	3.5	5.1
1958–59	191	118	6	61.8	3.1	5.1
1957–58	170	104	8	61.2	4.7	7.7
1956–57	156	106	8	67.9	5.1	7.5
1955–56	203	126	9	62.1	4.4	7.1
1954–55	181	114	6	63.0	3.3	5.3
1953–54	153	109	9	71.2	5.9	8.2
1952–53	164	114	7	69.5	4.3	6.1
1951–52	147	121	11	82.3	7.5	9.1
1950–51	152	104	6	68.4	3.9	5.8
1949–50	127	85	3	66.9	2.4	3.5

TABLE 8 (concluded)

Year	No. of Ph.D.'s Awarded in U.S.	No. of Ph.D.'s Awarded by 20 Top Quality Schools[a]	No. of Ph.D.'s Awarded by Berkeley	% of Total Produced by Top 20 Schools	Berkeley % of Total	Berkeley % of Top 20
1948–49	119	75	4	63.0	3.4	5.3
1947–48	99	72	4	72.7	4.0	5.6
Total, 21 years	4,472	2,839	194	63.5	4.3	6.8

NOTE: Other statistics based upon 21-year totals:

	Total U.S. Universities	Berkeley
Political science degrees as % of total degrees awarded in all 28 fields	3.33	3.49
% of degrees in political science awarded to men	92.2	92.8

SOURCE: H.E.W., *Earned Degrees Conferred.*

[a] Ranked by the Cartter Report.

well within the prestige system. Underlying this view was the assumption that quality of doctoral student placement reflects positively or negatively upon the prestige of the producing institution; it was argued that if a department "overproduced" to the extent that significant numbers of its placements were in inferior quality schools, the department's reputation would suffer. These assertions are open to empirical test, the purpose of this section.

In the theoretical section, it was suggested that conceptually one could categorize the colleges and universities in this country into five prestige classes, ranking them symbolically ++, +, 0, −, and −−. The argument was made that Berkeley departments control their output so that the vast majority of placements will be made within the first three groups; placements in the − and −− categories would be avoided by not overproducing. To give meaning to these classifications, we turn again to David Brown's publication *Academic Labor Markets*.[24]

For his own purposes, Brown produced a Prestige Index, by which he ranked 1,121 U.S. colleges and universities. With numerous caveats, he proposed the following eight factors as measuring elements of academic prestige:[25]

1. percentage of faculty with Ph.D.'s;
2. average compensation (salary and fringe benefits) per faculty member;
3. percentage of students continuing to graduate school;
4. percentage of students studying at the graduate level;
5. number of volumes in library per full-time student;
6. total number of full-time faculty members;
7. faculty-student ratio; and
8. total current income per student.

Every school was ranked from 1 to 1,121 on each factor, and an average rank, or composite rating, was computed for each institution. The schools were then broken into six groups, labeled A through F, with group A being the most prestigious, group F the least prestigious.

Brown's classification was accepted for the present study, with one major change. The ++ category in our conceptualization was reserved for universities ranked 1 through 10 in each field by the Cartter Report, for it was felt that the very highest prestige accrues to placement in such schools. Brown's "A" ranking included colleges such as Amherst and Swarthmore, which, while prestigious in their own way, do not have the status of graduate-oriented research institutions. Consequently, Table 9 sets forth the definitions of our proposed prestige rating system.

It is not feasible to reproduce the list of all 1,121 schools; the interested reader is referred to Brown's book.[26] To give an idea of the type of school included in each category, a few examples are provided:

TABLE 9 Definition of College and University Prestige Groupings

Group	Definition	No. of Institutions
++	Top 10 Cartter Report schools in each field	10
+	Brown's groups A and B plus schools ranked 11–20 in Cartter Report	65 (approximate)
0	Brown's groups C and D	335
−	Brown's group E	283
−−	Brown's group F	428
	Total	1,121

SOURCE: Cartter Report, and Brown, *Academic Labor Markets*.

++ Refer to Cartter Report for each field—generally the well-known universities, such as Harvard, Yale, Princeton, Michigan, etc.

\+ Amherst, Swarthmore, Williams, Wellesley, Rochester, University of California at San Diego, Tulane.

