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ABSTRACT

This document applies the tools of economics (consumer choice theory, wage theory, and collective choice) to develop an economic theory of learning. It examines the choice process of acquiring knowledge. The choice of one program (physics) over others (history, math) is clearly important in that physics knowledge and history knowledge cannot be considered as perfect substitutes in either a utility or production sense. Unlike conventional studies in the economics of education, the authors examine the ground between empirical demand studies for education and the studies that assume knowledge embodiment (human capital). Thus, student and faculty choice is examined that is internal to a university. Some questions considered are: What are the impacts of different student aptitudes on curricular choice and the decision to switch majors? What effects do student evaluations and varied grading schemes have on the learning process? Why do educational innovations appear to be ineffective? What are the choice implications of academic freedom? What are the causes and effects of grade inflation? Can faculty performance be evaluated? A variety of evidence is used to support models of student and faculty choice. However, the main thrust of this document is in developing a theory of learning based on economics and public choice. (Author/KE)

Final Report

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INTERNAL UNIVERSITY CHOICE: Faculty and Student Behavior and the Budget

(Changed to AN ECONOMIC THEORY OF LEARNING: Student Sovereignty and Academic Freedom)

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TO WINSTON

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This research applies the tools of economics (consumer choice theory, wage theory, and collective choice) to develop an Economic Theory of Learning. We examine the choice process of acquiring knowledge. The choice of one program (physics) over others (history, math) is clearly important in that physics knowledge and history knowledge cannot be considered as perfect substitutes in either a utility or production sense. Unlike conventional studies in the economics of education we examine the ground between empirical demand studies for education and the studies that assume knowledge embodiment (human capital) Thus, we are examining student and faculty choice internal to a university.

We consider questions such as: "What are the impacts of different student aptitudes on curricular choice and the decision to switch majors?" "What effects do student evaluations and varied grading schemes have on the learning process?" "Why do educational innovations appear to be ineffective?" "What are the choice implications of academic freedom?" "What are the causes and effects of grade inflation?" "Can faculty performance be evaluated?" A variety of evidence is used to support our models of student and faculty choice. However, the main thrust of this research is in developing a theory of learning based on economics and public choice.

AN ECONOMIC THEORY OF LEARNING:

Student Sovereignty and Academic Freedom

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CHAPTER I

INTRODUCTION

Conventional discussions of the economics of education are concerned with such questions as: What is the rate of return from education? What impact does education have on labor force participation, fertility, marriage, and household production? How does education affect economic growth, relative growth rates, and trade patterns among countries? Note that these questions consider education in an ex post facto sense. That is, they examine the behavioral implications of the embodiment of education, human capital. They do not study the process of acquiring education. Moreover, education, like physical capital in growth theories, is often treated as a homogeneous "glob" or "putty." Opposite the education embodiment studies are empirical studies of the demand for education that consider such constraints as tuition, income, and ability. Again, these studies do not treat the process of acquiring knowledge, but rather the decision to go to college or not to go to college; they are not studies of the consumption behavior once in an institution.

This book examines the choice process of acquiring knowledge. The choice of one program (physics) over others (history, math) is clearly important in that physics knowledge and history knowledge cannot be considered as perfect substitutes in either a utility or production sense. Unlike the conventional studies outlined above, we are concerned with behavior within an educational institution, the ground between that treated in empirical demand studies and in studies that assume knowledge embodiment. We feel this book offers a new contribution of applied economics, though we are somewhat puzzled that economists have not previously explored this area. Perhaps they have stressed the similarities rather than dissimilarities of human and non-human capital. Human capital, unlike non-human capital, cannot be purchased instantaneously in the capital market, nor once acquired can it be transferred readily. In addition, the constraints on acquisition are more complex than the income or wealth constraints that operate in stock markets.

While some of the models we develop (for example, the student sovereignty model) can be generalized to accomodate several alternative institutional arrangements, we have focused on American institutions of higher learning. Our analysis of the behavior of students and faculty would be different if we considered the educational systems of Great Britain or France or the Soviet Union. Thus, in one sense, this book could be titled An Economic Analysis of Internal University Choice.

We shall consider such questions as: What are the impacts of different student aptitudes and initial endowments of knowledge on student achievement levels and curricular choice? What effects do student evaluations and varied grading schemes have on the learning process? What are the causes and effects of "grade inflation?" Why do educational innovations appear to be ineffective? How can faculty performance be evaluated?

Some may think we are presumptuous to title this book An Economic Theory of Learning. While we do not claim to be experts in psychological learning theory, we have surveyed a number of learning theory texts. We agree with others [35, 34] that there are two main schools of thought: the Gestalt or Cognitive School and the Behaviorist or Connectionist School. Parallels to economic theory can be seen in each.

The Gestalt theory, as represented by Wertheimer [76], Lewin [41], and Tolman [67], relate learning behavior to an individual's goals, personality, drive, life space, and environment. Lewin's concept of a life space, defined with topology and vectors, can in some sense be identified with the economists' preference map[1], but Lewin uses the notions of positive and negative valence rather than utility. Hull [36] derives theorems similar to axiomatic choice theory and describes habit formation using the notion of diminishing marginal rate of return. Hull's notion of intervening variables (habit, drive, incentive motivation, and excitatory potential) is similar to the notion of utility. A dominance axiom is found both in economics and in Hull's habit-family hierarchy.

While economists and Gestalt psychologists may share intents, there are perhaps more dissimilarities in specific questions and methodologies. Psychologists are interested in the dynamics of choice--they attempt to explain habit formation, retention, and forgetting. This contrasts to the economists' comparative statics approach. Many of the psychologists' mental experiments are framed in a controlled laboratory. The economists' notion of substitution or opportunity costs of choice is not as prevalent in the psychologists' thinking. For example, leisure is not incorporated in the psychological models, although it is implied in the discussion of retention as related to stimili timing. Perhaps this is a cost of a dynamic view of choice as opposed to a comparative statics view. In summary, the Gestalt or Cognitive School encounters problems similar to those encountered by an external observer attempting to measure an individual's opportunity costs. This problem is traditionally one that falls under the London School of Ecnnomics and is succinctly presented in Buchanan's Cost and Choice [12].

On the other hand, the Behaviorist or Connectionist tradition, represented by Watson [74], Skinner [56, 57], and Estes [27], is more concerned with behavior per se than with attempts to develop theories of choice or to define intervening variables. This school, in using the stimulus-response model, is able to define and measure stimuli and behavior. There is no need to introduce intervening variables (habit, drive, excitatory potential), abstract concepts which are immeasurable except as observed behavioral responses.[2] The stimulus-response-reinforcement model is similar to the economists' behavioral framework of penalties and rewards. For example, Skinner, in discussing various forms of reinforcement, describes ordinary wages as fixed-interval reinforcement and piecework as fixed-ratio reinforcement--both control economic behavior [57]. This viewpoint resembles econometrics. The Behaviorist approach is manifested in such models as behavior modification, classroom-contingency management, competency-based cuuricula, performance criterion reference testing, and mastery learning. We shall examine some of these models in Chapter II, "Student Choice."

While the Behaviorist tradition may be more compatible than the Gestalt tradition with an economic framework, there are some major differences. Perhaps the major distinguishing characteristic is that our economic theory of learning does not rely on the social engineering concepts or the deterministic framework represented in Skinner's popular book, Walden II [56]. The individual student or faculty member in our models is not viewed as an academic robot responding mechanistically to stimuli, past and present. We accord the individual a preference and choice alternatives. The student or faculty member can, therefore, choose from a range of options or activities, only some of which are defined as learning or education. In subsequent discussions we shall emphasize that our models are not intended to predict behavior for a single individual, but rather to consider behavior at the margin.

Second, our approach differs from Walden II in that we do not define what constitutes "good" or "bad" behavior or learning. Psychologists have devoted considerable effort to educational measurement theory and techniques. To develop competency-based curricula, it is necessary to <u>define</u> and "objectively" measure knowledge. We discuss the collective choice problems of so-called "objective" tests in Chapter III. We bypass this issue by simply defining knowledge in terms of individual professors' preference functions. We do not assume there is a "truth" function that is similar to some economists' notion of a "social welfare function." Moreover, we examine learning in an environment of "academic freedom," operationally defined as the individual professor's preference (his definition of knowledge) in determining what he teaches and how he ranks or evaluates students. Therefore, we do not assume that students or professors are "searching for truth," a highly nebulous concept.

Third, we think in some sense our models of learning are more general than the psychologists'. In Chapter III, "Faculty Choice," we consider the stimuli that induce faculty behavior which in turn stimulate student responses. That is, rather than arbitrarily considering a range of stimuli that induce student responses, we view the choice process of the professor (in terms of teaching versus research activities, the incentives to innovate, etc.) as stimuli inducing student response. We also examine student responses and their effects on faculty behavior. We take into account the total environment, including the student/faculty choice between scholastic and non-scholastic (that is, leisure) activities. Income, like knowledge, is determined by the wage rate (abilities) and the level of <u>effort</u> devoted to working (scholastic activities). Our analysis is not conducted in an arbitrarily controlled environment, like a classroom where learning experiments take place, but in a more realistic environment in which we examine the trade-offs available to the student and professor between leisure and achievement. The psychologists do not explicitly introduce the overall time constraint which forces students (or professors) to choose between scholastic activities and non-scholastic activities. On the other hand, their definition of learning is more general than ours, since we bound knowledge by constraints imposed by individual professors.

The Gestalt or Cognitive School's [illegible] of intervening variables is likened to the ecnomists' notion of a preference map. The difficulty of the Cognitive School is perhaps best reflected by the term given to the other school--Behaviorist or Operationist. In other words, hypotheses of the Gestalt theory are not inherently testable as are those of the Behaviorist theory.

We treat student choice within the framework of ordinary consumer demand theory and models borrowed from wage theory. Our approach thus concentrates on the constraint side of the choice calculus by implicitly assuming preferences do not change. This assumption may be curious and unrealistic to some who would argue that changing preferences and attitudes is what higher education is all about. We treat the student as moving through a field of choice defined over various bundles of knowledge or courses (economics, psychology, history, etc.) as the student expends effort. Since this assumption is crucial, we shall offer further explanation.

First, Buchanan has convincingly argued that one definition of economics--"a science of choice"--is self-contradictory. "Choice, by its nature, cannot be predetermined and remain choice" [14 , p. 47]. In this book we are concerned with hypotheses about behavior rather than the pure logic of choice. In Buchanan's words:

> The fact that hypotheses refer to behavior of many actors greatly

> facilitates the predictive scientists' efforts. He need only make predictions about the behavior of the average or representative participants in the processes that he observes; he need not hypothesize about the behavior of any single actor. Hence, even if non-economic elements dominate the behavior of some participants, given certain symmetry in the distribution of preferences, the hypothesis derived from the absract theory may still be corroborated [15, p. 53].

Thus, we are concerned with behavior of the representative person at the margin. So long as the effects of constraints on choice behavior swamp the effects of preference changes at the margin for some individuals, our hypotheses about behavior can be tested. On the other hand, it is not that we feel the psychologists' attempts to specify the nature of preferences are not desirable (the importance of these is stressed by the London School of Economics tradition), but operationally it is difficult if not impossible to define preferences externally.

Second, consider students who switch broadly defined curricula from their freshman to senior year, a phenomenon that occurs, on average, for four out of ten students who graduate. One could argue that this behavior occurs because students' preferences change <u>or</u> that the realization of ability or time constraints force students into other curricula. Suppose we find that, on average, students who switched had marginal or below average grades. At the same time assume a survey instrument reveals that students stated they switched because of a change in preferences. Should switching be attributed to a change in preferences or the realization of binding constraints? Consider a student who decides to major in engineering. After taking a number of courses he discovers something similar to price discrimination--he finds that he is devoting more time and receiving lower grades than his average fellow classmate. This situation is analogous to a consumer who discovers he must pay a higher price than is marked, and at the same time the salesman (faculty) tells him he is stupid to make the purchase. After repeated experiences it is likely that the student (consumer) will lower his demand (change his preference) for the good and substitute (switch) courses (goods) for which he will not be discriminated against.

The above example attempts to determine whether the rank ordering for curricula has changed (preference change) or whether there is simply a realization that the initial choice is beyond one's feasible set. This situation is parallel to voting patterns at political conventions. Initially the voting may span a large number of platforms, but the realization that some alternatives are beyond the feasible set leads to a collapse in the number of alternatives and the switching of votes. Given the current state of the art, the testing of either hypothesis is difficult, to say the least.

Finally, our third argument in defense of using ordinary consumer demand theory is perhaps most convincing for economists. We see no intrinsic reason why education as considered in this book is radically different from other goods and services covered by ordinary consumer theory. If the demand curve does not hold for education in the disaggregate (economics, psychology, engineering), then it is not likely to hold for education in the aggregate (the empirical demand structures that consider such constraints as tuition, income, and ability).

In Chapter II the choice calculus of the individual student is discussed; we develop in some detail the very general behavioral assumptions undergirding the economic approach to learning. The model in a sense is the closest to the stimulus-response model of psychologists, but is developed in terms of consumer demand theory and models borrowed from wage theory. We also discuss the grading system as an allocation mechanism, the lecture as a public good, and the effects of considering knowledge as an inferior good.

Chpaters III, IV, and V deal exclusively with faculty choice. We deal with the difficulties of defining "good teaching," the value of screening, the influence of the fiscal crisis on faculty behavior, and "grade inflation." We also consider incentive systems and the faculty's choice between teaching and research. In Chapter VI we analyze the public benefits argument for "public" education and why students may be learning less in college than these arguments indicate. Chapter VII considers some public choice problems raised by the growing popularity of multidisciplinary programs. The final chapter summarizes the hypotheses developed throughout the book and offers concluding comments.

CHAPTER II: STUDENT CHOICE

Each year colleges and universities expend substantial resources to gather information on students' attitudes, preferences, and opinions. Educational psychologists and counselors feel that such information is valuable to students in curricular and occupational choices. In spite of counseling nearly half the students switch broadly defined curricula groups before obtaining a degree. According to educational psychologists the switching is due to dynamic changes in student preferences. Howeve, it is difficult or impossible to treat variable preference-oriented arguments operationally. We will examine student curricular choice within the framework of ordinary consumer demand theory. This chapter proposes a theory of choice based on the maximization of utility subject to time and ability constraints.

The major thrust of this chapter is to develop a choice model based on "limited student sovereignty." "Student sovereignty" allows students to operate in the <u>absence</u> of such constraints as entrance exams, course requirements, and a minimum grade point average. We also assume a tutorial model in which the teacher is perfectly responsive to student preferences. These assumptions (the absence of external constraints and tutorial instruction) will be relaxed to examine some comparative statics results.

The Student Sovereignty Model

<u>Preference Structure</u>

An axiomatic student indifference map has been constructed elsewhere [62]. Briefly, we assume that the comparability and transitivity axioms hold. Moreover, the dominance axiom (more of a good is preferred to less) is analogous to aspirations in the student choice model. Finally, we assume axioms that guarantee convexity of the indifference curves: the increasing personal rate of substitution and continuity of substitution.

The educational course space which a student confronts encompasses all courses of knowledge. A student may not aspire (prefer more to less) to knowledge for its own sake but may aspire to the accompanying prestige or income benefits. Furthermore, the comparability axiom need not extend over the entire field of knowledge. We do not assume that students seek a global optimum; the analysis is not altered significantly if we assume only a local optimum. A course in quantum physics may not be relevant to a student's field of choice if he has no experience in or awareness of the course. A student's field of choice at any point in time is conditioned by his preceding exposure and knowledge attainment.

Attainable Set

The distinction we make between aptitudes and achievement is fundamental to the analytical techniques employed here. Aptitude is defined as a learning rate. Achievement is defined as a <u>stock</u> of knowledge the student has at any point in time. Unfortunately, statements about a person's "brightness" or "dumbness" fail to make this distinction. An individual with a low aptitude may have a higher achivement level than a second individual with a higher aptitude, if the first individual devotes relatively more time to scholastic activities. We assume that any college student is able to master or achieve any particular course, concept, or "bit" of knowledge, given enough time. Obviously, the time expenditures will vary for individuals of varying aptitudes.

The student choice model defines an individual student's utility function as:

$$U_i = U(X_i, E_i) \tag{1}$$

where:

X_i = student i's achievement of a composite knowledge good;

E_i = the total level of effort or time expended by student i in achieving X_i.

We assume that knowledge, X_i, is a normal good and scholastic effort, E_i, a normal bad such that the marginal utilities of X_i and E_i are:

$$U_X > 0 \; ; \; U_E < 0 \tag{2}$$

We assume that X_i is some composite knowledge good--a course bundle. A course bundle is comprised of various fields of knowledge (social science, natural science, education etc.) such that $X = (x_1, x_2, \ldots, x_n)$.[1] We also assume a composite aptitude B such that $B = (b_1, b_2, \ldots, b_n)$ where the subscripts index the specific aptitudes for various fields $(x_1 \ldots x_n)$. A student's achievement of a composite X_i is a function of his composite aptitude (B_i) and the level of effort or time (E_i) devoted to scholastic activities.[2] The rate at which the student transforms effort into achievement (B_i) can also be considered a function of factors other than a student's aptitude. We shall examine these factors, including faculty ability, in Chapter III. For expository purposes we focus only on the aptitude of student as determining B_i in this chapter.

The general form of the production function or learning function is:

$$X_i = B_i E_i \tag{3}$$

Alternatively we could assume some initial achievement or initial endowment A_i so that:

$$X_i = A_i + B_i E_i \tag{4}$$

In either case, the first order conditions for utility maximization are:[3]

$$\frac{U_E}{U_X} = -B_i \tag{5}$$

The more general model in the absence of a composite knowledge or composite aptitude is:

$$\begin{aligned} X &= (x_1, x_2, \ldots, x_n) \\ B &= (b_1, b_2, \ldots, b_n) \\ E &= (e_1, e_2, \ldots, e_n) \end{aligned} \tag{6}$$

where 1...n index fields of knowledge

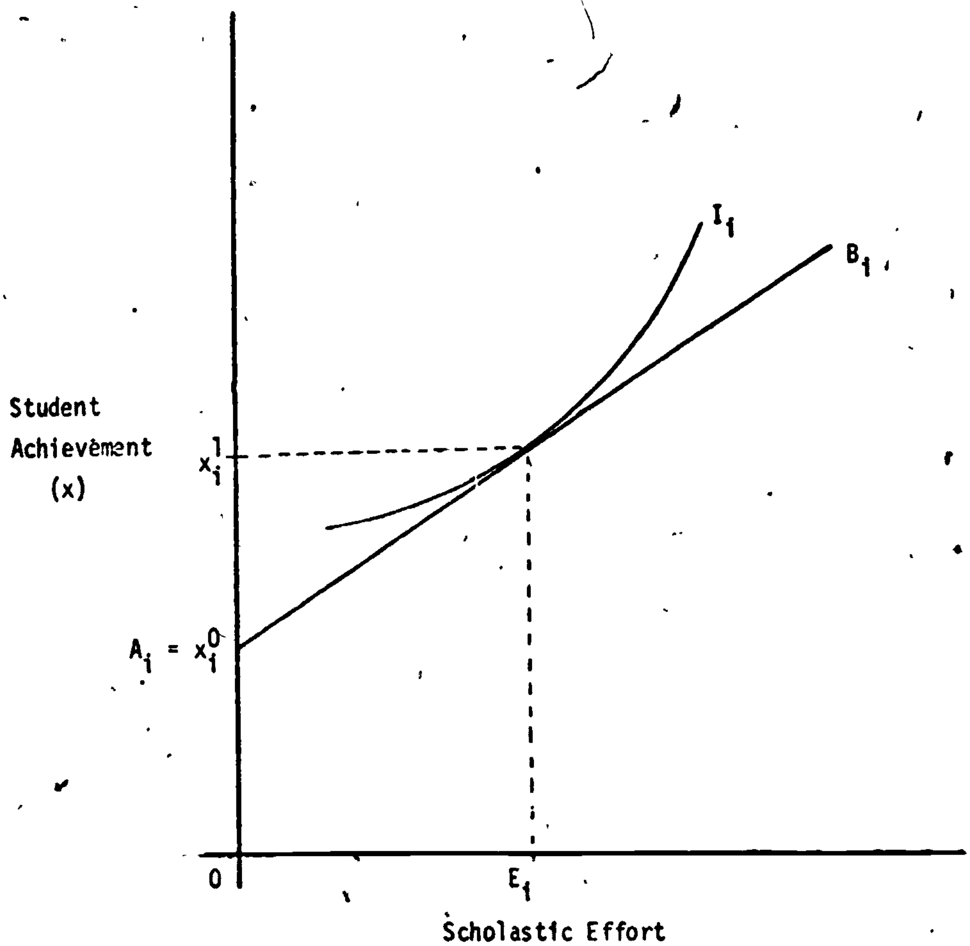
such that first order conditions for utility maximization are:

$$\begin{aligned} \frac{U_{e_1}}{U_{x_1}} &= -b_1 \\ \frac{U_{e_2}}{U_{x_2}} &= -b_2 \\ &\vdots \\ \frac{U_{e_n}}{U_{x_n}} &= -b_n \end{aligned} \tag{7}$$

The first order condition for utility maximization is that the marginal rate of substitution of a student's effort for knowledge achievement that he is willing to undertake equals his ability (b) to do so.

We shall first discuss scholastic choice in terms of a composite knowledge good (X) and a composite aptitude measure (B) using equation 4.[4] Consider Figure II-1, which illustrates the utility maximization of a student implied by equation 4.

FIGURE II-1



The prior achievement level of student i is X_i, represented by A_i in equation 3. Student i's composite aptitude (B_i) represents his "ability" to transform effort (E_i) into achievement (X_i). Given student i's preferences (I_i), he will expend E_i^1 effort to achieve X_i^1 of composite knowledge. By determining student i's utility maximization effort level we have also determined the student's level of leisure. The student faces a total time constraint T, which can be allocated between scholastic effort (E_i) and leisure (L_i) such that:

$$L_i = T - E_i \tag{8}$$

Having determined the amount of effort (time) that a single individual will devote to scholastic activities, assuming a composite knowledge and aptitude, we can examine in more detail a student's allocation of scholastic effort (E) among alternative fields of knowledge ($x_1, x_2, \ldots, x_n$). We consider only the existing state of knowledge, not the generation of new knowledge. We shall also restrict the student utility function. To simplify the analysis we assume an additive utility function U(X,E) such that $U = V_1(\sum_1^n x_i) + V_2(E)$. This allows us to examine student choice within a particular time constraint (E). In essence we divide student choice into a two-stage process. The first stage, equation 4, determines the level of effort the student optimally chooses. Having determined this level, we examine the choice of bundles ($x_1, x_2, \ldots, x_n$) that the student chooses, given the time constraint (E). Admittedly, this assumption is arbitrary; ideally we should handle the two stages simultaneously. The comparative statics results, however, are not altered. We caution the reader to be aware of the restrictions of the additive utility function.

We will also examine only a two-good model. The assumption of two goods (X_1 and X_2) is not terribly restrictive and can readily be generalized. The definitions of the two fields, x_1 and x_2, are somewhat arbitrary. They can be curricula, for example, natural science (x_1) and social science (x_2), or courses within a curriculum, for example, economics (x_1) and sociology (x_2). Given a level of E_i, we define the student utility function as:

$$U_i = U(x_1, x_2)$$

We assume each field has an associated aptitude (b) such that the production or learning functions for x_1 and x_2 are:

$$x_1 = b_1E_i \tag{10}$$

$$x_2 = b_2E_i \tag{11}$$

The previous section defined the time constraint (E_i) for student i so that we can write his constraint as:

$$E_i - b_1x_1 - b_2x_2 = 0 \tag{12}$$

Using the Lagragian multiplier we can define the constrained maximization problem as:

$$U_i = U(x_1, x_2) + \lambda(E_i - b_1x_1 - b_2x_2) \tag{13}$$

The first-order conditions are:

$$\frac{U_{x_1}}{U_{x_2}} = \frac{b_1}{b_2} \tag{14}$$

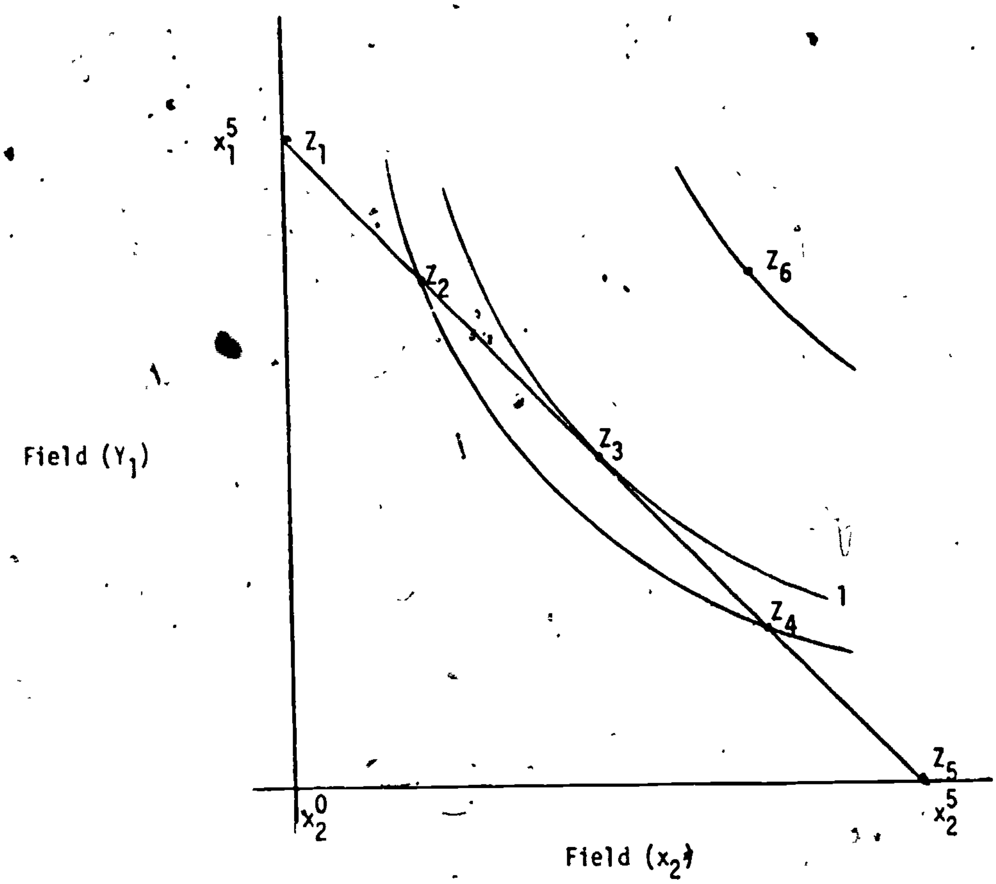
The above equation demonstrates that a student's willingness to sbustitute x_1 for x_2 (personal rate of substitution) equals his ability to substitute x_1 for x_2 (ars), given his relative aptitudes, b_1 and b_2, and effort (E). This formulation is equivalent to the consumer's constrained maximization problem: courses or fields are "goods," aptitudes are "prices," and study time or effort (E) is income. The value of λ is equal to the marginal utility of leisure. The students can choose a bundle of courses or fields (x_1, x_2). To avoid notational confusion we denote a bundle of courses or fields as $Z(x_1, x_2)$.

The above conditions are illustrated in Figure II-2. Assume the origin represents a student's past achievement levels, x_1 and x_2. (We shall call the student Albert, to remind the reader that he is an individual student.) Given some arbitary time constraint (for example, a week) and the portion of tne week that Albert devotes to scholastic activities (E), we can determine the course bundle he achieves. If he devotes his effort solely to x_1, he achieves the bundle Z_1 (x_1^5, x_2^0). If he devotes his time solely to x_2, he achieves bundle Z_5 (x_1^0, x_2^5). Alternatively, he can achieve any combination of x_1 and x_2, referred to as course bundles Z, along the line Z_1 - Z_5, depending on his effort allocation. Figure II-2 represents Albert's feasible set, given a scholastic effort constraint (E); the slope of the boundary represents Albert's ability rate of substitution (ars) of x_1 for x_2. It is important to distinguish between levels of aptitude and relative aptitudes (ars). A proportional increase in the levels of aptitudes for x_1 and x_2 would be represented by a parallel shift outward of the boundary without a change in the slope of the boundary. Alternatively, if Albert devotes more time to academic activites (less to leisure), maintaining the same levels of aptitudes, a parallel shift of the boundary would result.

Note that the bundle Albert chooses depends on his relative preferences of x_1 and x_2. Our previous assumption of dominance (aspirations) guarantees the choice will be on the boundary. Albert would prefer to attain a bundle like Z_6. However, it is beyond his attainable set, defined by his aptitude level and chosen effort expenditure. We have previously assumed his time allocation (T) between leisure (T_L) and academic activities (E) maximizes his utility.

Suppose Albert's preferences are such that he chooses the course bundle Z_3, which maixmizes his satisfaction. An external observer may feel that Albert "should" choose Z_1 or Z_4 to maximize knowledge. We assume that Albert's tutor automatically responds to Albert's wishes. Again, bear in mind that there is an absence of coure requirements, grades, and other institutional constraints.

FIGURE II-2



The Lecture as a Public Good

Let us now consider an additional student, Isaac, and the tutor, Plato. Assume Albert and Isaac have identical preferences, prior achievement levels (that is, start at the same origin), and aptitude levels for x_1 and x_2. This world-of-equals assumption is illustrated in Figure II-3.

FIGURE II-3

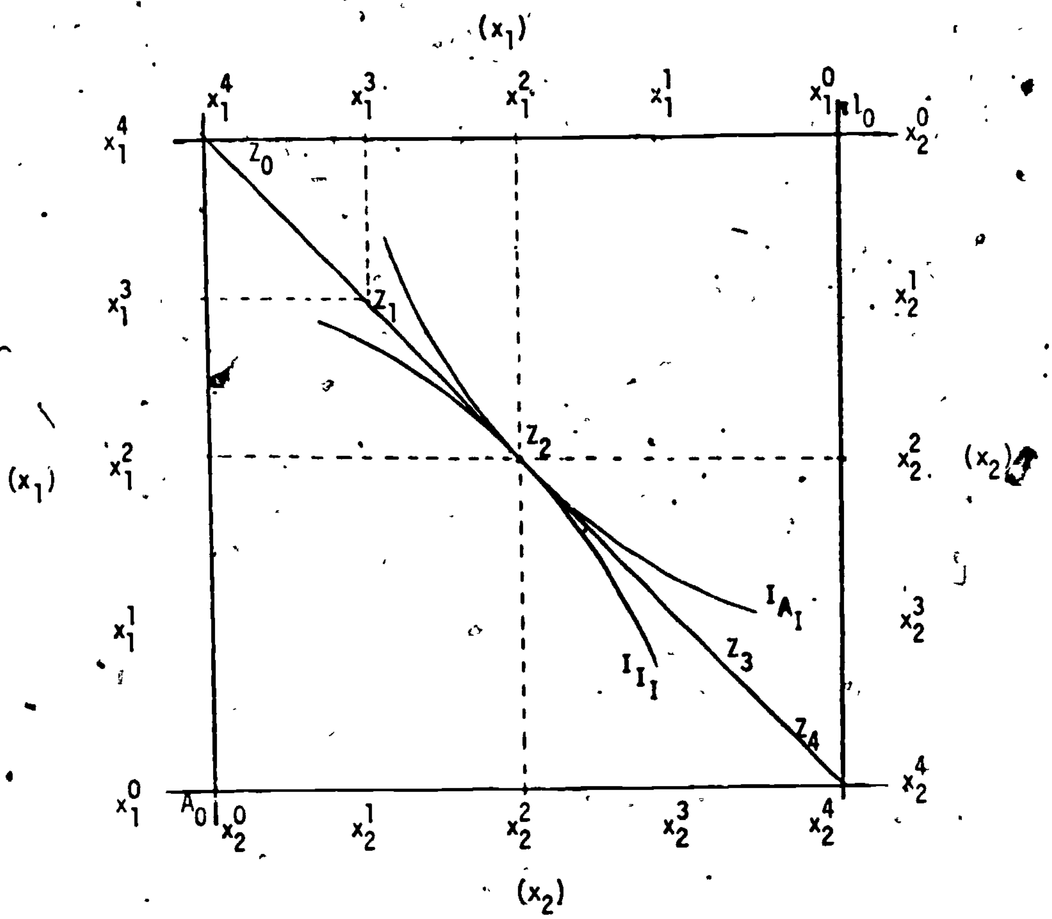


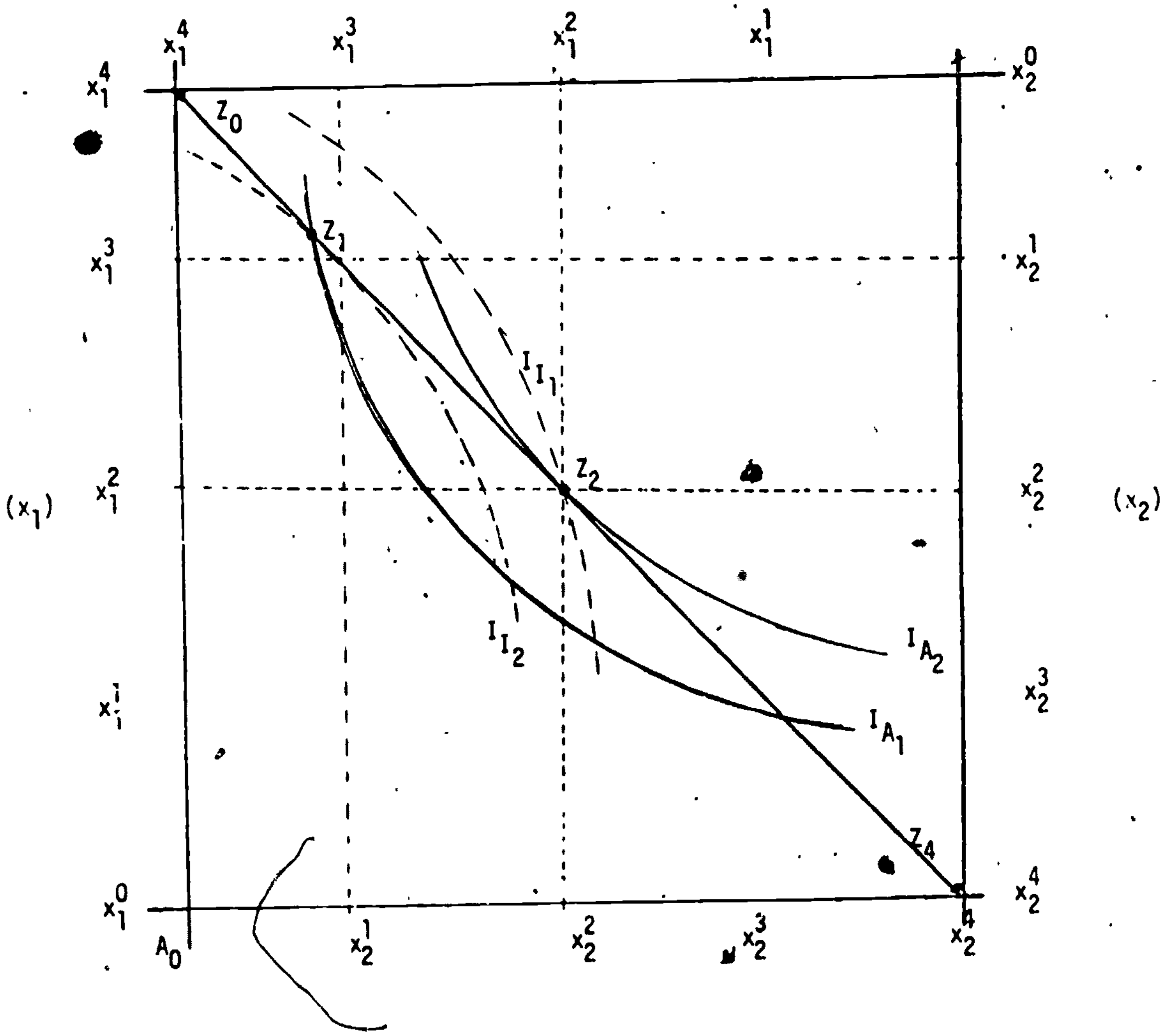
Figure II-3 is similar to an Edgeworth box, except that the Edgeworth box deals with private goods. The diagonal $Z_0 - Z_4$ represents alternative public good bundles (x_1, x_2). If Plato offers bundle Z_2, Albert and Issac have equal opportunities to attain it: $g_A(x_1^2, {}_2^2) = g_I\ (x_1^2, x_2^2)$. Plato's tutorial service is a pure public good in production; that is, any number of students (n) can be added to Plato's classroom without diminishing any student's consumption of knowledge, given the "world-of-equals" assumption. In addition, since we assumed students have identical preferences and student sovereignty determines which bundle Plato offers, each student in the class is maximizing his satisfaction. Note that, given the world-of-equals assumption, tutorial arrangements are not efficient. The addition of Isaac halves the average instructional cost. We can define the average cost function of knowledge achievement as A.C. = $g(\frac{c}{n})$, where c is Plato's salary and n is the number of students in the classroom; the marginal cost for each additional student is below the average cost. This production and cost function should lead to massively large lectures and few universities. We do not, of course, observe lecture classes as large and as frequent as would be deduced. By relaxing the world-of-equals assumption, we may discover why relatively small classes and a relatively large number of colleges and universities exist.

