AN ABSTRACT OF THE THESIS OF

Ahmad Saeed Khan for the degree of Doctor of Philosophy

in Agricultural and Resource Economics presented on July 22, 1977

Title: AN ECONOMIC ANALYSIS OF THE DEMAND FOR GRADUATE EDUCATION

Abstract approved: Richard S. Johnston

This study is an economic analysis of enrollment demand for graduate education at Oregon State University as well as in the United States. For the analysis of Oregon State University data on new graduate enrollment, data were obtained for 27 academic departments with 10 observations per department. The most important objective of this study was to determine the reasons for variation in demand for graduate education at Oregon State University and in the United States. Monetary gains associated with graduate education and the quality of the graduate program offered by the institution were hypothesized to have a significant, positive effect on graduate enrollment demand. The size of the tuition was hypothesized to be inversely related to the number of new enrollments demanded. The level of admission requirements was hypothesized to have a significant, negative effect on graduate enrollment demand. It was also hypothesized that the demand for graduate enrollment varies significantly among disciplines.

Along with a "size of tuition" variable, shown by other investigators to be related to college enrollment, the institutional model

incorporated the monetary gains associated with graduate education, minimum grade point average for admission and binary variables representing the academic department variables hypothesized here also to be associated with graduate enrollment demand.

From the estimated coefficients of the institutional model, it was concluded that the demand for new graduate enrollment varies significantly among most of the disciplines. Also, it was concluded that, for Oregon State University, a proportional increase in the graduate tuition level will be associated with a less than proportional decrease in the number of enrollments demanded. The positive sign and the statistical significance of the estimated coefficient associated with the monetary gains variable support the human capital view of the demand for graduate education.

For the national model only 12 observations on first year graduate enrollment were available. The unemployment rate for master's and doctoral degree holders and family income were hypothesized to have negative and positive effects, respectively, on enrollment demand for graduate education. For the ordinary least square estimation, the Durbin-Watson test was inconclusive. A generalized least square procedure was used to correct for the presence of a first order auto-regressive error term structure. The results supported the hypothesis of an inverse relationship between the unemployment rate and graduate enrollment demand. Results with respect to the role of income, however, were mixed.

An important implication of the institutional estimation is that, for an institution faced with graduate enrollment ceilings, any attempt by the administration to increase the grade point average for admission will place additional pressure on that institution to live within the enrollment ceilings. On the other hand, data limitations precluded examining the possibility that, for some disciplines and for some institutions, the demand-rationing aspect of the minimum grade point average requirement will overwhelm the "quality of the program" component. For such cases an increase in the grade point average requirement may, in fact, reduce enrollment demand.

An important implication of the national estimation is that one should be very cautious in recommending some kind of income enhancing program as a vehicle for increasing the demand for graduate enrollment. However, because it was not possible to measure the effect of direct financial assistance on enrollment demand, one cannot infer that increasing the availability of financial assistance for graduate study would not increase the enrollment demand.

An Economic Analysis of the Demand for Graduate Education

by

Ahmad Saeed Khan

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Completed July 22, 1977

Commencement June 1978

APPROVED:

Associate Professor of Agricultural and Resource Economics
in charge of major

Head of Department of Agricultural and Resource Economics

Dean of Graduate School

Date thesis is presented July 22, 1977

Typed by Barbara York for Ahmad Saeed Khan

ACKNOWLEDGEMENTS

To acknowledge all help received in various phases of this thesis would be extremely difficult, but major contributions deserve citation.

First and foremost was the role of my major professor, Dr. Richard Johnston -- without his advice, guidance, consultation, and patience, this project would have floundered. Other committee members, including Dr. Bruce Rettig, Dr. William Brown, and Dr. Roger Petersen, provided constructive criticism and helpful suggestions at various stages.

I am obliged to Dr. Emery Castle for his guidance and advice at the early stages of this study.

The Department of Agricultural and Resource Economics at Oregon State University should be recognized for supporting the project in numerous ways. Support and encouragement from faculty members and fellow graduate students was most appreciated.