0 Antioch, Colorado College, George Washington University, University of Colorado, Kansas, Rutgers, Ohio State, Temple.

− University of Alabama, Arizona, Butler, Central Michigan, Clemson, East Texas State, Elmira College, San Diego State, University of San Francisco, Southern Oregon.

−− Abilene Christian, California State Polytechnic, Brigham Young, University of Dayton, DePaul, Florida A&M, Golden Gate College, Slippery Rock, Memphis State, Seton Hall, Washburn University.

Data on first academic position taken by Berkeley doctorates were gathered from the National Academy of Sciences, "Survey of Earned Doctorates."[27] Beginning with fiscal year 1967, the computerized data list the name of the first academic employer or postdoctoral institution; thus, data on two years' placement (1967, 1968) were available for the twenty-eight departments. A total of 466 academic appointments were listed; of these, seventy-four new Ph.D.'s remained at Berkeley, presumably for postdoctoral work. These seventy-four were excluded from the ratings. The remaining 392 were ranked according to prestige groupings described in Table 9. Results for the total placements are presented in Table 10. Comparing the number of placements in each category to the number of schools in each prestige group (Table 9), we note that nearly half (47.5%) of Berkeley's graduates accepted first positions in

TABLE 10 Number of Berkeley Academic Placements in Each Prestige Grouping, 1967, 1968

Group	No. of Placements	% of Total
++	85	21.7
+	101	25.8
0	157	40.0
−	37	9.4
−−	12	3.1
Total	392	100.0

SOURCE: National Academy of Sciences, "Survey of Earned Doctorates," computer tape for University of California, Berkeley.

schools ranked either ++ or +, although these two categories encompass only 75 colleges and universities. Furthermore, of the 428 institutions listed as −− schools, only 12 secured the services of a Berkeley Ph.D. The 410 schools representing ++, +, and 0 categories employed 87.5 per cent of the Berkeley graduates entering academia; the fact that only 49 Berkeley doctorates (12.5%) accepted positions in one of the 711 institutions carrying a − or −− rating suggests that the departments have not been interested in serving this sector of the market.

Our understanding of academic placement is enhanced by examining the positions accepted from 1962–63 to 1969–70 by the graduates of Berkeley's English Department, a large department (492 graduate students enrolled in 1965–66) with attrition from the doctoral program in excess of 80 per cent. Information was gathered from the annual departmental reports of the Committee on Placements.[28] Table 11 lists the schools where jobs were taken, by prestige grouping. Note that of the 136 placements ranked on the prestige index, 118 (87%) were in schools in the top three categories. Clearly, during the 1960s, Berkeley's English Department was not producing Ph.D.'s for the vast, less prestigious portion of the academic market.

D. Interviews with Faculty and Students

The purpose of interviewing faculty and students in several departments was simply to gain more understanding of the factors perceived by the participants as affecting time to degree and attrition. The theory of Section II was not directly presented to the interviewees because we did not wish to bias the response; instead, the differences in departmental performance were described and interviewees were asked how they

TABLE 11 Placement of Berkeley English Ph.D.'s, 1962–63 to 1969–70, by Prestige Grouping

Year	++	+	0	−	−−	Unranked
1962–63	Harvard (2) Stanford Princeton Indiana	Virginia Amherst U.S.C. UCLA (2)	Rutgers	Hunter		
1963–64	Yale (2) Columbia (2) Indiana (2) Cornell	Reed (2) Williams Smith Dartmouth Stony Brook	Texas Bucknell Rutgers			
1964–65	Columbia Indiana	UCLA Tufts Pomona UC-Santa Cruz UC-Irvine St. John's UC-S. Barbara Wellesley	Carleton Mich. State Texas Massachusetts Colorado			McGill
1965–66	Harvard Princeton Chicago Columbia Yale Wisconsin	Virginia UC-Riverside	Kansas Buffalo Kentucky New Mexico University of Illinois, at Chicago Circle	Boston U.		McGill Victoria (2) University of British Columbia

