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ABSTRACT

It is generally difficult to appraise the efficiency with which resources are allocated in the education industry because the outputs of education are often difficult to measure. This study focuses on one output of the university: the Ph.D. degree and examines the factors that influence the production of that output. The case study was made at the University of California at Berkeley where a wide diversity exists among departments in their efficiency Ph.D. production. Specifically, the study develops and tests an economic theory that explains the extremes in attrition and time to degree in the University's 28 Ph.D. programs. Chapter I deals with the differences in departmental performance in terms of Ph.D. production, and the limitations of earlier research regarding this problem. Chapter II develops the theory of departmental behavior. It presents a theory of graduate student behavior and a theory of faculty motivation. It also examines the relation of faculty objectives to departmental objectives, discusses the factors that enter into the department's objective function, and synthesizes the elements of analysis into a theory that explains departmental differences in pattern and timing of graduate student attrition. (AF)

AN ECONOMIC THEORY OF Ph.D. PRODUCTION:

THE CASE AT BERKELEY

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PREFACE

This is one of a continuing series of reports of the Ford Foundation sponsored Research Program in University Administration at the University of California, Berkeley. The guiding purpose of this Program is to undertake quantitative research which will assist university administrators and other individuals seriously concerned with the management of university systems both to understand the basic functions of their complex systems and to utilize effectively the tools of modern management in the allocation of educational resources.

This report represents the theoretical section of a longer study entitled "The Determinants of Ph.D. Production at Berkeley: An Economic Theory of Departmental Behavior," a doctoral dissertation to be submitted to the Department of Economics at the University of California, Berkeley. The dissertation develops and tests an economic theory that explains the extremes in attrition and time to degree in 28 Ph.D. programs at Berkeley. Further reports will present empirical evidence in support of the theory, as well as implications for policy.

INTRODUCTION

The last decade has witnessed a vast growth in the literature devoted to the economics of higher education. Investment in human capital, manpower and educational planning, and the role of education in economic growth are aspects of the field that have received extensive treatment.[1] A relatively less developed area is the micro-economics of higher education, possibly because of the conceptual difficulties involved in considering education as an industry absorbing human and material resources like any other. In the Introduction to Economics of Education 1, Mark Blaug describes many of the problems succinctly:

> . . . in most countries, the whole of this industry is collectively provided and financed; although the inputs of the industry are typically bought in the marketplace, the output is not sold, at least directly; the production-cycle of the industry is longer than that of most other industries, and it consumes a relatively large fraction of its own output; it is not engaged in profit-maximizing activity and, indeed, it is not self-evident that it is maximizing anything at all. All of these peculiarities make it difficult to appraise the efficiency with which resources are allocated in the education industry and raise the question whether the traditional apparatus of economists is, in fact, applicable to the operations of schools and colleges.[2]

A further difficulty not explicitly mentioned by Blaug is the absence of a widely accepted operational specification of the outputs of a college or university. Only when we know what a university is producing can we begin to associate inputs with outputs and make meaningful statements regarding

the impact of alternative resource uses.

Much of the current micro-economic work focused on the university involves the use of simulation, programming, and input-output techniques in an attempt to model systematically the operating characteristics of the institution.[3] The great merit of such models is the explicit representation, through matrices of resource input coefficients, of the complex interactions existing between operating units and support facilities within the university. Furthermore, provided the structural relationships remain reasonably stable over time, such models can be used for predicting future resource requirements and estimating the attendant costs generated by shifting patterns of student enrollment.

Valuable as such models may be as planning tools, we must also recognize their limitations. First, many of the models simply transform a vector of student enrollments into a vector of resource requirements, with no explicit output measure of the system specified. Secondly, none of the models introduce behavioral assumptions regarding the objectives of university members. To leave out the human element from analysis of a complex institution like a university is to ignore the potentialities of the rich body of organizational theory literature that has been developed in the last twenty-five years.[4] These shortcomings suggests that a reasonable approach would be to focus upon one output of the university and examine the factors that influence the production of that output. The following study, "An Economic Theory of Ph.D. Production: The Case at Berkeley," was conceived with this aim in mind.

A word of explanation regarding the chosen output measure, the Ph.D. degree, is necessary. Several factors influenced this choice. First, Berkeley places special emphasis on the importance of its Ph.D. programs; the Revised

Academic Plan, 1969-1975 for the Berkeley campus states that, " . . . the major future responsibility of most departments in the professional colleges and the College of Letters and Science will be education for the doctorate."[5] Secondly, Ph.D. programs are generally the most expensive degree programs to offer in terms of university resources, and are even more costly in social terms when one adds the opportunity costs of the required student input, holders of Bachelor degrees. Finally, as we shall document in Chapter I, there exists considerable diversity among Berkeley departments in their "efficiency"[6] of Ph.D. production, a diversity that has not been systematically analyzed or explained. Since campus administrators are eager to improve the performance of certain departments but are uncertain as to the best way to proceed, this study may have practical as well as theoretical interest.

The decision to measure university output by degrees awarded directs our attention to an obvious but important distinction. Universities are engaged in two closely related but conceptually separable activities, education and certification. By defining degrees as the output measure, we are explicitly concentrating upon the university's role in certification as opposed to education. This seems particularly appropriate for an economist, since the significance of certification in our society is largely economic, the degree being required for admission to certain occupations. Thus, the study's concern with degrees as an output measure should not be construed as a rejection of other characterizations of university output; instead, the distinction between education and certification is discussed in order to draw attention to the clear economic significance of the latter function. One can easily imagine companion studies by psychologists, sociologists or educators, concentrating upon different characterizations of output of doctoral programs.

NOTES - INTRODUCTION

[1]An excellent survey article by Allan Cartter, "The Economics of Higher Education," is printed in Contempotary Economic Issues, edited by Neil Chamberlain, Richard D. Irwin, Inc., 1969, pp. 145-184.

[2]Mark Blaug, Economics of Education 1, Penguin Books, Baltimore, Maryland, 1968, p. 8.

[3]Examples include the CAMPUS simulation models developed at the University of Toronto by Richard Judy and Jack Levine, the "state-space" models produced at Michigan State University by H. Koenig, M. Keeney, and R. Zemach, the University Cost Simulation Model developed at the University of California by George Weathersby, and the RRPM model currently under development by the W.I.C.H.E.-M.I.S. program at Boulder, Colorado.

[4]See James March and Herbert Simon, Organizations, John Wiley, 1966; Anthony Downs, Inside Bureaucracy, Little, Brown and Co., 1966; Oliver Williamson, The Economics of Discretionary Behavior: Managerial Objectives in a Theory of the Firm, Prentice-Hall, 1964; and Richard Cyert and James March, A Behavioral Theory of the Firm, Prentice-Hall, 1963.

[5]W. Knight, et al, Revised Academic Plan 1969-75, University of California, Berkeley, 1969, pp. 27-28.

[6]This term will be defined in the next section.

CHAPTER I: DIFFERENCES IN DEPARTMENTAL PERFORMANCE

In the Introduction, reference was made to a wide diversity existing among Berkeley departments in their "efficiency" of Ph.D. production. In the present context, "efficiency" is defined by the ratio of degree output to the input of doctoral student time. Thus, a relatively "inefficient" department would be marked by an excessively long average time to degree and/or a high rate of attrition, particularly if the attrition typically occurs after students have spent several years in the program. Our concern is with the economic and psychic costs borne by the large number of graduate students who fail to complete doctoral programs, as well as the social costs incurred by the community from such failure.

Having defined "efficiency," our next step is to provide an operational method for measuring it. The ideal measurement would require several consecutive years of departmental cohort data that traced each student in a cohort through the system until a degree was awarded or the student dropped out. For each completed cohort, one would sum the number of enrolled student years and the number of doctorates awarded and have a measure of the number of student years per degree. An unpublished study by Rodney Stark[1] of four Berkeley departments was conducted in this manner, with results that will be presented later in this chapter. Unfortunately, cohort analyses require data on every individual student, and such information has not been kept in machine-readable form at Berkeley until very recently. Thus, the Stark study of four departments required the full time service of several clerks for nearly three months to perform the laborious hand-coding of information from Registrar's files. Consequently, cohort analysis for the

number of departments included in this study (28) is infeasible.

An alternative method for measuring a department's "efficiency" is to gather annual time series data on Ph.D. degrees awarded and graduate student enrollments. The ratio of degrees awarded to enrollment can serve as a measure of "efficiency." This technique, with some modifications, has been used in this study.

Two problems plague this second measurement technique. First, Ph.D. production is a multiple-year process, while degree and enrollment data are kept on an annual basis. To divide degrees by enrollment is thus to divide a flow by a stock, for the enrollment figures will include first year through fourth or fifth year students. For a department in steady state, i.e., constant enrollment, this will not be a problem; however, for growing departments, distortion will be introduced. This can be reduced to some extent by introducing various lag structures and by averaging over several years' data, but in principle there is no perfect solution.

The second problem, the separation of M.A. and Ph.D. programs, poses difficulties even for cohort analysis. Since we are examining only the Ph.D. degree programs, we need to exclude terminal M.A. enrollments from our data. However, the two programs are often so thoroughly integrated that they cannot be meaningfully separated. In some departments, all students, regardless of terminal degree aspiration, are required to enroll initially as M.A. candidates; in others, separate M.A. and Ph.D. programs exist, but many students who ultimately work for the Ph.D. may initially enroll in the M.A. program; some departments admit all graduate students into a common first year curriculum, and then allow a subset of the group to continue for the Ph.D. based on first year performance. Finally, some students may not genuinely know which degree they will ultimately want when first enrolling,

while in some circumstances students may have reason to disguise their true intentions in order to be considered for fellowships or teaching assistantships. Thus, the quest for a "true" enrollment series that includes all Ph.D. candidates and excludes terminal M.A. candidates is hopeless; in order to proceed, intelligent compromises must be made, which will be explained in context.

Given these caveats, we proceed to the data. The Stark study involved analysis of five cohorts of graduate students at three year intervals for 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 other three departments with respect to the percent of successful Ph.D. completions.

Table II 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 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 occurence of attrition in the program. By contrast, unsuccessful students in the other three departments were not terminated or did not drop out until an average of 2-3 years in the program. If we view the enrolled time of those students who received no degree as a cost to be charged against the degrees produced by the department, the contrast between Chemistry and Political Science, for example, is startling; 408 student years in Chemistry produced 94 Ph.D.'s and 14 M.A.'s, while 312 student years in Political Science produced only 6 Ph.D.'s and 26 M.A.'s.