Last but not the least, my wife, Rifat, deserves thanks for her patience and encouragement throughout the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

AN ECONOMIC ANALYSIS OF THE DEMAND FOR GRADUATE EDUCATION

I. INTRODUCTION

"On the whole, over the years, the graduate school has done a great deal for our society: It has grown from a few fields training a few students in institutions to a large and impressive national system of advanced training. It has trained a large body of professional people for American higher education and trained them in subject matter. It has increasingly trained staff for the secondary and elementary school system, especially at the level of leadership. It has increasingly trained personnel for administrative as well as research posts in government and industry. In addition to providing personnel for enriched graduate work on its own campus, it has led a number of educational experiments at the college level and it produces a number of leading texts used throughout the system of higher education... Its leading personnel have increasingly served as advisors and consultants on the largest issues of our national life -- foreign relations, economic affairs, scientific policy, civil rights and liberties, health and welfare... (36)."

Problem Statement

Education is of considerable interest and a matter of much concern to laymen, school administrators, policy makers and researchers. The demand for graduate education increased substantially during the 1960's. For example, in the United States, in 1960, the number of new enrollees in master's and doctoral programs was 197,000 and this figure reached 525,000 by 1971. During this period, enrollment trended upward, except for the year 1971. However, new graduate enrollment each fall term during 1966-75 at Oregon State University did not have the same upward trend but showed some fluctuations.[1] The absolute

---

1/ The reason for the selection of Oregon State University to estimate the enrollment demand is discussed in Chapter II.

increase in enrollments at the national level is not surprising because graduate education is considered to be a powerful vehicle for socioeconomic mobility and a major determinant of social stability. It produces a pool of highly skilled manpower needed to support the technical progress of our society (44).

In the past, all of the studies relating to the demand for new enrollment expressed enrollment as a ratio of those in a position to choose to go on to higher education. If we measure the first year enrollments in graduate programs in the United States relative to the number of bachelor's degrees awarded, then the ratio for these years does not form any trend but shows fluctuations. The expression of first year graduate enrollments as a ratio of bachelor's degrees awarded will allow one to compare the results of this investigation with the others. Figure 1 plots these enrollment ratios, first year graduate enrollments and bachelor's degrees awarded for the years 1960-71. The ratio of enrollments to the number of bachelor's degrees awarded is measured along the left hand vertical axis. The horizontal axis indicates the years under investigation. First year graduate enrollments and bachelor's degrees are measured along the right hand vertical axis. The enrollment ratios formed an upward trend until 1965, showed a slight decline in 1966, peaked in 1967, then formed a declining trend which continued for the rest of the period under investigation.

Figure 2 shows fall term new graduate enrollments at Oregon State University for the period 1966 to 1975. The horizontal axis gives the years and the vertical axis measures the new fall term graduate

Figure 1. First year graduate enrollment in the United States, B.S. degrees awarded and enrollment ratio (1960-1971).