1966–67	Chicago Cornell Wisconsin Indiana	Washington (2) Minnesota M.I.T. (2) Pennsylvania (2) Tufts Michigan	U. of Pacific Kansas Buffalo (2) Massachusetts	Hunter (2) Boston U. San Jose State		University of British Columbia
1967–68	Stanford Wisconsin	UCLA (2) Williams Washington Pennsylvania Pittsburgh Dartmouth UC-Santa Cruz	Nebraska (2) Texas Colorado (2) Rutgers Penn. State Mich. State Temple Buffalo	Boston U. (2) Harpur-SUNY Richmond-CUNY San Diego State San Jose State		
1968–69	Columbia Yale Chicago	Illinois UC-Riverside	Temple Penn. State (2) S.M.U. Colorado Hawaii Buffalo Fresno State Rutgers	Conn. (2) Indiana Northern Villanova	CSC at Dominguez Hills	
1969–70[a]	UC-Berkeley (Rhetoric) Harvard Indiana	Minnesota UCLA Illinois (2)	Texas (2) Rutgers Buffalo	California State University at San Francisco		

SOURCE: Berkeley English Department reports of the Committee on Placements.
[a] Interim Report, Jan. 20, 1970. Ten other students had received at least one offer and were still negotiating.

would explain the relative performance of their department. Two senior professors in each of five fields were interviewed separately for an hour or more. The men were chosen for their knowledge of the program; in all but one instance, the professors had been members of the Berkeley faculty for 15 years or more. Students were interviewed in groups of three to five, representing different amounts of time in the program. Highlights of the interviews in three fields follow.

Chemistry

From faculty interviews, a clear picture of the economy of a Chemistry Department emerged. A faculty member must publish in order to gain a reputation so that he may acquire research grants with which to support graduate students who help him produce more research so that larger grants can be acquired allowing more students to be supported, etc.—a true vicious circle. The department simply could not afford to have a nonproductive faculty member, since each professor is expected to generate enough funds to support several students in a research group.

> In this field, publish or perish is an understatement. I spend half my time supervising graduate students, making sure that the work gets done, and the other half in Washington begging for more money. My knuckles are raw from bowing and scraping in front of those agencies. I think it's a great tribute to our faculty that we manage to do as good a teaching job as we do under these circumstances.[29]

The economic pressure to publish felt by faculty members in this field has led to an efficient organizational adaptation in which faculty members suggest topics and provide guidance and the graduate students do the actual research. The final product is published jointly under both names, with benefits flowing to both parties. The faculty member expands his publication list, thereby increasing his reputation and ability to earn more grants, while the student gains his Ph.D. and a first publication. The student is thus a critical input into the faculty member's research production function, freeing the professor from the tedious work in the laboratory and allowing him to operate more productively as a source of research proposals and as a fund raiser.

> Back in the early 1940s when I was a young assistant professor at Berkeley working 90 hours a week to get tenure, I actually did a research project by myself one summer and published it under just my name. So many people quizzed me about that at the professional meetings, questioning my sanity and so forth, that I learned never to make that mistake again, and haven't published solo since then.

One can understand why course work is kept to a minimum—the student is simply much more valuable in the laboratory than in the classroom.

The departmental decision regarding the number of graduate students to admit has been dictated primarily by the availability of extramural faculty grants which support graduate students and their research; hence, external resources appear to be more important to the department than internal resources. However, the department is keenly aware of the work-load measures used by the university's budget personnel:

> Even though our students take very few formal courses, they're all enrolled for the maximum course load in 298's and 299's.[30] Believe me, we produce more than our share of student credit hours.

The market's influence on departmental decisions governing the output rate of Ph.D.'s was brought out in several comments:

> When we're considering a marginal student in an oral exam, we know that if we pass him he'll be able to get a job in an industrial lab somewhere and will probably be a damn good chemist, so we generally let such students through. Of course, if we had to place all our students in academic jobs, we'd have to change our requirements and eliminate marginal students. We couldn't let as many through.

> As far as prestige is concerned, we view a placement in Bell Labs, or at Dupont or General Electric, as very acceptable, almost as good as a top academic position. In general, however, we hope that our best students take academic jobs.

Queried about the department's response to the currently worsened job market, one professor expressed uncertainty as to whether this was a temporary decline or represented a more permanent change. Should the decline be long-lived, he thought the department would reduce enrollments somewhat (although noting that this would be resisted by many professors), and that the curriculum would be revised to include more course work in order to train less specialized, more flexible chemists. The clear implication was that the product would be adapted to enhance its marketability.