TABLE 1

THE OUTCOME OF DOCTORAL STUDIES BY DEPARTMENT AND YEAR OF ADMISSION, BERKELEY*

POLITICAL SCIENCE DEPARTMENT

	Year of Admission				
	1951	1954	1957	1960	1963
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	0	3	6	14	53
On leave of absence	0	0	0	8	0
Total	100%	100%	100%	100%	100%
Number of cases	29	35	49	49	42

ENGLISH DEPARTMENT

	Year of Admission				
	1951	1954	1957	1960	1963
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	3	0	3	37	34
On leave of absence	3	4	0	14	6
Total	100%	100%	100%	100%	100%
Number of cases	31	38	53	49	50

CHEMISTRY DEPARTMENT

	Year of Admission				
	1951	1954	1957	1960	1963
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	0	0	2	6	96
On leave of absence	0	0	0	2	2
Total	100%	100%	100%	100%	100%
Number of cases	28	35	51	50	50

HISTORY DEPARTMENT

	Year of Admission				
	1951	1954	1957	1960	1963
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	6	0	4	23	32
On leave of absence	0	7	2	20	8
Total	100%	100%	100%	100%	100%
Number of cases	33	26	48	51	50

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

TABLE II

ENROLLED STUDENT TIME PER DEGREE, 1951-54-57 COHORTS*, FOUR DEPARTMENTS, BERKELEY**

POLITICAL SCIENCE DEPARTMENT

	Number of Students	Enrolled Student Years	Ave. Years per Outcome
Received Ph.D.	6	44	7.3
Received M.A.	26	85	3.3
Received no degree	50	183	3.6
TOTAL	82	312	

ENGLISH DEPARTMENT

	Number of Students	Enrolled Student Years	Ave. Years per Outcome
Received Ph.D.	9	61	6.8
Received M.A.	27	80	3.0
Received no degree	45	114	2.5
TOTAL	81	255	

CHEMISTRY DEPARTMENT

	Number of Students	Enrolled Student Years	Ave. Years per Outcome
Received Ph.D.	94	358	3.8
Received M.A.	14	27	1.9
Received no degree	17	23	1.4
TOTAL	125	408	

HISTORY DEPARTMENT

	Number of Students	Enrolled Student Years	Ave. Years per Outcome
Received Ph.D.	16	108	6.8
Received M.A.	16	51	3.2
Received no degree	42	108	2.5
TOTAL	74	267	

*Limited to students who enrolled with B.A. or B.S. only. Chemistry includes the 1960 cohort.

** Source: Stark study, Berkeley, 1966.

In attempting to explain these differences, Stark explored numerous factors, including differences in undergraduate grade point averages, quality of undergraduate school, sex, and financial support. His conclusion was that differences in amount of financial support available to graduate students in the four departments explained the variation in success rates; " . . . the conclusion forced by these data is that if you support an historian as well as you support a chemist, he is as likely as the chemist to succeed in graduate school,"[2] and " . . . similar support yields similar performances."[3]

One may question the wisdom of reaching broad conclusions regarding differences in departmental "efficiency" by studying only four departments. Consequently, this study will focus upon the 28 Berkeley departments given a national quality ranking in the 1966 Cartter Report.[4] (Cartter ranked 29 fields, but Berkeley does not have a Pharmacology department.) Selection of the Cartter ranked disciplines provides a control for departmental quality as well as broad coverage of five major subject groups, the Humanities, Physical, Biological and Social Sciences, and Engineering. Thus, conclusions reached in this study should be broadly applicable to all major divisions of the university except the professional schools.

Lacking cohort data for these 28 fields, we can examine degree and enrollment figures in order to rank the departments by our "efficiency" criterion. Table 3 provides seven year totals (1961 to 1967) for Ph.D. degrees awarded and doctoral student enrollments in the 28 departments.[5] Note that the relative placement of Chemistry, History, Political Science, and English departments is what we would expect on the basis of Stark's findings.

Evidence that the differential pattern of attrition and time to degree observed in Berkeley departments is not unique to this campus is found

TABLE III: SEVEN YEAR ENROLLMENT AND DEGREE TOTALS, UNIVERSITY OF CALIFORNIA, BERKELEY, 1961-67*

DEPARTMENT	Ph.D. Degrees	Ph.D. Student Years[a]	Degrees per Student Year	Student Years per Degree
Entomology	79	397	.198	5.02
Chemistry	335	1802	.185	5.38
Chemical Eng.	75	404	.185	5.39
Electrical Eng.	175	1032	.169	5.90
Civil Eng.	129	763	.169	5.91
Physics	380	2438	.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 Eng.	94	716	.131	7.62
Psychology	162	1238	.130	7.64
Astronomy	32	246	.130	7.69
Spanish	18	150	.120	8.33
History	177	1517	.116	8.57
Math	194	1680	.115	8.66
Classics	13	118	.110	9.08
German	24	219	.109	9.12
Bacteriology	17	157	.108	9.24
Economics	137	1316	.104	9.61
Anthropology	69	720	.095	10.43
Political Sci.	96	1026	.093	10.69
Physiology	24	267	.089	11.12
English	105	1374	.076	13.09
Sociology	57	753	.075	13.21
French	28	374	.074	13.36
Philosophy	27	507	.053	18.78

[a]Enrollment figures are understated for those departments that require doctoral students to first earn the M.A. degree - those student years are not recorded.

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

in a recent study of attrition among Woodrow Wilson fellows reported by Joseph Mooney.[6] Table 4 contains the success rates as of 1966 for the 1958-1960 entering cohorts of Woodrow Wilson Fellows. The same general pattern emerges--high success rates in the Physical and Biological Sciences, followed by the Social Sciences, with the Humanities a poor third. The pattern does differ somewhat by university, however. Table 5 reports success rates by broad category for the ten graduate schools in which the majority of the Fellows enrolled. The fact that schools such as Princeton experienced a much higher success rate in Humanities and Social Science fields than did Berkeley suggests that those fields are not inherently "inefficient."

One of the conclusions of Mooney's analysis is of particular interest, since it contradicts Stark's result.

> Finally, although the results in this paper are not directly germane to an evaluation of the efficacy of allocating more financial resources to graduate education in the form of federal or private subsidies, they are highly suggestive. It should be recalled that Woodrow Wilson Fellows are of approximately equal intellectual ability, usually had full financial support for their first two years of graduate study, and, according to substantial but incomplete data on their financial support in their third and fourth years of graduate study, often had fellowships or research assistantships in these years. And yet, many of them failed to acquire a Ph.D. *The conclusion has to be that there are obstacles in the way of acquiring a Ph.D. related to sex, field of study, and graduate school, etc., which are not easily overcome simply by injecting more money.* (Italics added.)[7]

Kenneth M. Wilson's study, Of Time and the Doctorate,[8] provides survey information regarding factors that influence the differences in B.A. - Ph.D. time lapse among fields.[9] Wilson's data was compiled from questionnaires

TABLE IV

PERCENT OF WOODROW WILSON FELLOWS ATTAINING

THE Ph.D. DEGREE BY FIELD*

FIELD	TOTAL ENROLLED 1958-60	% ATTAINING Ph.D. BY 1966
Humanities		
English	698	22.6
Modern Languages	260	26.2
Philosophy	189	31.7
Classics	79	35.4
Fine Arts	40	7.5
Musicology	49	6.1
Speech, Drama	21	19.0
American Studies	20	45.0
Other	7	14.3
Subtotal	1363	24.5
Social Sciences		
History, History of Science	475	27.6
Political Sciences	256	27.3
Economics	157	38.8
Psychology	103	57.3
Sociology	68	19.1
Anthropology	65	27.7
Religion	28	7.1
Area Studies	53	17.0
Other	77	15.6
Subtotal	1282	29.2
Science		
Math	253	49.8
Physics	236	62.7
Chemistry	161	74.5
Biology, Medical Sciences	118	49.2
Geology	21	61.9
Astronomy	8	75.0
Statistics	2	100.0
Other	6	66.7
Subtotal	805	59.2
TOTAL→	3450	34.4

* Data taken from Table 1, Mooney [1968], pp. 52-53.

TABLE V

RATE OF Ph.D. PRODUCTION AT TEN GRADUATE SCHOOLS BY AREA OF STUDY*

(For Male Woodrow Wilson Fellows Only)

Name of School	HUMANITIES			SOCIAL SCIENCES			NATURAL SCIENCES			HUMANITIES & SOCIAL SCIENCES (Combined)		
	Total #	# of Ph.D.'s	% with Ph.D.	Total #	# of Ph.D.'s	% with Ph.D.	Total #	# of Ph.D.'s	% with Ph.D.	Total #	# of Ph.D.'s	% with Ph.D.
Harvard	89	41	46.0	161	75	46.6	78	54	69.2	250	116	46.4
Yale	103	48	46.6	69	24	34.8	23	19	82.6	172	72	41.9
Columbia	54	14	26.0	59	17	28.8	16	12	75.0	113	31	27.4
Berkeley	57	12	21.0	55	12	21.8	56	42	75.0	112	24	21.5
Stanford	19	9	47.4	31	12	38.7	17	14	82.3	50	21	42.0
Princeton	52	26	50.0	51	29	56.9	58	47	81.0	103	55	53.4
Chicago	21	3	14.3	57	24	42.1	17	11	64.7	78	27	34.6
Wisconsin	15	5	33.3	38	12	31.6	27	19	70.4	53	17	32.1
Michigan	21	5	23.8	23	7	30.4	9	5	55.5	44	12	27.3
Cornell	23	11	47.8	26	10	38.5	21	15	71.4	49	21	42.8
Totals	454	174	38.3	570	222	38.9	322	238	73.9	1024	396	38.7
Next 30 graduate schools	205	64	31.2	183	80	43.7	192	132	68.7	388	144	37.1

* Data taken from Table 2, Moonay [1968], page 59.

completed by 1,929 graduates of selected doctoral programs in more than 20 Southern universities who received a Ph.D. during the period 1950-1958. In addition, he received written responses to several general questions regarding the duration issue from 25 graduate deans and 100 faculty members from these institutions.

It is interesting to note the types of variables that Wilson included in his questionnaire; the 15 factors were:

(1) Lack of coordination between beginning and advanced stages of graduate work.
(2) Discontinuity of graduate attendance.
(3) Inadequate undergraduate preparation in graduate field of specialization.
(4) Transferring from one graduate institution to another.
(5) Change(s) in field of specialization during graduate study.
(6) Inadequate preparation in foreign languages prior to beginning graduate work.
(7) Change(s) in dissertation topic after some work already completed.
(8) Changes in membership of dissertation committee.
(9) Writing dissertation off-campus while engaged in full-time employment.
(10) Nature of the dissertation subject, per se.
(11) Work as a research assistant.
(12) Work as a teaching assistant.
(13) Family obligations.
(14) Health problems.
(15) Financial problems.[10]

The five most important factors cited by students as lengthening their time to degree were (in order of importance): discontinuity of graduate attendance, work as a teaching assistant, nature of the dissertation subject, writing the dissertation off-campus while engaged in full-time employment, and financial problems.

The deans and faculty members generally mentioned similar items as influencing time to degree, but also introduced additional factors:

> Deans, particularly, noted that the *degree of clarity of institutional and departmental expectations* regarding doctoral requirements was an extremely important factor, along with faculty attitude toward students and the nature or their advisory relationship with students. [11]

> Certain institutional and/or departmental policies were cited as important variables, e.g., requiring the master's degree of potential Ph.D. candidates, establishing a minimum number of credit hours for the Ph.D. degree, enforcing a rigidly sequential pattern of completing requirements, etc. [12]

> Institutional-departmental representatives, in accounting for more rapid completion times in the natural sciences than in other fields, mentioned the degree of "structure" which is characteristic of the natural science disciplines, their more "definite" program requirements, the closer relationship between course work and dissertation research, and other factors conducive to what we have termed "programmatic continuity." They suggested also that a *tradition* of "early completion" and earlier establishment of appropriate career and study goals among students were conducive to more rapid completion of requirements in the natural sciences. [13]

With reference to the role of financial support, Wilson comments:

> Of considerable interest is the fact that *less than one-fourth of the reasons given to account for more rapid completion of all requirements related to financial assistance and support;* almost one-half of all factors cited related to research organization and approach to the dissertation and/or the more structured nature of the natural science disciplines (more definite expectations and greater articulation of programs of examinations, studies, and research). [14]

The reason for concentrating on Wilson's study is that it is representative of much of the work undertaken in this area by sociologists and educators. Their descriptive studies have provided valuable data and some insight into the functioning of the system; however, we cannot conclude that descriptive work exhausts the topic. In particular, the following limitations of such studies suggests the need for further work:

(1) Descriptive studies focus primarily upon factors internal to the university; thus Wilson's list of 15 items thought to effect time to degree concentrates upon items such as changes in field specialty, problems with the language requirement, and lack of coordination between beginning and advanced stages of graduate work. By ignoring the university's relation to the outside social and economic environment, external factors that may affect degree production are overlooked. If external factors are of some importance, then internally-focused descriptive studies run the risk of dwelling on derivative effects of secondary import, missing entirely the major underlying cause.