Differential Preferences

In the above discussion we have assumed identical preferences. Therefore, it makes little difference who directs Plato to offer the desired course bundle. A student association, despotic or democratic, would order the same bundle, even under a unanimity rule.

Figure II-4 illustrates a two-student model where Albert and Isaac have identical abilities but different preferences. Given Albert's preference structure, the bundle Z_2 is comprised of (x_1^3) and (x_2^1). The points (bundles) between Z_1 and Z_2 form a contract or conflict curve. As the course offering moves from Z_1 towards Z_2, Albert's level of satisfaction increases at the expense of Isaac's satisfaction. Course bundles on the diagonal outside the range Z_1 - Z_2 will not be offered since both Albert and Isaac are better of with moves from Z_0 to Z_1 or Z_4 to Z_2. The range Z_1 - Z_2 is a conflict curve, since one student's satisfaction cannot be increased without decreasing the other student's satisfaction. The structure of the student government is now critical. If Albert is the despot (his preferences are controlling), he will select Z_2.

FIGURE II-4



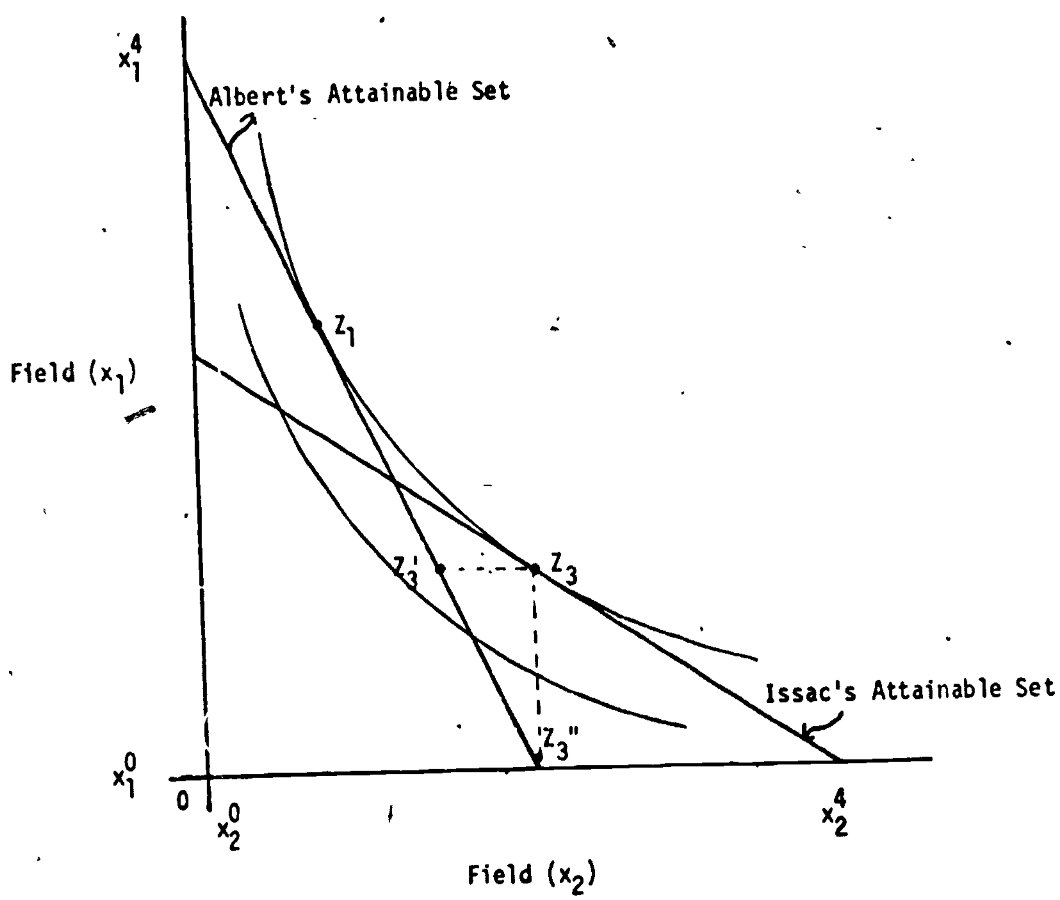
Similarly, if the student government is democratic, with Albert as median voter, Albert's preferences will again be determining. Either collective choice mechanism imposes external costs on Isaac (the minority). These external costs are externalities in consumption only. There still exist positive externalities in production of Plato's services. That is, whatever bundle Plato produces is equally available to all. Of course, each student has the option of hiring a tutor to avoid the consumption externalities. However, the positive production externalities (reduced costs of teacher services in a classroom) may more than offset the negative externalities of collective consumption.

A similar argument may be developed for a course with several dimensions--mathematical, verbal, factual, conceptual. Major and distributive course requirements may force a student to choose courses outside his preferred course bundle. For example, Isaac prefers more x_1 courses than x_2 courses (Z_1), but required distributive courses in x_2 may force him to take the course bundle Z_2. We have assumed that students are able to achieve the course bundle Plato presents. In a later section we examine ways that a student may allocate his time to achieve the preferred bundle in spite of institutional restrictions.

Equal Preferences--Unequal Ability Rates of Substitution

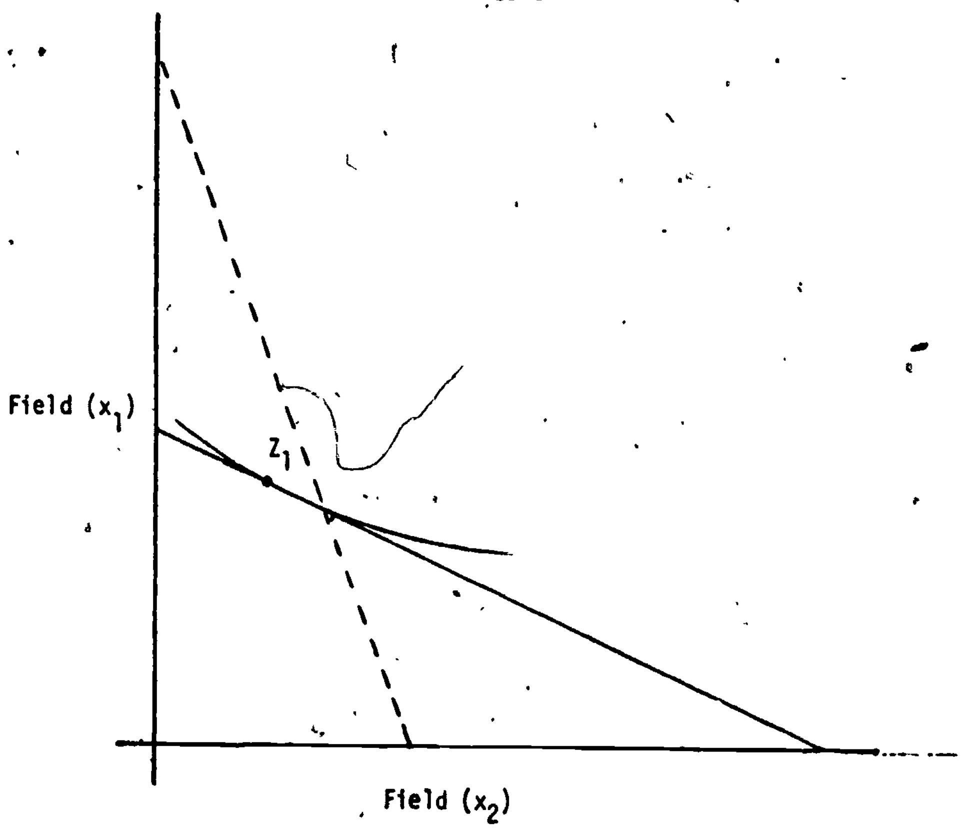
Consider the two-student/two-course model illustrated in Figure . Albert has a comparative advantage relative to Isaac in field x_1. Given student choice, Albert would select a major Z_1 whereas Isaac would select a major Z_3. If course requirements forced Albert to try Z_3, he would achieve between Z_3' and Z_3'' at a low level of satisfaction relative to Z_1. The bundle Z_3 is therefore beyond Albert's attainable set. Note that we are saying bundles Z_1 and Z_3 are equally satisfying to Albert. However, Albert is only <u>able</u> to obtain Z_3 if he expends more effort than that required for Z_1. Thus, the bundle Z_3 costs more in terms of time expenditures than Z_1 and would not be chosen, given student sovereignty.

FIGURE II-5



Relaxing the assumption of equal preferences, however, Albert may choose a field in which he has a comparative disadvantage relative to other students. Figure II-6 illustrates that the student sovereignty model allows such choices as Z_1 in which Albert specializes in the area of his comparative <u>disadvantage</u> relative to the class abilities represented by the dotted line. The choice may require that Albert hire a special tuto or that he sacrifice comprehension of classroom lectures.

FIGURE II-6



We can see that when students have different ability rates of substitution (slope of the boundary of the attainable set), a classroom situation leads to externalities: Plato cannot increase one student's satisfaction without decreasing the other student's satisfaction.

We may now consider a large number of students. Assume two groups: one group of students has attainable sets similar to Albert's and the other attainable sets similar to Isaac's. Assume Plato offers the bundle Z_1, illustrated in Figure II-5, perhaps because the majority of students have abilities similar to Albert's. This decision imposes considerable external costs to the minority of students who have abilities similar to Isaac's. The minority could reduce these external costs by hiring its own teacher to offer Z_3, if the costs of an additional teacher were more than offset by increased satisfaction from the reduction of externalities. This model demonstrates that students will organize themselves according to their comparative advantage, if there are a number of course bundles (teachers) from which to choose. Thus, the professor in the tutorial or student-sovereignty model is like the golf or tennis instructor who offers lessons in the private market. The professor cannot survive unless the student is willing to pay an hourly rate for his instruction time.

Unequal Levels of Aptitude--Equal Ability Rates of Substitution

In the model constructed above, the price of achievement is leisure; that is, the student must sacrifice leisure to achieve knowledge.[5] This model considers scholastic effort, ceteris paribus, a major determinant of acheivement. We borrow from conventional wage theory to examine student supply curves. Prior achievement, aptitudes, and scholastic effort are analogous to wealth, wage rate, and work effort, respectively. We consider two students who have identical preferences, defined over the entire field of choice, identical prior achievement levels (wealth), and identical ability rates of substitution.

The only difference is that student j has higher levels of aptitude in all fields that student i. That is, student j's composite aptitude is greater than student i's, even though both have identical ability rates of substitution (that is, a higher income but identical relative prices). Three types of individual student supply curves will be considered: perfectly inelastic curve, positive-sloping curve, and the backward-bending curve.

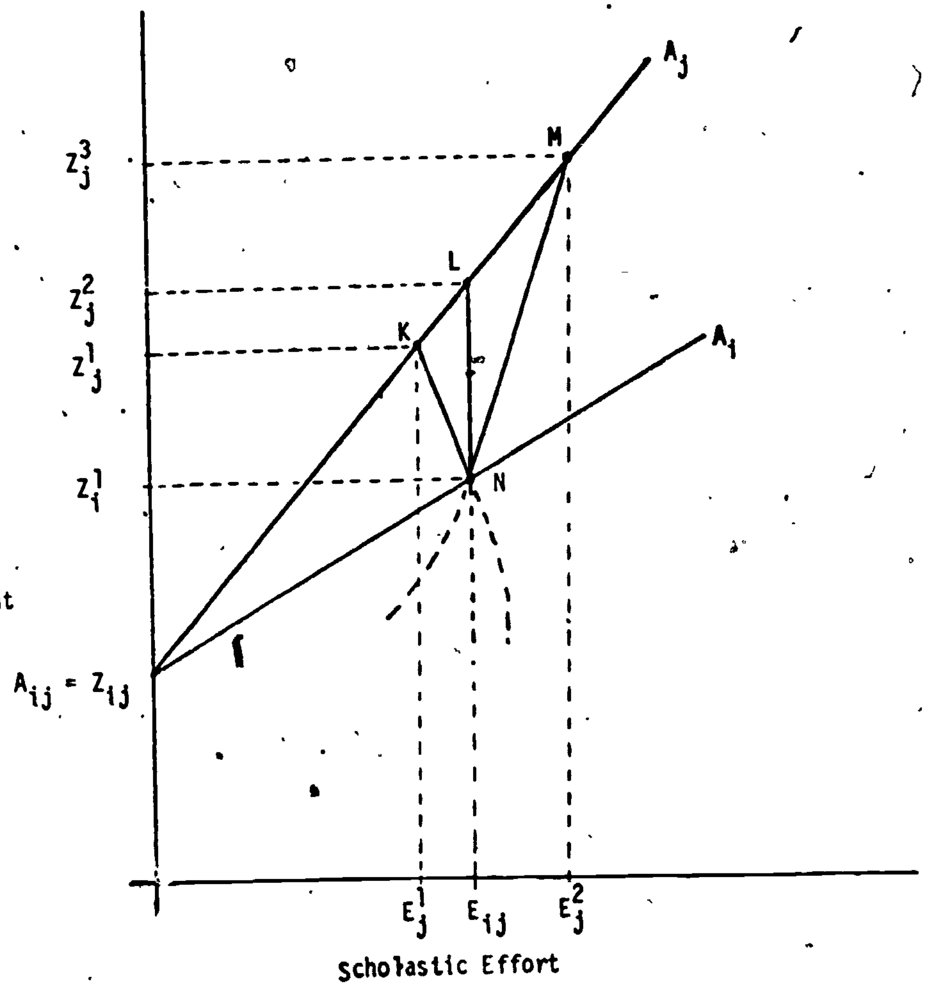
1. Inelastic Supply Curve

Student j in Figure II-7 has a lower price of achievement than student i, enabling him to have a higher achievement level and more leisure. A lower price of achievement (a relatively higher aptitude) is likely to have a substitution effect that induces more achievement. However, there is also an income effect that permits more leisure. If we assume that students have Cobb-Douglas utility functions, $U(X^{\alpha}E^{1-\alpha})$, then the substitution effect of higher aptitude levels working towards increased effort is exactly offset by the income effect of consuming more leisure (less effort). Therefore, our assumptions of equal preferences and Cobb-Douglas utility functions would imply a constant level of effort, regardless of a student's aptitude. The individual student effort (supply) curve is illustrated in Figure II-7 by the line N-L, where students i and j expend the same effort ($E_i = E_j$) but student j achieves Z_j^2, which is greater than student i's achievement (Z_i^1).

2. Positive-Sloping Supply Curve

If the substitution effect of higher aptitudes outweighs the income effect, a student supply curve illustrated by N-M would result. Student j has a greater achievement (Z_j^3) than student i (Z_i^1), in part due to greater effort (sacrifice of leisure), E_j^2, expended relative to student i (E_i). That is, the price of leisure (achievement) is more (less) expensive to the high aptitude student who thus consumes less (more) of it.

FIGURE II-7



3. Backward-Bending Supply Curve

The backward-bending portion of the supply curve is illustrated by the line segment N-K in Figure II-7. In this case the income effect outweighs the substitution effect, such that individual j devotes less effort to scholastic activities (E_j^1) than the lower aptitude student (E_i). Again, student j's achievement is higher (Z_j^1) than student i's (Z_i^1), even though j is consuming more leisure.

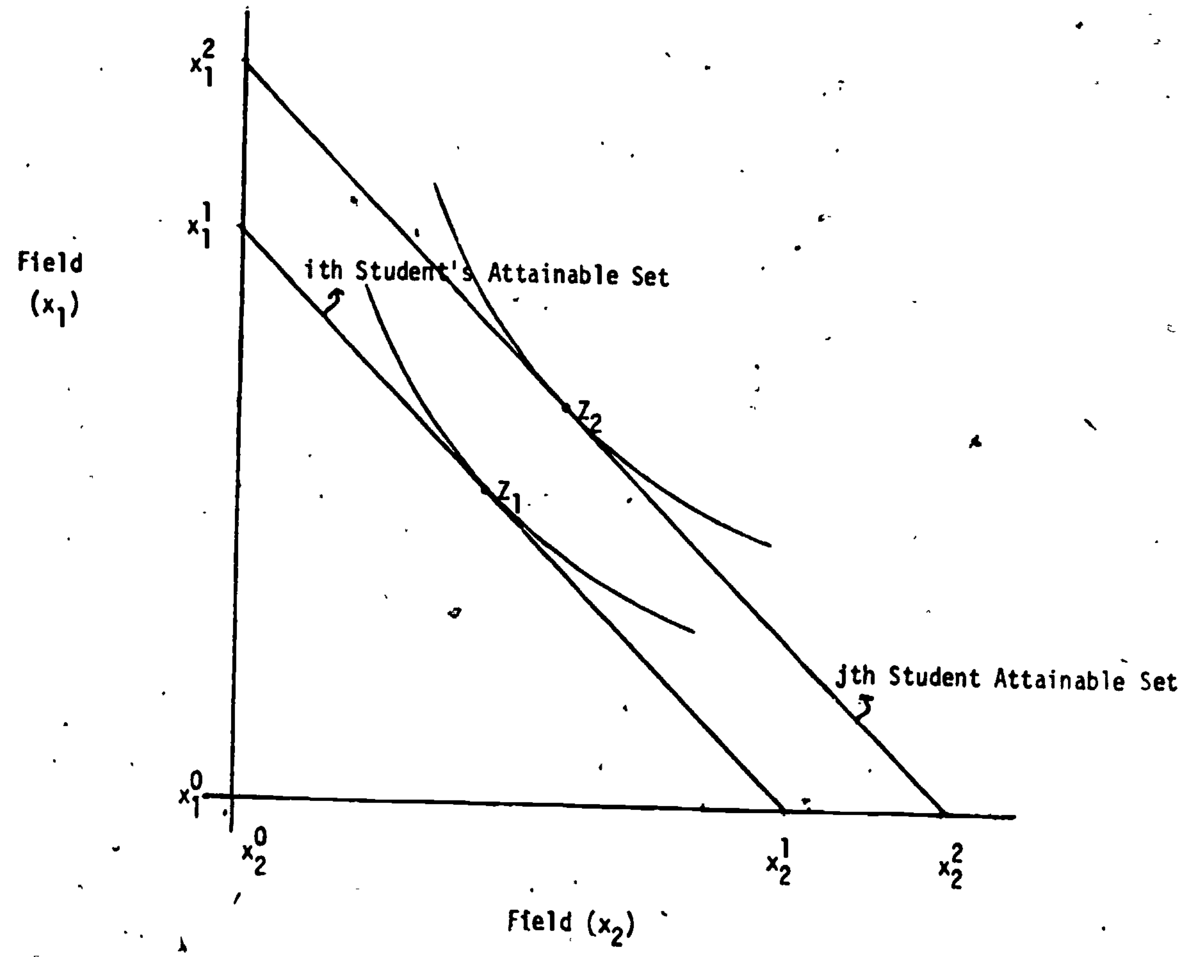
Relaxing the assumption of identical initial achievement levels ($A_i = A_j$) may also produce a backward-bending supply curve, similar to the "wealth effect" on leisure in traditional wage theory. Unequal initial achievement levels may lead to a backward-bending supply curve, even if aptitudes are identical.

Which student supply curve is realistic is an empirical question.[6] Moreover, we have assumed the preference maps of the two students are identical. Relaxing this assumption may permit the low aptitude student (i) to have a higher achievement level than j if he is "willing" to sacrifice enough leisure. We shall discuss this case later. We shall assume equal preferences. For expository reasons we shall also assume a Cobb-Douglas utility function, though the analysis is not changed significantly for utility functions yielding a positive scholastic supply curve or a backward-bending supply curve--all three lead to higher achievement levels of the high aptitude student relative to the low aptitude student.[7]

We are now able to translate Figure II-7 into the two-course/two-good model illustrated in Figure II-8. Assuming identical effort levels and disaggregate composite aptitudes (B_i and B_j) we can examine the implications of different aptitudes. Maintaining the assumption of equal <u>ability rates of substitution</u> between x_1 and x_2 and the same time expenditures (E), the higher aptitude student (j) has a larger attainable set, bounded by $x_1^2 - x_2^2$, relative to student i, whose attainable set is bounded by $x_1^1 - x_2^1$.

Under the tutorial model, if Plato offers Z_1, student j (Albert) will be dissatisfied, or if Plato offers Z_2, student i (Isaac) will be dissatisfied.

FIGURE II-8



If bundle Z_2 is offered, Isaac will find the material too difficult, given his effort-leisure choice. Isaac can achieve Z_2 only if he sacrifices leisure at the margin, which will lower his satisfaction. Similarly, if the bundles Z_1 is offered, Albert will find the material too easy. Again, both students could obtain their desired bundle if they hired separate tutors; however, the resulting satisfaction is offset by the economy that a classroom arrangement permits. Plato's lecture, again, is a pure public good available to all students but not necessarily equally attainable or desired by all.

In the absence of data on student effort levels and time allocation decisions among courses, it is difficult to validate these models. Supportive studies by Capozza [19] and Attiyeh and Lumsden [4] deal with student evaluations of faculty and with student achievement. They found that student evaluations of courses and faculty varied <u>inversely</u> with the gains scored on pre- and post-tests in Principles of Economics courses. The Principles of Economics course is a required course for many students. Those students with a low initial endowment (prior achievement level) in economics and/or a low aptitude for economics may have found that at the margin, in order to receive a passing or "target" grade, more leisure was sacrificed than the student desired (that is, the marginal evaluation of leisure or the marginal evaluation of time devoted to other courses was greater than the marginal evaluation of a unit of time expended in economics).

This model of unequal aptitudes--equal preferences, as well as the model of unequal preferences--equal aptitudes, suggest a different interpretation of student evaluations of courses and professors. A lecture is a "public good" In the absence of a quantity adjustment mechanism (for example, tutoring), not all students are equally satisfied. The nature of a lecture/classroom situation requires that some students are dissatisfied with the quantity of knowledge provided. It also raises the collective choice problems of what quantity to offer and who should assume the role of decision maker. We shall examine alternative property rights structures (students versus faculty) in a later section. We shall now consider institutional constraints that modify the student-sovereignty model.

Institutional Reouirements

Admissions Criteria

In the previous sections we have assumed identical initial achievement levels (that is, identical A_i) such that Albert and Isaac started at the same origin of the choice field. Such admissions criteria as minimum high school grades and scores on standardized achievement and aptitude tests (for example, the C.E.E.B.) to some extent minize the external costs of lectures as public goods. That is, the external costs of lectures would be considerably higher if a lottery determined which students were admitted.

Recent studies of college choice by Kohn et al [39] and Spies [61] recognize the significance of admissions criteria as a variable of the student demand function. These studies indicate that the probablility of attendance varies inversely with the difference between the entering aptitude scores (SAT scores) of an individual student and the average student enrolled. That is, the smaller the difference between the individual student's score and the institutional mean score, the more likely the student is to attend that institution. Kohn et al concluded that "...even in the absence of ability based admissions standards, students would desire to at least partially segregate themselves according to ability" [39, p. 49]. This phenomenon suggests that students have relatively good information about the ability composition of students in alternative institutions.

Moreover, if the admissions standards are low and the grading standards high, the entry is a revolving door to some students. We are not implying normative standards of ideal admissions policies but rather we are describing the existing situation. Given the scarcity of college places, a rationing mechanism based on aptitude and achievement may represent maximizing behavior of faculty, a possiblity that will be discussed in the next chapter. Admissions standards tend to be aggregate measures based on some minimum average of, for example, SAT varbal scores, SAT math scores, and high school grades. We now consider the grade contraint as an allocation mechanism.

Grade Constraint

To this point we have assumed student sovereignty--the student chooses the bundle that maximizes his utility, given his overall time constraint and relative aptitudes. The preferred bundle may be in areas where the student has comparative disadvantages relative other students. He may select a major (for example, engineering) for which he has a low aptitude, recognizing that to complete the degree it may take him eight years rather than the standard four. The student may feel so intense about engineering that he is willing to pay the additional price.

We now consider grades as a limit of some students' choice fields. Once a student has selected a bundle (degree program), he agrees to the rules governing that bundle. These rules constitute certain distributive (university-wide) and major (departmental) course requirements. In addition, a minimum grade point average (GPA) must be maintained each semester and a cumulative GPA must be attained in order to graduate. The assumption that the student prefers a degree bundle is not unreasonable, given the positive income differential of degree and non-degree students. This is not to say that under student choice (no course or grade requirements) he would choose an identical bundle comprised of the same courses. The assumption simply means that the degree bundle yields a higher level of satisfaction in terms of such factors as leisure, income, mobility, status, than a bundle of an equal number of courses (and student time expenditures) that do not meet degree course requirements. In other words, the degree program represents a tie-in sale with positive and perhaps negative components. We further assume that the student aspires to a degree, even if it is not the preferred degree.

Assume that the faculty member's preference function determining a classroom grade distribution is a monotonic transformation of the students' post-achievement scores distribtuion.[9] This assumption means the faculty member adheres to some standard distribution of grades, not necessarily a normal distribution, that preserves the ordinal ranking based on post-achievement levels.[10] This procedure is termed "normative reference testing" in educational literature. The grade a student receives is based on a population norm (the class) as opposed to some absolute standard. Criterion reference testing establishes a specific criterion, eliminating the norm as the reference. At this time we assume faculty members utilize normative preference testing and will subsequently discuss criterion reference testing.

Consider a class of students N that are indexed as $N = \{1,\ldots,n\}$ and a student i such that $j \in J = \{j \in N | j \neq i\}$ and $i \in N$. Let us consider only one field (course), x, and one aptitude, b_1, out of the entire set of X and B. For expository reasons, assume all students have identical initial endowments or pre-test scores. The ith students rank (r_i) in the class of N students in terms of being in the upper half or lower half can be defined as:

$$r_i = b_i e_i - \sum_{j \in J} \frac{b_j e_j}{N-1}$$

where:

b_i = student i's aptitude in a specific course

b_j = aptitudes of all other students in the course

e_i = the effort i devotes to this course, which is some portion of i's total effort (E_i)

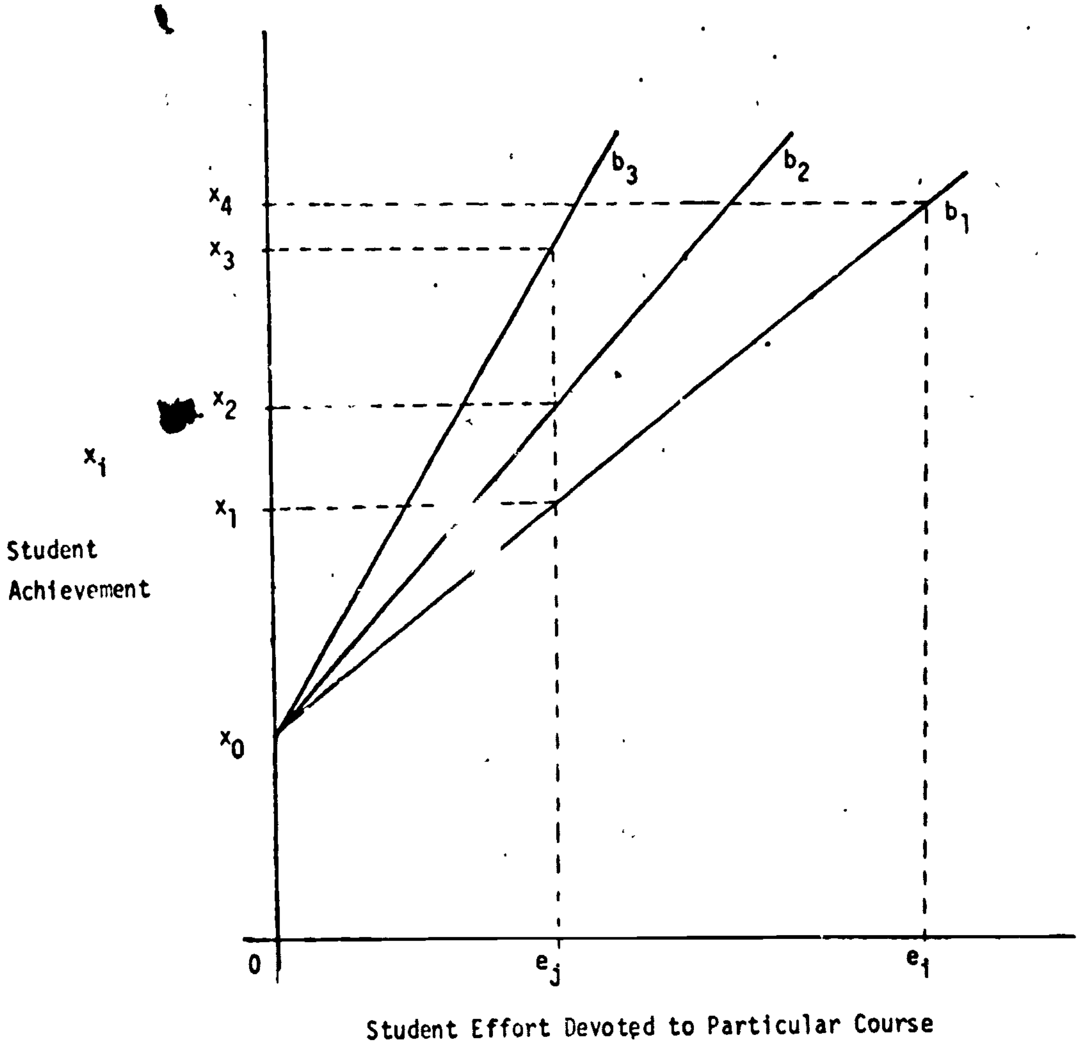
e_j = the effort j students devote to this course

The ith student is in the upper half if $r_i > 0$ and lower half if $r_i < 0$, where $\sum_{j \epsilon J} \frac{b_j e_j}{N-1}$ represents the mean post-achievement score, assuming N is large enough that the ith student's achievement is negligible. For mathematical convenience we assume that the mean score is identical to the median score.[11]

We see that the ith student's rank not only depends on his own aptitude and effort but on the aptitudes and efforts of the remaining N -1 students. Assuming academic grades are a monotonic transformation of the ordinal rankings of students, the grade a student receives in class is not solely determined by his behavior. The external effect imposed by other students on the ith student's rank, and consequently his grade, is clearly an externality imposed by the N-1 students. This may explain why students prefer small classes to large auditorium classes. As N becomes larger, there is an increased uncertainty of any particular student's rank, as there is limited feedback between student and professor. The model is further illustrated in Figure II-9.

Assume that all three individuals (1,2,3) have the same initial achievement levels (x_0) and expend the same effort (e_j). Individual three has a higher aptitude (b_3) than two (b_2) and two a higher aptitutde than one (b_1). Thus, the post-achievement ranks are $x_3 > x_2 > x_1$. Similarly, their grades, $g_i = f(x_i)$, would be $g_3 > g_2 > g_1$. Now assume individual one devotes a higher level of effort (e_i) while individuals two and three remain at (e_j). The rank order now becomes $x_4 > x_3 > x_2$ and $g_1 > g_3 > g_2$. Individual one has imposed a negative externality on individuals two and three by his increased effort. It is, of course,

FIGURE II-9



only an externality if grades enter students' utility functions or affect the survival probabilities. Similarly, individuals two and three may react to one's effort, inceasing their effort and imposing a reciprocal externality on individual one. The grading system is often criticized as too competitive. The externalities generated by a grading distribution may explain why students dislike grades.

These externalities generate competitive effort levels that may be higher than the level of effort chosen in the absence of grades (competition). If the class is small enough to permit collusion, some students could bribe other students to be low achievers (for example, x_1) resulting in relatively higher grades for some with less effort.

We now return to the constrained maximization problem of the student:

$$U_i = U_i\ (x_1,\ x_2) + \lambda(T_i - b_i^1 x_1 - b_i^2 x_2)$$

and introduce grades where $g = f(x_1 + x_2)$. The grade point average for student i is some function of his choice of x_1 and x_2, his effort, and choices and abilities of other students. The minimum grade point average for survival in school imposes a real constraint on some students. For mathematical convenience assume that grades are a continuous set of whole numbers (1 through 100). Assume that the mean grade in a classroom delineates those who pass and thsoe who fail (that is, the minimum grade point average for survival). Further assume that individual scores (x_i) above the class mean ($\bar{x}$) (that is, $x_i - \bar{x} > 0$; 70-60 = 10) can be used to offset scores below the mean (that is, $\bar{x}_i - \bar{x} < 0$; 50-60 = -10). An "A" (for example, 4 quality points) in history is weighted the same as an "A" in phsyics. Similarly, a "B" in history (3 quality points) can offset a "D" in physics (1 quality point) to maintain a minimum "C" requirement (3 + 1 = 4/2 = 2).

Referring to the ranking equation, consider two courses x_1 and x_2 and aptitudes b^1 and b^2, respectively. The cumulative rank of the ith individual is determined by adding his rank in x_1:

$$r_i^1 = b_i^1 e_i - \sum_{j \in J} \frac{b_j^1 e_j}{N-1}$$

and his ranking in x_2:

$$r_i^2 = b_i^2 e_i - \sum_{j \in J} \frac{b_j^2 e_j}{N-1}$$

In order to survive in school student i must satisfy the following constraint:

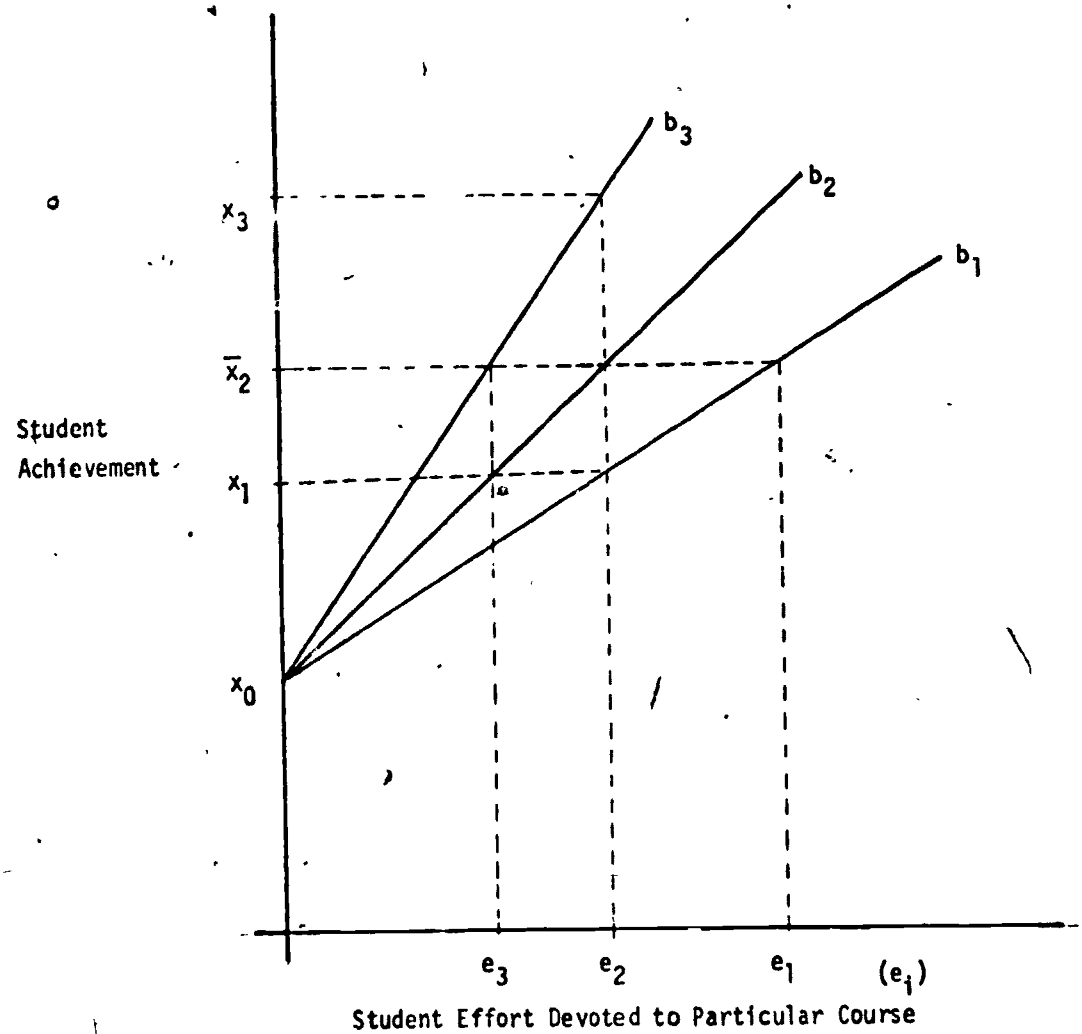
$$r_i^1 \gtrless 0 \ ; \ r_i^2 \gtrless 0 \ ; \text{ but } r_i^1 + r_i^2 \geq 0 \text{ or } \sum_i^n r_i^i \geq 0$$

where the superscript indexes courses and the subscript is individual i. Note that the student is able to choose courses for which he has a comparative disadvantage ($r_i < 0$) but must compensate by choosing other courses for which he has a comparative advantage ($r_i > 0$). We shall further consider the implications of grading in terms of curricular choice and students switching. However, we now turn to criterion reference testing, developed out of the behaviorist school of psychology, which has commanded a great deal of attention.