Two other factors importantly related to student success rates emerged from the discussions. First, both professors stressed the value of the student's belonging to a specific research group, a place where the student could "hang his hat." This affiliation means that a professor is concerned with the student's progress from the beginning and provides a supportive group to bolster the student's confidence when the work becomes discouraging. Secondly, it was very apparent that the faculty

expect and want the students to succeed; we were told that if there were any doubt concerning the ability of an applicant to earn the degree, he would not be admitted. Thus, the faculty does not expect a high attrition rate, an expectation that becomes self-fulfilling.

The chemistry students' description of the program was virtually identical with the faculty description. The students agreed that there was only one critical test—the ability to perform research adequately.

> We don't sweat course work or exams or the German requirement. The only thing that matters to the faculty is what we produce in the lab. The students who are asked to leave are the ones who spend a year trying to do research and make no progress.

When asked about student response to the worsening job market, it was observed that students are beginning to stay in Berkeley for a fifth year. By working as a T.A., the student can avoid the 25 per cent pay reduction accorded R.A.'s;[31] furthermore, it was noted that several faculty members have not reduced student pay if the research being done is useful. We asked the first-year student whether the worsening market had affected his decision to enroll:

> I don't give a damn about the poor market—who knows what it will be like four years from now? I just don't think about it because I'm doing what I want to do now. I want to teach when I finish, and I figure something will be available then.

Asked for their attitude toward the joint authorship of research, the students responded favorably, indicating that it was, "a help in establishing a scientific career." Departmental organization into research groups was strongly supported for giving the student a sense of belonging. Morale in the department appeared to be very high.

English

We began both faculty interviews by inquiring into department policies regarding graduate enrollments; we wanted to know how faculty explained the growth of the department to 492 graduate students during the 1965–66 academic year. The first professor was not aware of any conscious policy regarding departmental size. He had noticed, however, a tendency for enrollment growth to correspond rather closely to increased faculty size. He did not express an opinion regarding the direction of causality.

The second professor offered numerous explanations. He stated that the department had established objective criteria for admission and felt

obligated to accept all qualified applicants, noting the absence of physical constraints such as laboratory space and facilities that would restrict enrollments. Next, he observed that English professors display near "missionary zeal" regarding the teaching of their subject, seeing their duty as rescuing the country from "cultural barbarism and illiteracy." Presumably, this made it harder for the department to reject applicants. Finally, he commented:

> In reality, I suspect our growth had a lot to do with the way the University keeps its books—you know, that weighted enrollment formula. While this was never overtly discussed when considering applicants, I know we all had in the back of our minds the knowledge that more graduate students meant more faculty. I'm sure most department members would never admit this, but I think you should adopt a behavioral approach—don't go by what we say, but by what we did.

This professor felt that the department had gotten far too large in terms of both students and faculty.

> What sense of community can you have when the chairman's annual cocktail party for faculty, teaching assistants, and wives is attended by over 250 people? Why, we have to rent space off campus just to house the affair. . . . There are assistant professors who have been in the department for two or three years whose names I don't even know. It's a bit embarrassing when I pass them in the hall.

He felt that the department would be much better off if graduate enrollments were reduced to a number small enough so that all students could be supported. The loss of faculty positions that such a policy would entail was viewed as an acceptable cost, perhaps even a move in the right direction. "Perhaps we could regain a feeling of community."

The other professor did not express a desire for such substantial change. Shocked by the worsening job market, he indicated that the department was aiming for a steady-state enrollment of 340 Ph.D. students, with 75 to 100 new doctoral students admitted each year. When asked how many Ph.D.'s the department would want to award annually when in that steady state, he indicated that "with the new program we hope to reduce attrition to an acceptable level and award 30 to 40 Ph.D.'s each year."

Note that these figures imply an attrition rate in excess of 50 per cent, and yet the professor clearly indicated that such performance would be viewed by the English faculty as optimal. The pronounced difference between faculty expectations in the English and Chemistry departments certainly helps to explain why attrition rates differ so markedly. Of

course, my fundamental argument is that these divergent faculty attitudes are a reflection of the different markets being served.