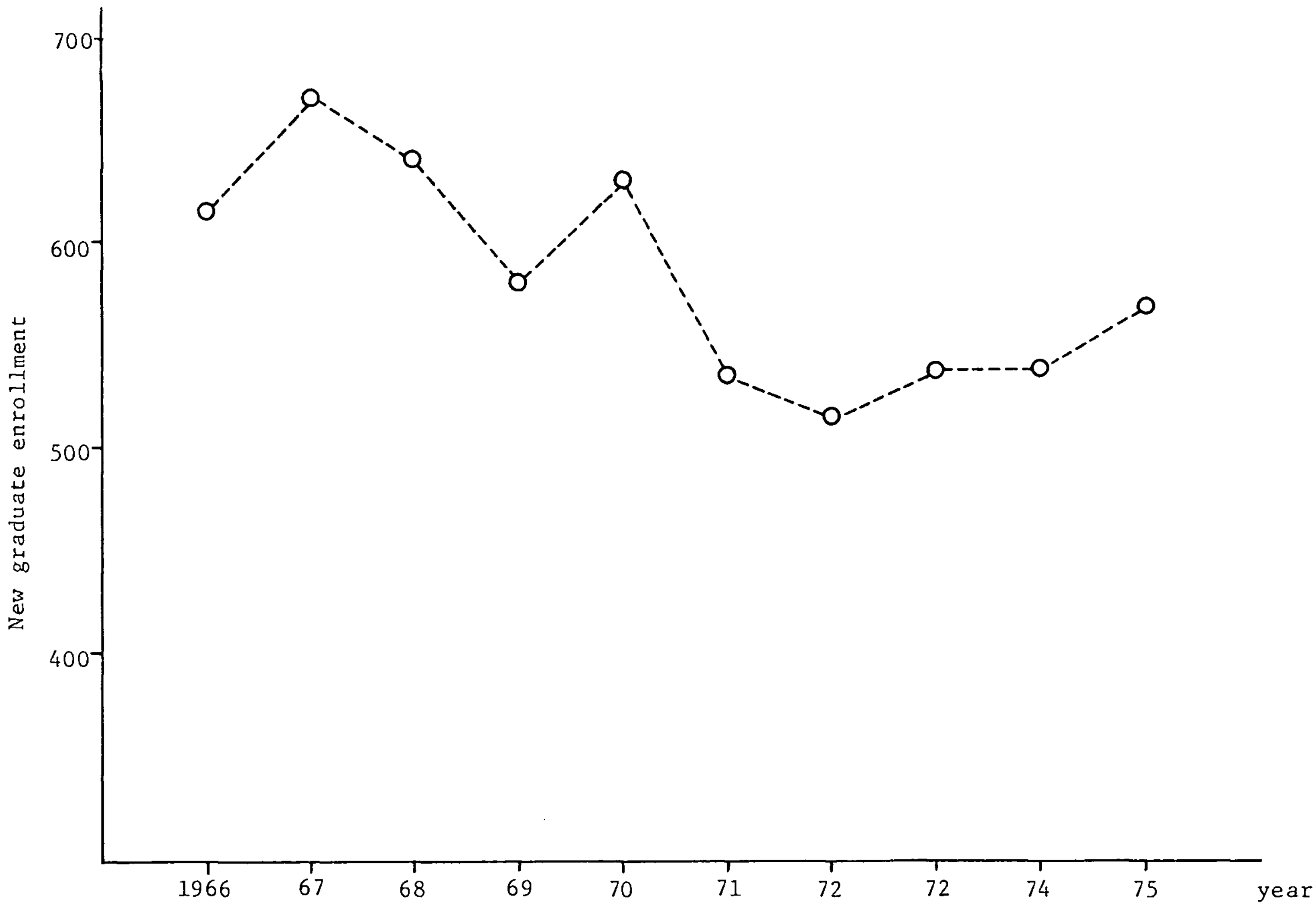

Figure 2. First term graduate enrollment at Oregon State University, Fall 1966 - Fall 1975.

enrollments. These enrollments peaked in 1967, formed a downward trend till 1972 with the exception of 1970 when new enrollment was the second highest. However, an upward trend existed for the years of 1972-75.

Figure 1 and Figure 2 indicate that for the years 1967-70, first year enrollments and the enrollment ratios at the national level form opposing trends whereas the fall term new graduate enrollments at Oregon State University show fluctuations for the same period. An educational consulting firm estimated that the freshman enrollment at four year U.S. colleges will drop 23.5 percent in the next 15 years. However, the graduate enrollments will continue to rise during the same period (12).

Education policy makers tend to think of enrollment and enrollment trends as independent variables that affect the educational system but are not affected by it (44). Nevertheless, the institutions do affect both their own enrollment and that of other institutions by tuition and fees, curricula, the quality of their graduate faculty, and by providing financial support to graduate students. The policy makers at the national level as well as at the institutional level need information about the major economic variables affecting graduate enrollment demand in order to evaluate the impact of alternative policies on future graduate enrollment.