(2) Descriptive studies tend to accept differences in departmental technology as the bed-rock of analysis. Given that departmental curricula are of human devising and are susceptible to change, a more satisfactory analysis would explain the differences in program structure and organization rather than simply describe them.

(3) In common with the input-output model builders, authors of descriptive studies fail to provide theories of student or faculty motivation. In particular, departments are implicitly viewed as passive organizations lacking objectives related to the numbers of Ph.D.'s awarded.

(4) In the absence of a theory with which to integrate survey results, realistic policy conclusions are difficult to derive. For example, Wilson concludes that graduate programs should be rationalized, i.e., made more programmatic. Lacking an analysis of the forces operating upon a department that have produced the present non-programmatic curriculum, Wilson's

laudable recommendation may simply be wasted effort.

Having outlined the problem and discussed the limitations of earlier research, we turn in the next chapter to a theory of departmental behavior.

NOTES ON CHAPTER I

[1]Rodney Stark, "Graduate Study at Berkeley: An Assessment of Attrition and Duration," Survey Research Center, University of California, Berkeley, 1966.

[2]Ibid., page 32.

[3]Ibid., page 30.

[4]Alan M. Cartter, An Assessment of Quality in Graduate Schools, American Council on Education, Washington, D. C., 1966.

[5]Prior to 1961, the Berkeley Office of Institutional Research did not distinguish between M.A. and Ph.D. enrollments. With reference to our earlier discussion, the enrollment figures in Table 3 understate the "true" number of student years by the number of students with Ph.D. aspirations who were enrolled in M.A. programs and thus labeled M.A. students at the time of data collection.

[6]Joseph Mooney, "Attrition Among Ph.D. Candidates: An Analysis of a Cohort of Recent Woodrow Wilson Fellows," Journal of Human Resources, Winter, 1968.

[7]Ibid., pages 61-62.

[8]Kenneth M. Wilson, Of Time and the Doctorate, Southern Regional Education Board, Atlanta, 1965.

[9]Thus the study dealt only with time to degree, not attrition.

[10]Wilson, op. cit., page 46.

[11]Ibid., page 55.

[12]Ibid., page 56.

[13]Ibid., page 58.

[14]Ibid., page 58.

CHAPTER II: A THEORY OF DEPARTMENTAL BEHAVIOR

Having described the problem which we hope to explain, a need arises for a plausible theory to guide the empirical research. Economists rely upon a "rational" model of human behavior, where the term "rational" is applied to the means used for attaining objectives rather than to the objectives themselves. If, as we have earlier argued, the significance of the output measure under study, the Ph.D. degree, is primarily economic and social, and if we believe that the determinants of Ph.D. production may be found in the economic and social spheres, then the economist's rational model of behavior may be appropriate to this problem.

The system under analysis, however, 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.

A. The Graduate Student

We assume that the vast majority of graduate students view the decision to enter graduate school as an investment, much as the literature on investment in human capital suggests.[1] 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 the following step function:

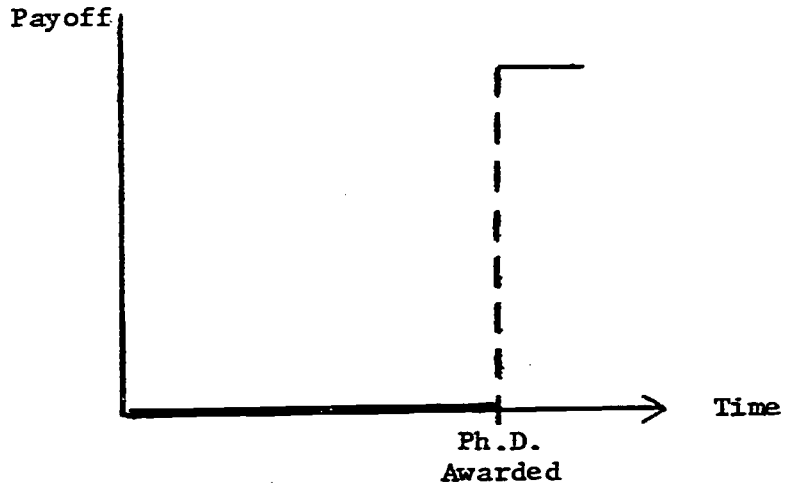


FIGURE 1

The student may study for several years, but if he fails to earn the degree, his payoff is zero, thereby making his investment extremely costly to him.

The step function portrays one extreme view regarding the value of incomplete degree work. Other views might be graphed as follows:

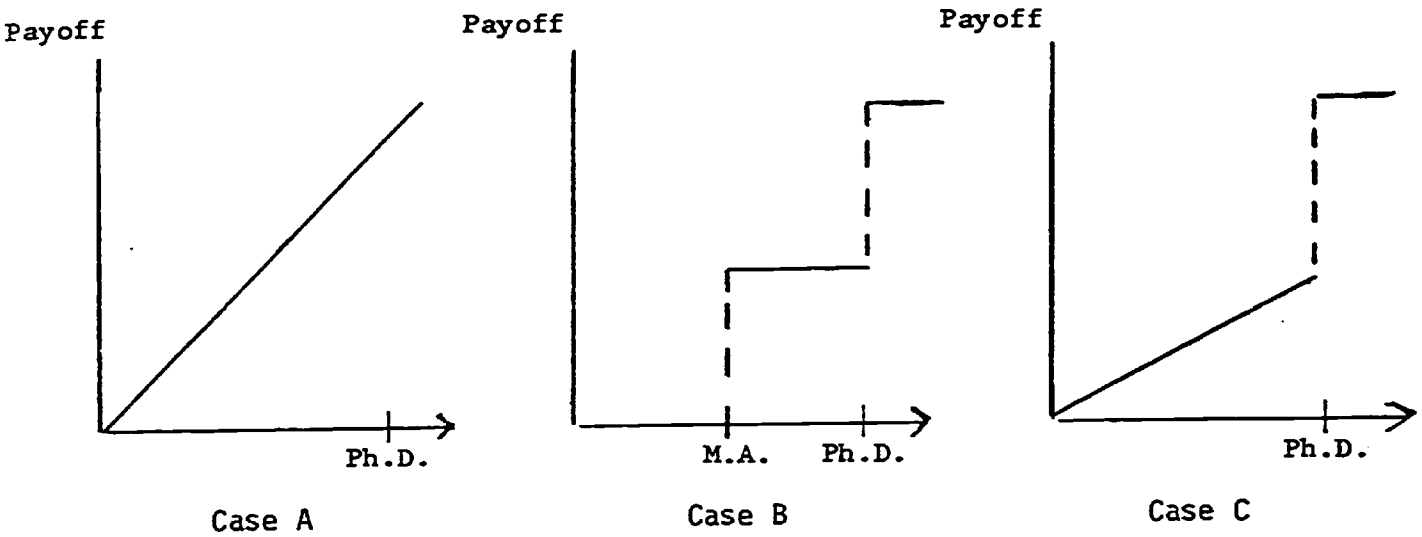


FIGURE 2

Case A portrays the view of a high school or junior college teacher who is rewarded with additional salary for every credit hour of instruction beyond the B.A. degree. Such a person is presumably not concerned about the awarding of advanced degrees because the degree is not required by the occupation. This case does not accurately describe full time Berkeley graduate students aiming at an academic career.

Case B suggests that the awarding of an M.A. degree provides some investment payoff, while preserving the essential step function of the original model. If the student's goal was college or university teaching in a respected institution, awarding a terminal M.A., possibly as a consolation prize, does not alter the student's view that his investment was a failure. However, some economic value may be gained from the M.A., and one cannot criticize the department for providing a certificate enabling the student to capture some value for his expenditure of time and money.

Case C is simply a modification of the original model, designed to

suggest that some value may accrue to incomplete degree work, but recognizing a final discontinuity in the function.

In considering these and other plausible models of the student's view regarding 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 will assume this factor to be of primary importance to students, and will continue to represent the investment as having a step function payoff, as in Figure 1.

A further issue that confounds the investment in human capital approach concerns the degree to which students are appropriately viewed as consumers rather than investors in higher education. It is often alleged that a high consumption component is present in the behavior of at least two groups of graduate students - women and humanities students. This allegation suggests an unwillingness to believe that women are seriously motivated by career considerations, a dubious proposition. Furthermore, since departments continue to enroll women as Ph.D. candidates, presumably in good faith, there seems no a priori reason for assuming that sex somehow determines the consumption versus investment dichotomy. We will therefore assume that women enrolled in doctoral programs share the same career aspirations as men.

The assertion that humanities students are more likely to be consumers rather than investors of graduate education seems to follow from the nonvocational nature of the subject matter in the humanities in contrast to the "practical" nature of advanced study of engineering, for example. Thus, it is suggested that graduate students in philosophy are studying in order to understand themselves and the world around them, with no concern for the

more mundane matter of earning a living. However, one might argue that the limited practical value of a discipline such as philosophy provides graduate students in that field with a very strong motive for successfully completing the doctorate, since college teaching is virtually the only career in which a person can earn a living doing philosophy. By contrast, the unsuccessful engineering graduate student may fail in his ambitions to join an engineering faculty, but his alternative career choices will directly utilize the training he has received. For this reason, Richard Freeman[2] has argued that the element of risk in undertaking graduate work in the sciences is very low. Thus, we argue that humanities students have, if anything, a greater need for the doctorate than do graduate students in the more "practical" fields.

In general, we know that the consumption element is present to some degree in graduate education; we do deny, however, that consumption is the dominant motive for most students, or for any particular group. We must remember that Berkeley graduate students are 21 years of age and older, adult, largely self-supporting, and, in many cases, married with families. To argue that more than a tiny fraction of these adults are uninterested in the career aspects of their decision to pursue graduate work and are instead exulting in the sheer joy of graduate study is to strain one's credibility. The assumption that most graduate students are motivated by career considerations to invest in higher education remains the simplest and most plausible position.

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 non-pecuniary), 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.[3] Certain costs can be determined with some precision - these include the opportunity cost of foregone earnings, net of fellowship or teaching assistant salaries, tuition, and out-of-pocket costs. Other costs occur only if the attempt to earn a Ph.D. is unsuccessful. These include the opportunity cost of the years spent in graduate study that could have been spent gaining on-the-job experience or in another degree program, such as law school. Another cost that will differ among individuals is the psychic cost of failure in graduate school, and this may also involve a more tangible cost if potential employers view the failure as a black mark on one's record. Presumably the potential graduate student evaluates the significance of these possible costs and relates them to his estimate of the risk of failure involved.