The English graduate students described the program as "a series of hurdles accompanied by continual anxiety and humiliation." A third-year student stressed the "feeling that you are not fully accepted by the department until you've neared the end of the program." A second-year student stated that, "the feeling in this department is, they're out to fail you." She noted that during the first year in the program she met few of her fellow students, largely because the intense competition was not conducive to friendships. And yet the students were stunned when shown the data from Stark's study; they had no idea that so few students actually earned the Ph.D.

The students described the Comprehensive and Oral examinations as the major obstacles in the program. The open-ended nature of the Comprehensive exam, coupled with the awareness that the department would fail some of the students, made that exam a particularly frightening experience. Although the brochure states that students must take the Comprehensive between the fourth and sixth quarter, the students knew several people who had managed to postpone the exam until the seventh or eighth quarter for fear of failure. (In keeping with the theory of Section II, such behavior may be perfectly rational given the all-or-nothing nature of the investment; an extra quarter's study is well spent if it makes the difference between passing and failing. Faculty attitudes are critical, for if the students know a certain number will be flunked, the incentive is to expand study time and minimize that risk.)

The language requirements were not viewed as a direct cause of attrition although it was felt that the Latin requirement does contribute to the "disgust" which finally causes some people to leave the program. The forced study of Latin is apparently viewed by many students as highly irrelevant; one student commented that:

> The faculty has preserved the Latin requirement because they view it as a hurdle which demonstrates the high quality of the Berkeley graduate program in English.

An advanced student argued that the department was constantly comparing its program to that of Yale and Harvard (the English departments ranked number one and two ahead of Berkeley in the Cartter Report), trying to outdo those two schools in the rigor of the doctoral program.

The Oral Examination was viewed as somewhat less an ordeal now that the student's area of interest occupies a larger portion of the exam. The students still characterized the exam as sadistic, marked by petti-

ness and competition among faculty members. Fear of the exam and the belief that a number will fail at that point does result in some postponement beyond the prescribed tenth-to-twelfth quarter.

In general, the English students expressed considerable bitterness toward their graduate experience. The faculty seem distant and unfriendly, large portions of the curriculum seem pointless and irrelevant, and the students express concern over their continually uncertain status in the department. Financial problems are also a contributing factor; for example, the second-year student had applied for a T.A. position next year and had been named an alternate, but the department will not tell her in what order she appears on the list. She expressed reluctance to borrow more money for a degree "which gets farther and farther away." One suspects that the willingness of humanities students to borrow is considerably reduced by the perception that the investment is very risky and replete with random factors over which the student has no control. The nature of the Ph.D. curriculum in English, and the humanities in general, with all the attendant uncertainties, may greatly reduce the value of an option to borrow, needlessly compounding the financial difficulties facing humanities students.

Electrical Engineering

Interviews in Electrical Engineering tended to confirm the theory almost precisely. One outspoken professor, having heard the topic described, burst out immediately:

> The differences between departments that you mention are obviously caused by differences in demand. We're teaching useful, relevant material in our department, and so we have a strong demand for our Ph.D.'s, both in industry and in the universities. Our students have valuable options with the M.S., and wouldn't stand for a lot of trivia in the Ph.D. program that wasted their time. Graduate students in the humanities have no right to expect financial support since those subjects are basically useless. No wonder they can't get jobs.

He commented on the "insanity" of an institutional incentive system that rewards departments for building up huge enrollments, regardless of whether degrees are ever awarded.

> The result is that a medieval corporation like the English Department packs in graduate students by the hundreds and then tries to keep them around forever because there aren't enough jobs. I'm sure that this crazy system has a lot to do with the student unrest at Berkeley—who can blame students in those departments for rioting?

Regarding placement of the Electrical Engineering Department's Ph.D. candidates, the professor indicated no preference for academic or industrial positions; the main concern is that students perform well in whatever position they accept. One professor mentioned the importance of feedback from industries employing the department's Ph.D.'s; apparently the Berkeley professors are very concerned that their students not be outperformed by graduates of competing Electrical Engineering departments.

> I think it would be really sick if more than half of our Ph.D.'s went into teaching each year. After all, we train our students to perform a useful service to society, and we don't want them all merely instructing others.