In the normative reference testing model we considered achievement ($\dot{x}$) as a variable determined by $x_i = b_i e_i$. If aptitude levels (b_i) are different among individual students, assuming all students devote the same time ($\bar{e}_i$) to scholastic activities, then there will be various student achievement levels (x_i). This variance is translated into a grade by ordinally ranking x_i. Criterion reference testing does not permit a variance in x_i. The criterion states that all students must master the course objectives. Assuming a variance of aptitude levels (b_i), and a fixed quantity of $\bar{x}_i$ for all individuals (criterion reference testing), time expenditures must vary ($e_i = \frac{\bar{x}_i}{b_i}$). Examples of criterion reference testing are probably typically more common in the private sector (for example, secretarial schools require X number of words per minute). Note that criterion reference testing allows students to quantity adjust and thus avoids the public good aspects of lecture discussed previously. This is illustrated in Figure II-10.

Note that once the objectives (criterion) are defined as $\bar{x}_2$, variances in

FIGURE II-10



aptitudes (b_1, b_2, b_3)fall out in terms of variances in time expenditures for individual students (e_1, e_2, e_3). If time expenditures were held constant ($\bar{e}_2$) for all individuals, the variance would fall out in terms of achievement levels (x_1, x_2, x_3). Much of the discussion over "normative" versus "criterion" reference testing implies that the former is the superior method. Either alternative imposes a cost on the low aptitude student, either in terms of a grade (r_i defined over x_i) or of a time expenditure. Moreover, in terms of student time allocation, the criterion reference testing and normative reference testing will probably lead to similar curricular choices. That is, at the margin, it is unlikely that a student will choose or remain in a curriculum if he receives lower grades or expendes a greater amount of effort, relative to other students.

Now let us consider the effects of higher education subsidies on curricular choice. While, in general, curricular choices may be similar at the margin under either normative or criterion reference testing, students who do choose an area of comparative disadvantage are able to survive under criterion reference testing where they may not under normative reference testing.[12] Under criterion reference testing a student who intensely prefers a curriculum for which he has a comparative disadvantage is able to survive if he is willing to pay the price (time). If students are not channeled into their areas of comparative advantage (as we shall later argue they are under a grading scheme), then the costs of higher education will increase, for any given level of achievement. This argument is, of course, based on the principle of gains from specialization in areas of comparative advantage.

While students pay a high price in terms of foregone learning or income by choosing an area of comparative disadvantage, they do not pay the full resource costs (subsidized tuition) of their choice. Such direct resource costs as faculty salaries and buildings (which are subsidized) are positively related to the amount of student time expended (that is, direct cost = f (E_i). Permitting students to major in their areas of comparative disadvantage increases the direct resources involved and raises taxes above the level required for the same level of knowledge achievement but with students channeled into areas of comparative advantage. Again, since the student does not pay the full resource cost, he faces a relatively lower price of choosing an area of comparative disadvantage.[13]

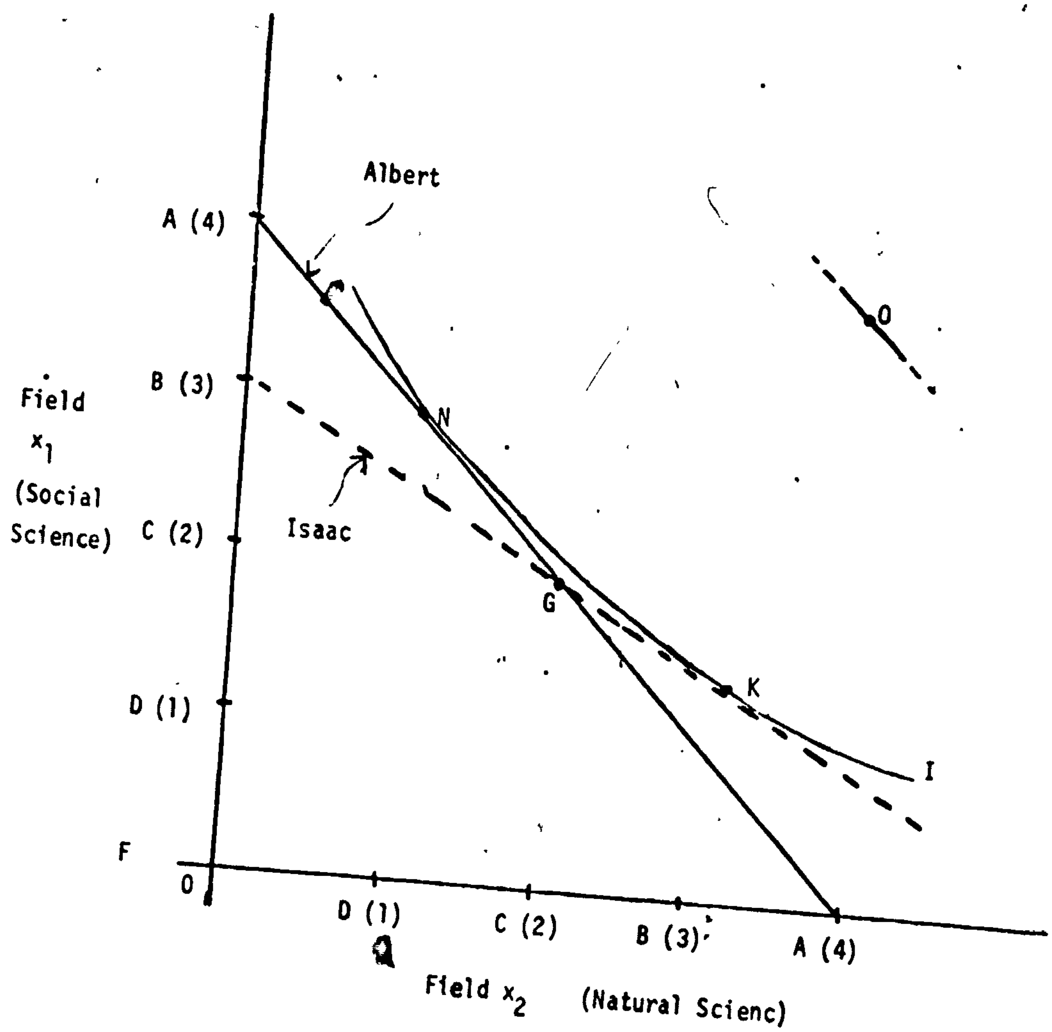
A student allocation mechanism that channels students into areas of comparative advantage may be preferred by taxpayers, since their expected costs are lowered. Note that we do not imply the overall attrition rates are higher or lower under either scheme, but rather the student's choice calculus is altered, since the constraints are different. Normative reference testing denies equal opportunity to any student to choose physics as a major (increases flunk out probabilities), whereas criterion reference testing provides equal opportunity to any student willing to pay the price (e_i).[14]

Curricular Choice

We now consider the effects of grades (normative reference testing) on a student's curriculum choice. We again assume a two-course/two-student model which can be generalized. The discussion thus far concludes a student will tend to major in the areas of his comparative advantage. This is illustrated in Figure II-11.

Assume the students are aware of the expected rankings or expected grades in fields x_1 (social science) and x_2 (natural science). Further assume that both students have identical preferences defined over x_1 and x_2. Assume both students are required to take an eight semester hour course in each field, x_1 and x_2, constituting a full load. Albert's feasible set is bounded by the solid line in Figure II-11. We assume Albert has moderate aptitudes such that if he allocated all his time to field x_1, he would earn an "A" in x_1 and an "F" in x_2. Similarly, if he were to allocate all his time to x_2, he would earn an "A" in x_2 and an "F" in x_1. If he were to allocate his time equally between teh two, he would earn a "C" in each course. The solid line, therefore, represents an overall "C" average, regardless of Albert's time allocation.[15] The

FIGURE II-11



particular time allocation ratio of x_1 and x_2 depends on Albert's preferences for x_1 and x_2. Given the preferences illustrated, he chooses point N, devoting more time to x_1 (earning a "B") than to x_2 (earning a "D").[16]

Now let us consider another student, Isaac, who has unequal relative aptitudes, but identical preferences for x_1 and x_2. The boundary of Isaac's feasible set is illustrated by the dotted line in Figure II-11. Note that point G is the intersection of the solid and dotted lines. This point, and the associated time allocation, represents a "C" average. If Isaac were to allocate proportionately more time to x_1 (less to x_2) relative to the allocation at point G, he would fall below a "C" average (allocations on the boundary left of G). On the other hand, if Isaac allocates proportionately more time to x_2 (less to x_1) relative to point G (all points on the boundary to the right of G), he would raise his overall average above a "C". Given Isaac's preferences, which are identical to Albert's, he will choose to allocate more of his time to x_2 as illustrated by point K. Isaac will not choose a time allocation identical to Albert's (point N) because he would be at a lower level of satisfaction. In addition, point N is not feasible in the long run if Isaac is to survive in school (beyond his attainable set).

We now drop the assumption that students are required to take an equal number of courses in fields x_1 and x_2. The above analysis implies that Isaac, given a choice of course bundles (degree programs) comprised of x_1 and x_2, will choose proportionately more x_2 courses than x_1. That is, <u>ceteris paribus</u>, students tend to choose fields for which they have a comparative advantage. For some students (those of moderate aptitudes), the grade constraint channels students into their areas of comparative advantage. The grade constraint partitions the field of choice (bundles of courses) we considered in the student-sovereignty model into feasible (the student can maintain a grade point average of "C" or better) and non-feasible (the student maintains a below-"C" average) regions.[17]

Now consider a student with high aptitudes in <u>both</u> x_1 and x_2. This type of student is represented by point 0 in Figure II-11. A high aptitude student has a larger feasible set from which to select a degree program, since the grade constraint is not binding. If grades enter the student's utility function, then our analysis applies to a range of students from moderate to high aptitude in all areas. If a student were to maximize his grade point average, it follows he would choose that curriculum for which his comparative advantage was greatest.

Consider the student's cumulative grade point average as a form of human capital. The institutional's minimum grade point average requirement is a prerequisite for student survival. However, an average above the minimum requirement is, in a sense, capital stock upon which the student can draw in the future for consumption activities (that is, leisure) and still survive. Alternatively, this stock can be invested in other ways that may not be productive in a "grade" sense. For example, a student can devote effort to areas of comparative disadvantage if he has "stock" to draw on. Thus, the learning process under a grading system is similar to the optimal path of investment [7]. Instead of examing the life cycle of earning we could examine the four-year cycle of grades and its implications in terms of time allocation. Even if above-average grades have no payoff in terms of future income, the student may still find it rational to maintain a surplus of grades, permitting him increased flexibility of future leisure and scholastic activity (investment) choices. The similarities between student decisions within institutions and decisions external to institutions, with respect to an optimal path of investment, define a possible area of research, which is beyond the scope of this book. There are, of course, many dissimilarities--the internal university environment differs from the environment external to a unversity, although there is an obvious interrelationship.

The Choice to Switch Curricula

An average of four out of ten students change broadly defined curricular groups (natural science, social science, education etc.) at least once during their undergraduate careers [3, 22].[18] This phenomenon is little understood. Educational psychologists invest substantial resources attempting to gather information about students' attitudes, preferences, and opinions, presumably intending to help students make better choices.

We believe constraints facing students in part explain curricular switching. Our curricular choice model assumes that the student is able to translate his field of choice, defined over course bundles, into a field of choice defined over grades. That is, he is able to determine his class rank. Our ranking equation suggests that this is a difficult task. The student needs to know the aptitude levels and effort levels of all students in the class. In high school such information may be obtainable, since curricular choice is limited and students are more familiar with classmates. In college, however, expansion of choice fields and lack of knowledge about the abilities of students from various backgrounds make the ranking determination considerably more difficult.

Consider our diagram of curricular choice (Figure II-11). Now assume that the individual student's estimated rank, represented by the solid line, differs from his acutal rank, represented by the dotted line. His choice of a bundle, illustrated by N (concentration of x_1) will lead to grades below the institution's minimum requirement. That is, the student, not recognizing his comparative disadvantage in x_1 (or advantage in x_2) will base his choice on preferences and <u>perceived</u> attainable set. Eventually, however, the information he obtains from the grading system will force him to switch to the curriculum in which he has the comparative advantage. Note that a well-endowed student (someone at point O of Figure II-11) will not find the grade constraint binding and so has no incentive to switch from his initial choice.

We predict, based on the above analysis, that the probability of a given student switching curricula is negatively related to the level of his aptitudes. Freiden and Staaf [30] have tested this hypothesis using a limited set of data at one university. Their results, obtained from the SAT verbal (V) and quantitative (Q) scores as an aptitude measure and from a linear logit estimation technique ($P_{ij} = a + V_i + Q_j$), are consistent with our model of switching. Using the high aptitude student as a reference point, there is a higher probability of switching (P_{ij}) if the student has: (1) low verbal and quantitative aptitudes, (2) a low quantitative but high verbal aptitude, (3) a low verbal but high quantitative aptitude. These results are also consistent with the hypothesized positive grade/aptitude relationship and support the premise that the grading system channels students into areas of comparative advantage.[19]

We have assumed that performance standards are identical among curricula. That is, the grade distributions are similar across curricular groups. This assumption would lead us to predict that the curricular distribution of a cohort of freshman and senior students would be identical and that the gains and losses of curricular groups would be symmetrical. However, several studies [3, 22, 62] indicate that the gains and losses are markedly asymmetrical. Such curricular groups as engineering, biological sciences, and physical sciences tend to be net losers (more students desert than are drawn in), while education, business, and the social sciences tend to be net gainers.

Data collected at the University of Delaware suggest a reason for the asymmetrical redistribution of students [48]. Eleven curricular groups were ranked according to average scores on two external examinations given during students' sophomore and senior years: the College Level Examination Program (CLEP) and the Graduate Record Examination (GRE). The subject matter areas on both examinations were natural science, social science, and humanities. The results show that physical science students, for example, scored above education students in all three areas. Also, the rank correlation coefficient between external test scores (that is, CLEP and GRE) and cumulative four-year GPA is .46.[20] In addition, the correlation between external test scores and the last two-year GPA is -.39 (significantly different from zero at a 99 percent level of confidence). Finally, grade averages for physical science, biological science, engineering, and humanities are lower in the rank order for the last two years, while the positions of home economics, elementary education, and physical education are higher. All of this evidence points toward significant differences in performance criteria across curricula. This evidence may also explain why students with low aptitudes in all areas may have a high probability of switching. Survival may necessitate that these students switch to a curriculum with lower performance standards (that is, distribution of grades skewed heavily towards "A's" and "B's").

While preferences no doubt play a significant role in explaining curricular choice, the above analysis suggests that considerable explanatory power at the margin is achieved by focusing on the constraint side of curricular choice.

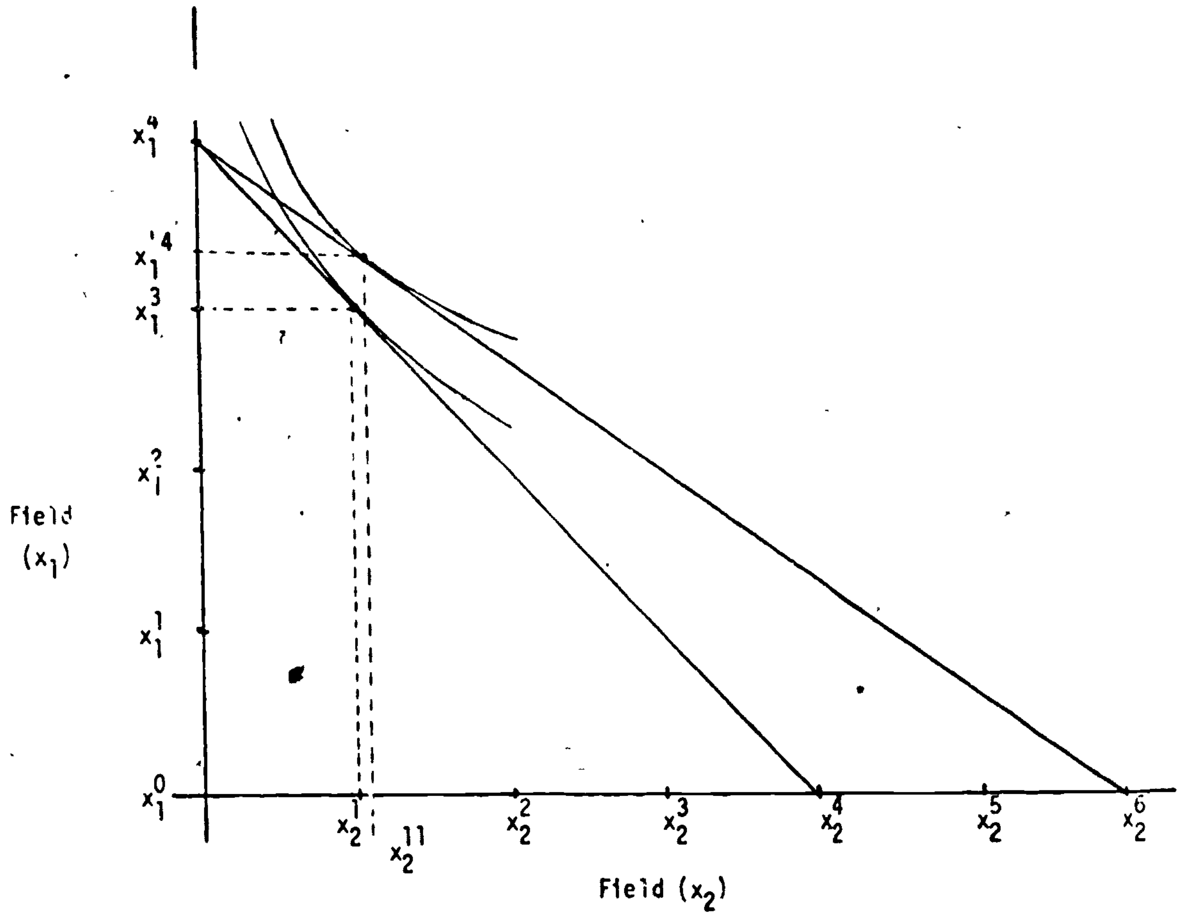
Changes in the Learning Technology of Required Courses

Considerable controversy and confusion exist in educational journals concerning the effectiveness of such input variables as different teaching methods, textbooks, and class size on student performance in introductory courses. In summary, the evidence suggests that these variables have an insignificant effect on student performance, or the available evidence is not conclusive. Possibly as a result of these inconclusive data and financial constraints, departments in many universities are adopting a policy of increased student/teacher ratios (large auditorium lectures) for "required introductory" courses.

In this section we are able to apply the basic model which has been developed in preceding sections.[21] This approach lends insight into the problems of measuring the impacts of a change in the input variable on the learning process. It is interesting to note before we continue that most of the changes or innovations have occurred in introductory courses which for many students are "distributive courses" (required courses for most, if not all, students). Our analysis suggests that for many students these course requirements may be "inferior goods," thereby leading to unexpected student behavior which results from a change in the input variables.

To illustrate, assume that the student, Albert, is able to allocate his effort between fields x_1 (e.g., social science) and x_2 (e.g., natural science). The model illustrated in Figure II-12 is similar to that in Figure II-11. Given the student's indifference map, the student will choose to achieve x_1^3 in field x_1 and x_2^1 in field x_2. Assume that changes in classroom techniques are effective in extending the boundary of the attainable set. That is, changes in teaching techniques, textbooks, and class size in field x_2, given a student's aptitude, really do make a difference. In this case the student's boundary of the attainable set will pivot on x_1^4 and move to x_2^6.

FIGURE II-12



Assume x_2 represents required "distributive" courses and x_1 "major" courses. Techniques that are technologically effective are defined as increasing a student's "apparent" aptitude in the technologically affected area or course. That is, technology in x_2 changes the student's ability rate of substitution. These techniques are assumed to be external to the student and do not require increased student effort for any given achievement level. In fact, technology is defined here as permitting a lower level of student effort for any given achievement level. Albert is now able to achieve x_2^6 if he devotes all his time to x_2. If performance standards (correspondence between achievement and grades) do not change, the effect of introducing learning technology in area x_2 is to lower the relative price of x_2. Indeed, the intent of introducing these techniques in required courses may be to induce a substitution effect towards x_2, thereby tempting students to specialize (major) in x_2.

However, an income effect is also associated with the relative price change in x_2. The introduction of new techniques allows the student to allocate more time to x_1, thereby increasing his grade in x_1, without affecting his achievement level or grade in x_2 prior to innovation. Given the indifference map illustrated in Figure II-12, the substitution effect is almost completely offset by the income effect. That is, x_2 courses are "inferior goods." The net increase in achievement resulting from the change in technology of field x_2 is $x_2' - x_2''$ which may not be statistically significant.[22] However, the technological change allows the student to allocate more time to his major field, x_1, thereby enabling him to increase his achievement $(x_1'^4 - x_1^3)$ and grades without significantly affecting what would have been his achievement level (x_2) and grades in the distributive courses (x_2). The assumption that required courses may be inferior goods for some students does not seem to be totally unrealistic. Therefore, studies that concentrate on changes in achievement levels in the technologically affected courses while ignoring effects in other courses may not find statistical differences if the courses are inferior goods.

Studies on pass/fail tend to support tradeoffs in a student's time allocation pattern over his course load. Note that pass/fail is not assumed to increase the student's attainable set in terms of achievement. This evidence only suggests that students do make tradeoffs when given the opportunity to do so at lower costs. A study at Dartmouth College by Feldmesser [28] revealed that the most distinctive characteristic of the option was that it was a way of reducing the burden of distributive requirements.[23] Users of the option tended to receive a full letter grade lower than nonusers in the option course, regardless of a student's cumulative GPA. Further evidence suggests that of two students of similar abilities taking a course in their major field, the one using the option in another course would average about half a grade higher than the one not using the option. The lower achievement effects of the pass/fail option in the course in which the option was being used seemed to spill over into other courses to increase a student's overall grade point average [28].

While high grade point average students more or less made up what was lost in the option course in a major course, no such compensation occurred among low grade point average students. The time released for low G students seems to have been expended in other activies [28, p. 133]. This suggests a backward-bending supply curve for low GPA students.

The analysis suggests that the role of distributive course requirements merits a study in itself. Statistical studies that focus only on one course in a student's bundle of courses are likely to overlook the spillover impacts of a technological change in teaching techniques. It is not at all clear that these teaching techniques are efficient in increasing a student's attainable set but they may simply be attempts to change student preferences.

The above-mentioned evidence suggests that a change in the relative prices brought about by the introduction of a pass/fail system affects student preferences and that distributive course requirements are inferior goods.[24]

Conclusion

The models presented in this chapter provide a new framework for the development of future empirical studies in education. Statistical models that consider only a single course are based on partial analysis and, in essence, deny the existence of student choice. Robert Dubin and Thomas Taveggia [25], after evaluating the results of ninety-one conventional studies in education, have concluded that unless future empirical studies are built on new models of teaching and learning, they will be a waste of time. Needless to say, we agree with the authors.

The models presented in Chapter II are similar to the stimulus-response framework of psychologists. However, student choice, by itself, is limited in terms of a learning theory. Stimuli and reinforcement do not fall from heaven. The choice of stimuli and reinforcement mechanisms that induce student response (behavior) are subject to anlaysis. We now turn to an examination of faculty choice. The models used are similar to those developed in this chapter.

CHAPTER III: FACULTY CHOICE

Several views dominate discussions and investigations of faculty behavior. Conventional education literature assumes that environmental factors determine the professor's behavior. These factors include socio-economic status, genetic make-up, and the physical features of his immediate surroundings (capital equipment, audio-visual machines, etc.). This view, represented by studies of per student costs as determinants of achievement, is mechanistic. Specific stimuli induce predetermined faculty responses. In essence, the professor does not have a preference independent of the environment or incentive system.

A second view, a kind of "knowledge for the sake of knowledge" argument, is that the professor, out of duty to a professional ethos, attempts to impart knowledge to students. It is as if the professor is a bifurcated man. He is self-interested in his private pursuits, but once the "academic cloak" is donned, his self interests are repressed in favor of social interests--the pursuit of knowledge and search for truth.

Finally, many of the discussions about faculty behavior tend to be normative; they prescribe how faculty members (and students) <u>should</u> behave. For example, Ramsett, Johnson, and Adams concluded, after an analysis of several variables which affect student performance, that "College teachers should stress being more effective teachers, with purposeful attempts to influence student attitude" [51, p. 16]. Mandelstamm, Petr, and Segebarth suggested in their examination of the problems of introductory economics courses that a major obstacle to student achievement in economics was that "We don't regard ourselves as teachers and we should not be surprised when our classrooms contain no learners" [41, p. 45]. Their solution for "improving" the introductory course is that teachers "must provide an atmosphere or environment of honest intellectual excitement, quest and curiousity and be a good learner, exude the excitement of learning, and be seen to value the quest--not merely the 'right answer'" [41, p. 46]. These types of pronouncements, which are all too easy to formulate, are made almost without exception with little or no analytical understanding of the reasons for teacher behavior; without some firm understanding of these reasons there is little wonder why the suggestions have virtually no impact on the performance of the typical professor in the typical classroom.

The deficiency of past investigations is not so much what has been considered as what has been overlooked. Little or no attention has been paid to the choice calculus of the teacher (or student) or to the broader institutional setting in which learning occurs.[1] Without some understanding of the choice behavior of those involved in education, there is little wonder that educators find it difficult to specify what constitutes a significant improvement in the learning process.

Desiring to introduce a faculty choice calculus into discussions of the learning process, we develop hypotheses concerning the determinants of professors' work efforts and the efficiency of the learning process. It is hoped that the analysis will provide a framework in which the educational process can be better understood and will suggest fruitful avenues of future inquiry. Our approach and conclusions differ from other work in one important respect: in rationalizing the rather low R^2's found in conventional education studies (for example [68]), researchers and others are prone to suggest that not all environmental factors have been included in the regression equation. Our approach recongizes that the behavioral response of faculty in part determine the amount students learn. By concentrating on faculty preferences, we fully recognize that preferences must be revealed within the constraints of time, teacher skills, environmental factors, and student ability.

The Institutional Setting

The present-day university has several notable features:

1. It is a bureaucracy.
2. Academic freedom is granted to faculty. Academic freedom, as we define it, gives the faculty member the right to determine what to teach and to rank students according to his preferences.
3. Because of academic freedom it is difficult to determine faculty teaching performance and consequently to devise incentive systems.

We shall examine each of these factors in detail.

The University as a Bureaucracy

Because the typical university is funded by state appropriations, government grants, endowments, charitable contributions, and student fees, the university can be appropriately termed a "mixed-bureau."[2] Recognizing the university is a bureau, we can draw several inferences. First, the university sells its product at a zero or below-market price to the consumer/student. This implies students are subject to such tie-in sales as course requirements, residence requriements, and other restrictions on student choice. This also implies, as Buchanan and Develetoglou have argued, that a "sizable proportion of university students, under any low-tuition scheme, may be placing less value on resources devoted to higher education than they would place on other uses of these resources" [16, p. 29].

If the below-market prices charged students create a shortage of openings, we should expect an alternative rationing mechanism--admission standards and survival standards (grades). Following Niskanen [47] and Williamson [78], we should expect bureau employees to establish a rationing mechanism that maximizes utility subject to the constraint of the sponsors (for example, legislators and donrs). As we shall examine later, the property right of academic freedom makes the output of the bureau difficult to measure and therefore difficult to control or monitor. Thus, the faculty has considerable latitude of activity choices. The professor's right to express his preferences as to the type of education provided, increases his non-pecuniary income. It is, therefore, understandable that professors are generally interested in having support (for example, from the state legislature) increased. It is also understandable that faculty accept and support, consciously or unconsciously, arguments that education is a means of effectively redistributing income and promoting the <u>public interest</u>. Further, the faculty may reject out of hand the suggestion, promulgated in this chapter, that any public interest achieved through education is largely fortuitous. Armen Alchian made the point suggested here in sharper language:

> Intentionally or not, with foresight or not, we keep the fees low in order to accommodate less wealty, more needy but deserving students. Low fees enable us (the faculty) to select students according to a non-money criterion. I select the better learners and smarter people who obviously "deserve" a higher education. How easy to swallow that self-serving contention!
>
> The same reasoning could be applied elsewhere. Concerts should be free and financed by the state, so that musicians can select the audience, admitting those who have the keenest ear and are best at making music themselves. Less discerning people can do other things. After all, there is no sense in wasting music on those less able to appreciate it. . . .
>
> Couturiers have long advocated that the state finance dressmaking, with zero prices for clothing, so that they too can select their clients with the gracious social beneficial care that we teachers employ. But not until the designers get tax-supported endowment subsidy, or non-profit dress design and manufacturing institutions, will they be able to serve society as well as we teachers do [1].

Other than to suggest the university promotes the "public interest" or "general welfare," attempts to expand the "frontier of knowledge" or educate the "whole man", the objectives of the university are not very well spelled out. Consequently, the university's performance is not amenable to objective evaluation by the public or the sponsoring agent. Therefore, it would be strange indeed to assume initially that the university was organized for any purpose other than to maximize the goals of the bureaucrates (faculty and administrators) subject to certain constraints internal to the university. This is not to suggest that legislatures and other interested groups cannot influence the behavior of the institution, especially through the "purse strings," but only that considerable explanatory power may be derived from a model built on the assumption that faculty preferences count, regardless of whether or not they conform to what others believe is the public interest.

The Professor and Academic Freedom

Professors are granted "academic freedom" in their contract packages. Although often considered a shield to protect scholars from whimsical and politically motivated attacks on unpopular ideas of faculty members, we prefer to view academic freedom as a property right. This right gives the professor freedom, within extremely broad boundaries, to teach what he wishes, to weigh the importance of any bit of knowledge as he wishes, and to distribute or rank students according to his preferences. In other words, it permits the individual professor's preferences to count in influencing and evaluating what the student learns.

In Chapter II we defined that student's field of choice over various fields of knowledge. We are now in a position to define knowledge more specifically.[3]

The student's field of choice is defined over individual professors' preferences of what constitutes knowledge. A different set of professors represents a different field of choice. For example, assume three "bits" of knowledge. A, B, and C. Assume student one, because of his abilities and effort, achieves all three; student two achieves A and B. Student one would be ranked above two. However, assume student abilities are such that only two "bits" can be achieved in the time allotted. Suppose student one achieves A and B and student two achives B and C. Their ranking depends on the professor's preference ordering of A, B, and C. If his ordering is such that A P B and B P C, then student one will receive the higher ranking. Now consider another professor whose preferences do not include A because it either has little importance or it is incorrect. He prefers the ordering B, C, D. In this case, student one would receive the lower ranking and student two the higher ranking.

It is possible to define a number of combinations and permutations of preference orderings. The point we wish to make is that the individual professor's preferences count in determining what constitutes knowledge.
As pointed out in Chapter II, the ranking an individual student is assigned influences his choice of curricula and survival probabilties. We do not wish to imply any normative implications of academic freedom, but rather to examine the positive implications of its existence. We are, therefore, bypassing the educational psychologist's problem of educational measurement. Economics is what economists teach. Sociology is what sociologists teach. Professors teach according to their preferences under academic freedom.[4]

The consequence of academic freedom is that a student's grade reflects the degree to which the student's achievement coincides with the professor's achievement preference. It does not necessarily reflect the student's achievement in any absolute sense. It does not necessarily reflect "truth." Therefore, it is rational that a student expend resources attempting to decipher faculty preferences. Expending resources in this endeavor may be more rewarding in terms of the grade than expending the resources to study the textbook. Although many faculty may believe, and correctly, that attending class is important to students because they can learn the course material more efficiently, a more important reason, from the student's viewpoint, may be that attending class provides the best opportunity to decipher faculty preferences. If testing and grading is removed from the professor and performed externally (by outside examiners or standardized tests) one would anticipate that class attendance would decrease.

Now consider the diminution of academic freedom. The faculty may be required, for example, to use standardized exams. Although one may think that testing and grading on some "objective" basis would improve student achievement, the change would not be an unmixed blessing. Student performance, in terms of the testing instruments, may rise. However, one unmeasured benefit of university education may be that students are forced to cope with a variety of faculty preference functions as revealed in different teaching methods and weighting of different bits of knowledge. Like rats learning a maze, the learning which results from the "struggle" may be more important than the specific information acquired in the courses. Indeed, the "sheepskin effect" of university education may be explained, in part, by this struggle to survive the "preference jungle" of higher education.

More importantly, if standardized tests are adopted by the university, the bits of knowledge examined on the test instrument, the types of questions employed, and the relative weights assigned to the different components of the test must be determined by <u>someone</u> or <u>some group</u>--we cannot expect this information to fall as "manna from heaven." Standardized tests are usually compiled by a group. Herein lie a number of collective choice problems. Faculty within a department or discipline do not agree on teaching methodologies, concept definition, and (perhaps most fundamental) relative importance of various concepts and material. The diversity of preferences is reflected in almost any department meeting or seminar. Two faculty members may agree on a concept's meaning, but vehemently disagree on the importance of that concept; one may argue (vote) for its inclusion on an exam, the other against.

Consider a unanimity rule to decide the type, number, and weight of questions on a standardized exam. A rule of unanimity is likely to produce an exam of trivia questions or no exam at all, especially in the absence of log-rolling. All controversial questions, concepts, and knowledge on new frontiers would be eliminated. The exam would consists of a core of knowledge, or tautologies, that commanded group consensus. This core is likely to be small in terms of either the discipline's activities and knowledge or the substance of present courses, allowing individual preferences to count.

If a standardized test is based on majority rule, the test would reflect the preference of the discipline's <u>median</u> member, ignoring faculty preferences on both ends of the distribution. Competition with the existing core of knowledge is likely to be stifled considerably. Other collective decision rules would be necessary to modify the exam in the future. We argue that competing hypotheses, concepts, facts are likely to increase the learning skills of students; resolution of competitive hypotheses cannot be achieved by majority rule but only through deductive reasoning (logic) indcutive reasoning, and empirical testing.

The point we wish to stress is that a standardized exam is not necessarily more objective that the individual faculty member's exam. The former merely reflects the preferences of a collective (that is, the median professor) rather than of an individual. There is a strong analogy here with the social welfare function in economics. If one assumes a social welfare function, then the individual's preferences are assumed away. Similarly, if one assumes that standardized exams are objective (represent "truth"), then the individual's role in a collective choice process of determing an exam's composition is assumed away. Collective decisions on consumer products could also determine a "standard" product, eliminating variations in quality or characteristics of products. This procedure would likely hamper competition and technological improvements of consumer products. New products could not be marketed without some "standard's" group, the sole determiner of what is good for others.