Within the past two decades, economic theorists and empirical researchers have dealt increasingly with the problems related to human capital. Most of the work is done to calculate the rate of return from four year college education. Econometric estimates of the demand for higher education in the United States have a comparatively recent history. The literature on the subject appears to begin in 1967 (7). With the exception of time series analyses by Campbell and Siegel (7) and Galper and Dunn (22) most of the studies are cross-sectional (11, 14, 41). The pioneers (7) defined their dependent variable as the ratio of undergraduate enrollments in four year institutions of higher education to the number of 18-24 year old high school graduates in the civilian population. They regressed this ratio over the period of 1919 to 1964 against real tuition costs and real disposable income per household. They neglected the human-capital explanation of the demand for college education by considering education only as a consumption good. The later studies, which were cross sectional, estimated the demand for college education using such exogenous variables as parental education, father's occupation, social status of the family, test scores, tuition and fees (8, 14, 26).

A search of the literature reveals that no attempt has been made either to calculate the rate of return or to estimate the effect of various investment related economic variables on enrollment demand for graduate education. Two separate studies are needed to calculate the rate of return from graduate education and to estimate the demand for graduate education. Due to time limitations, in this study we will attempt to estimate the demand for graduate education at the national as well as at the institutional level.

Objectives

Three general objectives for this study were identified:

1. To identify selected social and economic

variables relating to demand determination for graduate education.

2. To develop an econometric model which allows determination of the influence of various economic variables on the demand for graduate education.

3. To test the relation and significance of the exogenous variables on enrollment demand at the institutional as well as at the national level by using institutional and national cross-sectional and time-series data, respectively.

II. THE CONCEPTUAL FRAMEWORK

The economic analysis herein relies on conventional demand theory (15, 27), investment theory (1, 2, 45) and involves some non-market constraints.

The Investment Approach

Irving Fisher (16) and H. von Thünen (53) were among the few who have thought of human beings as capital. However, Marshall (35) said that while human beings are incontestable capital from an abstract and mathematical point of view, it would not be practical to apply the concept of capital to human beings.

The pathbreaking work of Becker (1), Schultz (45), Blaug (2), and Weisbrod (54) in the early and mid 1960's inaugurated a strong revival among economists in viewing human beings as capital. According to this viewpoint, an individual's lifetime earnings can be interpreted as a series of returns to investments made in his formal education, vocational training, on-the-job experience, health and other activities comprising his human capital.

Let us consider a hypothetical situation in which a college graduate (bachelor's degree holder) is faced with an "either - or" decision to join a graduate school or to enter the labor force. Human capital theory dictates that a college graduate will purchase a graduate education if the present value of the expected stream of benefits resulting from the graduate education exceeds its present cost.

The value of an individual's graduate education (V) is equal to the discounted stream of earnings he expects over his working life. It is calculated by the formula:

$$V = \sum_{t=1}^{n} (Y_t)/(1 + r)^t \tag{2.1}$$

where ... n = number of years remaining in an individual's earning life.

Y_t = expected earnings in year t

r = discount rate. It is assumed for simplicity that the discount rate remains the same in each year.

Graduate education requires an investment. The present value of the private cost associated with graduate education will be:

$$C = \sum_{t=1}^{n} (C_t)/(1 + r)^t \tag{2.2}$$

where ...C_t = expenditure on human capital augmenting activities in year t.

The net present value of earnings from graduate education may be thought of as the present value of a stream of the differences between annual gross earnings and annual costs associated with graduate education. Then the present value of the net earnings stream resulting from graduate education would be:

$$V_n = \sum_{t=1}^{n} (Y_t - C_t)/(1 + r)^t \tag{2.3}$$

or

$$V_n = \sum_{t=1}^{n} (Z_t)/(1 + r)^t \qquad (2.4)$$

where ...$Z_t = (Y_t - C_t)$

If "X" were the net earnings stream associated with another activity, for example, one in which the college graduate enters the labor force rather than joining the graduate school, then the present value of the net earning stream of "X" would be:

$$X = \sum_{t=1}^{n} (X_t)/(1 + r)^t \qquad (2.5)$$

Then the present value of the gains (G) from graduate education relative to the activity associated with "X" can be calculated as:

$$G = \sum_{t=1}^{n} (Z_t)/(1 + r)^t - \sum_{t=1}^{n} (X_t)/(1 + r)^t \qquad (2.6)$$

There will be a G associated with every X.