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 at Berkeley, 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 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[4] have all commented on the limited information available to participants in these markets. Most universities do not publicly advertise their openings, and no central clearing house 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.

Given that potential student investors have at least two serious gaps in the information needed for an informed decision (the estimate of risk and the forecast of demand) one wonders why so many are willing to undertake what may be the most costly investment of their lives. Two considerations may help to explain this willingness to embark upon graduate studies. First, although lacking an estimate of risk, students tend to trust departments to treat them justly. The student assumes that his admission is a sign of good faith from the department that he has the necessary qualifications to earn the doctorate. Furthermore, many students believe that satisfactory academic performance will insure continuing financial support. In their naiveté, students do not suspect that departments would have any reason to admit them without intending to graduate them. Therefore, the student discounts the unknown risk factor through an act of faith in departmental justice.

The lack of specific information regarding market demand for Ph.D.'s has probably not been a deterrent during the 1950's and 1960's, 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 18-21 age group going on to college during this period resulted in a series of crisis forecasts, sparked by the National Education Association biennial surveys,[5] 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 field. By and large, this belief seems to have been warranted until the last year or two.[6]

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 time to degree to arise from this source. In other words, a chemistry student is as likely as a philosophy student to react to these pressures in the same way, because the response is designed to minimize the risk of failure. 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. This motive may be operative in any field for individuals intent upon an academic career, but students in those departments where there is no non-academic demand for the Ph.D. should have on the average a longer time to degree than departments serving more diverse groups of employers. Unfortunately, there appears to be no way of isolating the impact of student decisions to stretch out the program since departmental curricula, under the control of faculty, also differ and affect time to degree. In other words, even if chemistry students had no incentive to slow their own progress, they might still have a longer time to degree than philosophy students if the chemistry department establishes an intrinsically longer course of study. We assume, however, that student awareness of opportunity costs is transmitted to faculty, as a pressure against excessive degree requirements. If one assumes that student pressure is an increasing function of their opportunity cost, then one might expect that curriculum adjustments coupled with student motivation would result in a shorter time to degree in those fields where opportunity costs are highest. Note that this conclusion involves the joint behavior of students and faculty, for both groups exercise control over variables affecting time to degree.

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 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.[7] In fact, as we have argued earlier, the group with the strongest incentive to complete the doctorate may well be the humanities students for whom acceptable career opportunities in their field of study are limited to academic jobs requiring the doctorate. 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 the demand for Ph.D.'s 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.

MATHEMATICAL COMMENT: THE MODEL OF STUDENT INVESTMENT

The following model is presented solely as a heuristic device to display the critical elements in a student's decision to invest in a graduate degree.

Three elements are present in the student's decision:

(1) The stream of costs, extending over the enrollment period. Conceptually, these costs include out-of-pocket expenditures and opportunity costs.

(2) The stream of benefits, accruing from graduation to retirement. Conceptually, benefits are not limited to monetary income, but include the psychic benefits of the occupations available to holders of the Ph.D.

(3) The student's subjective estimate of the probability of successful degree completion.

Let us represent the annual costs by

$$C_i \ , \ i = 1, 2, \ldots, K$$

and the benefits by

$$B_j \ , \ j = K + 1, K + 2, \ldots, K + N \quad .$$

The student's subjective estimate of the probability of success can be represented by α , where

$$0 \leq \alpha \leq 1 \quad .$$

We might assume that the student alters his estimate of α each year while in school, thereby giving α the same index as the costs, i.e.,

$$\alpha_i \ , \ i = 0, 1, \ldots, K$$

where α_0 would represent the student's probability estimate prior to

enrolling.

The student is assumed to apply a discount rate to the costs and benefits. For simplicity, assume a perfect capital market and equilibrium conditions, so that the student's marginal rate of time preference equals the borrowing rate equals the lending rate; call this rate r. Thus, the student will decide to enroll for the Ph.D., if the following inequality holds:

$$\sum_{i=1}^{K} \frac{C_i}{(1+r)^i} < \alpha_0 \cdot \sum_{j=K+1}^{K+N} \frac{B_j}{(1+r)^j}$$

In words, he will enroll if the present value of the costs is less than the expected present value of the benefits, i.e., the net present expected value of the investment is positive.

Assuming the student enrolls, let us characterize his decision process to be an annual re-calculation of the costs and expected benefits; thus, we view him deciding whether or not to continue at the end of year 1, year 2, on to year $K-1$. At the end of year 1, his remaining costs are reduced by one year:

$$\sum_{i=1}^{K-1} \frac{C_i}{(1+r)^i}$$

and the benefits are now one year closer:

$$\sum_{j=K+1}^{K+N} \frac{B_{j-1}}{(1+r)^{j-1}}$$

In addition, based on performance and feedback from the department, the student will have revised his success estimate from α_0 to α_1. As before, he will remain in the program if:

$$\sum_{i=1}^{K-1} \frac{C_i}{(1+r)^i} < \alpha_1 \cdot \sum_{j=K+1}^{K+N} \frac{B_{j-1}}{(1+r)^{j-1}}$$

If we assume that no change has occurred during the year in the student's evaluation of the cost and benefit stream, and if $\alpha_0 = \alpha_1$, then the above inequality, calculated at $t = 1$, will be greater than the inequality calculated at $t = 0$. This is the case, because at $t = 1$, $^1/K$ of the cost is past, while the benefits will begin in $K - 1$ years. Thus, the longer the student stays in the program, the greater is his incentive to finish, since the remaining costs decrease while the present value of the benefits increases. Consequently, attrition that occurs after a student has been enrolled for several years would involve one of the following:

(1) An unexpected increase in the remaining costs.

(2) A significant reduction in the student's evaluation of the benefits.

(3) A drop in the student's estimate of α sufficiently large to drive the expected present value of the benefits below the present value of the remaining costs.

We must consider briefly who controls each of these factors.

An unexpected increase in costs may arise from many sources; institutions may raise tuition, a working wife may become pregnant, parents may cut off support. Psychic costs, caused by fatigue or a shift in work to the dissertation, may also increase. However, two common sources of increased cost are added time required for the degree and loss of fellowship, teaching assistantship, or other form of university related support. To a considerable extent departments can control these latter two items, and can therefore encourage attrition by extending the student's expected completion date or by cutting off support. In such instances, the student may appear to be leaving voluntarily, but the department's action is critical to the decision.

A change in the student's evaluation of the benefits is likely to occur

in one of two ways. The student may decide that the academic life of a professor is not the delightful existence he visualized as an undergraduate, or he may discover that the type of job he hoped to acquire with his Ph.D. may, for some reason, not be open to him. Disillusionment with academic life occurs in a random number of cases, and is essentially outside the control of anyone but the student, his experiences and preferences. Student attrition in the first year is often the result of such disillusionment; anyone who has been around graduate school for two or three years knows the system and presumably still finds academic life preferable to other alternatives. The second factor, unavailability of desired employment, is a function of information. Since the department is a major source of information concerning job opportunities, this factor is, to a considerable extent, under departmental control. For example, professors may know that women Ph.D.'s are discriminated against for job placement; this knowledge might cause many women graduate students to quit the program. If the department has some reason for wanting these students to remain in the program, then the department will carefully avoid discussion of job opportunities with female students.

Changes in the student's subjective estimate of the probability of success are very largely under departmental control. Since the faculty has complete control over the awarding of degrees, the student must look to the department for information regarding his likelihood of success. Thus, if the department wishes to keep a student in attendance, faculty members need only assure the student that his work is excellent and his progress satisfactory. The age old analogy of the donkey and the carrot seems appropriate.

Our analysis of the student investment model has produced the following

results:

(1) Holding initial cost, benefit, and risk estimates constant, the longer the student is enrolled, the greater is his incentive to complete the program.

(2) To a considerable extent, the variables that determine the pattern and timing of attrition (costs, benefits, risk), are under departmental control.

B. The Individual Faculty Member and the Department

Our ultimate aim is to propose a theory of departmental behavior, but we must first explain our 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. We exclude from this definition students, teaching assistants, associates, lecturers, and other nonregular faculty ranks. Thus, in seeking a theory of departmental behavior, we 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. Analysis of the motivation of individual faculty members as a prelude to the analysis of the department is necessitated by the collegial form of departmental organization, with its highly decentralized control and revolving chairmanship. Whereas operating units within a business firm or government bureau may reflect the manager's particular goals and values since he is held responsible for the unit's performance, an academic department's looser organizational form precludes us from examining the goals of the chairman alone.

The fundamental assumption of the analysis is that behavior of faculty members may be explained by the theory of utility maximization. In this assumption, we draw upon that body of organization theory literature best exemplified in the work of Anthony Downs.[8] We 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 the employing institution. Prestige, therefore, is understood to mean

a man's professional reputation within his discipline as judged by his peers in the same field in other universities. Reputation is enhanced by the quality of a man's research publications and by the quality of the graduate students who serve as apprentices under him.[9]

It seems reasonable to assume that 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. This occurs because most people within the academic system know the "rules of the game." A newly graduated Ph.D. whose primary interest is teaching will tend to avoid (and be avoided by) schools such as Berkeley. 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 the same way that a firm will not survive if it fails to maximize profits, a faculty member at Berkeley will not survive if he fails to maximize prestige.

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 a man's 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 men, power, income, independence, self-esteem, accrue to the academic who successfully maximizes prestige.

Assuming that each faculty member, motivated by rational self-interest, is intent upon maximizing his own prestige, we must now examine the implications of such behavior for the prestige of the department as a whole. In other words, will individual prestige maximizing behavior be consistent with prestige maximization for the department?

Caplow and McGee describe the relation between individual and departmental prestige in the following passage from The Academic Marketplace:

> 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.[10]

We might recast the above algebraically for a three man department as follows:[11]

$$P_1 = \alpha_1 A_1 + a_{12}P_2 + a_{13}P_3 \quad (1)$$

$$P_2 = \alpha_2 A_2 + a_{21}P_1 + a_{23}P_3 \quad (2)$$

$$P_3 = \alpha_3 A_3 + a_{31}P_1 + a_{32}P_2 \quad (3)$$

$$P^* \equiv \beta_1 P_1 + \beta_2 P_2 + \beta_3 P_3 \quad (4)$$

where

P_i = prestige rating of the i^{th} faculty member

A_i = prestige accruing to the i^{th} faculty member from publications, citations, and all non-department related sources

P^* = prestige ranking of the department.

The system indicates that an individual faculty member's prestige (P_i) is a weighted function of the recognition accorded his own work (A_i) plus the prestige of his colleagues. Total departmental prestige (P^*) is simply defined as a weighted linear function of the prestige ratings of the individual members. Clearly, if all coefficients (α_i , β_i , a_{ij}) are positive, then behavior that increases individual prestige ratings (P_i) is fully consistent with increased departmental prestige (P^*) .

The weights α_i and β_i will be positive under virtually all reasonable circumstances; of interest, however, are the a_{ij} that measure interactions of faculty prestige. The a_{ij} should be non-negative for department members who are not working in competing areas· thus, the publication of a new book by an economic historian should not affect adversely the reputation of the department's mathematical economists. However, the same book written by a "New Economic Historian" may severely damage the reputation of a department's older institutional historians. The latter case would involve negative a_{ij} coefficients, and it is possible that departmental prestige might fall depending upon the nature and magnitude of the inter-relationships. However, the presence of competing schools of thought within a department need not reduce departmental prestige if the β coefficients shift to give greater weight to the professor responsible for the discipline's advance. For example, in equation (4) suppose that an increase in P_1 produced an even larger decrease in P_2 , e.g., a young "New Economic Historian" refutes a well established institutional historian, both

men being in the same department. The profession, however, might give much greater weight to the contribution of the young professor than to the lost status of the older man, in which case β_1 might increase and β_2 decrease such that:

$$\hat{\beta}_1\hat{P}_1 + \hat{\beta}_2\hat{P}_2 > \beta_1 P_1 + \beta_2 P_2$$

where $\hat{\beta}$, $\hat{P}$ indicate the values formed after publication of the new book.