Academic freedom, as we have defined it, is the right of faculty members to determine what subject matter is presented and how students are ranked. How does one evaluate teachers and devise an incentive system promoting good teaching if the individual faculty member defines the performance criteria? The "publish or perish" incentive reflects the fact that we have no external criteria to determine good teaching. No one would advocate explicitly that faculty be paid on the number of "A's" and "B's" they give out.[5] Consider standardized exams as an alternative. It is operationally feasible to develop standardized exams in a discipline from the first introductory course through the final Ph.D. exam. One could evaluate professors and determine salaries using student scores on these exams. Salary benefits could provide faculty an incentive to maximize these scores. On the other hand, when individual faculty members devise their own exams according to their preferences, there is little monetary incentive, beyond a threshold, to allocate considerable time to good teaching.[6]

A paradox exists in the sense that an incentive system inducing good teaching requires some external criteria other than the faculty member's preference. One external criterion, as we have seen, is the standardized exam. On the other hand, standardized exams present a number of collective choice problems which, in the long run, are likely to impede the transmission and growth of knowledge. This paradox arises in part because the student does not normally pay the full resource cost of his education and because faculty salaries are not paid in full by students. Vouchers or full resource cost tuition would provide faculty members incentives to be good teachers, at least as perceived by students. As Adam Smith wrote a century ago:

> In some universities the salary makes but a part, and frequently a small part of the emoluments of the teacher, of which the greater part arises from the honoraries or fees of his pupils. The necessity of application, though always more or less diminished, is not in this case entirely taken away. Reputation in his profession is still of some importance to him, and he still has some dependency upon the affection, gratitude, and favourable report of those who have attended upon his instructions; and these favourable sentiments he is likely to gain in no way so well as by deserving them, that is, by the abilities and diligence with which he discharges every part of his duty.
>
> In other universities the teacher is prohibited from receiving any honorary or fee from his pupils, and his salary constitutes the whole of the revenue which he derives from his office. His interest is, in this case, set as directly in opposition to his duty as it is possible to set it. It is the interest of every man to live as much at his ease as he can; and if his emoluments are to be precisely the same, whether he does, or does not, perform some very laborious duty, it is certainly in his interest, at least as interest is vulgarly understood, either to neglect it altogether, or, if he is subject to some authority which will not suffer him to do this, to do this, to perform it in as careless and slovenly a manner as that authority will permit. If he is naturally active and a lover of labour, it is his interest to employ that activity in any way, from which he can derive some advantage, rather than in the performance of his duty, from which he can derive none [58, pp. 717-718].

We now turn to the model of faculty choice. We assume faculty members, receive a lump sum salary independent of teaching effort or performance.[7] In this chapter we focus only on teaching activities and leisure. Chapter V considers faculty choice among teaching, research, and leisure. Unlike Adam Smith, we assume that professors receive satisfaction from raising student achievement levels, although salaries are not dependent upon these levels. Therefore, we are most charitable in defining the professor's utility function.[8] However, some external observers may feel that the diligence and effort of some professors is not nearly what it should be

The Model

We shall utilize the same model developed in Chapter II for Faculty Choice. The professor's utility function is defined as:

$$U_i = U\ (x_i\ ;\ E_i) \tag{1}$$

where the marginal utility of

$$U_x > 0\ ;\ U_E < 0$$

We assume that x_i is the knowledge level attained in the ith professor's classroom by an individual student, if a tutorial, and the median student, if a classroom. Note that this knowledge is what the professor considers important and is represented by answers to a professor's exams. In addition, we use the lower case "x" to signify it is knowledge in a specific field (class). Professor i considers effort expended in teaching (E_i) to be a normal bad, leisure a normal good.

The general form of the ith professor's production function is:

$$x_i = a_i + B_iE_i \tag{2}$$

The constant, a_i, is assumed to be the student's initial knowledge endowment (prior achievement in x_i) in class i. The constant, B_i, in the student choice model, was assumed to be the student's aptitude. We did not consider faculty influences on student achievement. In this model we assume that B_i is comprised of the following four factors:

1. student aptitudes, in the same manner as Chapter II
2. the technology used in the classroom
3. the professor's ability to teach
4. the amount of effort the faculty member is able to induce from his students.

Factors 2, 3, and 4 are under the control of or attributed to the faculty member. Student aptitudes and prior achievement levels, a_i, are, of course, exogenous. We shall examine each of these factors independently, assuming all other factors constant. Our analysis focuses on faculty choice rather than student choice. As in the student choice model we assume identical preferences of faculty.

The professor faces an overall time constraint, T, which is exahusted by teaching activities (F) and leisure (L_i).

$$L_i = T - E_i \tag{3}$$

We define leisure as all activities other than teaching. "Teaching" is defined as preparing and delivering lectures, grading, advising students, etc. We can now define the professor's constrained utility maximization problem as:

$$U_i = U(x_i, E_i) + \lambda(E_i - B_i xi) \tag{4}$$

The first order condition for utility maxmization is:

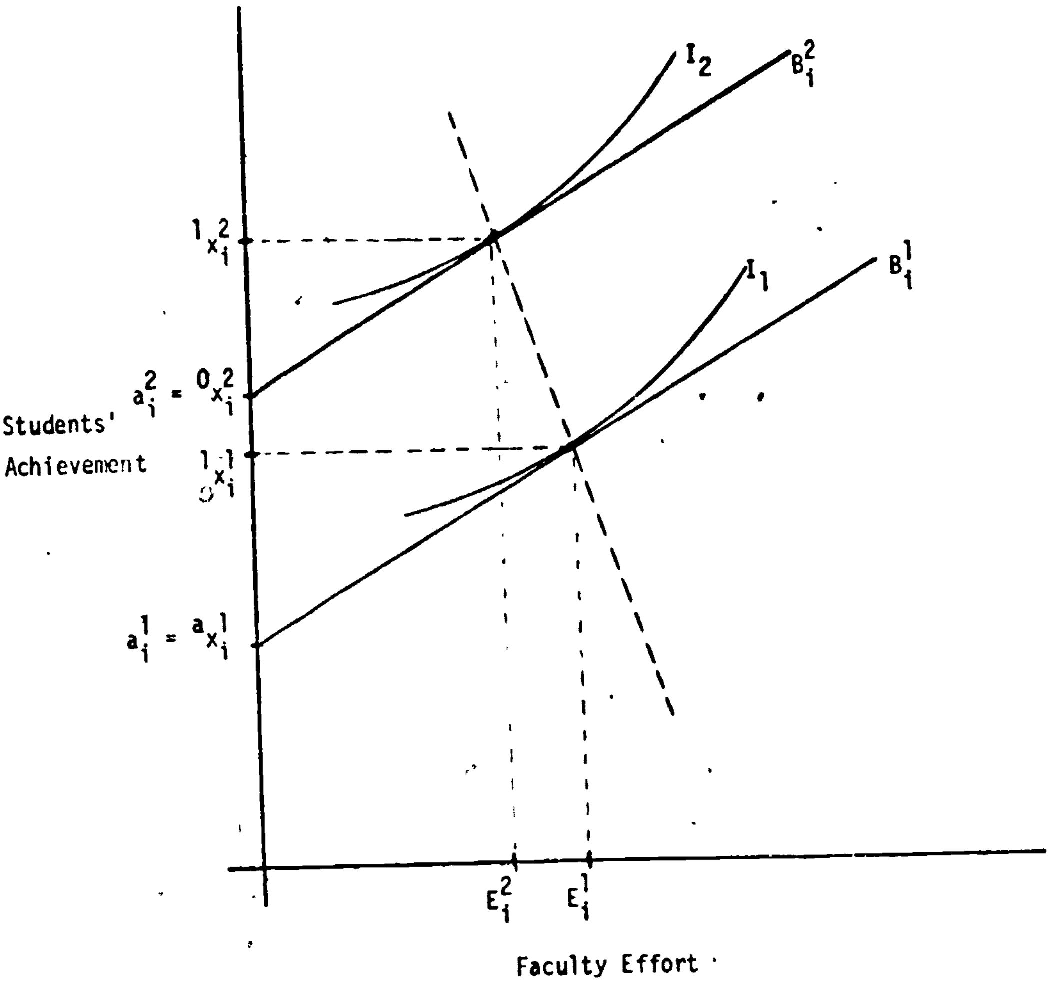
$$\frac{U_E}{U_x} = B_i \tag{5}$$

Condition 5 simply states the professor's <u>willingness</u> to substitute effort (leisure) for achievement is equal to his <u>ability</u> to substitute effort for achievement. Note that his ability depends on factors other than his teaching ability (that is, student's ability). We now examine several cases.

Case I: Differential Student Initial Endowments

We assume a two-student/two-professor model. As pointed out in the discussion of the lecture as a public good, we recognize the difficulties of a distribution of student abilities and preferences within a classroom. For expository reasons we assume that the professor teaches to the median student. This permits us to consider a student in the classroom as representative of the class. Consider two students (classes) with identical preferences and aptitudes but with different prior achievement levels. This case is illustrated in Figure III-1. We could assume either two different professors with identical preferences and abilities or one professor teaching two students (classes). In the first case, the professor with higher initial-achievement student, B^2 expends less effort (E_i^2) and attains a higher level of post achievement ($^1x_i^2$) than the professor assigned lower prior-achievement student B_i^1. The professor assigned the lower prior-achievement student expends more effort, resulting in a larger gain score ($^1x_i^1 - x_i^1$) but a lower post-achievement score ($^1x_i^1$). Alternatively, we can examine the behavior of a single professor with different class assignments. Assigned the lower prior-achievement class he expends E_i^1 effort; post achievement is $^1x_i^1$. Assigned the higher prior-achievement class, he expends less effort (E_i^2) resulting in a lower gain score but a higher post-achievement score ($^1x_i^2$). By varying the prior-achievement levels, all other things being equal, we can trace an effort-achievement curve illustrated by the dotted line. Borrowing from wage theory, we assume a wealth effect--the higher the student's initial-achievement level, the more leisure (less effort) the professor chooses. In addition, a professor, given choice of class assignments, chooses the class with the higher prior-achievement level, since a higher level of satisfaction results.

FIGURE III-1



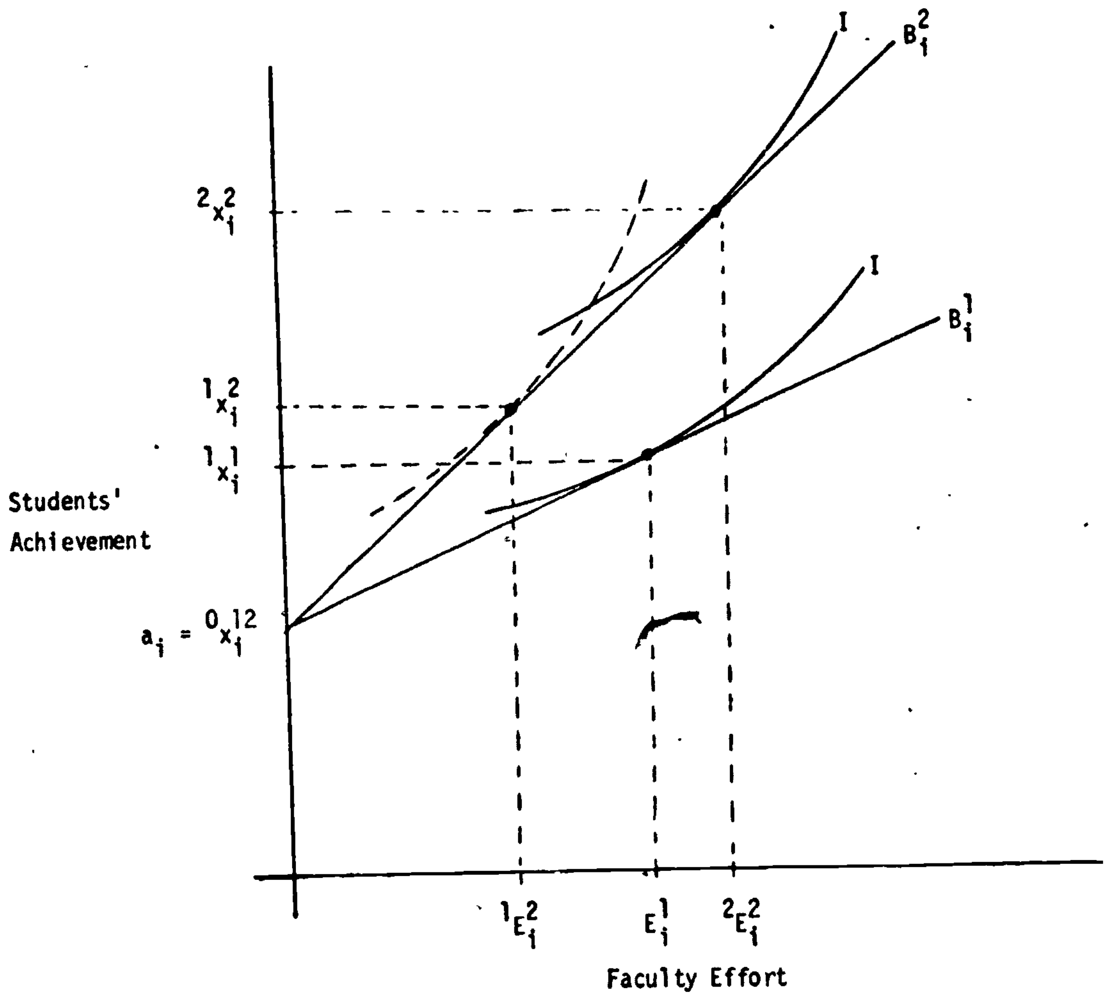
This model is suggestive of the popular beliefs that the only difference between Harvard and Clinch Valley Community College is the higher admission standards at Harvard and that the two schools do not differ significantly in terms of value-added or net gain scores. Astin and Panos [3] present some evidence to support this view. We are suggesting the net gain scores may even be less at schools with high admission standards because of the wealth effect. Further empirical investigation of faculty behavior (effort) is necessary to substantiate this hypothesis.

Case II: Differential Student Aptitudes

Consider two median students (classes) with identical preferences and initial-achievement levels but different aptitudes for a particular course. We now examine the behavior of the professor assigned a class with high aptitudes relative to a class with low aptitudes, illustrated in Figure III-2. The professor, given a choice, will always choose the higher aptitude class (B_i^2) where he can attain a higher level of satisfaction (that is, his attainable set is increased). Furthermore, Figure III-2 illustrates that the higher aptitude class will have a higher post-achievement score as well as a larger gain score, regardless of whether the professor's effort (supply) curve is positive or backward-bending. However, the magnitude of the gain scores is a function of the professor's behavioral response to higher student aptitudes.

Consider first the traditional positive-sloping effort (supply) curve, represented by the solid line indifference curves. In this case, the professor assigned a high aptitude (B_i^2) class exerts additional effort (${}^2E_i^2$ versus E_i^1) because the substitution effect outweighs the income effect. That is, the professor assigned the high aptitude class finds that the price of leisure (in terms of class achievement) has increased or, alternatively, the price of class achievement (in terms of leisure) has decreased. At the same time there is an income effect (increased attainable set) which works towards decreasing effort (increasing leisure). However, the substitution effect towards more effort (achievement) outweighs the income effect. In this case higher student aptitudes and additional professorial effort increase class achievement.

FIGURE III-2



Now consider the case of the backward-bending effort (supply) curve, illustrated by the dotted line indifference curve. The high aptitude class achievement is still higher ($^1x_i^2$) than the low aptitude class ($^1x_i^1$), but lower than it was when the professor's effort curve was positively sloping ($^2x_i^2$). This happens when the income effect outweighs the substitution effect, resulting in less effort expended (more leisure consumed) by the professor. The backward-bending effort (supply) curve has primarily been considered an unusual case. James M. Buchanan [15] has demonstrated that the income effect is not necessary to illustrate a backward-bending supply curve. His point is that in any act of exchange the individual participates as <u>both</u> a demander and a supplier. We could trace out a professor's achievement demand curve in terms of the alternative good (in this case, leisure). If we now develop conceptually an income-compensated demand schedule which exhibits price inelasticity over a portion of the schedule, we observe a backward-bending supply curve (the reciprocal of demand). The professor who expends fewer hours (less effort) when student aptitudes are higher exhibits a demand for student achievement that is price inelastic. It is beyond the scope of this book to fully discuss the backward-bending supply curve. We briefly refer to Buchanan's article to highlight the fact that the backward-bending supply curve need not be a bizarre or unusual case. Whether the typical professor's effort curve is positively sloped or backward-bending is ultimately an empirical question.

Cases I and II deal with differences in students. Differential achievement can be attributed mainly to student abilities with incidental effects due to faculty behavior or skills.[10] If professors have positively sloped effort curves, the differentials in class achievement will be increased relative to a perfectly inelastic or backward-bending effort curve. We now consider a case in which student achievement is a function of professor's ability.

Case III: Differential Faculty Ability

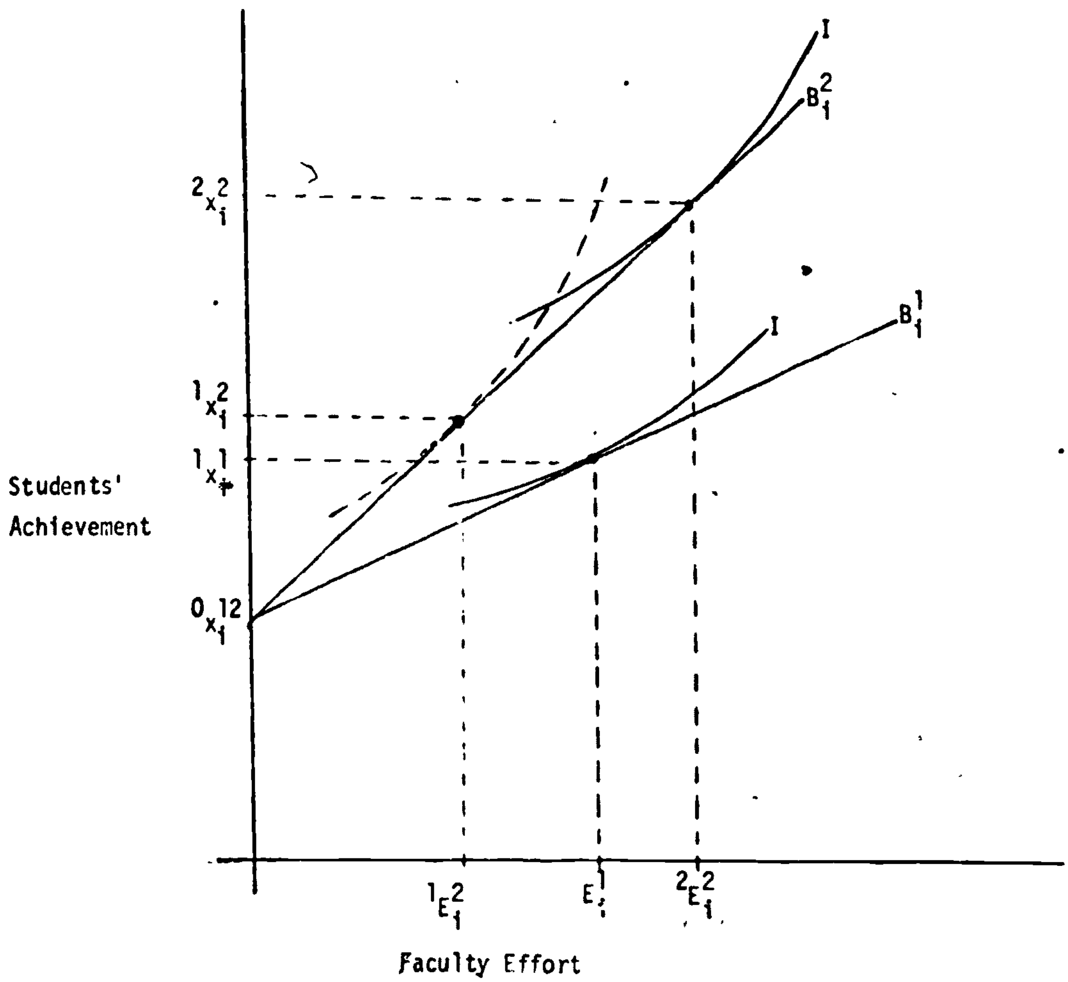
Assume two classes of identical abilities (prior achievement and aptitudes) and preferences (effort levels). Previously we examined the behavior of a single professor confronted with different class assignments, although we could have assumed two professors with identical preferences and abilities. We now examine behavior of two professors with identical preferences but different teaching abilities. The identical preference assumption allows us to look at the same field of choice defined by each individual professor and the same personal rate of substitution of effort and achievement. The only difference between the two classes is the professor's ability to transform effort into student achievement. This is illustrated in Figure III-3, which is similar in construction to Figure III-2 (faculty ability differentials are substituted for student ability differentials).

Like the illustration of student differential aptitudes, the professor with the higher teaching ability (B_i^2) will have higher class post-achievement scores that the lower ability professor, whether effort curves are positively sloped or backward-bending. If sitively sloped, the professor will be a "good" teacher, because his ab.lity to teach is greater and he devotes more effort to teaching (${}^2E_i^2$). If backward-bending, the high-ability teacher may not be as "good" a teacher (${}^1x_i^2$ instead of ${}^2x_i^2$) as he could be if he devoted at least as much effort as the low-ability professor. Alternatively, the low-ability teacher is not as "bad" as he could be; he partially compensates for his lower ability with additional effort. A positive sloping effort curve increases the divergent class post-achievement scores while the backward-bending effort curve decreases the differentials in post achievement. In either case, however, the higher ability professor will have higher post-achievement scores, other things being equal.

Case IV: Differences in Classroom Technology

We discussed the effects of a technological change in the classroom on student choice. In Chapter II we defined an efficient change in technology

FIGURE III-3



as one which increases the ability of the student to transform effort into achievement. We also discussed the effects of an "inferior goods" course--there is little statistical impact of technology on such a course as measured by student test scores, but technology does allow increased effort expenditures in other courses or activities (leisure). In Chapter II we did not inquire into the effects of a change in classroom technology on faculty choice. Note that an improvement in student efficiency due to classroom technology may require a compensating increase in faculty effort. In this case we would argue that the technological innovation is not efficient and is simply a movement along the professor's effort curve.[11]

We define an improvement in efficiency resulting from a change in classroom technology as an improvement which increases the professor's ability to transform his effort into student achievement. We also assume that the change in technology does not require additional effort on the part of students for any given level of achievement prior to the innovation. Thus, we are talking about technological changes that are Pareto efficient from both the student's and professor's standpoints. The students and/or professor can be made "better off" without the other being made "worse off."

Figure III-3 illustrates an efficient change in classroom technology, which has the same effect as increasing the professor's teaching ability. Figure III-3 can represent the behavior of a single professor, illustrating his choice prior to the innovation (B_i^1) and after the innovation (B_i^2). The backward-bending effort curve is relevant here. While the innovation will increase student achievement under either effort supply curve, the potential gains to students are diminished if the professor decides to take some of the gains for himself as increased leisure. This does not mean the students are worse off, because of the innovation, but only that their gains could have been greater if the professor's effort had remained constant or had increased. Moreover, studies which indicate little significant difference in student achievement, regardless of teaching techniques, support the backward-bending effort curve as well as the inferior good argument. If teaching performance is not rewarded in monetary terms, technological innovations may reward professors in terms of increased leisure.

Summary

We have examined four cases that can explain differences in student post-achievement scores or gain scores. In the first two cases different student abilities rather than different teaching productivities explain the achievement score differences. The third case, and indirectly the fourth case, focus on differential faculty productivity as determining differential student achievement scores. To be fair, if faculty members were paid on the basis of student achievement scores, they should be paid only on their effort levels and not the students'. However, how does one separate these effects? We have used the "heavy pound" of ceteris paribus to do so theoretically. Operationally, it is a difficult task. There is a lack of consensus, even among educational psychologists, as to the possibility of devising a test that measures raw aptitude independent of prior achievement or vice versa. How does one monitor the effort levels of professors and students?

At the beginning of this section we mentioned that academic freedom permits the professor to teach and rank students according to his preferences; therefore it is difficult to devise an incentive system to induce good teaching. Even if this were not an obstacle, it is clear from the preceding discussion that measuring good teaching is a difficult task, given the state of the art. The learning process is a complex phenomenon, even given our restrictive definitions of student and professor production and utility functions. Devising incentive structures to increase student achievement beyond what is done at the present requires considerably more theoretical and empirical research.

A critical assumption in this section has been that the professor prefers more student achievement than less. Grade distributions support this preference ordering. High-achievement students are rewarded with "A's" and "B's," while low-achievement students are given "D's" and "F's." Moreover, the professor's utility function is generally defined over post-achievement scores, since professors seldom give pre-tests to measure gain.

Functional Roles of Professors

We have focused on the teaching function of professors in the previous section. That is, we assumed the professor, with the student, was a productive input to increase student achievement levels. We now examine some other functional roles of the professor.

Screening Process

Assume that professors do not really teach in the sense of increasing the ability of a student to obtain knowledge, but rather present and define material that the student is expected to know. Achievement is strictly a function of the student's effort and abilities; independent of faculty effort. This assumption is perhaps closer to European higher education philosophy than American. In the French universities, for example, a student is presented a program, but class attendance is not required. The professor's role is primarily to certify, through examinations, that the student has learned x amount. The professor is like an egg sorter (no pun intended) in a discipline. As discussed in Chapter II, the student has a wide range of different sorters (disciplines). We have assumed throughout this book that there are important differences among individuals The identification of these differences or qualities (that is, student abilities) we shall term "labeling." The faculty, through grade distributions, label individual students according to student abilities.

This anlaysis will borrow heavily from Stiglitz's recent work on screening [65]. His model makes the following assumptions:

1. all screening occurs in the education process;
2. all individuals have inelastic labor supply curves;
3. occupations are such that individuals are combined in a production process that produces a joint product;
4. the costs of obtaining information on any single individual's marginal product in the joint production process is prohibitive.

Stiglitz assumes that individuals within a population can be described by a single characteristic, denoted by θ which is proportional to the individual's productivity: $p = m\,\theta$. The fraction of the population that is of type θ is given by $h(\theta)$. He considers a case where there are only two groups:

$$\theta_1 \text{ and } \theta_2, \text{ where } \theta_1 > \theta_2 . \tag{6}$$

The costs of the screening process are denoted by C*; he assumes perfect screening. He assumes C* is such that:

$$\theta_1 - \theta_2 > C^* > \theta_1 - \overline{\theta} \tag{7}$$

where

$$\overline{\theta} - \theta_1\, h(\theta_1) + \theta_2\, (1 - h\theta_1) = \text{average value of } \theta \tag{8}$$

Two equilibria are considered. First, the no-screening equilibrium. Since no differentiation is made among individuals, all individuals receive the same income $\overline{\theta}$. He notes that it does not pay the more able individuals to be screened, since with screening they would obtain incomes of θ_1 and net incomes, after paying screening costs, of θ_1 - C* which, by equation (7), is less than they would receive in the absence of screening. Thus, it is an equilibrium.

The second case is the full-screening equilibirum. Individuals of type θ_1 receive a gross income of θ_1 and a net income of θ_1 - C* and individuals of type θ_2 receive θ_2. Individuals of type θ_2 are assumed to know they are less able and thus do not pay for any screening. However, individuals of type θ_1 do pay for screening since by (7):

$$\frac{\theta_1 - \theta_2}{C^*} > 0 \tag{9}$$

Individuals who are not screened are automatically typed together and receive an income of θ_2. Since individuals are assumed to know their abilities, individuals of type θ_1 will always pay for screening; they receive a positive net return and would otherwise by typed as θ_2. Once θ_1 abilities are typed, then θ_2 is automatically determined.

Note that Stiglitz's model suggests that screening may be socially unproductive as defined in (7), even though there are individual returns, because the net effect is simply a redistribution of income. That is, there is an externality to θ_1 individuals of having θ_2 individuals around; similarly, there is an externality to θ_2 individuals of having θ_1 individuals around.

We shall consider a more restrictive case of Stiglitz's model. We assume that there are two characteristics which describe the population, θ^1 and θ^2 (for example, verbal and mathematical ability), and two occupations where productivity in each occupation is defined as:

$$p_1 = m\ \theta^1 \tag{10}$$

$$p_2 = m\ \theta^2 \tag{11}$$

We shall also consider two types of individuals:

θ_1 where $\theta^1 > \theta^2$ (individual who has a comparative advantage in θ^1) (12)

θ_2 where $\theta^1 < \theta^2$ (individual who has a comparative advantage in θ^2) (13)

Consider a case where screening is not perfect.[12] The mean productivity is defined in . tions (1) and (2) as:

$$\theta^1 = \theta_1 h(\theta_1) + \theta_2[1-h(\theta_2)] \qquad (14)$$

$$\theta^2 = \theta_2 [1-h(\theta_1)] + \theta_2 h(\theta_2) \qquad (15)$$

such that (h) represents the quality of screening. Perfect positive screening (individuals are channeled into their areas of highest comparative advantage) exists when h = 1, imperfect screening when $0 < h < 1$, and negative screening when h = 0. Negative screening is defined as a situation in which individuals are perfectly mismatched, channeled into areas of comparative disadvantage.

The term (h) is positively related to productivity in each occupation and is an expression of channeling individuals into an area of comparative advantage. The total national product and wages would be at its highest when h = 1 and at its lowest when h = 0. It is, of course, unlikely that h would ever reach zero since firms could increase their productivity simply by selecting individuals at random from the population and paying a mean salarly or by inverting the labels given to individuals. A no-screening situation would result in a value of h between 0 and 1 and each individual receives $\bar{\theta}_1$ or $\bar{\theta}_2$ similar to condition (8). We can see that, in this case, screening is highly productive because of the comparative advantage axiom and results in social benefits where everyone can potentially gain. Occupational productivity, θ, can be put into the context of student prior-achievement levels, aptitudes, and effort. That is:

$$\theta_i = a_i + b_i E_i \qquad (16)$$

We have assumed that students do not necessarily have full knowledge of their relative abilities. This is reflected in the fact that an average four out of ten students switch broadly defined curricular groups between their freshman and senior years. If the grading system does channel students into areas of comparative advantage, as suggested in Chapter II, then the role of faculty members as screeners is useful in terms of both student and national income. Moreover, if this functional role is weakened or abolished, the rate of return to higher education is likely to decrease. (We shall discuss lowering screening quality through grade inflation in the next chapter.) Firms will turn to alternative rationing mechanisms and broaden the population of individuals eligible for employment beyond those holding degrees. Thus, if firms must rely on their own screening instruments, it would be rational for them to consider the population with high school diplomas rather than restricting applicants to those who have completed college without screening.

Some faculty seem to be disturbed about current grading policy. This may in part reflect a belief that the educational screening process results in a redistribution of income without social benefits. (Some argue that it is human capital punishment.) On the other hand, if there are significant gains from channeling students into areas of comparative advantage, a redistribution of income could be achieved more directly through taxation and subsidy schemes without making anyone worse off and at least some better off. Others argue that the pass/fail system should be designed to induce students into areas of comparative <u>disadvantage</u>. If pass/fail is used to a large degree, higher education may result in negative returns. Others have argued that a student's grade point average is not related to success determined by almost any measure, including income. These arguments are never fully documented. However, the relation of grades to success has been interpreted in a restrictive sense. First, approximately one half the entering freshman never complete a degree program in the normal period. There are a number of reasons for withdrawal, but involuntary withdrawal (flunking out) constitutes a major cause of this high attrition rate. A study by Boling [8] examined a cohort of students in one institution and found that two of three students who withdrew had earned a grade point average below the institutional minimum GPA (for example, C average).[13] Therefore, the grading mechanism at an aggregate level appears to result in a considerable amount of screening.

As noted previously, approximately 40 percent of freshman students switch broadly defined curricular groups. Each curricular group has its own survival probabilities. Curricular groups such as engineering and natural science are net losers in terms of the initial cohort of freshmen. Net losses occur more from students switching out of the curriculum than switching into it. On the other hand, such curricular groups as education and the social sciences are net gainers. A ranking of curricula by the degree of net loss to net gains correlates fairly well with the ranking of relative wage rates by curricula.

Firms may therefore not be interested so much in the overall GPA of the successful degree holder as in the fact that he managed to survive the screening process in a particular field. Many firms are not indifferent to a student's overall grade point average. The process of switching curricula is similar to Stiglitz's notion of a self-selection screening mechanism. If students find that they cannot survive within a particular discipline without high costs they simply self-select an easier discipline or a discipline where they have a comparative advantage. If a student does not have an option to select another discipline <u>and</u> survive, then the system might be termed a conventional or non-self-selecting screening mechanism.

The suggestion that grades are meaningless predictors of success has to be reconciled with the more general process of screening and self-selection. To look at the narrow range of grade distributions of successful degree holders overlooks the whole screening process. Degree holders generally receive higher salaries than dropouts, or those who did not enter (were screened out of) higher education.[14] This is certainly one criterion of success.[15]

In summary, we have focused on the activity of faculty distributing grades, which can be interpreted as a screening mechanism. Faculty effort in grading can be considered productive in a Pareto sense if redistribtuion is achieved through a system of taxes and subsidies, providing that the grading system channels students into their areas of comparative advantage. It is still an open issue whether a cheaper "egg sorter" is available or can be developed. One might argue that screening is not a proper role for educational institutions or for faculty members who should be engaged in the search for knowledge. We offer Stiglitz's justification of this function of the educational institution [65, p. 19]:

(a) The efficient allocation of scarce educational resources requires the identification of different individuals' abilities, e.g., some indiviuals would gain little from a Ph.D. program in economics, but would clearly benefit greatly from a course in automobile mechanics, and conversely for other individuals.

(b) Most educators would argue that even within a given educational level there are returns from recognizing that some individuals learn certain skills faster than others.

(c) Part of the social marginal product of educational institutions is finding each individual's comparative advantage (as educators are wont to say, "helping the individual find out about himself") and information about absolute advantages is almost an inevitable by-product of obtaining information about comparative advantages.

(d) In the interchange between teacher and student which is common to many (but not all) educational processes, the teacher obtains a great deal of information about his students. The fact that there a large number of teachers making these "observations," makes the information more valuable that the judgment of a single individual (e.g., employer).

Grades as Rewards and Punishments

Our previous discussion of faculty choice assumed that the achievement-effort (leisure) equilibirum of the professor was identical with the achievement-effort (leisure) equilibirum of the median student discussed in Chapter II. We treated students as passive individuals who responded automatically to the professor's behavior. In this section we examine the grading system as an exchange mechanism where additional student effort can be exchanged for higher grades. We assume the professor has a certification function and a teaching function. A by-product of the certification function (grades) may induce more student achievement (effort) relative to the student sovereignty model, which assumed that grading did not exist.

The utility functions for both the professor and student, as previously defined, are assumed to be identical. The subscript (P) stands for the professor:

$$U_P = U(x_i, E_P) \tag{1}$$

and the subscript (S) stands for student:

$$U_S = U(X, E_S) \tag{2}$$

The student's utility function was defined over a bundle of n courses such that $X = \sum_1^n x_i$ and $(x_1, x_2, x_3, \ldots, x_n)$ represent alternative courses or fields of knowledge. Having determined the student's equilibrium total effort (E) we can determine the equilibrium effort expended in each of the ith courses such that $E_S = \sum_1^n e_i$. Note that we define the professor's utility function over only one of these fields, x_i, and his effort in this field is his total effort (E_P). Consider the ith course or field. Previously, we have assumed student achievement x_i to be a function of student effort:

$$x_i = a_i + b_i e_i \quad \text{where } e_i \leq E_S \tag{3}$$

We have also assumed that faculty effort(E_P) contributes to student achievement such that:

$$x_i = a_i + b_i e_i + B_i E_P \tag{4}$$

where b_i and e_i are the student's aptitude and effort in the ith course and B_i and E_P are the ability and effort levels of the ith professor.

If the professor takes the student's prior-achievement level (a_i) and specific aptitude (b_i) as given, then student achievement in his course becomes a function of the student's effort and the professor's effort. Substituting in the professor's utility function we can rewrite (1) as:

$$U_P = U(e_i, E_P) \tag{5}$$

The utility the professor receives is therefore a function of both his effort and the student's effort. This formulation seems intuitively plausible. It explains phrases like "earned" grades and why high absence rates of students disturb some professors. To the professor, the student's effort (e_i) is a normal good resulting in higher achievement levels, and E_P, his own effort level, is a normal bad which also may increase achievement levels. The professor has the potential to trade his effort for student's effort for any given desired achievement level. Devising, administering, and evaluating exams constitutes one dimension of faculty effort. The grade distribution may induce more student achievement, <u>ceteris paribus</u>, than effort devoted to making it easier for students to learn (that is, the transformation of faculty time into student apparent aptitude increases b_i). If students do consider maximization of grade point averages and survival in school or in a curriculum important, a professor who is an easy grader is likely to induce less student effort (achievment) relative to a professor who adheres to a normal grade distribution or skews the distribution towards "D's" and "F's." At the same time, students in the latter professor's class are likely to be more disgruntled than those in the easier professor's class. This may not be true for <u>all</u> students but the <u>average</u> class member is likely to be less satisfied in the harder class than in the easier.[16] In Chapter II we discussed the externality effect upon a student in a class where his classmates have high aptitudes, high prior-achievement levels, high effort levels, or a combination of the three that generate a highly competitive environment to maintain an acceptable class standing. Similarly, the professor can generate a highly competitive environment which induces effort levels at the margin for some students beyond the levels that would be forthcoming in the absence of grades. This would be particularly true for the median student for whom our models are constructed.