The private benefits from the graduate education is the sum of 1. monetary benefits -- the additional lifetime earnings resulting from the graduate education, and 2. the additional psychic benefits gained through broadened occupational opportunities, prestige, and social and cultural awareness made possible by the graduate education. The monetary benefits make the purchase of graduate education similar to an investment in physical capital, while the psychic benefits make graduate education similar to what Becker (1) calls a "consumer durable" in that it yields future consumption benefits.

The relevant private cost of graduate education likewise appears in three forms: 1. Direct institutional outlays such as tuition and fees, cost of books and supplies, and differential living costs of going to school. These direct costs are influenced by the method by which they are financed. Financial aid in the form of tuition remission, research assistantships,teaching assistantships, grants, fellowships, low or zero interest loans, or government benefits serves to reduce educational expenses of an individual, thus increasing the expected net returns to graduate education. 2. Opportunity costs -- any additional income the student could have been earning had he not been in graduate school. The opportunity cost of graduate education will be influenced by the prevailing unemployment rate for college graduates. The higher the unemployment rate for college graduates, the lower will be the opportunity cost associated with graduate education. 3. Finally, certain aspects of graduate education may be viewed as work. Such activities can also be considered costs of obtaining graduate education. The magnitude of these psychic costs (e.g., the burden and pressure of studying and, for some students, the undesirability of being away from home) depends upon the type and quality of the particular institution of higher education (IHE) and the individual's taste for graduate education.

The benefits from graduate education do not come with perfect certainty. For example, Marshall (35) said, "not much less than a generation elapses between the choice by parents of a skilled trade for one of their children, and his reaping the full results of their choice. And meanwhile the character of the trade may have been almost revolutionized by changes, on which some probably threw long shadows before them, but others were such as could not have been foreseen even by the shrewdest person and those best acquainted with the circumstances of the trade" and "circumstances by which the earnings are determined are less capable of being foreseen (than those for machinery)."

There has always been considerable uncertainty about the length of life, one of the important determinants of the returns. Uncertainty also exists about the return to an individual of a given age and ability because of numerous events that are not predictable. Hence investment in graduate education is like most other investments in that it involves risks. Since the benefits from graduate education will be realized in the future, their value must be estimated on the basis of prevailing knowledge. Circumstances may change and the value of graduate education may become greater or less than had been anticipated.

A college graduate makes his/her decision to enter the graduate school on the basis of expected benefits and costs associated with graduate education. For a given set of costs and benefits there will be an implied rate of return.[2] The rate of return is defined as the

---

2/ It is variously called -- the rate of return, internal rate of return, internal rate, marginal efficiency of capital, marginal efficiency of investment, and rate of return over cost.

discounting rate that makes the present value of gains of equation 2.6 equal to zero (29) and can be calculated as:

$$0 = \sum_{t=1}^{n} (Z_t)/(1+m)^t - \sum_{t=1}^{n} (X_t)/(1+m)^t \qquad (2.7)$$

where ... m is the internal rate of return.

Since the benefits and costs associated with graduate education are pecuniary as well as psychic in nature, the rate of return will also have two components: 1. psychic rate of return -- related to non-pecuniary benefits and costs, and 2. private pecuniary rate of return -- associated with the monetary costs and benefits from the graduate education. It was assumed that the college graduates place some sort of monetary valuation upon the stream of the expected psychic benefits and costs; whether or not they actually do this is not clear to us. Also it was assumed that the college graduates act according to the total rate of return, with due allowance for risk and uncertainty involved in graduate education investment. In addition, I assumed that college graduates can borrow on expected earnings from graduate education. They would compare their expected rate of return to the market interest rate. The college graduate will enter the graduate school if the expected rate of return is greater than or equal to the market interest rate.

Let us consider a hypothetical situation in which the expected rate of return for a particular college graduate is greater than the market interest rate.[3] If we assume that monetary as well as psychic returns associated with graduate education can be realized only after obtaining a master's or doctoral degree, then the demand function for investment will give us only two points as shown in Figure 3.