The relationships described by equations (1) through (4) could be analyzed in much greater detail, since numerous interesting interactions can be considered within that framework.[12] For present purposes, however, we conclude that individual prestige maximization is fully consistent with departmental prestige maximization in the majority of cases.

Departmental prestige is not, of course, an absolute measure but is determined on a relative scale by comparison with the same department in other universities. Surveys are published periodically ranking departments by the quality of faculty, thereby establishing relative prestige ratings, the most recent publication of this type being the 1966 Cartter Report.[13] 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 allocation 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 FTE faculty, 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. Again, the analysis will begin with the individual faculty member and lead on to the departmental level.

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. If a bright graduate student produces an excellent thesis under the direction of Professor X, and is rewarded for his efforts with job offers from prestigious universities, the reputation of Professor X is enhanced thereby. Conversely, if a professor works with a weak student who produces poor work and is employed by a low quality college, the professor's reputation may be damaged. This may occur in two ways. First, the academic community observes one of Professor X's students receiving poor acceptance on the job market, thereby damaging Professor X's image, and

secondly, other graduate students within the department observing this phenomenon may decide to avoid working with Professor X in favor of Professor Y, whose students are being well placed. Thus, the prestige maximizing professor has a definite incentive to seek out the best graduate students and 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.[14]

Note that the major, visible test of the quality of the student and his work is the job placement 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 both the student and his adviser. Given this analysis, we can conclude that in the absence of constraints, a certain number of graduate students who manage to reach the dissertation stage may experience difficulty in securing a thesis adviser. Such students, shunted from professor to professor, will experience difficulty in formulating a dissertation topic and are likely candidates for attrition. Reversing this process would require a deliberate departmental policy of assigning faculty members to work with these students. In considering whether the department would have any incentive to reduce this cause of attrition, the relation between student quality, job placement and departmental prestige

must be examined.

It has been argued that individual faculty members may rationally decide to minimize their involvement with students who will be difficult to place well within the academic prestige system. This strategy by the faculty member is rationally consistent with his goal of prestige maximization. Assuming that departmental prestige is the sum of individual faculty prestige, maximization of departmental prestige would require policies consistent with the rational behavior of the individual members. In fact, one might view the department as simply a single professor, and apply the above analysis. 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 be able to attract better students than those departments foolish enough to produce Ph.D.'s for low prestige institutions.

The following statement by Philip Cartwright, an economist and Dean at the University of Washington in Seattle, is included to demonstrate that this reasoning regarding the importance of placement is not entirely specious.

> Graduate instruction contributes to the image and returns of the university since many of the students who consume this product subsequently become faculty of other institutions. If the instruction is highly regarded by other institutions, these students will be sought by them. Every effort must be made to place the students on the faculties of the best possible institutions, although one can expect that students in general will be placed at equal or lesser institutions than those from which they receive their train-

> ing. If the institution providing this product finds that it can place students only in greatly inferior institutions, this may damage the reputation of the producing institution. An institution with a reputation for producing "inferior" Ph.D. candidates suffers losses in over-all reputation which could be avoided by the cessation of production. Reallocation of the resources in almost any direction would improve the ranking of the institution. It is, therefore, irrational to devote resources to graduate instruction in any discipline where the reputation of the faculty is insufficient to enable the institution to successfully market its Ph.D.'s. This same principle may apply to whole colleges or universities.[15]

Considerations 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.[16] In general, references to the "prestige system" will refer to the academic market although industrial placements may have a well established prestige ordering also. 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. Objective standards defining requirements for a Ph.D. simply do not exist, whether we look across

departments within a university, at the same department in different universities, or even within a department as between individual students in different specialities. 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 might be organized under four headings: admissions, curriculum, information, and use of resources.

Admissions: Since all Berkeley departments do reject some applicants, one may assume that departments are able to control the number admitted, although not the actual number who enroll. Over time, the department gains experience at estimating the enrollment-admissions ratio, and can be presumed to exercise fairly close control over enrollments. Only in the last two or three years has the Graduate Division at Berkeley exercised control over the number of graduate students enrolled in each department; attainment of the campus enrollment ceiling of 27,500 students led to the establishment of departmental quotas, published in the Revised Academic Plan.

It is further assumed that departments only admit people who are qualified for doctoral work. Any individual enrollee, then, can interpret his admission as a sign of good faith from the department regarding his potential for successfully completing the program.

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 dissertation required. Related to cur-

riculum content is the philosophical stance a department chooses to adopt regarding the meaning of the Ph.D. One extreme position might be characterized as the "finished product" view, in which a student cannot be certified until he has mastered virtually the whole range of knowledge, past and present, encompassed by his field. An alternative would be to view the Ph.D. as a "step down the road" toward comprehensive knowledge, coupled with the assumption that a well motivated Ph.D. can and will continue to learn on his own. A department clearly has a choice as to the location of its own program along a continuum suggested by these two extremes. A department that selects a curriculum near the "step down the road" position will argue that this choice rationalizes the program, eliminates waste, and hence increases the quality of its Ph.D., while a department oriented toward the "finished product" approach will insist that the comprehensive requirements and broad coverage of the field also increase the quality of its Ph.D. Thus any curriculum change, whether it involves dropping or adding requirements, will always be defended in the name of increased quality, and no one outside of the department is deemed fit to judge the merit of these claims.

The nature of the curriculum will effect 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 rather precisely determines 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 he is making no clear progress toward the degree may experience frustration and discouragement, and will reduce his estimate of the probability of success (α), possibly reaching a point where the expected

function. Removal of support may increase the present value of the costs to a level greater than the expected present value of the benefits, thereby causing the student to abandon 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 was 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 included 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 was 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 general, departments do not share equal access to resources, since funds are often provided by external agencies to support a particular activity within a specific department. Resources of this type are excluded from this analysis since conditions that govern their allocation are field specific, while our model focuses primarily on those resources for which all departments compete on a roughly equal basis. Thus the analysis will concentrate upon those university resources allocated internally by university administrators. Of primary importance is the faculty resource, measured by the number of academic FTE positions alloted to a department. Of secondary importance are the factors such as space, nonacademic personnel, library acquisitions, computer time, and so forth. Given that departments compete for these resources within the university, we need to know the basis for their allocation.

If the dean knew what each department was producing, if he could apply a common standard of value to the output, and if he knew the production function facing each discipline, then resources could be allocated optimally to insure equal marginal benefits for the last dollar of resources allocated to each department. Needless to say, these conditions do not begin to be met in practice, so administrators are forced to rely on quasi-analytical,

quasi-political methods of decision making. In many universities, the common measure available for departmental comparison is student enrollment, and one of the oldest analytic measures in education is the student-faculty ratio.

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:

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

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

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. The number of faculty positions allotted an established campus such as Berkeley presumably follows this formula. Note that each advanced doctoral student enrolled brings the campus $^{1}/_{8}$ FTE faculty position.

Given this overall campus formula, the hypothesis that administrators allocate positions among departments on the same basis suggests itself. Department chairmen receive computer print-outs each quarter listing the number of student credit hours (SCH) taught by level and major; thus, each chairman has a precise workload measure to use in justifying new positions. Interviews with Budget office personnel indicated that requests for faculty are often based on these enrollment-workload figures. In addition, cross-

section regression analysis for 68 Berkeley departments was used to test the hypothesis that the number of FTE faculty positions per department is a function of the department's weighted FTE student enrollment, including service load; the coefficients were significant and the model explained 82% of the variation in faculty 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; whether or not the enrollments ever lead to degrees is irrelevant to this standard of resource allocation.

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:

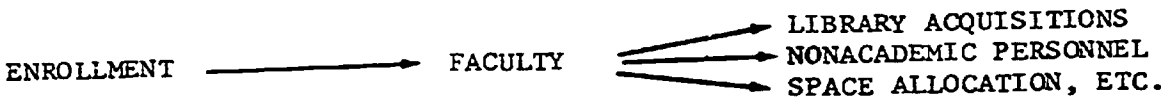


FIGURE 3

The relationships in Figure 3 form the basis of the University of California Cost Simulation Model,[18] developed in the Office of the Vice President, Planning and Analysis, University of California.

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.

Assume that at any point in time a department can rank order its graduate students from best to worst. Assume also that a department and its graduate students would generally agree on a ranking of university, college and junior college departments along a prestige scale from most to least prestigious. (We might think of a clustering of departments into possibly five groups, rated along the prestige scale.)[19] The above situation might be schematized as follows:

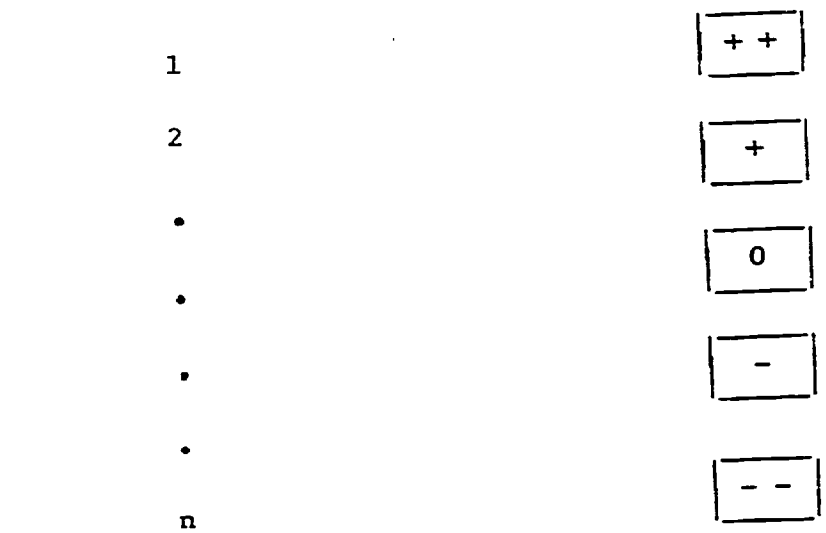


FIGURE 4

In addition to the assumptions of student rank ordering and department prestige grouping, three additional assumptions are introduced:

(1) 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. Furthermore, if the department were to award one more degree, this would go to student ranked number 4, not 5 or lower.