Consider a hypothetical example. Suppose our median student chooses to devote fifty hours (E_S) a week to scholastic activities; if he expends an additional hour, his level of satisfaction is reduced, because the marginal evaluation of that hour in leisure activities is greater than in scholastic activity. Assume students have identical initial achievement levels but different aptitudes. For expository reasons, assume only two courses: i and j. Finally, we assume that aptitudes can be connected to grade point measures. Note that such a conversion depends on a number of factors other than the student's aptitudes--the ability and effort levels of his classmates and the professor's grade distribution. We assume the exchange rate (aptitude) of this median student for converting effort into grades in course i is .16 and in course j is .04. The grades (G_i) in each course can be calculated as follows:

$$G_i = b_i e_i \text{ in course (i)} \qquad (6)$$

$$G_j = b_j e_j \text{ in course (j)} \tag{7}$$

where:

$$e_i + e_j = E_S = 50 \text{ hours.} \tag{8}$$

If our median student allocates his time equally between courses i and j ($\frac{50 \text{ hours}}{2}$), he will receive a 4. 0 ("A") in course i and a 1.0 ("D") in course j for an overall average of 2.5 ("C+").

$$4.0 = (.16)\ (25) \text{ in course (i)}$$

$$1.0 = (.04)\ (25) \text{ in course (j)}$$

Now suppose the student recognizes that he has a lower aptitude in course j than in course i and consequently allocates a proportionately larger amount of time to course j; for every one hour in i he spends three hours in j, allocating 12.5 hours to i and 37.5 hours to j.

$$2.0 = (.16)\ (12.5) \text{ in course (i)}$$

$$1.5 = (.04)\ (37.5) \text{ in course (j)}$$

This time allocation results in a grade of 2.0 ("C") in course i and 1.5 ("D+") in course j, for an overall average of 1.75. Thus, his attempt to pull the grade of "D" in course j to a "C" has failed (1.5 < 2) even though his effort level in course j increased substantially. Moreover, the reallocation lowered his grade in course i from an "A" to a "C" and lowered his overall grade point average below a "C" (1.75). The student's only solution to this dilemma, receiving more than a "D" in course j without lowering his overall grade point average, is to increase his scholastic effort at the expense of leisure activities, not of time allocated to course i. In evaluating professors i and j, the student is likely to give a substantially lower rating to j than i. Moreover, he is likely to feel his ratings are justified, since he has sacrifice either leisure <u>or</u> time devoted to other courses with only marginal success.

Rodin and Rodin [53] and Attiyeh and Lumsden [4] have found that student achievement (as measured by standardized exams) and student evaluations of faculty are inversely related. Nichols and Soper [45] and Capozza [19] have found that the grades a student recei.es and his evaluation of the professors giving the grades are inversely related. If possible, the student in the above example would opt to take course j pass/fail, which in effect gives the student a time grant (income effect). Under pass/fail the student can achieve an "A" in course i and a "ass" in j, so that he need not sacrifice leisure nor receive a lower grade in course i.

It is assumed that faculty do not base grades on student effort, except to the extent that student effort falls out as achievement on an exam. One reason for this assumption is that professors do not have a way of monitoring student effort. While the professor may sympathize with the student in the previous example, it is difficult to distinguish low aptitude/high effort students from high aptitude/low effort (lazy) students.

A faculty member who is a "tough" grader lowers the value of the coefficients (grade returns from effort) for all students in the class. Similarly, an easier grader increases the coefficients. Therefore, faculty choice of the type of grade distribution can inflence student achievement. If the student maintains a constant total effort level (E_S), the gain in one course comes at the expense of a loss in other courses, resulting in a zero sum game. It is a positive sum game in an achievement sense if grades induce more student effort; alternatively, it can be viewed a negative sum game in terms of student utility if grades induce less leisure than the student prefers. The professor is able to extract consumer surplus from students because tie-in sales exist. In order for the student to receive subsidies (degree) he is tied to maintaining minimum grades, taking required courses, living in dormitories, etc. Even though certain dimensions of these tie-in arrangements yield dissatisfaction to the student, his overall satisfaction is higher by staying in college than if he left.

This contrasts to the criteria in the market place. Student survival in golf lessons, for example, does not depend on his performance but only on his ability to pay. A golf instructor does not insist that anyone must leave the class because his drive is less than 150 yards. Moreover, the student is permitted to choose, at the margin, that which maximizes his satisfaction--the time allotted to golf versus to other activities. The reason we observe faculty behavior that does not necessarily maximize consumer (student) satisfaction is that the student does not directly pay the faculty member nor does he pay the full resource costs in public and private colleges. Other preferences (those of legislators, taxpayers, donors) count. Legislators could clearly eliminate admissions and grading standards if they felt taxpayers desired to do so.

In summary, we draw no normative conclusions about faculty behavior. We have attempted to develop some rather simple positive models to describe student and faculty behavior. This section is not intended to be a tract on the "Defense of Grades" but rather to give an interpretation of grades that differs from the existing interpretations. We have assumed that faculty members rank students vis-a-vis a grade distribution according to their utility function: more student achievement is better than less. We have not assumed that faculty are rewarded on the basis of their grade distributions , but that their utility increases with increased student achievement. We now turn to a discussion of a situation in which the grade distribution the professor may allot might indirectly affect his salary.

CHAPTER IV

GRADE INFLATION: A PRISONER'S DILEMMA

The Carnegie Commission on Higher Education has noted that universities and colleges will probably not return to the "Golden Age" of the 1950's and 1960's, an age of assured progress, growth, and funding [72]. A study by Cheit [20] indicated that sixty-one percent of all higher education institutions are in financial distress or headed for it in the 1970's. The AAUP [2, p. 191] reported a steady decline in the growth rate of average faculty real salaries, from a 3.7 % growth in 1961 to 1963 to a -1.2 % in 1970 to 1971[1]. Balderston and Radner [5, p. 23] project continual decline in the growth of student enrollments from 1972 to 1984, resulting in an absolute decrease in demand for faculty in 1984, if not earlier. All of theses signs support the prediction that higher education will not return to the "Golden Age" for some time.

Concurrent with the above trends are trends towards the following

1. formula budgeting
2. student evaluations of professors as a basis for promotion and salary raises
3. a relaxation of restrictions on student choice

This chapter is an attempt to relate these trends with another trend--GRADE INFLATION. Grade inflation can be defined as a continual increase of "A's" and "B's," given by faculty with a simultaneous decrease of "D's" and "F's:" in other words, a continual skewing of the grade distributions towards a higher frequency of "A's" and "B's." David Reisman has popularized the term "grade inflation," cited in a nationally syndicated article, "Grade Inflation on Campuses Add to Debate on Marks," suggesting its significance [49]. While a nationally comprehensive study on grade inflation does not exist, as far as we know, there are a number of reports and articles that suggest a growing concern about the phenomenon. A national survey of 435 colleges and universities by Burwen [18] indicates a marked rise in grade point averages, especially in the last few years. At the same time, it appears there is a slight decline in college entrance examination scores of entering freshmen [49]. A California college reported that forty percent of those enrolled received "A's" and only three percent received "D's" or "F's" [40]. Let us now examine each of the three trends enumerated above.

Formula Budgeting

Formula budgeting is a response to "accountability." Legislators and administrators insist that it is necessary to "account" for the subsidies provided institutions and that monies will no longer be appropriated simply in lump sums. The formulas to determine the appropriations to universities are often based on the number of earned student hours generated. That is, a university receives appropriations according to some function of the number of students times the course hours taken in a unit of time. This formula is often used internally by a university to allocate state appropriations among departments and colleges. Many schools have had formula budgeting for some time. However, the trend towards declining appropriations to higher education has been a recent phenomenon. The post-World War II baby boom and the "sputnik" impetus to upgrade higher education in the U.S. contributed significantly to the growth of higher education expenditures. Higher education became a growth industry in which sufficient funds existed so that all departments could share in the growth. The late sixties and early seventies have experienced an opposite trend. The higher education system in the sixties was set up to accomodate an increased number of students, but it is now faced with a significant decline in the <u>growth rate</u> of potential students. Departments now utilize formula budgeting to maintain the status quo in budgetary growth or to minimize the decrease in budget allocations.[2] A stationary state budget permits no faculty promotions or salary raises; a decline may require faculty reductions. The current rate of monetary inflation also permits administrators to decrease the real salaries of faculty. Thus, formula budgeting, together with decreased student enrollments and budget allocations, have created strong incentives for departments to attract students in order to earn budgets. The internal competition among departments to attract students has increased considerably in the last five years.

Student Evaluations of Professors

Budget declines and formula budgeting have led deans and department chairmen to cater more to student preferences than they have in the past.[3] They have, for example, allowed students a say in faculty hiring, promotion, and salary decisions. Deans or charmen announce that good teaching, often defined in terms of student evaluation, will be rewarded. Evaluation forms are often comprised of such questions as:

1. How do you rank this professor with all the other professors you have had?
2. Are you <u>satisfied</u> with this teacher's ability to teach?
3. Would you take a course in this area again or would you recommend this course to your friend?

Many student evaluation questions may be considered indices of happiness or satisfaction. A survey of 669 institutions in the spring of 1973 by Creager [21] indicated that student evaluations of teaching effectiveness are conducted in nearly all departments in sixty-five percent of the institutions surveyed. Thirty-six percent used student evaluations for faculty promotions or salary increases.

Relaxation of Restrictions on Student Choice

The relaxation of course requirements and the freedom of students to design their own programs have also generated more competition among departments for students. A department may no longer be able to have, in effect, tie-in sales where a student must select a bundle of courses (degree program with requirements) or no courses at all. In addition, the student has more flexibility, in that he can transfer courses to another major without losing time invested initially. Creager [21] reported that twenty-eight percent of the institutions surveyed had individualized programs with no specific course requirements beyond the distributive or university requirements; eleven percent had programs with complete freedom of choice (no requirements).

These trends, coupled with declining budgets, prompt departments to compete with one another to attract students. An individual faculty member or department chairman has relatively little influence on the university's total enrollment where entry demand is primarily a function of tuition, scholarships, and admission standards. Similarly, he has little influence on the survival probabilities of the total student body. However, a faculty member does have considerable influence on the enrollment in his department and even more so on enrollments in his courses. Therefore, for each individual professor the total market (total enrollment in a university) represents a parameter, and the market share (course or department enrollment) is subject to his influence.

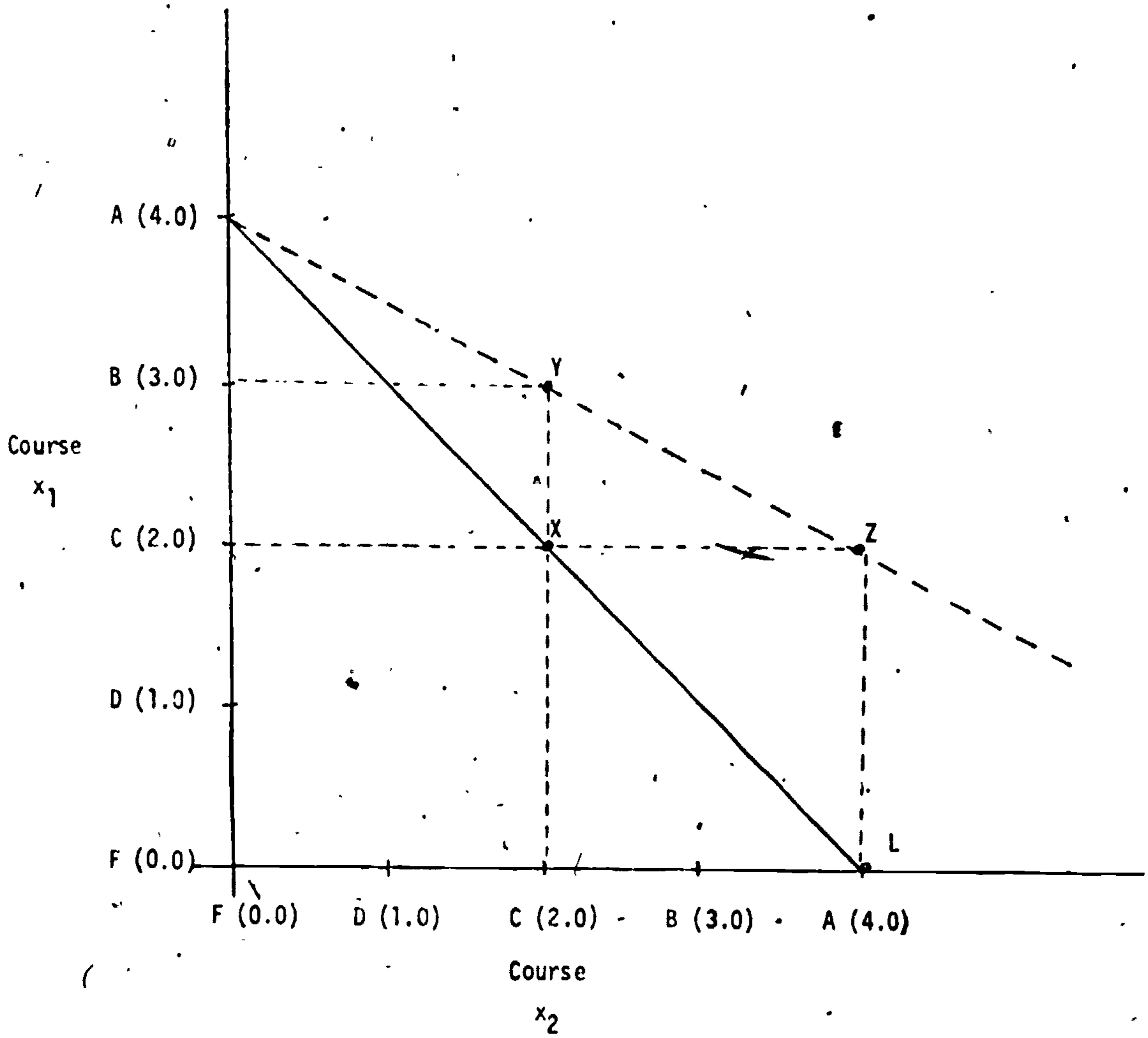
The Model

Faculty members, given academic freedom, determine the shape of the grade distributions, within broad constraints, in their classes. The professor can increase his market share if he lowers the price of enrollment. In Chapter III we formulated the professor's utility function, dependent upon his effort (E_S) and the student's effort (e_i):

$$U_F = U(E_F, e_i) \tag{1}$$

In Chapter III we also discussed that "hard grading" could increase the professor's satisfaction by inducing more student effort than the student would choose to maximize his satisfaction. This leads to a situation in which the utility of the professor and that of the marginal student conflict. That is, the student must sacrifice more leisure that desired <u>or</u> sacrifice his grade average. Either case lowers the student's level of satisfaction. On the other hand, if the professor lowers his performance criterion (shifting the grade distribution up) he relaxes the level of student effort previously required for any given grade. It is as if the professor gives a time grant (income effect) to the students in the sense that the student can either expend the additional time in the form of leisure, maintaining his expected GPA, or devote more effort either to preferred courses or the particular course, increasing his expected GPA. This is illustrated in Figure IV-1. Assume the student is taking six semester hours in course x_1 and six semester hours in course x_2. Assume also that the student, given time allocation between leisure and scholastic effort, can either receive an "A" (4.0) in x_2 and an "F" (0.0) in x_1, if he allocates all of his time to x_2, <u>or</u> he can receive an "A" in x_1 and and "F" in x_2, if he allocates all his effort to field x_1 and none to x_2. Similarly, he can receive a "C" (2.0) in x_1 and in x_2 if he allocates his efforts equally between the two courses (point X). The solid line in Figure IV-1 represents alternative student time allocations of a fixed effort between x_1 and x_2, which yield an overall grade point average of "C" (2.0). It is unlikely he would choose a corner solution (for example, L) where he would flunk course x_1 or x_2 and have to repeat

FIGURE IV-1



the course.

Now assume the professor who teaches x_2 radically lowers his performance standard (raises his grade distribution). This is illustrated by the dotted line in Figure IV-1. As in conventional consumer theory, the relative price of x_2 is now much lower, given the student's time constraint. There is both a substitution and income effect. The student can take the additional income (time) and consume more leisure while maintaining his overall grade point average, "C". Alternatively, the student can maintain his effort level and increase his grade point average. If he allocates one-half his time to x_2 he can receive an "A" instead of a "C" while maintaining a "C" in x_1, which yields an overall GPA of "B" (3.0) illustrated at point Z. Similarly, he can cut back his allocation of time in x_2 to one-fourth his total effort and receive a "C" while allocating three-fourths his effort to x_1, receiving a "B" (3.0), for an overall GPA of 2.5 (point Y). Either way, the grade constraint of the sutdent has been relaxed, permitting him more freedom and increasing his level of satisfaction. Note that we are talking about the marginal student. The lower performance standard in x_2 does not directly affect the high aptitude or high ability student since his class rank is high whether inflation exists or not. We can see that the lower performance standard in x_2 will attract students into that field, if there is a substitution effect due to the lower relative price. In addition, the course may be taken to relax the time constraint for other courses (income effect). It is as if the professor had raised the student's apparent aptitude in x_2.

It is evident that grade inflation is one way to increase a department's market share of the total university enrollment. Note that the professor's utility function, as we defined it, is a function of the student's achievement.

To the extent grade inflation reduces student effort, the professor's level of satisfaction decreases. However, he is compensated by maintaining or increasing his department's market share and thus increasing his chances for survival or promotion within the department. We would also hypothesize that younger faculty members (non-tenured) are likely to give out higher grades than their tenured colleagues whose survival is not so much in doubt.

We have illustrated how formula budgeting based on the number of students taught is likely to lead to grade inflation in the face of a declining market (enrollments). However, there is a more direct effect of salary raises and promotions that are based, in part, on student evaluations of faculty. Nichols and Soper [45] have calculated at one institution that a one-point increase, on a four-point scale, in the class's expected mean grade implies an increase of more than on-half point in the class's mean rating of the professor. They have found a steady trend of grade inflation at their institution, which uses faculty evaluations in salary determinations. As mentioned previously, Rodin and Rodin [53] have found student achievement within twelve sections of calculus courses to be inversely related to student evaluations of professors. In Great Britain Attiyeh and Lumsden [4] found student achievement scores on standardized tests in economics to be inversely related to student evaluations of professors. These studies support our model of student choice. If the professor's utility function encompasses income raises and promotions as well as student achievement, he must consider the results of inflating grades. If his grading is lenient, he increases his evaluations (income); if his grading is more strict, he lowers his evaluations (income). Note that formula budgeting based on student enrollments induces the individual professor indirectly, since the whole department receives the budget. An individual professor who does not inflate grades can take advantage of his colleagues' grade inflation, benefitting from the department's increased budget. However, salary increases based on student evaluations are a direct incentive to an individual professor and counteract the tendency to "take a free ride."

The discussion thus far may explain a once and for all increase in grades, but does not explain the continual rate of increase--grade inflation. In addition, not all department enrollments or budgets are declining and not all departments utilize student evaluations in salary determinations. Consider the matrix illustrated in Figure IV-2. Assume a university of only two departments, x_1 and x_2. We shall extend this two-department model to a more realistic example subsequently. The figures in the cells are hypothetical student enrollment figures. The first enrollment figure in each cell refers to department x_2's enrollment and the second figure to x_1's enrollment. Cell I, in the upper left corner of the matrix, refers to the status quo enrollment where each department adheres to an historical grade distribution year after year. Note that the grade distributions in each department do not have to be identical nor normal distributions. As cited previously, some curricula have higher grade distributions that others (for example, education versus engineering) after controlling for ability (evidenced by SAT scores). This simply reflects the fact that students choose curricula on the basis of factors other than grade maximization. A student may choose on the basis of future income expectations of a course or on an interest in the specific knowledge of a course.[4]

We assume total university enrollment is two hundred, enrollment split equally between departments x_1 and x_2. Assume department x_2 grades more leniently because of the department's policy to base promotions and raises on student evaluations. If our previous model of student choice is correct, there will be a substitution of students switching out of x_1 into x_2. This is illustrated

FIGURE IV-2

		Department x_2 Maintains Grade Distribution	Department x_2 Increase Grade Distribution
Department x_1	Maintains Grade Distribution	I 100, 100	II -150, 50
Department x_1	Increase Grade Distribution	III 50, 150	IV 100, 100

in Cell II, in the upper right corner; department x_2 has attracted fifty students from x_1. If formula budgeting is based on enrollments, then department x_2 will gain revenues at the expense of x_1. Consequently faculty in department x_1 will find it difficult to obtain salary raises and promotions; some faculty members may lose their jobs. If department x_1 inflates its grades while department x_2

maintains its grade distribution, as illustrated in Cell III, department x_2's revenues will suffer at the expense of x_1. It is unlikely that either department will maintain its present grade distribution in the face of a declining market, share of the total enrollment brought about by a change in relative prices (change in the grade distribution of one department). If x_1 initiates a change then x_2 will probably follow suit. Similarly, if x_2 initiates a change, x_1 will follow suit. The second department's counter strategy to in turn raise its grade distributions tends to reallocate students between departments as they were originally distributed, but both departments have now inflated their grades. This equilibrium is represented in Cell IV. Note that neither department gains more students in the long run, except for intertemporal changes in the distribution of students (revenues). The equilibrium of Cell IV represents lower faculty satisfaction brought about by lowering standards which induces lower student achievement (effort). Therefore, grade inflation results in a negative sum game to the faculty.

With only two departments in the model we should expect cooperative agreements to prevent raiding one another's departments, which would produce no long-run gains and would make the faculty worse off. If we extend the model to n departments, cooperative agreement is much more difficult to obtain. In addition, such explicit cooperative agreement runs counter to the tradition of academic freedom. Recall that our operational definition of academic freedom was the right of the individual professor to rank and evaluate (grade) students according to his preferences. This model is a classic example of the Prisoner's Dilemma, since each department is damned if it inflates grades and damned if it doesn't.

The model applies at an individual level within a department or within the entire university. Good student evaluations may not be bought for the gentleman's "C" any longer. In fact, "B's" may merit only average evaluations. Student evaluation questions like "How do you rank this professor relative to other professors in the department or university?" require that the individual faculty member keep his prices (grades) in line with the market (grades of all other professors) if he does not desire a low evaluation and consequently no raise or promotion. Not all departments need base their salaries on student evaluations. Grade inflation can begin if one department changes its price; coupled with declining appropriations and formula budgeting, this can cause other departments to generate successive counter strategies to compete for students.

If student evaluations of professors are, in fact, inversely related to achievement and expected grades, one wonders how such a system began. The professor's value or productivity is a function of the price he charges such that the lower the performance standard the higher the professor's quality. What, then, is the alternative? We have discussed in considerable detail the problem of evaluating faculty performance when academic freedom allows the professor to structure the courses and evaluate the students according to his preferences and when student post achievement is a function of a number of factors that are not solely attributed to the professor and are not easily discernible or measurable.

Declining growth rates have produced a favorable climate in which administrators can cater to student preferences. Because grade inflation is a national phenomenon, there is a negative incentive for an individual university to deflate grades. That is, the university as a whole, not only the individual departments, is caught in the prisoner's dilemma (Figure IV-2)

We have focused on the negative sum game (lower faculty satisfaction) which grade inflation produces. However, a more serious dilemma confronts higher education graduates. In Chapter III we discussed grades as a screening mechanism distributing students to their areas of comparative advantage. The importance of this screening is suggested by the fact that nationally forty to fifty percent of students switch broadly defined curricular groups and approximately fifty percent of freshmen students do not graduate in four years. Assume that a portion of the rate of return from higher education is due to screening. Taubman and Wales [66] suggest that over thirty percent of the return is due to screening, although their analysis does not consider the comparative-advantage argument.[5] In Chapter III we denoted the quality of screening by h: h = 1 denoted perfect screening and no screening existed when h lay between 1 and 0. Consider Figure IV-3, which illustrates some hypothetical values of h resulting from departmental strategies to compete for students.

The first number in each cell refers to the value of h for department x_2 and the second number to the value of h for x_1. Assume screening is not perfect, even under a status quo arrangement (Cell I) where grade inflation does not occur. If department x_2 lowers its performance standards there is a weakening of the grading system such that marginal students are not channeled into areas of comparative advantage. The value of screening goes down to .50 in department x_2, but there is no deterioration of screening in department x_1. If x_1 reacts strategically to department x_2's grade inflation by inflating grades, the value of screening for both departments decreases to .50 (Cell IV). Cell IV illustrates that some students who have a comparative disadvantage in x_1 and some in x_2, respectively, are able to survive. Students no longer receive signals indicating their relative class standings nor are they labeled for external

FIGURE IV-3

		Department x_2	
		Maintain Grade Distribution	Increase Grade Distribution
Department x_1	Maintain Grade Distribution	I .95, .95	II .50, .95
	Increase Grade Distribution	III .95, .50	IV .50, .50

purposes (firms).

We also know that the rates of return to various curricula are different. If the Stiglitz model holds in the sense that firms are not able to distinguish an individual's marginal productivity in a joint production process, some students may enroll in x_1, though that may be their area of comparative disadvantage, so that they may take advantage of that field's higher rate of return. Although these students may gain in the short run from this behavior, in the long run the firm will discount the labels (degree programs) given the students. Thus, grade inflation will lead to degree devaluation. In addition, if grade inflation leads to less student effort, and therefore less student achievement, a further devaluation of degrees will take place independent of screening effects. Note that the value of screening will deteriorate if the effects we described above work at the margin for a sufficient number of students. Firms will no longer be able to utilize the degrees (university-conferred labels) to distinguish those students who have a comparative advantage and/or high achievement (effort) level in a specific field from those marginal students who have a comparative disadvantage and/or low achievement (effort).

We can see that grade inflation is also a negative sum game for students, in the long run. However, short-run benefits accrue to average ability students, in the sense that grade inflation permits more freedom of curricular and time allocation choices. University-wide grade inflation, in effect, gives the student a time grant (income effect) so that he can spend time on a variety of courses or on increased leisure. Thus, grade inflation allows students to trade future benefits (higher earnings) for present benefits (increased student choice in school). To the extent the demand for higher education is sensitive to the rate of return, grade inflation will produce additional enrollment decline, thereby increasing the negative feedback of grade inflation for faculty.

From the standpoint of students, grade inflation also is a prisoner's dilemma. The influence of any single student or class of students is likely to be negligible. Grade inflation, by devaluating the degree, imposes significant costs to high ability students who do not receive any short-run benefits. It interesting to note that the Phi Beta Kappa society, in 1969, was the first group to recognize a form of grade inflation created by the pass/fail system [50]. This group was concerned about using the student's overall grade point average as a criterion for Phi Beta Kappa membership, given the general increase in the use of pass/fail grading. As expected, the society examined alternative screening mechanisms. However, while the high ability students may dislike grade inflation, the majority of students may be expected to vehemently protest deflating grades, which would restrict their feasible sets. Therefore, it is unlikely that a massive student movement to halt grade inflation or to initiate grade deflation will be organized.

We have argued that grade inflation will eventually lead to a decline in the rate of return to education. Popular attitudes increasingly support this argument; as a result, vocational and trade schools are becoming more attractive. Assume there is a decline (real or perceived) in the rate of return to higher education due to factors other than grade inflation. For example, the decline could result from excess supply of college graduates. A decline in the rate of return is defined in a relative sense; the lifetime earnings of a college graduate may still be greater than the lifetime earnings of an individual with only a high school diploma, but at the margin this differential is smaller and makes a college degree marginally less attractive. The decline in the rate of return may then cause grade inflation, rather than grade inflation causing the devaluation of a degree.

Referring back to Chapter II, we defined the student's utility function as:

$$U_i(X_i, E_i) \tag{2}$$

and the student's production function as:

$$X_i = A_i + B_i E_i \tag{3}$$

The first order condition for utility maximization is:

$$\frac{U_E}{U_X} = B_i \tag{4}$$

This condition states the <u>willingness</u> of the student to substitute effort (leisure) for achievement is equal to r , (B_i) The student can receive utility from knowledge or scholastic achievement in many ways. He may receive utility from knowledge for the sake of knowledge. He is also likely to receive utility from associated income. If there is a decline in the real or perceived income associated with education, he is likely to lower his marginal evaluation of knowledge. In other words, the marginal utility of achievement (U_X) decreases in equation (4), assuming the student's ability (B_i) constant, he will decrease his effort, U_E, (increase leisure, U_L) to satisfy the first order condition.

A decline in the rate of return, while maintaining grading standards, results in a decrease in student (consumer) surplus. We have discussed the possibility of the faculty member extracting some of this consumer surplus by imposing high standards which require effort levels beyond what the student would choose in the absence of such standards. Therefore, loss of the student's consumer surplus, due to a decline in the rate of return, limits the amount of consumer surplus the professor can extract. Thus, one way to maintain the student demand for courses in the face of declining returns from those courses is to lower the price (inflate grades). Moreover, the decline in rates of return does not have to extend to all disciplines. The high degree of publicity given such curricula as engineering and education may have set off the initial grade inflation in these curricula. Adding the declining population growth, formula budgeting, and student-evaluation-based salary raises and promotions, the initial inflation spreads from one or several departments throughout the entire university.

Whether grade inflation started from an excess supply of college graduates or from the higher-education fiscal problems or from both is irrelevant. We wish to emphasize that each of the models feeds the other and may ultimately lead to hyper-inflation. Grade inflation generates an excess supply of degrees because of devaluation; the devaluation in turn leads to more inflation, and so on.

The two models of inflation are like the "demand" versus "supply" models of monetary inflation. Also analogous is the role of the Federal Reserve Board--it controls the money supply and thus also is responsible for monetary inflation. Likewise, the faculty controls grade currency, and it permits grade inflation.

This chapter has focused on the role of faculty in selecting performance standards (grade distributions). One department or professor can impose externalities on other departments and professors as well as on students.[6] There are several ways that faculty can internalize these externalities, avoiding the prisoner's dilemma of grade inflation. First, an academic constitution could be designed, requiring all professors to adhere to some standard grade distribution, preventing changes in relative prices. It is not likely that the constitution could be unanimously passed. However, support for a constitution restricting faculty freedom should increase as inflation increases to its upper limit (all "A's"). Second, student evaluations could be adjusted to account for the grades a professor gives to his students. Third, criterion reference testing, discussed in Chapter II, which does not utilize grade distributions, could be increasingly implemented. Different student abilities fall out in terms of time expenditure distribution rather than grade distribution.

CHAPTER V

TEACHING AND RESEARCH: SUBSTITUTES OR COMPLEMENTS

In earlier chapters we have assumed that the professor engages only in leisure activities or instructional activities. Student achievement is a normal good to the professor; that is, all other things being equal, the professor prefers more student achievement to less. This assumption agrees with the generally accepted notion that the scholar is interested in his pupils and that he does not have to be externally motivated. The professor's utility function, as we have defined it, produces faculty behavior that is benevolent and charitable towards students. Every professor may not exhibit identical charitable behavior (faculty effort), and to some external observers faculty may not exhibit enough charity to justify his salary. However, while higher education was a rapidly growing industry and the faculty had a sellers market, there was little real concern about faculty behavior.

In the previous chapter we discussed the post-baby boom effects and apparent fiscal crisis in higher education. Our examination of these circumstances, relative to faculty and student behavior in a model of grade inflation, has changed our previous assumption that salaries are independent of faculty behavior. If the professor's behavior extracts the "consumer surplus" of the students, he is likely to receive lower student evaluations and consequently a lower salary or a lower probability of promotion or raises. Therefore, the initial model of faculty choice based on the absence of monetary incentives was replaced by a model based on an incentive system related to student evaluations for faculty survival. Our discussion so far is descriptive of many colleges and junior colleges that are non-"publish or perish" institutions. This chapter structures a model that includes research activities as well as teaching and leisure activities, a model incorporating an additional incentive system that exists in "publish or perish" institutions.

We again assume a two-stage choice process in which faculty chooses between scholastic effort (research and teaching activities) and leisure, recognizing that there is an implicit additive assumption. Once having determined the total scholastic effort (E_i) where $E_i = T - L$ and T equals total time and L leisure time, we can examine the professor's choice calculus of allocating his scholastic effort (E_i) among teaching the research activities. We assume that under academic freedom, the faculty member has considerable latitude in this allocation decision.

Research and Instruction as Substitutes

It is often argued that research activity produces joint outcomes of research and teaching,[1] a phenomenon which can be construed in several ways. The classic example is the interaction of the faculty member and his graduate assistant or the thesis advisor and the student. As joint products seem obvious in this case, we will not discuss it further. It is also argued that research activity increases the productivity (ability), previously defined as B_i, of the professor in the classroom. On the other hand, some argue that research activity decreases teaching ability because the faculty member's ideas become too complex, and he teaches beyond his students' comprehension levels. These arguments are hypotheses which have not been empirically tested. However, we shall consider several studies that suggest the interrelationships of teaching and research.

We shall first consider the complete absence of joint products--research activities produce <u>only</u> research outcomes and teaching activities produce <u>only</u> teaching outcomes.[2] We define the professor's utility function over research (x_1) and teaching (x_2) outcomes:

$$U_i = U(x_1, x_2) \tag{1}$$

where the marginal utility of x_1 and x_2 are:

$$U_{x_1} > 0; U_{x_2} > 0$$

The professor's production function for research (x_1) is:

$$x_1 = a_1 + b_1E_i \tag{2}$$

The production function for teaching is:

$$x_2 = b_2E_i \tag{3}$$

where b_1 is the professor's ability (that is, faculty aptitude) to produce research outcomes (x_1) and b_2 is the ability to produce teaching outcomes (x_2).

We shall abstract from such inputs as capital (buildings, laboratories, etc.) and other labor (clerks, secretaries, graduate assistants). The constant a_1 represents the professor's initial endowment or initial achievement as a researcher. There is no constant for the professor's production function of teaching outcomes since we have assumed that function is strictly a rate concept (b_2) dependent on the "student's" (class) initial endowment (initial endowment level). Without loss of generality we can assume away the initial research endowment (a_1) so that the production functions are:

$$x_1 = b_1E_i \tag{4}$$

$$x_2 = b_2E_i \tag{5}$$

Having determined the effort-leisure choice, the constraint facing the professor is:

$$E_i - b_1x_1 - b_2x_2 = 0 \tag{6}$$

Using the Lagragian multiplier we can define the professor's constrained utility maxmization problem as:

$$U_i = U(x_1, x_2) + \lambda(E_i - b_1 x_1 - b_2 x_2) \tag{7}$$

The first order conditions for utility maximization are:

$$\frac{U_{x_1}}{U_{x_2}} = \frac{b_1}{b_2} \quad \text{or} \quad \frac{U_{x_1}}{b_1} = \frac{U_{x_2}}{b_2} \tag{8}$$

The above states that a professor's willingness to substitute research outcomes (x_1) for teaching outcomes (x_2) equals his ability to substitute x_1 for x_2, given his relative abilities of b_1 and b_2 and effort (E). The absence of joint products from undertaking either research or teaching activity can be defined as (and illustrated in Figure V-1):

$$\frac{\partial x_1}{\partial x_2} = 0 \quad \text{and} \quad \frac{\partial x_2}{\partial x_1} = 0 \tag{9}$$

Realistically, the average professor does not have complete freedom of time allocation since some threshold level of time must be allocated to teaching (he must go to class, grade exams, advise students). This threshold is represented by x_2', a minimum time or effort ($x_2' = b_2 e'$) out of the total effort (E) that the professor must devote to teaching to survive in the institution. (We shall discuss this threshold in more detail in a later section of this chapter.) The professor, however, has considerable latitude in allocating the residual effort (E - e') between research and teaching outcomes. Therefore, his feasible choice set is bounded by $x_2' - Z' - x_2''$. Research outcomes beyond x_1' are not feasible since we assumed that a portion of his total effort (e') must be devoted to producing x_2' of teaching outcomes. The slope of feasible set x_1' /. x_2'' is determined by his relative abilities to produce research and teaching outcomes (b_1/b_2). Recall that b_2 is affected by his student's abilities (aptitude, prior achievement), effort levels, and preferences.