One professor commented that the Mathematics and Physics departments had very foolishly allowed their curricula to become so academic that industry was becoming increasingly less interested in hiring Ph.D.'s from those departments.

> The last thirty years have witnessed a tremendous broadening and deepening of the engineering curriculum, allowing our doctoral students to compete very effectively with students trained in the pure sciences. At this point, I think our students have the edge over applied math students when it comes to industrial positions.

The interviewer commented that the job market for Ph.D. electrical engineers was reported to have worsened dramatically this year, and asked what the department's response would be if the decline proved long-lasting. The professor smiled and said, "We'd simply have to enforce stricter standards and flunk a few more out."

SUPPLEMENTARY NOTE—1976

In the six years since this paper was written, several major changes have occurred in the environment of graduate education nationally and within California and the University of California specifically. Nationally, the labor market for new Ph.D.'s switched dramatically from substantial excess demand to conditions of oversupply in many fields, and the federal government and many state governments sharply reduced support for graduate students and for research. In California, the budget formula described in this paper was set aside and did not determine the state appropriation for several years. New funding formulae have been considered, including a proposal to change from an input to an output

budgeting approach based on degrees granted rather than on enrollment levels.

At Berkeley, the Graduate Division now has the power to set graduate enrollment ceilings for each department, and a simple debit-credit system has been created to monitor departmental performance (departments are debited for each enrolled student-year and credited for each Master's degree and Ph.D. awarded). The Graduate Division determines enrollment levels and the allocation of student financial support, to a degree, on the basis of this monitoring system.

Changes in the environment and in the incentive system would be expected to modify departmental performance, and an update of this study would be most interesting. Investigation into the economic behavior of nonprofit institutions remains a challenging and intriguing area of research.

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5. A less extreme assumption allowing positive payoff to incomplete degree work would not alter the analysis as long as a significant discontinuity between no degree and degree is present.
6. David Brown, *Academic Labor Markets* (a report to the U.S. Department of Labor, Washington, D.C., September 1965); and T. Caplow and R. McGee, *The Academic Marketplace* (New York: Basic Books, 1958).
7. National Education Association, "Teacher Supply and Demand in Universities, Colleges, and Junior Colleges" (published biennially from 1955 to 1965, Washington, D.C.).
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9. Allan Cartter, *An Assessment of Quality in Graduate Education* (American Council on Education, Washington, D.C., 1966). (Known also as the Cartter Report.)
10. In a different form and context, this description of a university's functioning was suggested to me by C. B. McGuire.
11. This fact was noted in a recent study of Berkeley doctoral students. See Ann M. Heiss, "Berkeley Doctoral Students Appraise Their Academic Programs," *Educational Record* 48 (Winter 1967): 40.
12. This formula has not been met in very recent years because of the state's decision to reduce the level of funding for the University of California.

13. National Academy of Sciences, *Doctorate Recipients from United States Universities 1958–1966* (Publication 1489, Washington, D.C., 1967), p. 82.
14. Stark, *Graduate Study at Berkeley*.
15. In May 1970, this requirement was eliminated. The analysis of this section helps explain why the change was bitterly contested by the language departments.
16. Allan Cartter, "The Supply of and Demand for College Teachers," *Journal of Human Resources* 1 (Summer 1966): 22.
17. Ibid., p. 38.
18. Brown, *Academic Labor Markets*.
19. Ibid., p. 87.
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21. Reported in the Cartter Report.
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23. Ibid., p. 17.
24. Brown, *Academic Labor Markets*.
25. Ibid., p. 337.
26. Ibid., pp. 341–352.
27. National Academy of Sciences, "Survey of Earned Doctorates" (Washington, D.C.; computer tape for Berkeley graduates, 1958–67, supplied by Graduate Division, University of California, Berkeley).
28. Department of English, University of California, Berkeley, "Report of the Committee on Placements" (provided by the English Department, 1962–1970).
29. Extracts are reproduced from notes.
30. Research seminars and individual research for graduate students for which course credit is given.
31. To provide an incentive for students to finish in four years, the department reduces an R.A.'s stipend by 25 per cent in the fifth year.