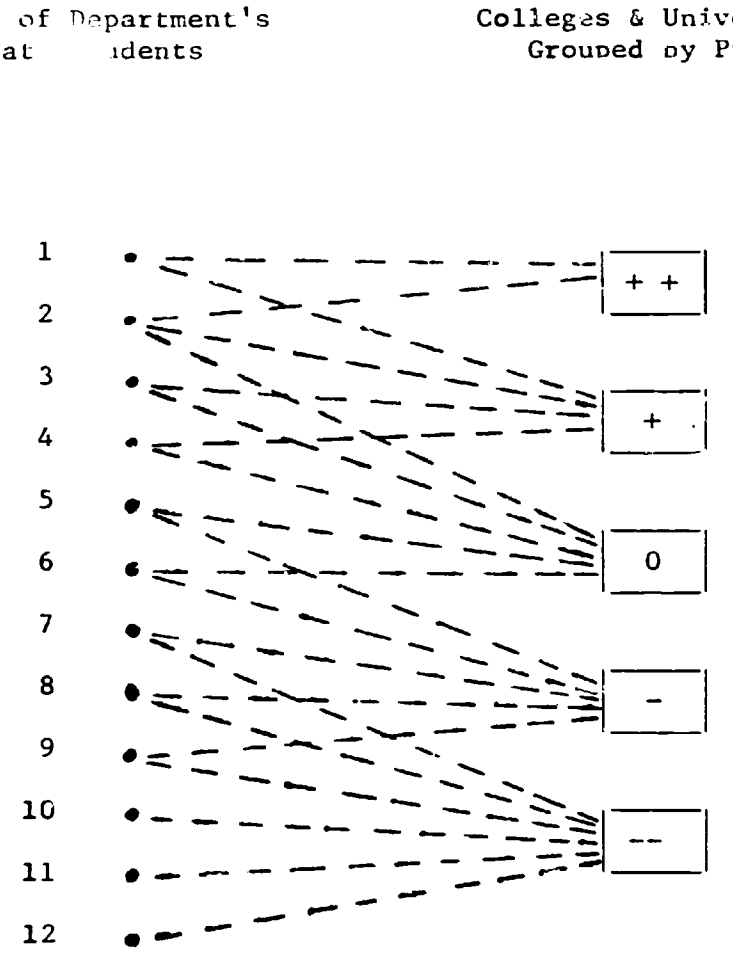
(2) Considering just the academic market, assume a strong positive correlation between the prestige ordering of job offers and the department's rank ordering of its successful Ph.D. candidates.

(3) 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 might be depicted as in Figure 5.

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 presumed 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.

Consider a department that enrolls 12 new graduate students each year. If the department organized its program and resources such that all 12 students successfully completed the doctorate, the students might encounter a placement pattern similar to that in Figure 5. The figure suggests a stratified market in operation, with considerable overlap and multiple offers to the best students.



Dotted lines indicate job offers

FIGURE 5

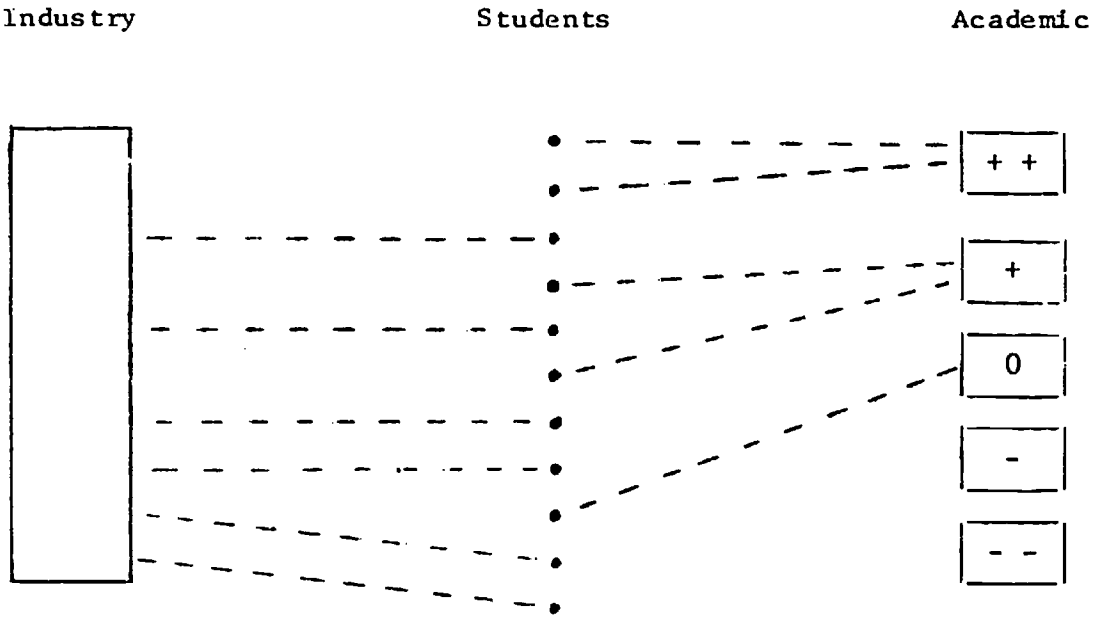
Since we assume that each student will accept his most prestigious offer, students 1 and 2 will take top prestige jobs, students 3 and 4 will accept prestigious jobs, students 5 and 6 will go to the neutral schools, while students 7 through 12 will be forced to accept positions in the negative prestige group. The actual number of offers made by each prestige grouping to Berkeley students will depend on the discipline and its growth rate.

The department whose market is characterized by Figure 5 would maximize its prestige if it produced between 4 and 6 Ph.D.'s a year, assuming a stable demand pattern. Thus, we would expect to see an attrition rate of approximately 50% over time within this field.

A further implication of this model follows from the assumptions. Suppose the department has reached an equilibrium in which it produces 6 Ph.D.'s a year, all of whom, as in the example, go to neutral or positively prestigious schools. Given our assumption, the department knows that if number 7 is produced, he will necessarily go to a lower prestige school than did number 6.

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, consider a department with the potential market for its Ph.D.'s as shown in Figure 6.

The presence of a large, prestige-neutral, employment sector such as industry means that the department's graduates are not all forced into the academic system. Students from all quality ranks may accept industrial employment, but this alternative will seem particularly attractive to the



dotted lines indicate <u>accepted</u> job offers

FIGURE 6

students in the bottom of the class who do not find desirable academic posts open to them. Thus a department fortunate enough to have an outside demand for its Ph.D.'s is 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 rather 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 notoriously 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 perfect information and considerable foresight. Nonetheless, the following simple model captures the essence of the optimization problem facing the department.

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:

$$\text{Max. Prestige} = f(\text{Resources}, \text{No. of Ph.D.'s produced}) \quad (1)$$

where

$$\text{Resources} = g(\text{enrollments}) \quad (2)$$

and

$$\text{No. of Ph.D.'s produced} = h(\text{enrollments}) \quad (3)$$

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

Graphically, the functions might be expressed as follows:

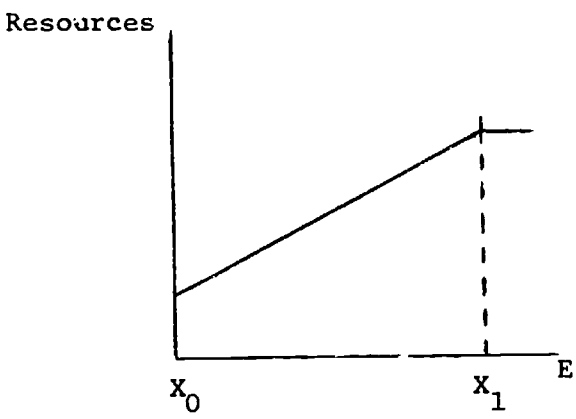


FIGURE 7

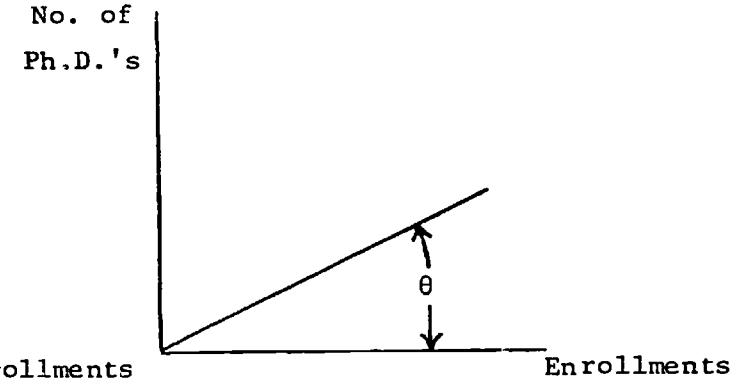


FIGURE 8

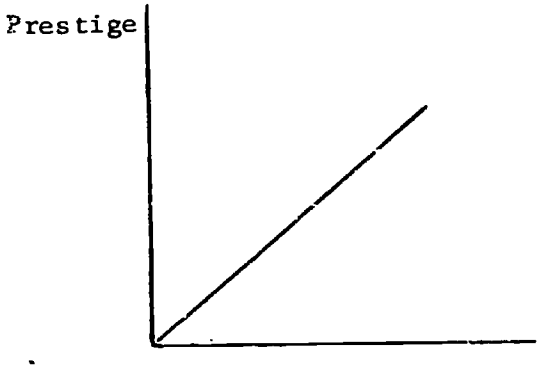


FIGURE 9

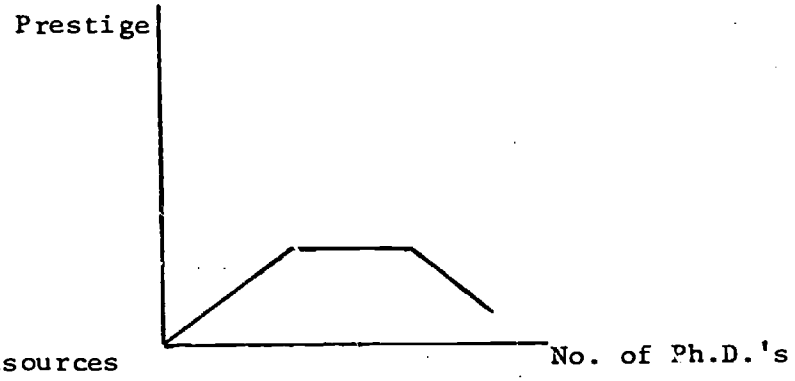


FIGURE 10

Figure 7 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. In fact, X_1 might represent an

actual upper bound on enrollments imposed by the administration, as is currently the case at Berkeley.

Figure 8 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% attrition and $45°$ representing no attrition.

In this simple case the function has been depicted as linear, implying a constant success rate independent of the enrollment level. Other possibilities certainly exist; for example, the function might be as follows:

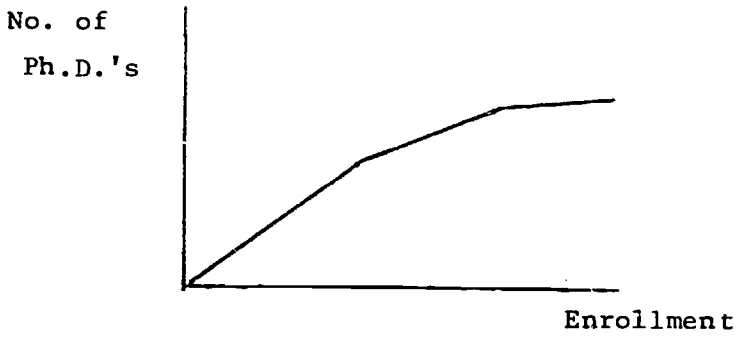


FIGURE 11

However, results are not fundamentally altered by adopting the simplest relationship of Figure 8.

Figure 9 depicts the relation between resources and prestige. The function may or may not be linear; the only restriction is that it be monotonically increasing.

Figure 10 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. Several cases will be examined.