Let us assume teaching outcomes are not measured in terms of student evaluations. As discussed previously, the property right of academic freedom, which allows professors to determine what constitutes knowledge and how students are ranked, makes a definition of teaching outcomes difficult. This problem is further compounded by the fact that student abilities and effort levels enter into the final outcome, making it difficult to isolate the professor's performance (marginal product). Therefore it is <u>not</u> likely that faculty teaching performance beyond the threshold (x_2') will be rewarded in terms of income. This is one factor that explains the reliance on publishing as the main determinant of salaries. Articles are measurable in terms of quantity and quality. Furthermore, even if the dean has some intution that a professor has high teaching abilities or performance, the professor is at a comparative disadvantage in salary negotiations. Because there is no clear definition of teaching outcomes or teaching performance, the professor is not able to export this skill in the market to increase his bargaining strength. The dean of the college is a monopsonist and is <u>unlikely</u> to promote his "good" teaching faculty in the academic market beyond his university.[3]

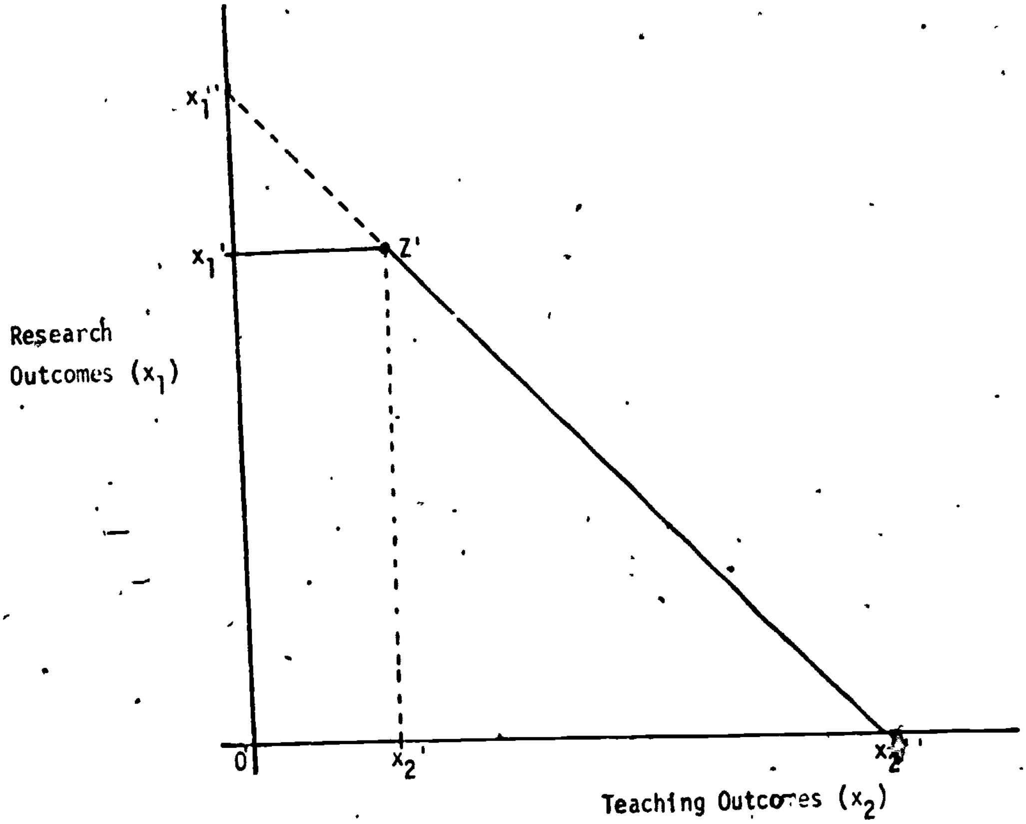
The conclusion that there is no market for good teachers is not entirely accurate, however. In economics, for example, there is an emerging market for "principles" teachers who are receiving relatively high salaries and known throughout the discipline. How does one reconcile this phenomenon with our previous analysis? First, the market appears to be restricted to "principles" teachers. A standardized exam has been developed to measure understanding of economics (Test of Understanding College Economics). While there are still difficulties in interpreting the exam scores, there is a standardization and measurement of knowledge. Second, "principles" sections are usually large mass sections drawing both economic majors and non-majors. Thus, if formula budgeting based on enrollment exists, the "principles" courses are often the "bread-and-butter" of a department's budget. These courses are increasingly being taught as massive auditorium classes. Therefore, a professor who has demonstrated effective handling of large classes (maintain or increase enrollments) presents an opportunity for the department to generate profits (from a budget based on increased enrollment minus one salary). These profits can be used to subsidize other activities and smaller classes for more advanced courses.[4]

On the other hand, there does not appear to be a "good" teacher market developing for more advanced courses with smaller student/faculty ratios. This may be due in part to reduced possibilities of profit generation and to the absence of standardized measures of teaching performance in advanced courses. The only current measure of the performance of the faculty member teaching advanced courses is his publication record. Where does this lead us? First, if the professor is interested in maximizing income, given research ability, he will allocate his residual effort totally to research activities;[5] the exception is the "principles" teacher. However, it should be noted that the "principles" market is limited due to massive class sizes and the demand from only large-enrollment universities. It is worthwhile for a professor to engage in research even if his present institution does not follow the "publish or perish" doctrine. The distinction between research and teaching is that the former can be exported.[6] Consequently, the professor's bargaining power is increased. Where formerly the dean or chairman could put the professor on his "all or nothing" demand curve, the publishing professor can put the dean or chairman on his "all or nothing" demand curve. Second, publications increase the probability that a professor will receive research grants. Many of these grants carry indirect costs or overhead budgets which increase the financial health of the university. While government expenditures for research and development appear to be declining, they are perhaps even more important to universities in light of the overall fiscal crisis. Third, publications also increase the probability that professors can obtain independent grants that increase their income. Fourth, because research is exportable, job opportunities are likely to be expanded beyond the university to include industry and government.

Therefore, it is rational that both administrators and professors behave similarly with respect to the "publish or perish" doctrine. We shall present evidence that this is true. In spite of the public pronouncements of both administrators and faculty of the concern for "good" teaching, little progress has been made to define what constitutes good teaching. At present, the only measure of "good" teaching used is student evaluations.

Our previous discussion assumed that the professor was primarily interested in maximizing income. This is not necessarily true for all professors. Some professors may willingly sacrifice income to produce teaching outcomes defined as student achievement. Referring to Figure V-1, which illustrates the constraint facing the professor, if he allocates his time such that he produces teaching outcomes beyond x_2', we can describe his behavior as being truly charitable. That is, if he has the ability to do research, and yet allocates a portion of his residual effort to teaching beyond x_2', he has chosen to sacrifice income in favor of imparting additional knowledge to his students beyond the minimum required. We do not doubt that some professors behave this way. However, because it is difficult to measure this charitable behavior, it is not probable that charity will be used as a hiring criterion. For professors who do not have the ability to do research, the opportunity cost of teaching activities beyond x_2' is sacrificed leisure.

FIGURE V-1



Finally, what effect would defining student evaluations as teaching outcomes have on faculty choice between research and teaching activities? The "hard" professors (who have high performance standards which require students expend more effort than they would choose, given their own preferences) may simply devote less time to teaching and more time to research and/or leisure. If the professor makes the course easier, he can reduce his effort level, the students' effort levels, and receive higher evaluations (assuming achievement is inversely related to student evaluations). Only if student evaluations and student achievement are positively related is it likely that more faculty effort will be expended on teaching activities. One way to decrease effort is to use multiple choice exams instead of essay exams. This may also improve the students' evaluation of a professor's fairness since a multiple choice exam is often perceived as more objective.

On the other hand, students may evaluate on the basis of the professor's entertainment value. For some professors, the development of entertainment skills may be terribly difficult and require considerable effort. It is not clear what effect defining student evaluations as teaching outcomes will have on faculty choice. As mentioned previously, empirical data on time allocations of students and faculty are almost non-existent, and the faculty acitivity data that do exist are self-reported and not entirely valid. We suspect that lowering admission standards and grade inflation lead to faculty members choosing more research and leisure, less teaching.

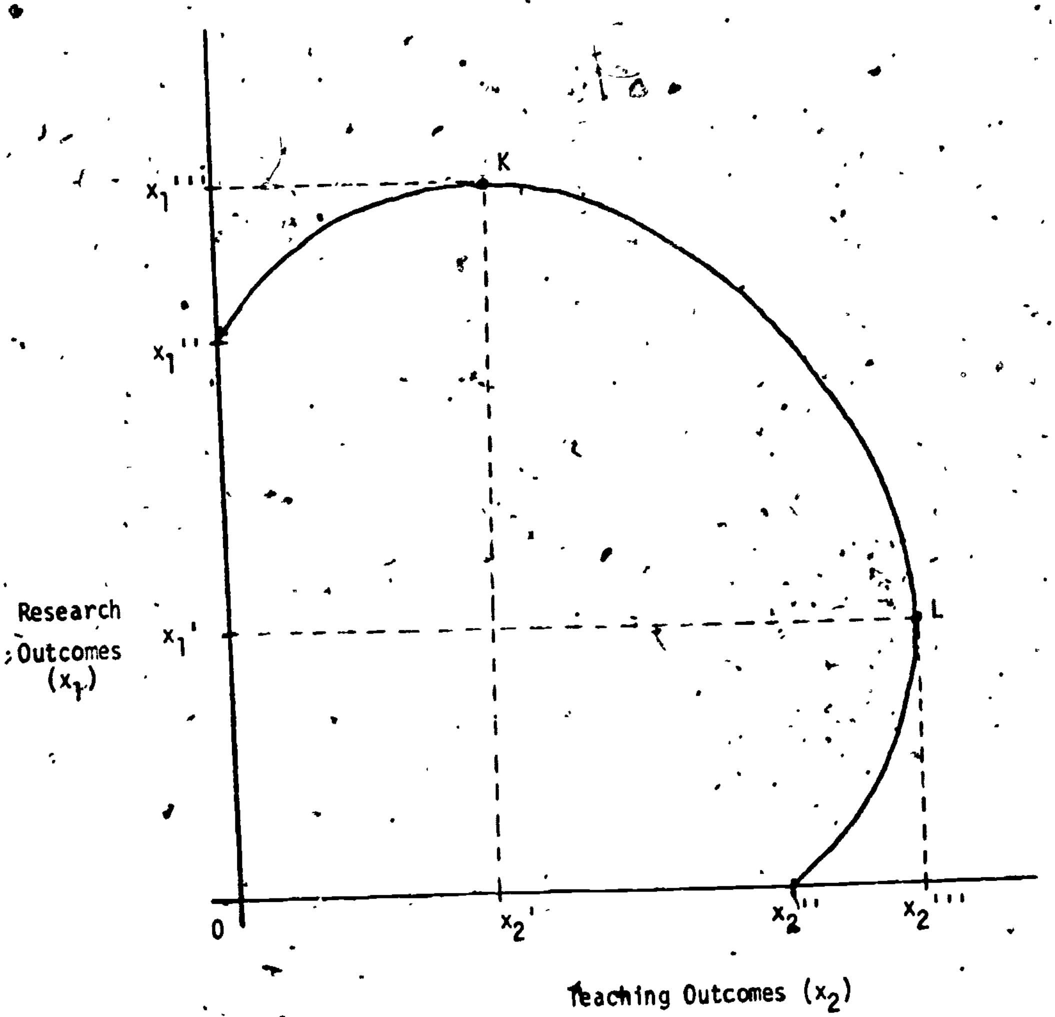
Teaching and Research as Joint Products

The previous discussion assumed the absence of joint products. Let us now assume that research activity produces teaching and research outcomes and that teaching activity produces research and teaching outcomes. We can define these relationships as follows:

$$\frac{\partial b_2}{\partial x_1} > 0 \quad \text{and} \quad \frac{\partial b_1}{\partial x_2} > 0$$

We shall assume this is true only over a certain range of the production function where eventually a further increase in research outcomes must lead to a decrease in teaching outcomes, as illustrated in V-2.

FIGURE V-2



Certain allocations of faculty time (between research and teaching activities) will produce outcomes that are in the substitutable range (an increase in research can only come at the expense of teaching and vice versa), illustrated by the K-L portion of the feasible set. Moreover, other time allocations would produce complementary outcomes where an increase in research produces an increase in teaching outcomes. These allocations are illustrated by the x_1'' - K and L - x_2'' portions on the boundary of the feasible set. Note that we are holding faculty effort (E) constant, and the feasible set is determined by the teaching/research activity alternatives available to the faculty member. An increase in total effort would expand the boundary and a decrease in effort would contract the boundary. The existence of joint products as illustrated in Figure V-2 significantly changes the implications of the "publish or perish" doctrine and the choice calculus of administrators. Deans or department chairmen would not hire faculty who specialized solely in research or teaching. Those who specialized only in teaching could produce x_2'', whereas the same individual could potentially produce x_2'' of teaching outcomes and x_1' of research outcomes, if he reallocated a portion of his time to research. Similarly, those engaged only in research could potentially produce more research outcomes and teaching outcomes through a reallocation of effort.[7]

The argument of joint products reinforces "publish or perish" behavior. Since it is difficult to define teaching outcomes, and research produces joint outcomes, then research serves as a proxy for teaching abilities. Attitudes towards the existence or non-existence of joint products may partially explain the behavior of different types of institutions. Joint products are likely to exist only when the research activity of a professor is compatible with the subject matter of the courses he teaches. Thus, empirical research on the determinants of Gross National Product are likely to have to have relatively little or no spill-over into an introductory course in micro-economics, but significant spillovers into an econometrics course or advanced macro-economics course. Most junior colleges and small colleges do not follow the "publish or perish" incentive scheme. Moreover, these schools have a limited variety of courses and are often restricted to introductory courses. Therefore, it is perfectly rational that these colleges do not reward research. On the other hand, large universities have a wide variety of courses in both undergraduate and graduate programs. Therefore, the joint product notion is much more applicable since the subject matter of research and teaching has a higher probability of being compatible. One can generate a number of hypotheses; the crucial question is what, in fact, is the behavior we observe?

Some Suggestive Evidence

There appears to be supportive evidence at selected universities that research publication is the principle determinant of salaries. Katz [38] found in analyzing a large number of departments at the University of Illinois that "Of all variables included in this regression student evaluations of teachers were the least predictive of salary." Most department chairman that he interviewed had a mistrust of student ratings. On the other hand "the publication of a book, article, or excellent article during a professor's lifetime was worth annually an extra $230, $18, and $102, respectively in 1969 [38, p. 473]. He also found diminishing return to publishing.

Siegfried and White found in analyzing the economics faculty at the University of Wisconsin--Madison, found the following using student evaluations as a measure of teaching quality [55, pp. 23-24]:

> If a professor were able to excel in teaching and raise his ranking from that of the departmental "average" to the top 15 percent (i.e., raise his transformed evaluation score one standard deviation above the mean) he could expect a salary increase of $490. At the mean faculty salary

level of $19,360 this represents a salary increase of only 2.5 percent. This salary increase can be compared to the financial reward that would accrue to the faculty member who allocated his time and energies toward excelling in research. If the same professor were successful in raising his research inventory from the "average" to the top 15 percent of the department, his salary would be expected to increase by $3,450 (assuming the impact of monographs to be zero). This represents an increase of 18 percent at the mean salary level.

Several studies have attempted to test whether student evaluations are related to research publications. Voeks [73] found that student evaluations were not significantly correlated with faculty publishing at the University of Washington. Bresler [10] discovered at Tufts University that faculty holding research grants received more favorable ratings than their nonresearching colleagues. Hayes [33] found that the faculty publication rate at Carnegie-Mellon University does not correlate with teaching quality as determined by student evaluations or department head ratings. Finally, Siegfried and White [55] found evidence supporting Voeks and Hayes that there appears to be no conclusive positive association between students' evaluations of teaching performance and faculty publication rates.

What is surprising from these studies is that there is not a significant relationship either positive or negative. The studies seem to support our model of the absence of joint products. Some of the studies have policy recommendations to change the incentive structure to improve instruction quality. We have gone to considerable pains to point out that this is easier said than done in the absence of criteria for good teaching. Moreover, department heads seem to be acting rationally in rewarding faculty outcomes. If there is no correlation between research and teaching, why should the department head not pay for research, which has some positive value in terms of prestige to his department.

The above studies used student evaluations as proxies for quality teaching. The absence of achievement scores or other evaluative schemes in these studies supports our models. There is, however, one study that indirectly uses a criterion other than student evaluations as a teaching outcome. Solmon [59] in examining a cohort of students from various schools found student salaries after graduation (controlling for student experience and ability) significantly correlated with the quality of the institutions as measured by the Gourman Academic Index or the average faculty salary in the institution. The Gourman Index uses faculty research as an important determinant in its rating scale. We should also expect average faculty salaries to be positively correlated with research institutions. Thus, this study offers indirect evidence that quality teaching, as measured by a student's future income, is related to research activity and supports our joint product model. Solmon calculated an elasticity measure, defined as the percentage change in students' future incomes with respect to a change in average faculty salaries. This elasticity coefficient was estimated to be .4985, which means for every one dollar change in average faculty salary (all other things being equal) we observe a one-half dollar change in students' annual future incomes. If one sums across all the students the teacher is responsible for, the total returns to quality are significant. For example, assume there is a 20/1 student/teacher ratio. Every one-dollar increase in faculty salary represents a ten-dollar increase in students' annual future incomes.[8] If we assume the average faculty salaries across the institutions are correlated with research productivity, then the monetary benefits of the joint products of research activity are signficant.

The general conclusion one can draw from these studies is that further research is needed. Using student evaluations as a measure of teaching quality may simply reflect lower student achievement scores, if one believes some of the studies cited previously. To design explicit incentive systems based on student evaluations may simply induce lower student achievement and give a further boost to grade inflation. Solmon's study was not designed to test the joint product hypothesis and only indirectly suggests support of the hypothesis. Further specification of teaching quality (for example, the effects on future income) is a step toward testing the joint products hypothesis. We now consider what peer group influences affect teaching thresholds defined as minimum teaching effort levels.

Faculty Externalities

We have previously discussed a minimum teaching effort or threshold consisting of faculty effort devoted to attendance in class, grading exams, student advising. The minimum effort may be considered a lower bound set by the administration. Low levels of teaching effort by a professor may also generate externalities to his colleagues. In such programs as economics in which courses build directly upon previous learning, the effort of the "principles" professor affects the prior achievement levels of students entering more advanced courses. In this sense teaching involves externalities. As an illustration, consider Figure III-1 as the advanced professor's choice set. If the "principles" professor increases the students' achievement levels to a_j rather than a_i, the advanced professor is able to choose more leisure for any en achievement level than if the students' prior achievment levels were at a_i. Whether the advanced professor chooses more, less, or the same amount of effort (leisure), he is still better off (higher indifference curve), assuming student achievement is a normal good in his utility function. Similarly, any increase in the technology of teaching at the "principles" level can be absorbed by the professors of more advanced courses.

These teaching externalities may, for two major reasons, be internalized to a greater degree in smaller departments than in larger ones. First, the contribution of the individual professor in a small department is more easily detected by himself and by other professors, and colleague dissatisfaction can be applied to change his behavior, that is, increase his teaching effort. In a large department, the instructor at the advanced level will find it more difficult (more costly) to determine who is doing a poor job at the lower levels, since students from several different "principles" professors are likely to be mixed among his classes. Also, because he belongs to a rather large group of faculty members and his overall contribution to the average capability of all majors is likely to be rather small, a goal of attempting to produce "quality" graduates will have little influence on his teaching behavior. His contribution (or lack thereof) may simply be undetectable, and he can "take a free ride."

Second, because the professor in a small department may be teaching the same students in a sequence of courses from "principles" to specialized courses, the professor himself reaps the benefits of his own efforts at the "principles" level; his task at higher levels will be easier. In addition, the opportunities to "take a free ride" in a small department are lower since each professor makes a significant contribution to the average capability of all students who major in the department.

CHAPTER VI

SOCIAL BENEFITS OF LEARNING

A number of arguments attempt to explain why higher education is subsidized and not left strictly in the private sector. Some of these are arguments based on equity or distributional grounds and implicility assume that subsidies will lead to increased income equality. Stiglitz's model [65], discussed previously, suggests the opposite. Hansen and Weisbrod in their study of higher education in California [31] also suggest that higher education leads to more inequality. Staaf and Tullock [64] argue that subsidies to higher education violate an equity norm if reducing inequality is viewed as equitable. In addition to equity questions there are also efficiency arguments for subsidies. The most notable of these arguments is the claim of social benefits (externalities to society) of an educated individual. This chapter focuses on the popular "good citizenship" argument. The efficiency arguments are based on the notion that there will be an under-allocation of resources to higher education if higher education is not subsidized. Before going to the "social benefits" argument we briefly examine the imperfections in the human capital market argument, which has both efficiency and distributional aspects.

A number of reasons are offered to explain the market imperfections of the human capital markets. First, since slavery is illegal, lenders are not willing to accept as collateral the uncertain future earnings of students requesting investment funds. Personal bankruptcy laws inhibit lending money without some tangible collateral that can be attached in the case of default. Even if lenders were willing to lend money on the basis of future earnings, the actuarial risk associated wtth such loans may be higher than the allowable interest rates.

Therefore, it is questionable whether these arguments are market imperfections or legal restrictions on markets. West [77] presents an excellent treatment of this issue, concluding that at best a weak argument for government loans can be made but not for student or institutional grants. Assuming West is correct we now examine the "social benefits" argument for subsidies (grants) to students and/or institutions.

According to the "social benefits" argument, the student benefits society by becoming educated. Since the resulting benefits are externalities (external to the student), the student will choose education only as far his own marginal private benefit equals the marginal cost of his last unit of education. Therefore, unless the student's higher education is subsidized such that the student's marginal costs are lowered, resources to higher education will be inefficiently allocated. That is, an equilibrium will result in which the total social marginal benefits to both the student and society exceed the marginal cost of non-subsidized education. There have been a number of attempts to define the social benefits more specifically: reduced crime rates, increased charity, good citizenship (as manifested in voting behavior). Most of these results may be due to the higher incomes associated with education. That is, crime is less profitable to an individual whose opportunity cost (wage rate in other professions) is higher. Similarly, charity and good citizenship may be goods that exhibit positive income elasticities. Therefore, direct income redistribution may be a more efficient way to achieve these social benefits than the indirect effects of increasing education.

The good citizenship argument, however, is a dominant argument supporting subsidies to higher education. In essence, supporters of the citizenship argument believe there are externalities associated with certain kinds of literacy (for example, economics, political science, sociology), so that education is a public good. If the individual becomes more knowledgeable in those subject areas, he will be able to analyze public issues more astutely and consequently can make more informed decisions at the polls.[1] For example, he may vote against tariffs thereby lowering the price of products for all consumers. Thus, the educated individual can contribute to improved efficiency in government policy and can enhance the public welfare. We now examine this argument in terms of the Downsian Paradox.

The Downsian Paradox

Let us consider the payoff to the individual of voting. Following Downs [23], ch. 13) and, more specifically Tullock [70, p. 109], we can compute the payoff to voting:

$$BDA - C_V = P \tag{1}$$

B = benefit expected to be derived from success of your party or candidate

D = likelihood that your vote will make a difference

A = probability estimate of the accuracy of your judgment

C_V = cost of voting

P = individual payoff

If the individual were a dictator, his influence on policitical decisions would clearly be greater than if he were an individual citizen in a democracy. Similarly, if the decision were made in the private market rather than the voting booth, the influence of his decision would be greater; his influence is determining. However, in an election, the influence of his vote is reduced considerably--the probability of his vote determining the election (or that he is the median voter) is extremely low. Using Tullocks' example, suppose that it costs an individual $1.00 to vote. Assume the differential of his candidate winning is worth $10,000 to the individual and that his judgment is .5 accurate. Assume also he is one of ten million voters thus the likelihood of his vote making a difference is .0000001 (value of D). The voting payoff is negative:

$$(\$10{,}000 \times .5 \times .0000001) - \$1.00 = -\$.9995$$

These assumptions appear fairly realistic and are positively biased, if anything (for example, $10,000 differential benefit). However, given these assumptions, there is no incentive to vote. Currently there is no satisfactory explanation of why people do, in fact, vote. Thus, the paradox remains.

One may quibble about the magnitudes involved and introduce qualifications, many of which have been handled elsewhere [23 , 70], and yet still conclude that the rational voter will incur little cost in voting. Because of social pressures and what Downs has called the "long-run participation value" of seeing democracy work, the voter may be willing to register, learn the candidates' names, and go to the polls on election day, but he will typically be uninformed about the issues of the election. He will be "rationally ignorant."

The argument that the social benefits of good citizenship motivate students to learn has an appealing sound. It is as if Plato's "Philosopher King" government were applied to democracy. However, the Downsian Paradox casts considerable doubt on whether the "college educated" voter will be more rationally informed than the average voter. Again consider equation 1. Suppose a college education increases the accuracy (A) of the individual's judgment to 1. That is, he is always sure that his vote is correct. Even this assumption yields negative payoff. Moreover, there is still little incentive to invest heavily in collecting information to support one's judgment. Suppose a student is perfectly informed about the theoretical structure of the economy (a highly unrealistic assumption even for economics professors). A decision on an economic issue requires basic information about the money supply; government expenditures, investment, etc. This information is not readily available or digestible. The University of Pennsylvania model, for example, has over one hundred equations. In other words, students who do not incur the costs of using their acquired analytic tools will vote no more intelligently than those who have not had the "public good" courses.

Downs [24] has used the "rational ignorance" argument to suggest that government expenditures may be too small in a democracy. On the other hand, he has argued that government expenditures may be too large if the voter is informed only on the issues that affect him to a considerable extent. For example, the voter will favor any proposal if the gains he receives exceed the private costs--if the (differential) benefits he personally receives from the enactment of government policy exceed the taxes he pays. He will, therefore, vote for proposals under the following conditions, regardless of how literate he is or how much his literacy is raised by public goods institutions:

1. the costs are imposed on others and the benefits are general;
2. the costs are imposed on others and the benefits are epecially aimed at his own private interest or those of his particular interest group,
3. the costs are spread through general taxation and the benefits are discriminatory in his favor (and the benefits exceed the costs).

For example, we should expect students, professors, and administrators to vote in economics to vote for politicans who oppose tariffs on the importation of foreign textiles; we should not expect students, professors, and administrators to vote for increased subsidies tohigher education, though taxes to support the subsidies come partly from the poor; we should expect aerospace workers to favor proposals to send men to Mars because such proposal will redistribute income in their favor. If men vote in this way, rationally, fully realizing the arguments against the proposals, either the benefits of public literacy are reduced from what they would be otherwise or the costs of achieving any given level of benefits are raised.

One might object to this line of reasoning on the grounds that people do vote with the welfare of others in mind--a textile worker may vote against a tariff on textile imports in order that others may be able to buy textiles at a lower price. This weakens but does not destroy the argument. There is nothing in the discussion thus far which would not permit the inclusion of charitable feeling in the preference function of the voter, although it does seem obvious that few textile workers support free trade in textiles. Education may, however, increase the number of voters who express charitable feeling at the polls, possibly because, by making voters (including textile workers) aware that tariffs on textiles raise the price of domestic textiles, the cost to the "charitable" voters of supporting tariffs is correspondingly increased. To the degree that there are charitable voters, one can expect a marginal response due to public goods education; however, only those people for whom the charitable benefits exceed the private benefits received directly can be expected to switch their support.

The issues in an election campaign are generally numerous and varied. The typical voter finds it impossible or exorbitantly expensive to consider all the issues in any depth, and, consequently, he may minimize the costs of selecting a candidate by considering only those issues which have the greatest potential benefits exceed the [illegible]onal costs of those issues which he considers, even if it is agreed, for example, that the national income may be reduced. The costs of making decisions bias the voter's choice calculus. The analysis required for the voter to uncover logrolling and the resulting inefficiencies in the total program may be too costly. Therefore, voters who have been given public goods courses will continue to vote their preferences because these issues dominate the platform of the candidate and their choice calculus. Persons who have a high stake in the maintenance of the "military industrial complex" may focus on the candidates' position on military appropriation and ignore many other planks in the platform, which may have a net negative impact on him.

Finally, higher education is not universal. Far fewer than half the high school graduates receive a college degree. Today only fifty percent of high school graduates enroll in a college or university. If higher education radically changes preferences or attitudes (we have assumed throughout our analysis that preferences remain unchanged) one might argue that higher education produces more friction between those who have and have not attended college. The "hard hat" versus "intellectual" controversy popular in the 60's makes government less stable. Unless we are willing to accept a "philosopher king" government rather than democracy, it is difficult to understand the "good citizenship" argument for higher education, given the current participation rate in higher education. Moreover, higher education that is not universal may allow the "educated" to extract more from the government, because they have been educated at the expense of the uneducated.[2]

The good citizenship argument for subsidies to higher education has been primarily based on emotional appeals with little analysis of the collective choice process. Such required courses as economics, sociology, and political science may attempt to instill good citizenship. The mere fact that they are <u>required</u> supports our premise that the individual benefits from these courses may not be sufficient to induce students to valuntarily select them. Secondly, there is some evidence to suggest that these courses may be considered as "inferior goods" as discussed in Chapter II.[3]

Social Allocative Benefits

Welch [75] and Schultz [54] have recently introduced another social benefits argument--in a "technically dynamic economy, educated persons are more adept than less educated persons at critically evaluating new opportunities because they can distinguish more quickly between the systematic and random elements in such an economy..." [54, p. 17]. Thus, it is argued that resources will be allocated more efficiently and much faster because of educated entrepreneurs. The allocative benefits are the sum of two parts: (1) the benefits that accrue to the educated persons as a reward for his expeditious response to the opportunity and (2) the benefit that accrues to the consumer sooner than it would if the production response had occurred with a longer lag. To quote Schultz [54, p. 19], "The educated person who is capable of exploiting such opportunities first (fastest) stands to gain relative to those who respond less expeditiously. Then, as these opportunities are realized under competition, the gains from a set of better production possibilities, for example, are transferred to the intermediate, and through them to the final product, where they become consumer surpluses." Welch found that more educated farmers did have an advantage compared with less educated farmers in responding to the dynamics of growth [75].

Note that this argument contrasts with the good citizenship argument. The allocative social benefits rests on the self-interested gain of educated persons exploiting new opportunities in a dynamic economy.[4] There is no need to introduce a social conscience or social benefit calculus since educated individuals exploit the opportunity for their own gains. The externalities of increased consumer surplus are incidental by-products of the choice calculus of the individual exploiting the opportunity. Following Buchanan and Stubblebine [17] these externalities may be properly termed infra-marginal or Pareto irrelevar.. The benefits that reward the educated person for his expeditious response to the opportunity can be considered a part of his rate of return from education. If the rate of return is sufficient to induce individuals to invest in education wit out subsidies, taking into account the market imperfections discussed previously, then these allocative social benefits would be forthcoming in the absence of subsidies.

On the other hand, the good citizenship argument maintains the educated individual incorporates the potential social benefits into his choice calculus with considerable information cost to himself and negligible private benefits of his informed vote. The student leaving formal classroom instruction must decide whether or not he will maintain his capital stock of knowledge and whether he will use his knowledge in his voting decisions. If the benefits of higher education are truly external to the individual and he is forced to learn as a result of externalities, the student upon leaving the classroom is in the same predicament that he was in before he ever took the coursework: there are no private benefits (of the benefits may be too small to entice him to voluntarily take the courses) and the costs of maintaining the capital stock can easily be greater than the private benefits. He may therefore rationally refuse to maintain the citizenship-related knowledge. To put the point another way, the student may let those aspects of his literacy relating to "intelligent voting" depreciate to zero. What is remembered in the long run may be completely fortuitous. The fact that educators have found that students' retention deteriorates rather rapidly is perfectly understandable from the point of view of public choice theory. The allocative benefit aspects of education may not deteriorate as rapidly as the public good aspects.

Social Benefits of Communications

Another argument for education subsidies is that educated individuals can more readily communicate with each other deriving greater returns from education. It is also argued that because the students study similar things and because of improved communication skills, education can generate greater social compatibility which may reduce the cost of daily living and add more stability to society.

The problem of optimizing social learning in analogous to the classical public goods/externalities problem of the bee keeper and the apple grower. The bee keeper may underproduce bees and honey because he does not privately receive the benefits the bees have on the production of apples, and similarly for the apple grower. If the bee keeper alone expands his holdings of bees, diminishing returns can set in since the input of apple blossoms is held constant; if the number of apple trees is increased at the same time the number of hives is expanded, the percentage increase of honey and apples production can be greater than if either party acted independently. If the bee keeper and apple grower cannot agree (meaning the cost of agreement is too high) to simultaneously expand production, an underallocation of resources in the areas can result. If the enforcement costs are low or nil, a government requirement that the bee keeper and apple grower expand production can be Pareto efficient. Herein lies a justification for compulsory education <u>up to some level</u> (for example, high school). All students can benefit (in a manner simlar to a required expansion of bee and apple production) if certain courses or a certain duration of schooling are required; because each student knows that others will be increasing their literacy levels, and he may want to converse with them and relate to them, the student may be motivated to learn more.

However, the public good argument is considerably weakened if the level of education is not universal (as it is not in higher education). Students with higher education may generate negative externalities in terms of communications on those who do not have degrees. The net effect of higher education may be divisive rather than cohesive.

Conclusion

We have attempted to introduce some logic into the good citizenship argument of higher education rather than appeal to emotions. The Downsian Paradox makes this argument highly questionable as grounds for subsidizing higher education. Moreover, the more recent social allocative benefit argument does not necessarily imply subsidies if these benefits are considered Pareto irrelevant. The good citizenship argument implicity assumes higher education can mold individuals (with preferences, opinions, and attitudes) into good citizens. Since higher education is not universal, one has to wonder if the argument can be used in a democracy. Moreover, Tullock [70, ch. 1] has convincingly argued that preferences are not as plastic as many would have us believe. His argument is that advertisers would find it more efficient to cater to existing preference distributions rather than attempt to shift preferences which may be costly. This, of course, runs counter to Galbraith's thesis. Similarly, in our model faculty and student choice may lead to learning situations where preferences are not drastically altered. In addition, students may emulate faculty preferences for a grade but this emulation may not be lasting.

Considerably more research on voting behavior is necessary to document what might be called an allocative benefit to society of educated persons' voting behavior as opposed to their behavior in the market.

CHAPTER VII

INTERDISCIPLINARY AND MULTIDISCIPLINARY PROGRAMS

Considerable interest and controversy has developed around new undergraduate and graduate programs that involve two or more traditional academic disciplines. We have previously mentioned the number of institutions that offer "freedom of choice" programs. Craeger [21] has reported that 70.6% of the institutions surveyed have interdisciplinary seminars and discussions, and 74.6% of the institutions have interdisciplinary projects. Various organizational structures in the academic community exist to serve these programs. In the hard sciences, for example, integration of biology and chemistry, engineering and chemistry, has been firmly established. However, integration among soft sciences and integration between hard and soft sciences have only recently received widespread appeal. Among the more popular labels for these programs are policy science, urban studies, social policy, and social studies. In this chapter we explore organizing principles for such programs.[1] A model is developed which conceptually delineates multidisciplinary programs from interdisciplinary programs. More importantly it examines some policy implications of pursuing either program. We attempt to identify the reward or incentive devices and the costs of interdisciplinary study from a student, faculty, and organizational viewpoint. In addition, we examine alternative entry and survival characteristics of students and faculty.

Erich Jantsch has presented a typology for classifying and defining various programs, presented in Figure VII-1 [37]. Jantsch deals with epistomological issues not treated in this paper.[2] Our limited objective is to examine the organizational and output characteristics of alternative program designs. For expository purposes, we modify Jantsch's types and give a somewhat different interpretation of the four program groups. Our intent is to concentrate on the input and output characteristics of alternative programs and more specifically the foregone costs (benefits) of students and faculty in pursuing alternative program designs relative to a single discipline. For our purposes,

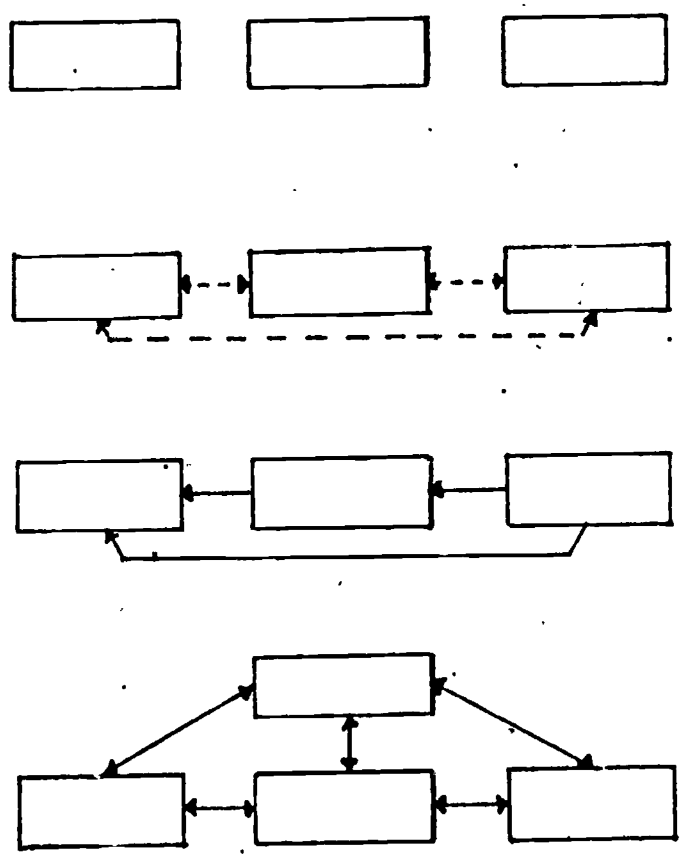
FIGURE VII-1

Multidisciplinarity: no cooperation

Pluridisciplinarity: cooperation without coordination

Cross-disciplinarity: rigid polarization toward specific monodisciplinary concept

Interdisciplinarity: coordination by higher-level concept



Jantsch's first two types (Multidisciplinarity and Pluridisciplinarity) will be defined as multidiscipline programs. In both of these, disciplines are essentially juxtaposed to one another with the student organizing the former and the faculty organizing the la''er. These programs do not explicitly extend the subject matter or analytic framework boundaries of the respective disciplines. On the other ha , we define Cross-disciplinarity and Interdisciplinaity programs (Jantsch's latter types) as extending the boundaries of the respective disciplines in either of two ways. In a Cross-discipline program the boundary of one discipline is extended. We define Interdisciplinary programs as the extension of knowledge in a new dimension not specifically bounded by either the analytical frameworks or the subject matter of the respective disciplines from which it is derived. It utilizes a set of common axioms to derive new theories.[3] For example, public choice can be defined as a discipline that uses the analytical tools of economics as applied to the subject matter of political science.