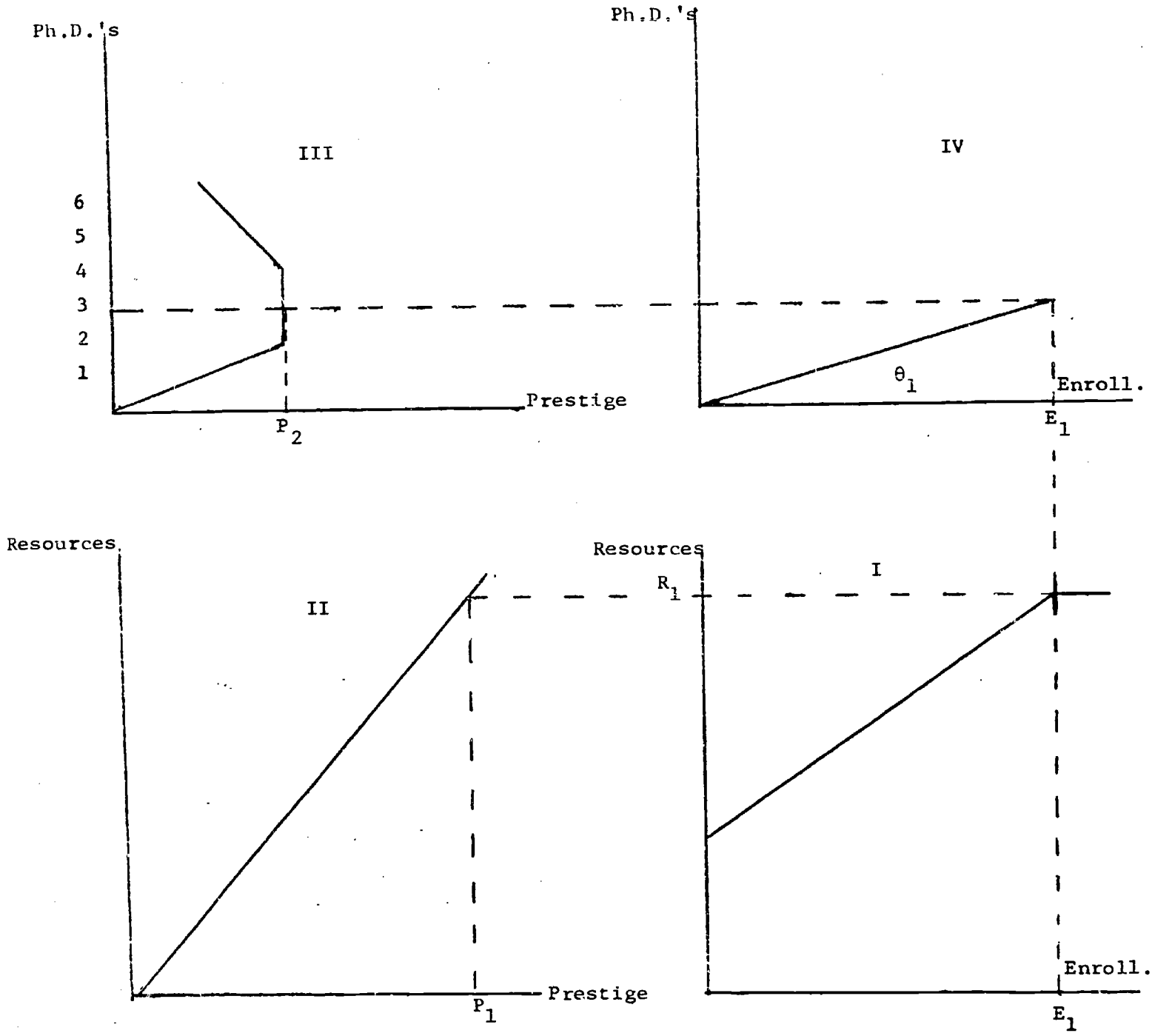
Case 1, The French Department

The French Department is a typical humanities department whose Ph.D.'s only enter academia. For the past 21 years, the department 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 12. 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 maximimum 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, 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.

If departments could not control attrition rates, a choice would have to be made. For example suppose that every student enrolled necessarily received the Ph.D. In this instance, the department would be forced to



Case 1, French Department

FIGURE 12

trade-off prestige derived from resources with prestige derived from Ph.D. placement. We can imagine the following transformation curve:

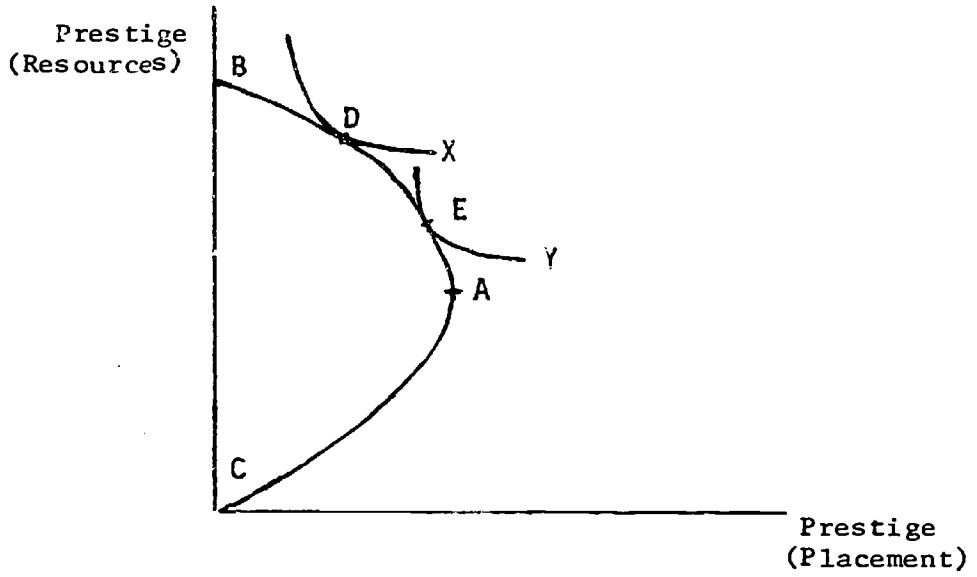


FIGURE 13

The decision range for the department would be the surface from point A to B , for on the surface from C to A , placement and enrollments are working together, not in opposition. The tangency solution will depend on the department's relative weighting of the two types of prestige. Department X may be more concerned over resources than placement relative to Department Y; thus X's optimal position is D , while Y's is point E . However, the major point is that departments are not forced into this type of calculus since they have control over the enrollment-output function.

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

Case 2, The Economics Department

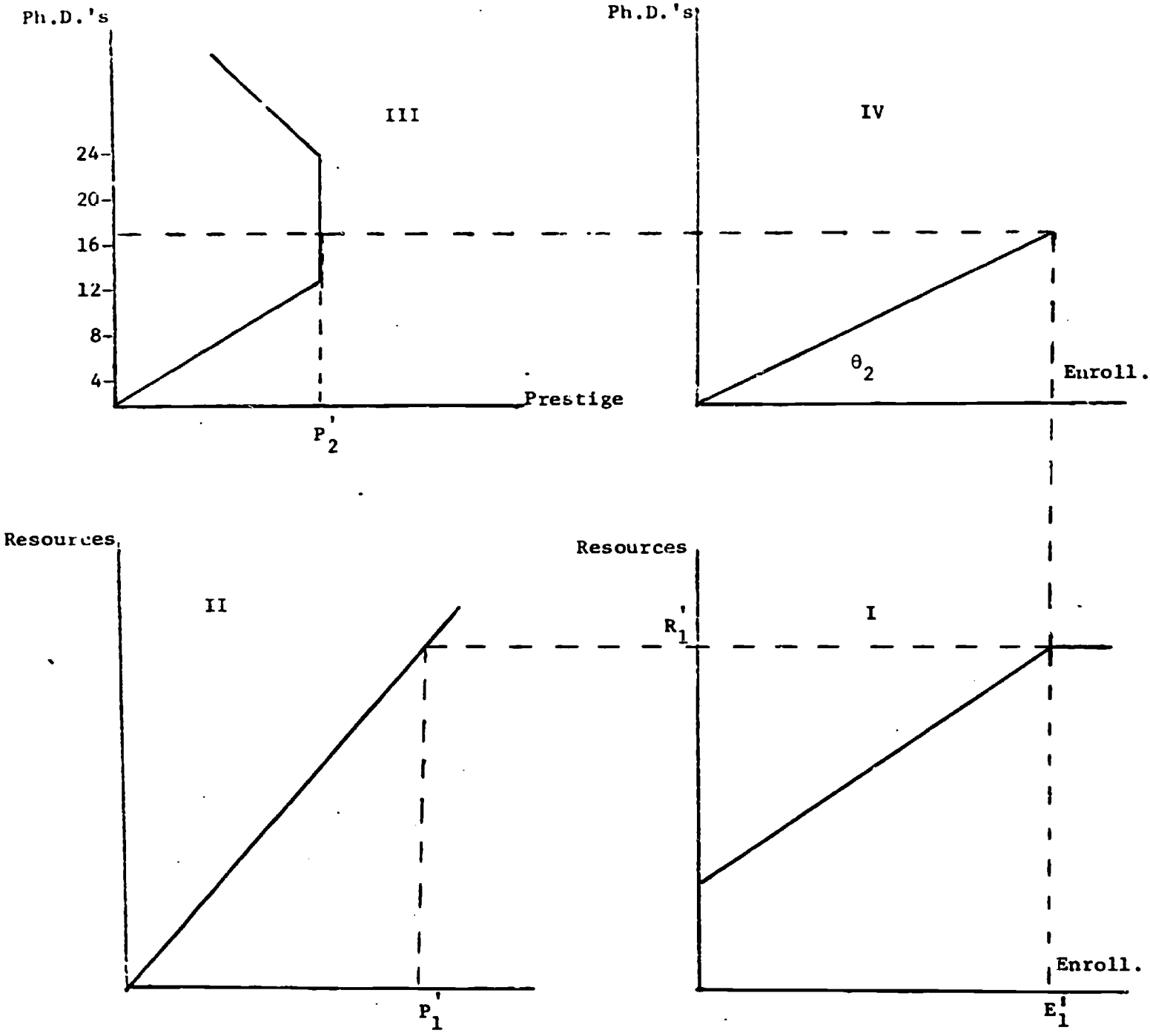
The majority of Ph.D.'s in a social science field such as economics accept academic positions, although many opportunities do exist in business and government. Furthermore, the social sciences have experienced good job markets and growing demand in the 1960's with higher growth rates of demand than the humanities. Thus, we would expect the Economics department to perceive a better, broader, demand for its Ph.D.'s than the French department. Thus, this field might be depicted as follows in Figure 14.

Given its much better market, reflected in the shape of the function in quadrant III, the angle θ_2 for economics is much larger than θ_1 of the French department, resulting in a lower attrition rate in Economics.