In summary, we shall concentrate on the production and demand sides of program design of studies involving more than one traditional discipline. We shall not discuss the academic relevance of traditional disciplines.

Multidisciplinary Model

Assume that two traditional disciplines, x_1 and x_2, are to be combined into a single graduate program.[4] The two-discipline model may be expanded to "n" dimensions. These disciplines may be both from the social sciences or one may be from social science and one from natural science. This mix is critical since aptitude and achievement inputs may be considerably more demanding in the latter case than in the former. The options open to the student are represented in Figure VII-2. It is assumed that separate courses are offered side by side with no attempt at integration (for example, team teaching). Program organization is simply some ratio of courses x_1 and x_2 (with necessary prerequisites) taken in the respective disciplines. The student selects the courses, and the ratio of x_1/x_2 within some institutional rule (for example, between Z_1 and Z_2).

Assume x_0 (at the origin) represents the achievement level of an undergraduate who has sufficient prerequisites (achievement) to enter either a graduate program in x_1 or x_2. Further, assume this hypothetical student has sufficient aptitude to successfully achieve or complete a graduate program in either field, given the respective performance standards. That is, he has no comparative advantage (disadvantage) either in an aptitude or achievement sense at the time of entry. The scale is ordinal in that knowledge (courses) is structured like building blocks: $x^3 > x^2 > x^1 > x^0$. Assume x_1^3 is the necessary achievement level in field x_1 to successfully pass comprehensive examinations for a Ph.D. The line from x_1^3 to x_2^3 in Figure VII-2 represents a time constraint (for example, three years) to the student, given his aptitudes. A student with higher aptitudes (but the same relative aptitudes for x_1 and x_2) would be represented by a parallel line to the right of x_1^3 - x_2^3 under the same time constraint of three years. These assumptions about student aptitudes are critical and will be examined in more detail in a later section.

Assume the rays (dotted lines) emanating from the origin represent parameters (institutional constraints) on the allowable mix of x_1 and x_2 to qualify for a multidisciplinary Ph.D. program. The student must achieve a minimum of x_1^1, given he achieves x_2^2 (specialization in x_2) or similarly he must achieve a minimum of x_2^1 if he decides to specialize in x_1, achieving x_1^2. The straight line running from x_1^3 to x_2^3 assumes that one field of knowledge can be sacrificed at a constant rate to achieve another field of knowledge. That is, the opportunity cost of learning x_1, within a time constraint, is the foregone opportunity to learn x_2. We have assumed x_1 and x_2 to be independent from one another and the opportunity cost to be constant: $\frac{\partial x_1}{\partial x_2} = k$.

FIGURE VII-2

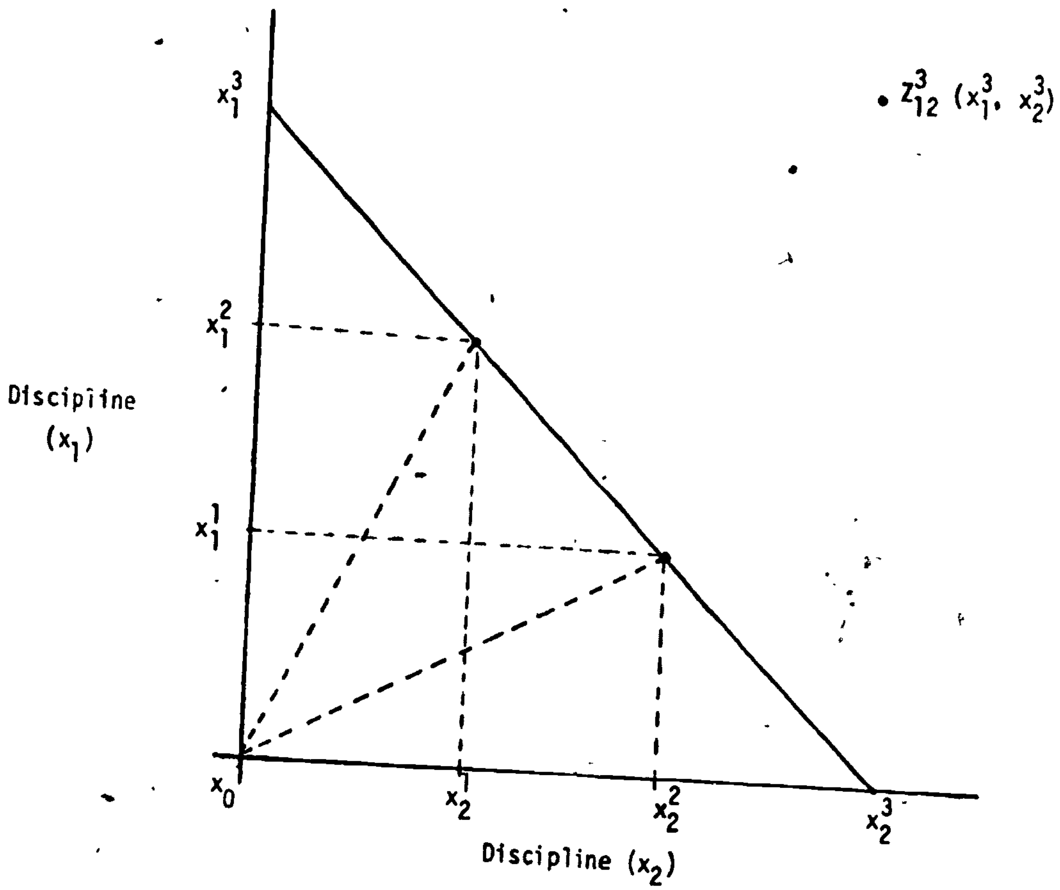
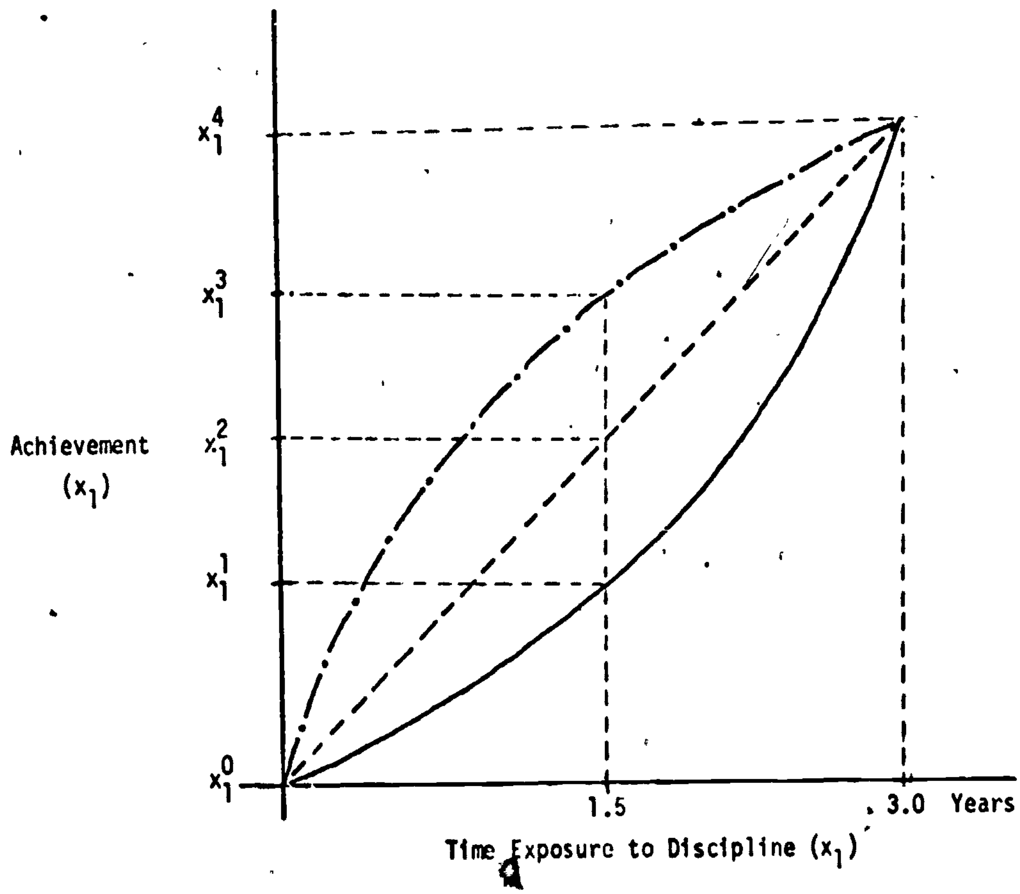


Figure VII-3 represents two alternative hypotheses of learning curves. Consider a single traditional discipline (x_1). The achievement level, x_1^4, (level sufficient to pass comprehensives) within a time constraint of three years may be accomplished in a process sense (over time) in a number of ways. The dotted line represents a linear acquisition of knowledge. The solid line represents achievement increasing at an increasing rate while the dot-dash line represents achievement increasing at a decreasing rate. Definitional

FIGURE VII-3

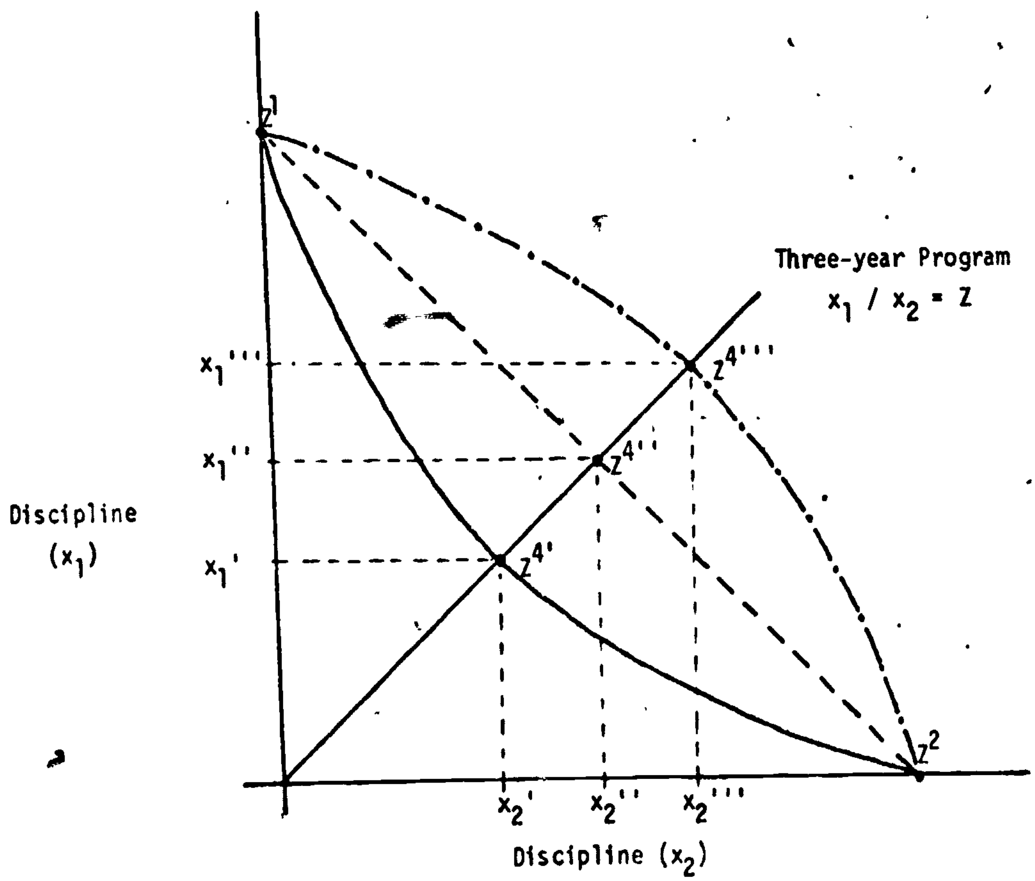


problems arise in interpreting what is measured on the vertical axis. The problem does not arise with our other models which use comparative statics and are not dynamic. The vertical axis is not to be interpreted as course work, but rather the acquisition of knowledge or theory which may be applied to a broad spectrum to facilitate understanding and/or prediction. Speaking from our own discipline (economics) we feel that a learning curve, similar to the solid line, is most representative. Though our evaluation is admittedly subjective, we feel that economics students are not fully aware of the theory ramifications until continued exposure "opens the door" suddenly at some point. (The psychologists' S-shaped learning curve, a case not illustrated here, demonstrates that knowledge increases at a decreasing rate in the initial stage, at an increasing rate in the intermediate stage, and then again at a decreasing rate.)

Another view of the vertical axis is to consider the student's ability to apply abstract theory to specific "real world" circumstances. Such an ability would appear to be essential for such applied theory programs as policy science. A student with limited exposure to a discipline may have a good understanding of generalized models in the abstract but may not have the capacity for application.

The solid line in Figure VII-3 (increasing achievement at an increasing rate from exposure to discipline x_1) may be reinterpreted when two disciplines are considered as both exhibiting achievement increasing at an increasing rate. This is illustrated by the solid line in Figure VII-4 and results in a convexed opportunities tradeoff curve.[5] Students do not expend a sufficient amount of time in either discipline to reach the stage of high increasing returns. The dotted frontier represents a case in which both disciplines have linear learning curves. The dot-dash frontier in Figure VII-4 represents a case where both disciplines have learning curves in which achievement increases at a decreasing rate with the amount of exposure (time) to the disciplines. Each of these frontiers represents an identical time expenditure (three years). The corners (Z^1 and Z^2) of each of the axis represents this particular student specializing

FIGURE VII-4



in a traditional degree program. The tradeoff frontier for multidisciplinary programs is critically affected by the underlying learning curve. For example, if the learning curves for x_1 and x_2 are increasing at an increasing rate ($Z^{4'''}$) then x_2''' and x_1''' are achieved by the student in three yea On the other hand, if learning curves are such that they increase at a decreasing rate ($Z^{4'}$) considerably less achievement is obtained in three years (x_2', x_1').

There may also be interaction effects of multidisciplinary programs that lead to different frontiers aside from the notion of learning curves. If x_1 and x_2 are complementary, then knowledge in one field increases the ability of the student to learn in the other field, p icing the dot-dash frontier. On the other hand, if the two fields are conflicting in the sense that knowledge in field x_1 lowers the ability of the student to learn x_2 (relative to the case where he had no knowledge of x_1) and vice versa, then the tradeoff frontier will look like the solid line in Figure VII-4. In a later section we shall examine some of the implications to multidisciplinary students in terms of job opportunities. Admittedly, the learning curve is a rather abstract notion; however, subjective judgments based on teaching and research experience may as a proxy for objective measures to be considered in the decision process of offering new program designs.

Pluridisciplinary Model

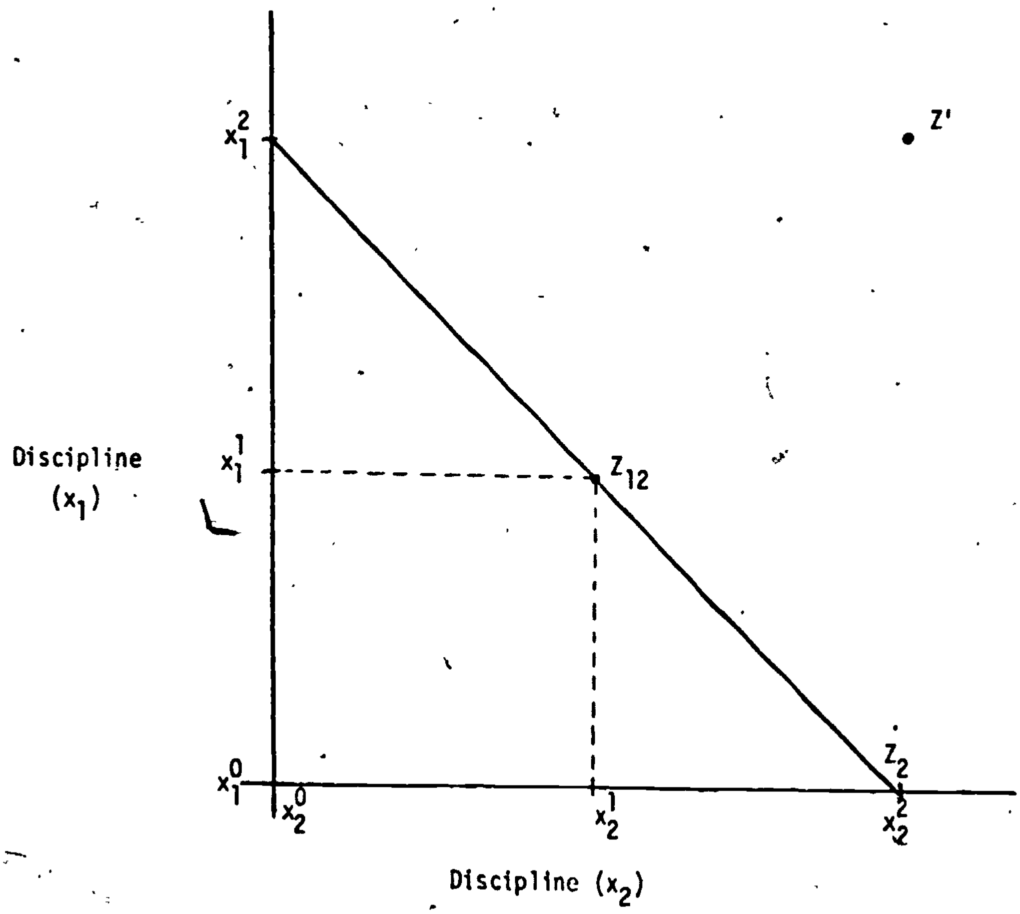
Pluridisciplinarity is defined as faculty cooperation without a high degree of coordination as opposed to multidisciplinarity which involves no faculty cooperation or coordination. In an organizational sense, multidisciplinary programs may be defined as programs where the student designs his own program by taking a block of courses that are not organized from the supply side (faculty). However, in order to obtain a degree the student must satisfy such institutional constraints as a minimum number of semester hours and the accepted ratio of x_1/x_2 courses. A pluridsciplinary program, on the other hand, is either a coordinated program among disciplines that have specific course requirements and/or team-taught courses in which faculty from different disciplines teach certain segments of the course. The distinction between the two programs therefore lies in who makes the decision--demanders (students) or suppliers (faculty) with respect to program structure.

The pluridiscipline program offers some promise of expanding the tradeoff frontier through faculty cooperation by eliminating redundant concepts, thereby leaving more time available in the three-year span for learning (teaching) concepts in the respective disciplines that are distinct and unique to each discipline. For example, the concept of functionalism in sociology appears to be somewhat similar to specialization in economics. Cost-benefit analysis seems to be a component of many political science, economics, and engineering programs. A concerted effort on the part of the faculty would have to be made to avoid semantic and terminology differences in these conceptual similarities. It is assumed that multidisciplinary faculty are drawn from the traditional disciplines and that an incentive structure to encourage involved faculty participation is absent. A later section will discuss the costs to faculty of engaging in a program that involves a strong commitment to understand other disciplines. Therefore, it is assumed that courses or concepts are juxtaposed to one another with limited cooperation that may avoid redundancy as long as faculty costs are not high.

Market and Status Implications of a Multidisciplinary or Pluridisciplinary Program

Figure VII-5 represents achievement possibilities within a three-year time constraint assuming a linear tradeoff frontier. Assume $Z_1\ (x_1^2, x_2^0)$ represents a degree in field x_1 and $Z_2\ (x_1^0, x_2^2)$ a degree in field x_2, and $Z_{12}\ (x_1^1, x_2^1)$ a multidisciplinary degree. The multidisciplinary student who chooses a bundle of courses such as $Z_{12}\ (x_1^1, x_2^1)$ is at a relative disadvantage in achievement at the end of a three-year time constraint when compared with either traditional discipline Z_1 or Z_2 since $x_1^2 > x_1^1$ and $x_2^2 > x_2^1$. The multidisciplinarian, of course, has a comparative advantage in x_1 over the traditional student in x_2. Whether the comparative advantage outweighs the comparative disadvantage or vice versa remains to be seen. A convexed tradeoff curve increases the differential and a concave curve diminishes the differential. This differential may be a sufficient barrier to entry into a traditional academic department in either field x_1 or x_2. The multidisciplinarian may lack the competitive position as a colleague. We have not found data to support or reject this hypothesis. On the positive side, a strong demand for products (students) from multidisciplinary programs would appear to exist where firms, governments, or academic institutions have problems of indivisibility of resources. For example, a junior college may find these students exceptionally well-suited because they do not have adequate resources to hire one specialized student in x_1 <u>and</u> one in x_2. The choice in the absence of Z_{12} is Z_1 <u>or</u> Z_2. Similarly, government agencies and small firms may also have high demands for training such as $Z_{12}\ (x_1^1, x_2^1)$. Agencies, firms, and institutions who can afford to hire at least one x_1 type student <u>and</u> one x_2 type student are presumably better off with students from traditional degree programs. Two students who complete a multidisciplinary program in x_1 and x_2 are not equivalent to two students each of whom completes a program in the traditional disciplines, x_1 and x_2 respectively, (that is, $x_1 + x_2 \neq 2(1/2\ x_1 + 1/2\ x_2)$ since the latter is not multiplicative). That is, the specialized degree has a comparative advantage relative to multidisciplinary student because the specialized student has gone into more

FIGURE VII-5



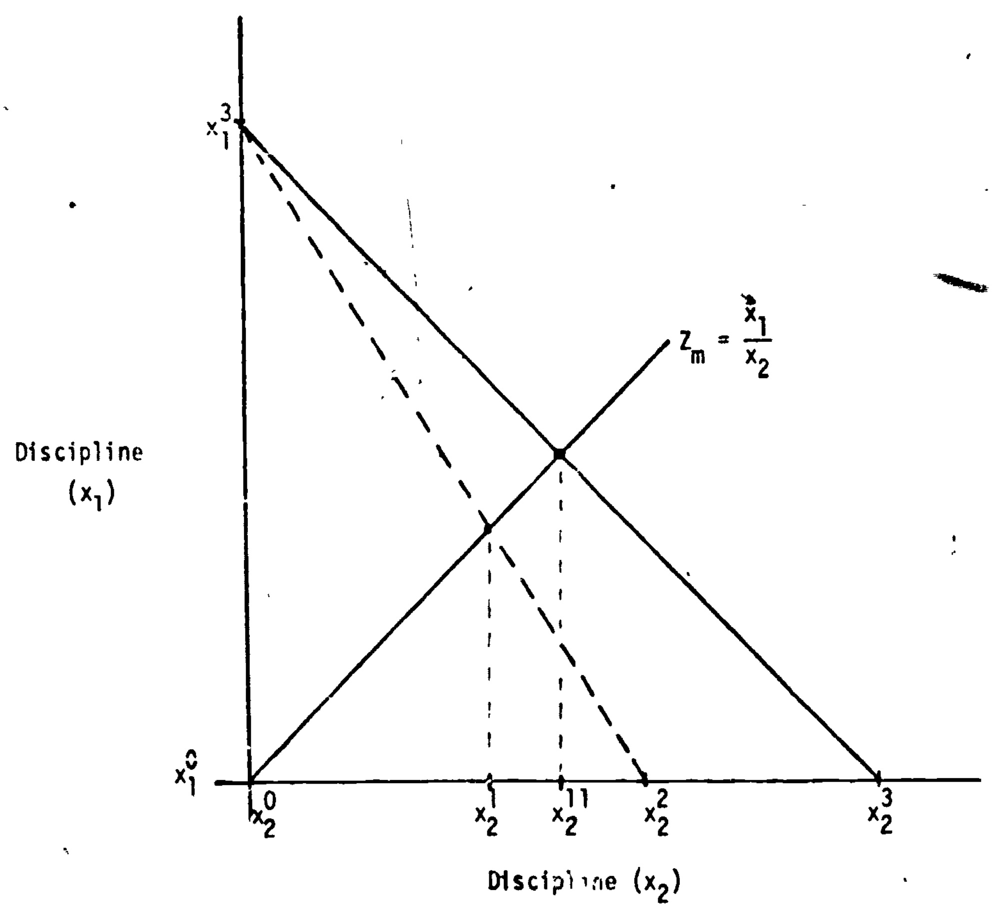
depth. In terms of the knowledge space, one individual who specialized in x_1 and one individual who specialized in x_2 is represented by the point Z' in Figure VII-5, whereas two interdisciplinary students a^ represented by the point Z_{12}. Of course, some departments may find it advantageous to have multidisciplinarians because of the potential cross-fertilization of fields. More will be said on this at a later stage.

Expanding the number of traditional disciplines in a multidisciplinary program from two to "n" increases the student's comparative disadvantages in each field and diminishes the comparative advantages vis-a-vis traditional disciplines. To the extent peer group and status relationships among faculty or professionals are a function of some critical level (threshold) of expertise in an area, the student may find it increasingly difficult to compete in the market as the number of disciplines combined into a program increases, given a certain time expenditure. Assumptions about the learning curve in each discipline become even more critical as the number of disciplines involved in a program increases.

Student's Relative Aptitudes and Achievements

Figure VII-2 assumes that the student has present achievement levels (x_0 at the origin) that enable him to enter either program (x_1 or x_2) without preparatory courses for either discipline. In addition, it is assumed that the student has sufficient aptitudes to successfully compete in either (but not both) program within a three-year period. A student who possesses sufficient aptitudes for either program is represented by the solid line in Figure VII-6. The dotted line represents a student with a low aptitude in program x_2 and a sufficient aptitude to complete program x_1 within three years. In other words, it is assumed that the student represented by the dotted line is not able to reach an achievement level x_3 in three years that is required for graduation if he specializes in x_2 (that is, he has a comparative disadvantage in x_2 relative to x_1).[6] Therefore, a student who chooses a multidisciplinary program may have aptitudes such that he will not be channeled into his area of comparative advantage. Moreover, his comparative disadvantage relative to traditional

FIGURE VII-6



discipline students in x_2 is even greater (x_2' instead of x_2'').

Form a policy viewpoint, it seems that students comtemplating multidisciplinary programs should be made fully aware of the competitors in the job market and the consequences of the curricular choice. Unfortunately, we do not have aptitude measures that enable us to predict potential achievement in specific areas. Graduate school entry is based on undergraduate achievement in terms of courses and area tests (for example, Graduate Record Exams). As the number of disciplines involved in program design increases, the amount of reliable information in terms of past achievement decreases. Lack of sufficient information to establish an entry criterion may result in a number of issues to consider in program design. If the performance criterion (for example, Z_m) in multidisciplinary programs is not to be varied <u>and</u> attrition rates minimized, several alternative courses of action may be followed:

1. Insure that the dsciplines require similar aptitudes.
2. Increase time expenditure for students--that is, spread the course work out over a longer time spand and/or have pre-requisites and/or have students repeat courses.
3. Make expenditures in gaining information on student's relative aptitudes and make selections accordingly (information costs may be quite high.
4. Adjust the performace criterion (for example, level of achievement below Z_m).

Interdisciplinary Programs and Faculty

The preceeding analysis focused on the student. Our definition of multi- and pluri-discipline programs assumes that the student is responsible for "getting it all together," with a minimum level of faculty cooperation (due to a lack of incentive structure) in pluridsciplinary programs. However, a major criticism of a multi- or pluridisciplinary approach is that the burden does rest with the student. Within a time constraint, the student in a multidisciplinary program does not attain the same achievement levels in x_1 or x_2

vis-a-vis students in the traditional disciplines. Therefore, there is a question as to whether a student is able to coordinate the material.

Cross- or interdisciplinary programs are assumed to be organized by faculty, and the faculty has the responsibility for "putting it all together." In the case of a cross-discipline program, a set of axioms derived from one discipline is the focal point, and other disciplines are fed through this axiom set. In an interdisciplinary program a new or eclectic set of axioms are developed towards which all disciplines are directed. Emphasis is on faculty behavior; student abilities play a passive and receptive role in program design and content.[7]

This section considers aspects of interdisciplinary programs in terms of faculty costs and benefits. The aspects covered include: opportunity costs, expected payoffs, time incidence of costs and benefits, aptitudes and achievement levels, psychic and status costs.

The individual faculty member trained in a traditional discipline who engages in interdisciplinary study does so at the cost of foregone opportunities of further research and learning in his traditional discipline. A learning possibilities curve, similar to that in Figure VII-2, could be viewed from the perspective of faculty instead of students. However, according to our previous definition, cross-disciplinary or multidisciplinary programs expand the frontier (extend or generate new theories). In the absence of extension or generation of theory, the program falls under the previous definition--multidisciplinary programs where fields are juxtaposed to one another.

Let us assume for the moment that faculty interaction with other disciplines does not extend the theory of either discipline. The interaction is assumed to be a juxtaposition of the two fields embodied in a single faculty member. This would surely increase his market power since he has a dual discipline, but would not necessarily increase his teaching effectiveness over two persons (one from x_1 and one from x_2). Obviously, this is an extreme case, since knowledge of two fields by one person presumably increases his perception of both fields. However, for an individual to gain human capital such as Z^3_{12} (x^3_1, x^3_2), illustrated in Figure VII-2 requires a significant investment costs (for example, six or eight years) for a single individual. In addition, it is not clear that specialization in a single discipline in the same time constraint would not have greater returns to the individual. Therefore, a priori, it would seem that only a program with a specific intent to develop new theories is justified in combining disciplines into a single organization. A program that realize this intent may not leave the student in a significant comparative disadvantage vis-a-vis a single discipline program.[8]

The extension (cross-disciplinary) or new (interdisciplinary) theories may be organized in several ways. It appears that a necessary prerequisite is that the traditionally trained person change his environment from constant contact with his own discipline to constant contact with other disciplines. Physical location of the faculty from the respective disciplines within one organizational structure may contribute to this environment. This factor, however, which may be a necessary condition, may not be a sufficient condition for the development of an extended or new theory. In any event, new programs are being designed this way. Interaction with other disciplines may occur in a number of ways. A faculty member in x_1 can take courses in x_2. Faculty member x_1 and x_2 may interact with a common objective to integrate and develop theory. Whatever the means to obtain the end (extended or new theory), the traditionally trained person has an opportunity cost of engaging in interdisciplinary program development.

There is a high degree of uncertainty in the future realization and payoffs of an interdisciplinary program. Different individuals (faculty) may have various expectations of the program's realizations, in spite of a strong desire for the development of an interdisciplinary program. The expected payoffs of remaining in one's own discipline are relatively certain because the faculty member has a grasp of the entire framework and information costs are therefore lower. Weighed against the certainty of the single-discipline approach is a high degree of payoff uncertainty in interdisciplinary work. This uncertainty is two fold: (1) the program's future realization is uncertain and (2) the individual's ability to grasp and integrate theories other than he is trained for is also uncertain. Therefore, the costs (foregone opportunities in the traditional field) of interdisciplinary work are immediate, whereas the benefits (expected payoffs) are distant and more uncertain than the returns from the traditional program. In a present value sense it can be argued that the returns to faculty engaging in interdisciplinary activity are negative or below that which could be achieved in traditional programs.

A faculty member may not have the achievement levels or aptitude levels (expected or real) to learn another discipline without tremendous time and opportunity costs. That is, if the faculty member has aptitude levels similar to the dotted curve in Figure VII-6, the investment costs of engaging in interdisciplinary work involving x_2 are even higher. Furthermore, there would appear to be psychic costs in attempting to learn other disciplines. Integration of the disciplines may require rejecting some of the traditional framework. After a number of years of mental conditioning devoted to learning a discipline, such rejection may be extremely disturbing.

Finally, the uncertainty costs are presumably less to the faculty member who has sufficiently established himself in a traditional discipline relative to a younger member. If the interdisciplinary program fails, the younger member may not find it easy to transfer back to his traditional field, at least not as easy as his more established colleague. In summary, there may be considerable talk about interdisciplinary programs and strong preferences for integrated disciplines. However, because of the constraints or opportunity costs of traditionally trained faculty, we hypothesize their behavior will be inconsistent with their stated objectives. That is, there will be only token attempts to integrate.

Decision Rules

An organizational structure is necessary to design and to carry out a new program. There are a number of alternative organizational structures and possible decision rules. One alternative is a program director who makes all decisions. A director with dictatorial decision power has the potential ability to inflict considerable costs upon the faculty and is unlikely to be selected as faculty have more democratic choices available to them in traditional departments.[9] Committee organization seems to be the rule in academia. Assume our interdisciplinary program develops committees with an implicit constitutional rule that the respective disciplines have equal representation on all committees. Assume three traditional disciplines A, B, and C are drawn upon to form an interdisciplinary program. Note again that equal representation may be necessary to attract faculty from other disciplines.

This section introduces the voting paradox which has been considered an anomaly in the literature and perhaps underestimated, since we do not have a great deal of empirical information on the process of voting. One empirical study has demonstrated that the "paradox of voting" has occurred in university elections [46].

Table 1 is constructed to illustrate the "paradox" with a three-member committee which can be generalized to "n" dimensions.

Table 1

Individuals

	R	I	II	III
1	a	A	B	C
2	n	B	C	A
3	k	C	A	B

It is assumed that there are three alternative motions (A, B, C) which are to be voted on under a majority rule. The columns represent the preference orderings of the three members (disciplines). If alternative A is put up against alternative B in a straight majority vote it can be seen that I and II vote for A and A wins. Similarly, if B is put up against C, B wins. If A is preferred to B and B is preferred to C, it should follow that A is preferred to C. However, we see that C is preferred to A, given the preference orderings of I, II, III. This outcome has been termed the voting paradox. For a number of reasons, the importance of the paradox may be limited. Of course, the relevant question is the frequency with which the paradox occurs. "If rankings are equally likely over all the alternatives for all persons, and if the number of voters becomes large, in the three-candidate or three-alternative model, the probability of a cyclical majority occurring approaches 9 percent" [13, p. 119].

On some issues (alternatives) of this hypothetical three-member committee, the frequency of preferences as illustrated in Table 1 may be quite high, given our assumptions. For example, consider the alternative methods of student evaluation. Assume student A has an economic background, B has a sociology background, and C a political science background. Assume the three students are in an interdisciplinary course that utilizes team teaching. It may be likely that the first-order preference for each faculty member (I, II, III) corresponds to the students' backgrounds. The ordering of students may reflect the information and background of each faculty mmeber. The information costs to a sociologist to obtain information for evaluating a student's knowledge of economics and political science may be extremely high. Assuming second- and third-order preferences are equally likely, a pair-wise comparison of student performances may increase to 25 percent the probability of the "paradox" occurring.[10] This assumes that the interdisciplinary faculty team uses a majority rule in ranking students. If each student needed a majority of faculty to give him high marks (that is, first preference ordering) in order to pass, we should expect a high attrition rate.

The occurrence of the paradox leads to considerable confusion to the student who is not able to understand his relative class standing. For example, student A may ask faculty members I and III how he compares with student B and may receive encouragement, but when A asks faculty members II and III about his performance relative to C he may receive discouragement. If the program uses a unanimity rule and preferences like those in Table 1 are frequent then the attrition rate (flunk out rate) will be relatively high.

In practice, the paradox may not occur since the inconsistency is obvious. Table 1 is simply an ordinal ranking. It is likely that the preference intensities of some faculty may vary considerably among different students. For example, referring to Table 1, faculty member II may feel very strongly about keeping student B in the program while faculty member I ranks A over B and faculty member II ranks C and A over B, although the intensity of their rankings may be so low as to be almost indifferent. In other words, students A and C, who have backgrounds similar to professors I and II respectively, are ranked higher simply because the professors lack information which would allow them to evaluate these students in fields other than their own. Under this hypothetical example, B is likely to receive the highest ranking (an "A"). The outcome is a result of vote-trading between faculty member II and faculty members I and III. That is, I and III may not vote their first preferenece because they do not feel intensely about their first preference relative to the second and third preferences. Note the public choice problems of grading that do not arise in traditional disciplines.

The analysis suggests that implicit or explict vote trading (logrolling) may be more prevalent in interdisciplinary programs than in traditional disciplines due to the increased probability that preferences are determined in a unique manner, leading to the occurrence of the "paradox."[11] The analysis suggests that the optimal strategy for a student is that he have at least one faculty member of an interdisciplinary team who feels extremely intense about his performance.