Case 3, The Chemistry Department

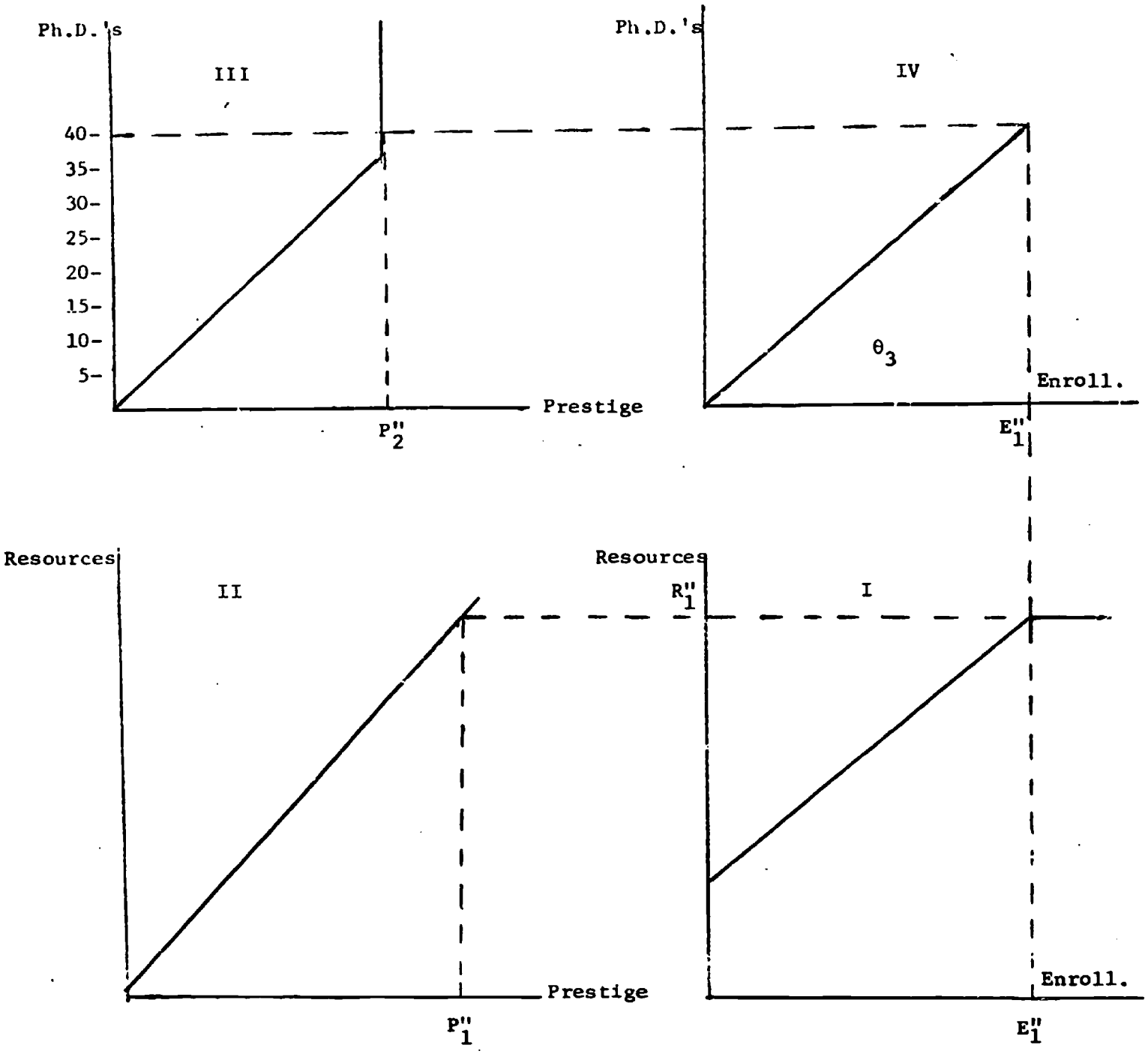
Finally, consider a field such as chemistry. During the 1950's and 1960's, demand for Ph.D. chemists was very strong. Fewer than 50% of the chemists produced by graduate departments accepted academic positions,[20] as industrial firms sought to hire these individuals. In this circumstance, one might assume that the chemistry department would view the demand for their Ph.D.'s as unlimited, with each student 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_3 very near to 45°. This field would be graphed as follows in Figure 15.

The three cases presented demonstrate how market forces operate upon prestige maximizing departments to produce different rates of attrition. The analyses have been static rather than dynamic, representing presumed



Case 2, Economics Department

FIGURE 14



Case 3, Chemistry Department

FIGURE 15

long-run equilibria. A dynamic element would be introduced through changes in market demand which would alter the department's prestige maximizing output. Imagine, for example, a sudden increase in demand for Ph.D.'s in French. This increased demand would shift the function in Quadrant III as follows:

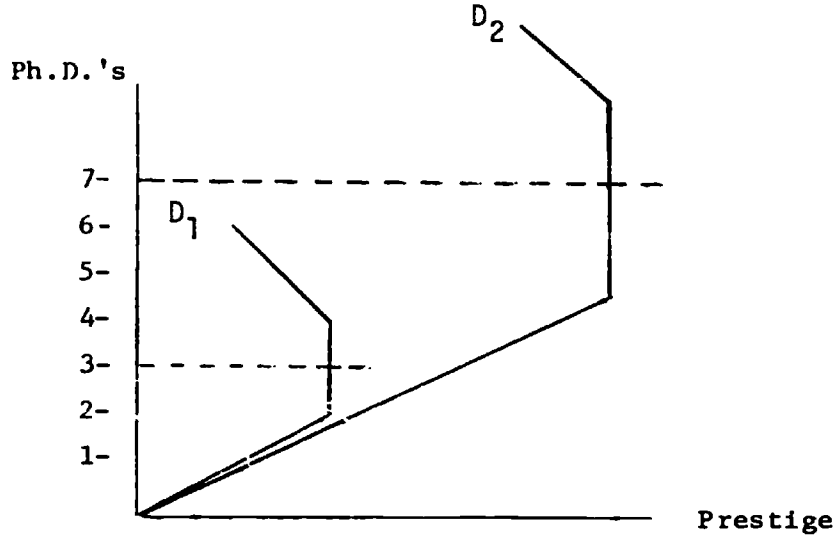


FIGURE 16

D_1 represents the perceived demand postulated earlier, with the optimal output level of three Ph.D.'s a year. Improved market conditions results in a new perceived demand curve, D_2, with the old output rate clearly not optimal. The department would now like to produce seven Ph.D.'s a year rather than three. With an enrollment of 70-80 Ph.D. students, this increased output is clearly possible. All that is needed are slight curriculum revisions, elimination of a few requirements not central to the program, scaling down of the dissertation, and the careful reorganization of financial resources and T.A. duties to insure most efficient use of funds. In short, the theory suggests that rationalization of Ph.D. programs can

only be expected in response to increased demand for Ph.D.'s, given an institutional incentive system that operates to keep enrollments high and unrelated to demand.

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[21] revealed two disturbing aspects of attrition at Berkeley, the differences in departmental success rates and 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 2, 3, even 4 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. In keeping with the first part, elements of the theory will be developed by considering the production process in a humanities, social science, and natural science department.

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 of 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.[22] 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 check-points by which to measure his progress.

(4) Feedback from the department designed to keep the student's estimate of success (α) 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 experience 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 1950's and through most of the 1960's, 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 of 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.

A social science department, such as Economics, would seem to fall between the two extremes of humanities and natural science departments. Whereas the market for humanities Ph.D.'s is limited and relatively stable, and for natural science Ph.D.'s in the post-Sputnik era broad and virtually unlimited, the social sciences have faced a growing market with increased demand from both academic and nonacademic sectors. Thus we would expect to see more evidence of curriculum change in the social sciences in the 1960's than in the other disciplinary groups, as the social sciences move to rationalize their programs in response to growing demand. The social sciences might be expected to display somewhat more erratic output patterns than the other groups, but with a definite trend toward increased Ph.D. output per student year.

In terms of technology, the social sciences also seem to fall somewhere between humanities and physical sciences. The social science graduate student may not work as closely with his adviser as does a physical science student in a laboratory setting, but the student-professor relationship may be closer in social science than in humanities fields because of the growing trend toward social science research institutes. The Economics student increasingly makes heavy use of computer time, often using funds provided from a professor's grant. As large social science research projects have developed, the trend toward team research has increased, as in the physical sciences.

Thus, we might view the social sciences as evolving during the 20 year period under study from an early organizational form similar to the humani-

ties toward the style of the physical sciences. This transition should be evidenced by a steady rationalization of the curriculum, shorter time to degree, and a declining rate of attrition accompanied by screening earlier in the program. The result would be a greater degree output per student year in the late 1960's than in earlier years, the measure falling between the humanities and the physical science degree outputs per student year.

NOTES ON CHAPTER 2

[1]The consumption motive will be discussed two pages hence.

[2]Richard Freeman, "The Labor Market for College Manpower," unpublished doctoral dissertation, Harvard University, Cambridge, Massachusetts, 1967.

[3]A mathematical treatment of the investment model is contained in the Mathematical Comment at the end of this section.

[4]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, Basic Books, Inc., New York, 1958.

[5]National Education Association, "Teacher Supply and Demand in Universities, Colleges, and Junior Colleges," published biennially from 1955 to 1965, Washington, D.C.

[6]For a survey of the literature on teacher supply and demand, see Allan Cartter, "The Supply of and Demand for College Teachers," Journal of Human Resources, Vol. I, No. 1, Summer, 1966, pp. 22-38.

[7]For exceptions to this statement, see the Appendix to this section.

[8]See Anthony Downs, An Economic Theory of Democracy, Harper & Bros., 1957; and Inside Bureaucracy, Little, Brown and Co., 1967.

[9]The interaction of individual and departmental prestige will be examined subsequently.

[10]Caplow and McGee, op. cit., p. 92.

[11]The following notation was suggested by Dr. Frederick Balderston.

[12]For example, Professor #1 may be a "star" so that $\alpha_1 A_1$ is dominant for his prestige, while Professor #2 may be mediocre, so $a_{21} P_1$ dominates $\alpha_2 A_2$ for him. Given sufficient complexity, one might explore the implications of such relationships for departmental staffing strategy.

[13]Allan Cartter, An Assessment of Quality in Graduate Education, American Council on Education, Washington, D. C., 1966.

[14]In a different form and content, this description of a university's functioning was suggested to me by Professor C. B. McGuire.

[15]Philip W. Cartwright, "The Economics of Deaning: The Care and Feeding of Homo Academicus," Western Economic Journal, Vol. III, No. 2, Spring, 1965, p. 159.

[16]Interviews with Chemistry and Electrical Engineering professors at Berkeley revealed that doctoral student placement in certain industrial positions such as Bell Laboratories is viewed by the department as being positively prestigious, on a par with the best academic placements. The majority of industrial placements appear to be prestige-neutral, however.

[17]W. Knight, et. al., Revised Academic Plan 1969-1975, University of California, Berkeley, 1969. Table 6, pp. 119-129, contains provisional estimates of departmental enrollments to 1975.

[18]See George Weathersby, "The Development and Applications of a University Cost Simulation Model," Graduate School of Business Administration and Office of Analytical Studies, University of California, Berkeley, June, 1967.

[19]In the empirical work, a prestige index adapted from David Brown's Academic Labor Markets, op. cit., pp. 341-352, was used. To give the reader a feeling for the type of school included in each category, the following examples are given:

+ +	The top ten universities in each field as ranked by the 1966 Cartter Report.
+	Amherst, Swarthmore, Williams, University of 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, San Diego State, Elmira College, Southern Oregon.
- -	Abilene Christian, Brigham Young, University of Dayton, Depaul, Florida Agricultural and Mechanical, Memphis State, Seton Hall, Washburn.

[20]National Academy of Sciences, Doctorate Recipients from United States Universities 1958-1966, Publication 1489, Washington, D. C., 1967, p. 82.

[21]Rodney Stark, op. cit., 1966.

[22]In May, 1970, this requirement was eliminated. The analysis of this section helps explain why this change was bitterly contested by the language departments.