The "paradox" has been discussed in terms of student evaluation, but it may also occur in committee decisions on other issues where first-order preferences are uniquely determined by a faculty member's discipline. For example, statistical methodologies in the social sciences seem to differ considerably. Decisions concerning course offerings that are derivations of the traditional disciplines are another example. Finally, if faculty members are not responsible to a single departmental organization, it is likely that vote-trading will not occur as frequently, since there are fewer issues to trade (promotions, hiring, or new faculty, etc.)

The importance of the paradox may have been overstated in this chpater. However, little attention has been given to the organizational and decision rules in multidisciplinary or interdisciplinary programs. These collective decision rules become all the more important, when by definition, these programs are an attempt to reconcile different perspectives and frameworks of the traditional disciplines. The choice of decision rules may be a major factor that inhibits a convergence of traditional disciplines.

Finally, it is not clear that proposed interdisciplinary programs should inolve teaching. If the intent of these programs is to develop or extend theoretical frameworks, teaching may detract from this goal which may properly be considered research. Funding arragnements tied to student enrollment may, of course, be the reason that these new programs are implemented without a developed theoretical framework.

Conclusion

University resource allocation is an important policy issue. Too often decisions are made in the university community that reflect vested interest groups within academia. This chapter has examined some tradeoffs that must be made when considering the development of new multidisciplinary or interdisciplinary programs. We have tried to be neutral about the value of these programs relative to the traditional discipline approach. Rather than criticize the programs, we hopefully presented a useful set of ideas to those institutions contemplating new programs in multidisciplinary or interdisciplinary studies. The classification of programs in terms of student and faculty organization is an operational rather than epistomological concept and seems to necessarily be the first step in program design. Institutions considering multidisciplinary programs should consider the market potential for such students. Government and private organizations that have problems of resource divisibility represent the best market potential for products (graduates) of these programs. The comparative disadvantage of students in multidiscipline programs relative to the traditional disciplines increase as the number of disciplines involved increases.[12]

Similarly in interdisciplinary programs, as the number of disciplines increases faculty costs of integrating disciplines also increase. Finally, the decision-making rules that determine student evaluation and program design may lead to unexpected outcomes. All of these factors suggest that multidisciplinary and interdisciplinary programs should be initially restricted to two disciplines.[13] The two-discipline approach may represent the greatest gains from exchange and minimize the opportunity and decision-making costs.

CHAPTER VIII: CONCLUSIONS

One can argue that the emergence of disciplines is the result of attempting to minimize the externalities associated with public good type lectures. Critics of the status quo in higher education seem to implicitly have a tutorial faculty-student exchange model in mind when advocating change. Clearly such arrangements would internalize the externalities associated with student and faculty interactions in the learning process; however, significant economies of scale associated with classrooms would have to be sacrificed. In addition, critics are often expressing an opinion that certain preferences (for example, students) should count more than others (for example, faculty or taxpayers). We have used the realistic assumption that the professor has the right to determine what is taught (he defines the student's field of choice) and the right to rank students according to his preferences. These rights are granted under academic freedom. While the professor can be considered as a despot in the classroom, the student still has considerable freedom of choice. He can choose to allocate his time according to his preferences and can vote with his feet (that is, change curricula). Consider the Coase Theorem in this context. Suppose students had the right to determine what is taught and how they were ranked. Would the allocative outcome be considerably different?

First, such a property right arrangement would raise a number of collective choice problems. Some decision rule would be necessary to detemine what is taught and the criteria for ranking. If a rule of unanimity were used, it is likely that nothing would be taught and no ranking scheme would be decided upon. If majority rule, then the median student's preferences are satisfied with externalities generated to non-median students. Moreover, a grade distribution is likely to result with the minority getting D's and F's. It is not clear that the grade distribution would reflect the ordinal ranking of students in an achievement sense. Considerable student effort would be devoted to logrolling that would otherwise be devoted to scholastic activities or leisure. A full discussion of this issue is beyond the scope of this book. Further research along the lines of Tiebout's model versus voting models would appear to be fruitful in examining alternative property right arrangements for students and faculty.

We devoted a considerable portion of this book to examining the inherent difficulties of def ning the marginal product of professors (for example, good teaching). Academic freedom permits decentralized decision making (individual professor's preferences count) which has attributes of a competitive environment, while at the same time creates difficulties of devising an incentive system on a performance criteria. On the other hand, standardization of exams and/or the definition of knowledge would inhibit competition and raise a number of collective choice problems. Professors would mechanistically attempt to maximize student scores with little motivation to extend inquiry beyond the "standardized" boundaries of knowledge. Academic freedom versus stadardization represents a dilemma for which we see no pat answers.

We have applied the tools of consumer choice theory, wage theory, and collective choice theory to learning. We have attempted to take a positive approach in describing student and faculty behavior as "it is" rather than how it "ought" to be. Even though our definitions of utility functions and learning functions have been extremely simple, the implications derived from them ha e a certain degree of complexity. While theoretically we have been able to distinguish between aptitudes (a rate concept), and achievement (a stock concept), operationally this is a difficult task. Moreover, there is the operational difficulty of externally defining opportunity cost associated with any choice (learning) process. We have used the heavy pound of "ceteris paribus" to do so theoretically.

Finally, there is the problem of data to support the models. We have focused on time allocations of students and faculty in developing our theory of learning. It is not likely that data on time allocations will be forthcoming in the near future. The data required would entail considerable expense. However, we do feel our analysis should lead to improved empirical studies given existing data by emphasizing the general framework in which students and faculty make choices. Partial analysis of behavior in a single classroom in essence denies student choice or the existence of alternatives. Moreover we have defined improvements of efficiency in learning in a way that does not ignore costs imposed on students and faculty. Efficiency definitions to date have for the most part ignored opportunity costs by focusing on physical resource costs.

We hope this book has presented a new and useful framework to analyze learning. Further integration with psychological learning theories would appear to be a fruitful avenue of further research. The integration of a comparative statics methodology with a dynamic approach would undoubtedly improve the analysis. An examination of other institutional arrangements such as the European system would also provide some indirect evidence to support the models presented in this book. We are perhaps optimistic in our view that we have "learned" something about learning.

NOTES

Chapter I: Introduction

[1] Attempts to Build "expectations" or "risk attitudes" into economic models are similar in intent to psychology models. We do not have measures of these attitudes independent of revealed behavior.

[2] Not only is there absent the notion of opportunity cost and inherent difficulties of measurement from an external observer's viewpoint as discussed by Buchanan [12], but also the educational psychologists have not attempted to deal with problems of interpersonal utility comparisions in much of the surveys on attitudes, values, and opinions.

Chapter II: Student Choice

[1] We assume the proper signs for the second order conditions.

[2] We are considering the learning process as defined over these fields of knowledge. This assumption is far more restrictive than the psychologists' which would consider the behavior of children not touching a burner on a stove as learning.

[3] We assume aptitudes are constant. This assumption is in marked contrast to psychological learning theories which examine the variability of aptitudes to arrive at learning curves. For example, the linear relationship in Figure II-1 is often drawn as an "S"-shaped learning curve. For comparative static purposes, the constant aptitude assumption is not as critical relative to attempts at defining learning curves. See [62] for models that do not assume constancy. These models lead in the direction of corner solutions of "specializing" in knowledge.

[4] An alternative approach would have been to start with Becker's [6] full income model. Full income would have been equivalent to full achievement where time devoted to activities other than scholastic effort would be an incidental by-product

[5] We could substitute foregone income for leisure. However, we are primarily considering the full-time student who has limited job opportunities and confines his activity to the campus.

[6] Echause [26] has presented evidence that those who have higher educational levels seem to expend more hours working in their jobs. This is, of course, a different setting from that we are considering.

[7] Again, assuming the preferences of both students are identical.

[8] Note that this argument is not necessarily symetrical. That is, a student who has test scores below the average student body scores may be rationed out by

formal admission's criteria. On the other hand, students with test scores above the average do not appear to choose schools that are highly divergent from their individual scores.

[9] We shall go into considerably more discussion of the relationship between grades and faculty preferences under academic freedom in Chapter III.

[10] We are not considering grades to be based on gain scores but rather the final achievement scores of students represented by the final exam or a weighting of exams. We also assume grades are generally based on an ordinal ranking and not a cardinal ranking.

[11] We do not wish to imply that in fact there is a normal distribution of achievement such that the mean equals the median. Our argument can be generally applied to distributions other than a normal distribution.

[12] If variance in achievement is permitted, then criterion reference testing is similar to normative reference testing which involves a distribution of achievement levels among students. We are considering only full-time students usually defined as taking a minimum number of courses per semester. Of course, time adjustments can be made to adjust to normative reference testing by students not taking what is classified as a full load.

[13] We have not introduced goods and services other than education into the student's utility function. If he were to pay the full resource cost of his education, it would be necessary to consider the tradeoffs involved in an increase consumption of knowledge for which he has a comparative disadvantage versus a decrease in the consumption of other goods and services or more generally a decrease in income.

[14] Again, the distinction between the two criteria largely disappears if students can adjust their course load. However, full-time status, defined as carrying a minimum number of courses, conveys certain advantages such as lower tuition, scholarships, loans, etc. Note that if we defined full-time status as a minimum time expenditure rather than course load, taking three credit hours per semester may be considered full time for some students if they choose some fields (that is, comparative disadvantage).

[15] We are assuming that grades are a constant function of student effort. If grades are based on a normal distribution, it is likely that the boundary of the feasible set will be concave. Similarly, if aptitudes are not constant, the boundary will be non-linear. See [62]. It is also unlikely that a corner solution will be chosen, since the student would have to repeat the course resulting in a higher time expenditure for the degree.

[15] Field x_1 can be considered as Albert's major for which he prefers to receive relatively high grades (B) even at the expense of lower grades (D) in x_2.

[17] Staaf [62] used SAT verbal and math scores and CLEP verbal and math scores as proxies for the ability rate of substitution in a regression to predict the probability of curricular choice.

[18] The rate of change would be considerably higher if we considered more narrowly defined fields such as switches within one curricular group (for example, switch from sociology to political science in the social sciences curriculum) or if we considered multiple switches within a student's college experience.

[19] It sould be noted that the number of observations for each cell was quite small. In addition, the standard errors were high. This analysis is only suggestive and a much larger sample would be desirable.

[20] The correlation between four-year cumulative grade point average and final two-year average grade point average is only .42 [48, pp. 23-24].

[21] A study at Virginia Polytechnic Institute and State University [8] indicates that those students who switch tend to have a success rate as high as those who do not switch. This evidence also indirectly supports the differences in performance criteria and the pattern of redistribution to lower performance curricula.

[22] This section is an abstracted version of a published article [63].

[23] In addition, it is conceivable that preferences may be such that less of x_2 is chosen (that is, a Giffen good).

[24] Other studies on pass/fail reveal similar results. However, Feldmesser's methodology appears to be more satisfactory since he concealed the intent of the study and considered a student's entire bundle of courses as well as obtaining data on student time expenditures in various courses.

Chapter III: Faculty Choice

[1] Important exceptions are Buchanan and Devletoglou [16] and Breneman [9].

[2] Following Niskanen [47, p. 15] a bureaucracy can be characterized as: (1) the owners and employers of these organizations or bureaus do not appropriate any part of the difference between revenues and costs as personal income; (2) some part of the recurring revenues of the organization are derived from other than the sale of output at a per-unit rate.

[3] We fully recognize that the totality of knowledge is not defined by professors. We are examining learning only in the context of a formal institutional process. A student who reads a book that has no relationship to his course work is no doubt learning. In this sense the psychologist's definition of learning is far more general than ours.

[4] There are of course broad constraints on what is taught. For example, today there are few, if any, geographers who would teach that the earth is flat although there are other concepts that are not well-settled.

[5] This may well be happening if faculty are paid on the basis of student evaluations. See Chapter IV on Grade Inflation.

[6] We shall present evidence that teaching does not appear to enter into salary determinations in spite of public announcement.

[7] We assume the professor satisfies some minimum threshold of effort devoted to teaching such as attending lectures and administering exams. This effort is what Adam Smith refers to as "to perform it in as careless and slovenly a manner as that authority will permit." The authority in this case consists of administrators and legislators. Therefore, we assume $E_i > 0$ in all cases.

[8] In another sense faculty behavior may not be considered as charity. The professor in ranking students in his class essentially screens out those students whom he will not have to deal with later on (in advanced courses). Thus, he makes his job easier in the sense that he will have to devote less effort for any given achievement level if he can screen low aptitude students out. For a detailed discussion of the distributional question see [32].

[9] The reader should consult the article [15] for a full explanation of the model.

[10] We leave to the reader the figuring out of the effects of different aptitude levels and different prior achievement levels of two classes.

[11] Efficiency in learning is not very well defined in the literature. Often what is called efficiency is simply a faculty member's higher effort levels. In the absence of an incentive system to induce higher effort levels, it is no wonder that few of these so-called innovations are adopted. Our efficiency definitions require either a lower time expenditure on the part of the student <u>or</u> professor for any given level of achievement. A more general definition would also include other factors of production (that is, buildings, machines, etc.). See McKenzie [43] for a discussion of the effects of a change in technology in teacher evaluations.

[12] Stiglitz does examine the case of comparative advantage. We wish to relate this case with the professor's role of grading.

[13] There were also a number of students who withdrew who were just barely maintaining the minimum C average.

[14] Some studies [26] are indicating that the rate of return to drop-outs is higher than degree completers. The rate of return may be higher but the salary of the degree holder appears higher than drop-outs when the cost of investment is excluded.

[15] As a side note self-employed persons, aside from the professions, tend not to have high educational levels. This fact may partially be explained by the absence of the joint production process and no need for external labels. (screening) since the employer and employee are one in the same.

[16] This analysis is not applicable for high aptitude students who expend considerable effort since their class rank will be high regardless of the shape of the professor's grade distribution.

Chapter IV

[1] Salary figures are adjusted by the consumer price index. Thus, the nominal change in average salaries was 4.3% from 1970 to 1971 which is below the change in the consumer price index.

[2] Note that formula budgeting internal to a university may not mathematically be determined such as receiving one full-time faculty position for every 320 earned student hours. However, at the margin, we would argue that budget increases will go to departments that experience in increase in enrollment as opposed to departments that experience a decrease.

[3] The student protests on campuses in the sixties has also led to administrators catering to student preferences. Campus riots and discruptions can cause legislators to react negatively to future appropriations.

[4] See Freeman [29] for a model that looks at the effects of a change in relative wage rates on curricular choice. Freeman is essentially assuming the relative non-pecuniary benefits across curricula do not change and looks at a change in relative wage rates. We assume relative wage rates are constant and look at changes in relative non-pecuniary benefits (that is, leisure) from a change in the relative price of a curriculum (that is, increase grades). He examines a different margin than we do, so in a sense the two models are compatible. A more general model of student choice would include future incomes as well as the factors we consider.

[5] Taubman and Wales [66] consider higher education in the aggregated and not the potential gains from identifying (labeling) a student's comparative advantage. Therefore, their estimates are understated relative to a case where students were not channeled.

[6] This chapter is similar to the discussion of pecuniary externalities, where grades play the analogous role of prices.

Chapter V

[1] Some have also argued that the relationship is symetrical in that teaching adds to research ability.

[2] It should be noted that one can view some research as a teaching outcome in the future when the research becomes an accepted part of the stock of knowledge and widely disseminated. Thus, one can think of an expected present value of research in terms of teaching outcomes.

[3] Token payments to good teaching often come in the form of teaching awards or excellence in good teaching. These payments are seldom very high ($100 or $200) and usually given only on a once and for all basis with some schools stipulating that faculty are ineligible to receive further awards until a certain time period has expired.

[4] In addition, principles teachers can often make an agreement that their textbooks will be used, thus generating additional income in the form of royalties.

[5] If we were to draw a relative wage rate line on Figure V-1 it would be perfectly elastic resulting in a corner solution at Z which maximizes income.

[6] It should be noted that there are probably diminishing returns to publications after a threshold has been reached. Thus, we might expect either more leisure or teaching activities as a professor's "vita" expands.

[7] Figure V-1 is borrowed from Buchanan [11, p. 138] who used it in a slightly different context. The same sort of analysis of research and teaching as joint products is developed in much more detail in an article by Nerlov [44].

[8] One could also calculate the lifetime earnings of students to arrive at an even larger benefit/cost ratio of quality institutions.

Chapter VI

[1] The citizenship argument for public education in economics is summarized in the following statement: "Economic literacy is vital to the survival of the American society....Our human freedoms, as reflected in our democratic form of government, depend upon the decision making of millions of individual citizess. Our living standards, so long the envy of other peoples, can grow no faster than the soundness of the economic decisions made by the people. Finally, our ability to meet our obligations abroad and to defend ourselves rests to a large degree on economic wisdom at home" [52, p. 9].

[2] This argument as well as the previous argument rests on the degree to which individuals are charitable towards others. See Tullock [71] for a discussion of what seems to be a lack of charity in the political process.

[3] Since the private benefits of these types of courses are low, we should expect lower effort levels from students taking these courses.

[4] This sort of motivation is often apparent by the introductory comments of students taking principles of economics courses. We have often heard the statement that students feel economics will teach them about the stock market.

Chapter VII

[1] This chapter is a revised version of an unpublished paper by one of the authors and Francis X. Tannian of the Division of Urban Affairs, University of Delaware. The experiences of designing a Ph. D. program in urban affairs led to the development of this paper. The authors are indebted to Francis X. Tannian for his permission to use the paper.

[2]Jantsch refines and elaborates on his types in more detail in his article. In addition, there is one higher level called "Transdiciplinarity" which is a multilevel coordination of entire education/innovation system.

[3]Jantsch distinguishes between teleological, normative, and purpositive levels of interdisciplinary studies.

[4]The analysis may be extended to the undergraduate level with considerably weaker conclusions especially with regard to market implications.

[5]The convexed opportunities curve obtains with either one discipline (x_1) representing increasing returns and the other discpline (x_2) constant returns or both representing increasing returns.

[6]Expanding the time expenditure beyond three or four years may result in a zero or negative discounted net return to education, unless future payoffs are extremely high.

[7]Passive in the sense that he has limited responsibility for developing substantive interdisciplinary studies.

[8]As Gordon Tullock has indicated [61] some theories seem to be the result of "accidents" and, therefore, it may be questionable whether organization will lead to theoretical developments. In addition, we believe that new theories cannot be derived from any arbitrary set of concepts or frameworks in the respective disciplines, but requires narrowing the field to a subset of "basic" and fundamental behav ·ral postulates or axioms that are as neutral as possible with respect to th normative aspects of the respective disciplines.

[9]There are, of couse, some areas, that the faculty may agree to a dictatorial rule. These areas may be administrative tasks or decicions which faculty are indifferent or decision-making costs are too high--duties similar to the traditional department head or chairman.

[10]Second and third order preferences may of course not be equally likely. If preference orderings are like Table I rather consistently, the probability of the paradox occurring is increased. However, if, for example, sociology and political science rank economics as a second order preference frequently, the probability of the paradox occurring is decreased considerably.

[11]Explicit vote trading may be taken to mean I will pass your student if you pass my student. Of course, the traditional discipline courses are taught by one member of the faculty and grades are not determined by committee decions.

[12]A multidisciplinary student has a comparative advantage and disadvantage relative to a student from a single discipline. He has no comparative advantage when compared with a number of students from different traditional disciplines.

[13] ote that the voting paradox requires three or more members.

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SCHOLASTIC CHOICE: AN ECONOMIC MODEL OF STUDENT BEHAVIOR*

I. INTRODUCTION

Each year colleges and universities invest substantial resources in their attempts to gather information on students' attitudes, preferences, and opinions. Educational psychologists and counselors feel that the information obtained is valuable to students for curriculum and occupational choices. However, in spite of counseling, nearly half of all students switch broad curriculum groups[1] before obtaining a degree. The educational psychologists base their explanation of this phenomenon on the dynamic changes in student preferences.[2] We believe that this approach suffers, as do most other preference-oriented arguments, from being difficult or impossible to deal with operationally.

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1 We are defining our curricula broadly to exclude switching between closely related disciplines. For example, a switch from political science to sociology is excluded, while a switch from civil engineering to sociology is included.

2 More accurately, educational psychologists tend not to use a choice model framework. Emphasis appears to be placed on survey instruments using variables or indices of people-money-originality orientation [2]. Others have used the Opinion, Attitudes, Interest survey (OAIS) and conclude: "students have tended to sort themselves out in major fields fairly well in line with the OAIS predictions of major field interest" [3, p. 24].

We proposed to treat student curriculum choice with the framework of ordinary consumer demand theory and to develop an operational means of predicting the likelihood of a given student switching broad curriculum groups. Section II of this paper sets out a theory of choice based on the maximization of utility subject to time and ability constraints. Section III presents an application of the model to the statistical prediction of curriculum switching probabilities. Finally, Section IV will discuss the implications of the theory for analyzing university politics.

II. THE MODEL

The economic theory of choice stresses not only preference but also the contraints which limit the set of feasible alternatives available. Our approach concentrates on the constraint side of the choice calculus by implicitly assuming that student preferences do not change. Students actually switching curriculum groups are assumed to do so because they have acquired more information about their alternatives.[3] Student preferences are for "bundles" of courses which represent the fulfillment of alternative degree requirements. A student selecting a given bundle (degree program) has essentially agreed to conform to a set of explicit rules governing that particular bundle. These rules involve certain distributive (university-wide) and major (departmental) course requirements that must be fulfilled. Also, a minimum overall grade point average (GPA) must be achieved in order to graduate.

To illustrate student choice, let us consider a hypothetical student with average (moderate) aptitudes in two fields of study such as social science (Y) and natural science (Z). Given a limited amount of time for course assignments, reading, etc., our average student will face a feasible set of course grades bounded by the straight line representing an average GPA.[4] This is illustrated by Figure 1.

Suppose the student chooses to allocate all of his time to course Z. Then he will earn an "A" in this course and an "F" in the other.[5] This

3 At present we shall exclude changes in relative earnings potentials from consideration. This will not affect our results qualitatively but may be of significance in formulating a more elaborate empirical model.

4 There is, in fact, a third dimension to this constraint since the student may substitute between study and leisure time, thereby shifting his attainable GPA. It can be shown that the partial analysis we present is also valid for this more general case. This is also true if we consider other than a constant rate of ability substitution or the practice of distributing grades according to the normal distribution, both of which would imply a more concave grade production possibilities curve (see Staaf [5], pp. 187–195).

5 These measures are assumed to represent objective rankings of the knowledge gained in a particular course.

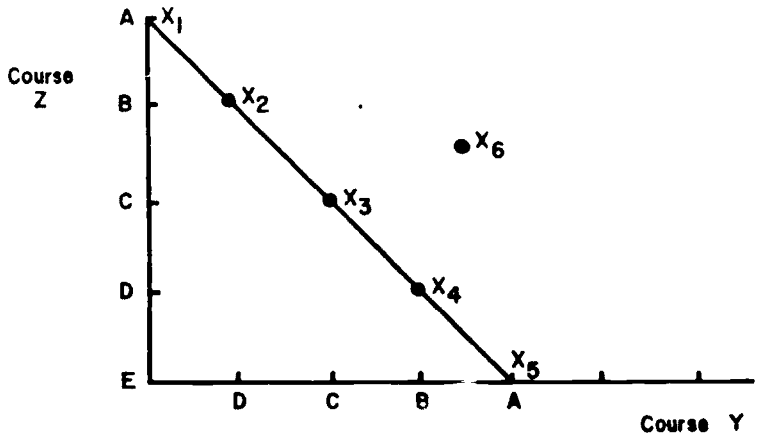

FIGURE 1
THE FEASIBLE SET

results in a "C" average. Point X_3 represents equal time allocations in both Z and Y.[6] This result is again a "C" average. Note that the line X_1X_5 does in fact place a bound on the feasible set. There is no way for our student to attain point X_6. However, a student with greater than average aptitudes will face a constraint to the right of X_1X_5. The particular bundle chosen from the set of feasible alternatives (X_1, X_2, X_3, X_4, X_5) depends on the student's relative preferences for Y versus Z.

Next let us compare our student (named Albert) with another student (named Isaac) who has unequal relative aptitudes but the same relative preferences for Y and Z. This case is illustrated in Figure 2. We have drawn two constraints through point X_3 which represents equal average GPAs for Albert and Isaac.[7] The slope of Isaac's constraint indicates that he has a comparative advantage in course Y. He will, therefore, choose course bundle X_I which contains relatively more of course Y than does Albert's bundle X_A. With differences in aptitudes, each student will concentrate on the field in which he has the higher relative aptitude (comparative advantage). Note that if Isaac were to choose the same bundle as Albert, he would find himself at a point such as X'_A where both his GPA and his level of satisfaction (U_O) would be lower.

Now let us extend our analysis to include responses to institutional requirements—in particular, the minimum GPA. We may consider degree programs (curricula) as being a vector of Y and Z imposed by course requirements. It is not likely that an incoming freshman is fully aware of his

6 His equilibrium choice will be that which equates his rate of technical substitution in grade production (here equal to unity) with his marginal rate of substitution in the consumption of the two courses.

7 The substitution effect we are analyzing is equivalent to the Hicks definition.

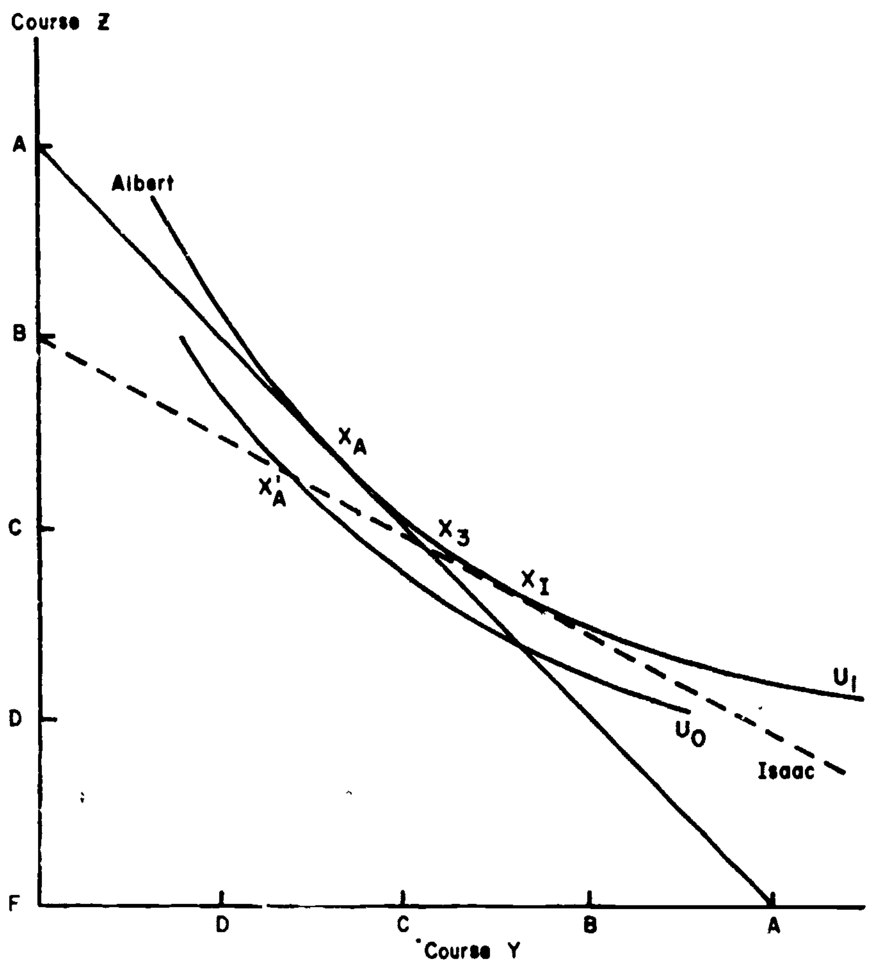

FIGURE 2
STUDENT CHOICE

attainable set in the absence of experience.[8] The average student will, therefore, choose his curriculum on the basis of preferences subject to his average aptitude constraint. Eventually, however, the information flowing to him through the grading system will force him to switch in the direction of the curriculum in which he has the highest comparative advantage if he is to avoid flunking out. Note that a well-endowed student (such as someone at point X_4 of Figure 1) will not find the GPA constraint binding, and so he has no incentive to switch away from his initial choice. Note that any of the

8 High school experience may define broad areas of aptitude, but the range of choices is extremely limited.

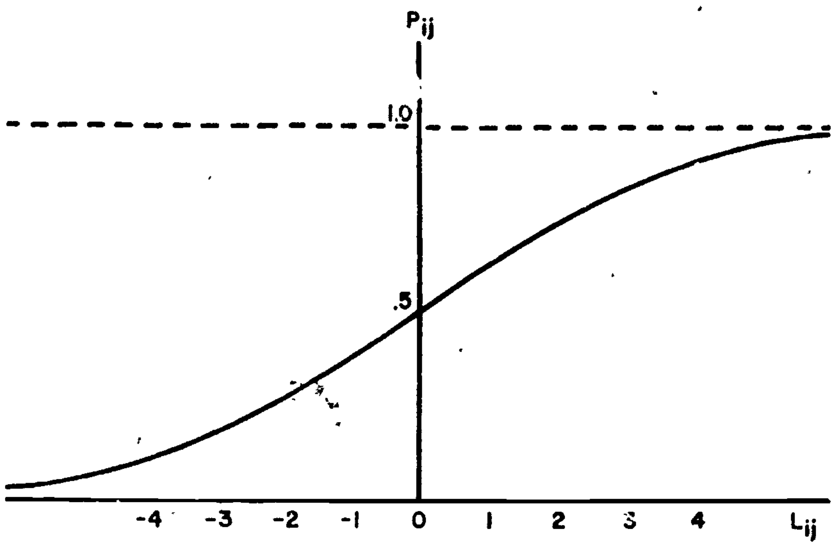

FIGURE 3
THE LOGIT TRANSFORMATION

observed switching by well-endowed students will tend to be symmetrical between curriculum groups and of relatively minor importance in the aggregate.

Our prediction, based on the above analysis, is that the probability of a given student switching curricula is negatively related to the level of his aptitudes. After discussing an empirical test of this prediction, we will elaborate a few implications of the analysis and its possible extensions.

III. EMPIRICAL IMPLEMENTATION

Our problem is to formulate a model suitable for predicting the probability that a given student will switch curriculum groups. The standard linear model is not acceptable since predicted probabilities outside the range 0 to 1 must be excluded. Let us consider the ratio $P_{ij}/(1 - P_{ij})$ to be the odds in favor of a positive response (a curriculum switch) under the condition (V_i, Q_j). V_i represents the student's verbal SAT score and Q_j represents his quantitative score, where 1 implies a high score, 2 a medium score, and 3 a low score. These odds range from 0 to ∞ as P_{ij} ranges from 0 to 1. The logit of these odds,

$$L_{ij} = \log_e [P_{ij}/(1 - P_{ij})]$$

has the desired property, that is, a range from $-\infty$ to $+\infty$ as shown in Figure 3.

TABLE 1
PROPORTION OF MALE STUDENTS SWITCHING CURRICULUM GROUPS BETWEEN FRESHMAN AND SENIOR YEARS BY SAT SCORE[a]
(Number of Observations in Parentheses)

Quantitative	Verbal High	Verbal Medium	Verbal Low	Total Number
High	.28 (39)	.28 (18)	.33 (12)	(69)
Medium	.21 (29)	.37 (19)	.56 (18)	(66)
Low	.40 (5)	.39 (18)	.35 (37)	(60)
Total number	(73)	(55)	(67)	(195)

a The groups are divided at the 33rd and 66th percentiles.

Our data are from the cohort of University of Delaware students entering the freshman class in 1966 and graduating in 1970. The sample is restricted to those students whose freshman and senior curriculum choices were within three aggregated curriculum groups defined as: (1) *Sciences*—physical science, biological science, engineering, nursing; (2) *Liberal Arts*—arts and humanities, social sciences; (3) *Other*—education, home economics, business, physical education. A student whose senior curriculum group differed from the one he chose as a freshman is said to have switched curricula. The University of Delaware is a state school that has an admission policy favoring residents. In addition, 40 percent of the class is from only five school districts in the state. The average freshman was graduated in the top fifth of his class, with SAT scores about one-half standard deviation above the mean for U.S. college freshmen. Therefore, students are aggregated with respect to SAT scores using the distribution of scores within the sample rather than the national distribution. These factors suggest that the student data used in our analysis are relatively homogeneous in exposure to curriculum and other forms of institutional constraints, student attitudes toward the grading system, and achievement levels.

We will estimate the effect of SAT scores on the logit using the technique described by Theil [6]. The linear logit specification based on Table 1 is:

$$L_{ij} = a + V_i + Q_j$$

We may choose $V_1 = Q_1 = 0$ since L_{11} is thereby normalized to a. The parameter estimates for Table 1 (with standard errors in parentheses) are as follows:

TABLE 2
ESTIMATED PROBABILITIES FROM LOGIC SPECIFICATION
(Discrepancies in Parentheses)

	Verbal		
Quantitative	High	Medium	Low
High	.25	.33	.38
	(.03)	(−.05)	(−.05)
Medium	.29	.37	.4[illegible]
	(−.08)	(0.00)	(.13)
Low	.26	.34	.40
	(.14)	(.05)	(−.05)

Note: $X_4^2 = 3.70$. $X_4^2\ (.5) = 3.36$.

$a = -1.11\ (0.31)$: the logit estimate of the proportion of students with high verbal and quantitative scores switching curriculum groups.
$V_2 = 0.38\ (0.41)$: the effect on the logit of a medium rather than a high verbal score.
$V_3 = 0.62\ (0.41)$: the effect of a low rather than a high verbal score.
$Q_2 = 0.21\ (0.39)$: the effect of a medium rather than a high quantitative score.
$Q_3 = 0.07\ (0.13)$: the effect of a low rather than a high quantitative score.

While the large standard errors imply imprecision in the estimates (see Table 2), the overall validity of the specification suggests satisfactory agreement of the model and the data.[9] However, if this method is to be used to predict student curriculum choices, a much larger sample is desirable. We believe that the positive sign of each of the SAT score effects is in substantial agreement with our theoretical prediction.

IV. CONCLUSIONS

Our evidence clearly supports the view that students are channeled into the curriculum groups for which they have a comparative advantage. It is useful to extend the analysis further to predict possible changes in university structure that might be induced as the economic and political environment becomes less favorable to higher education.

First, we can relax our implicit assumption that all curriculum groups

9 See [6], p. 115, for a description of this test. An additional analysis for females failed to achieve a satisfactory level of significance.

maintain identical performance standards. This assumption would have led us to predict that the curriculum distribution of a cohort of students in their freshman and senior years should be the same; that is, the gains and losses by curriculum groups should be symmetrical. However, several studies [1, 2, 5] indicate that the gains and losses are markedly assymetrical. Curriculum groups such as engineering, biological sciences, and the physical sciences tend to be net losers, while education, business, and the social sciences tend to be net gainers [1, 2, 5].

Data collected at the University of Delaware suggest a reason for the asymmetrical redistribution of students. Eleven curriculum groups were ranked according to average scores on two external examinations given during students' sophomore and senior years. The examinations were the College Level Examination Program (CLEP) and the Graduate Record Examination (GRE). The subject matter areas on both examinations were natural science, social science, and humanities. The results show that physical science students, for example, scored above education students in all three areas. Also, the rank correlation coefficient between external test score (that is, CLEP and GRE) and cumulative four-year GPA is .46.[10] In addition, the correlation between external test scores and the last two-year GPA is −.39 (significantly different from zero at a 99 percent level of confidence). Finally, grade averages for physical science, biological science, engineering, and humanities are lower in the rank order for the last two years, while the positions of home economics, elementary education, and physical education are higher. All of this evidence points toward larger differences in performance criteria across curricula.

Now, how can our findings be applied to university decision-making? Clearly, performance standards are analogous to prices in terms of resource allocation. Curriculum groups may undertake a great deal of "gaming" in the form of adjusting relative prices (grades) in the face of serious fiscal difficulties. Our model and others based on competition among departments suggest that in order to maintain budgets and staff, departments may undertake a policy of grade inflation. As a consequence of this, we would predict degree devaluation. As an alternative, suppose that the university required all professors to adhere to a strict standard grade distribution. This would mean that all faculty, departments, and curriculum groups would have identical grade distributions. The assymetrical redistribution of students among curriculum groups would tend to become symmetrical. The policy implications of such a move are interesting. "Gaming" could no longer take the form of relative price adjustments. Instead, departments would compete on

10 The correlation between four-year cumulative GPA and final two-year GPA is only .42 [4, pp. 23–24]