The vertical axis measures the expected rate of return (marginal efficiency of investment, m) as well as the market interest rate. The horizontal axis gives the level of investment. If i_0 and i_1 are the amounts of investment required to complete master's and doctoral programs, respectively, then "M" and "M'" will be the expected rates of return associated with these degrees, respectively, and "r" function represents the supply of funds schedule.[4]

If we modify the above so that each level of investment brings an expected rate of return, then the demand function for investment in graduate education may be a discontinuous function "$NFMEM'$" as shown in Figure 4. The demand function is discontinuous because the monetary as well as the psychic benefits associated with graduate education increase substantially when an individual completes his master's or doctoral program. Similar to the demand function, the supply of funds schedule "r" is also a discontinuous function.[5]

3/ Practically, for some individuals the rate of return to investment in graduate education will be greater than the market interest rate and will be less for others.

4/ These demand and supply functions are hypothetical in nature. The shape of these functions is a matter of empirical investigation. However, we did assume that total gains associated with the Ph.D. degree are greater than those associated with the master's degree.

5/ The demand and supply schedules of investment shown in Figure 4 are hypothetical. The shape and slope of these curves is a question of empirical investigation.

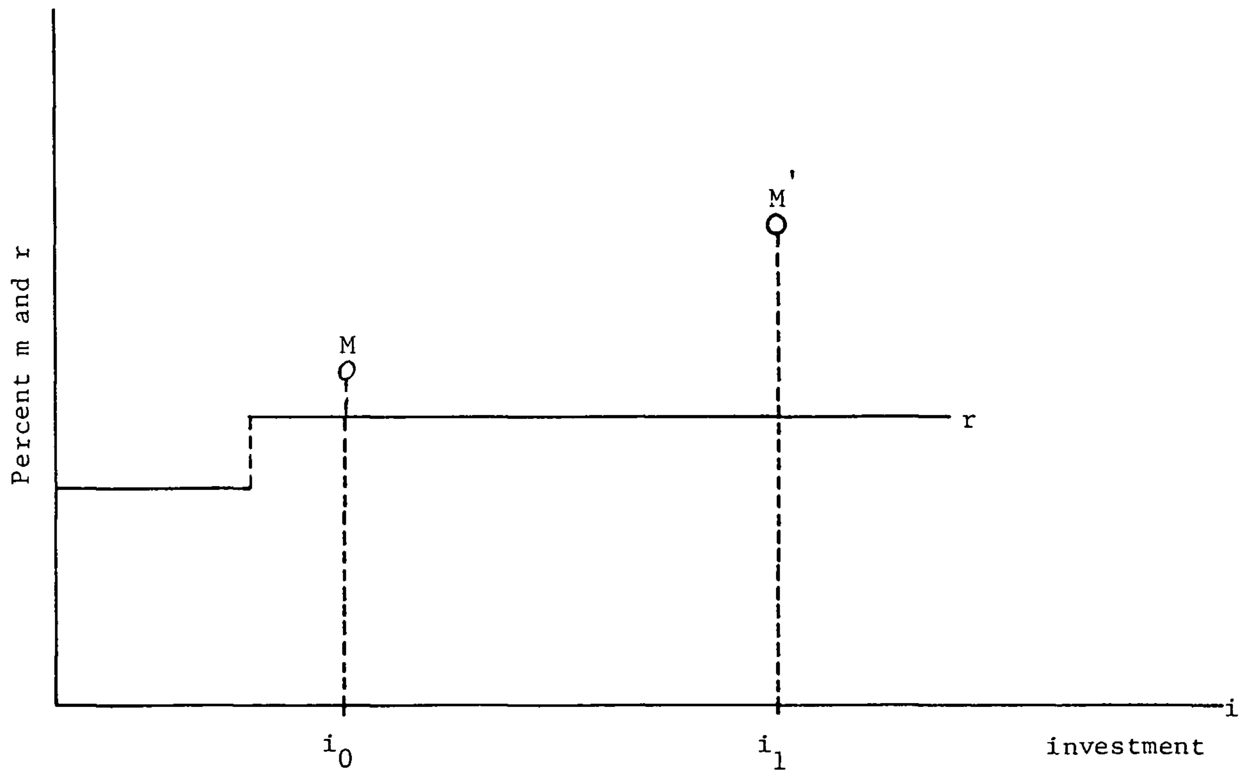

Figure 3. Investment demand and supply of funds schedules.

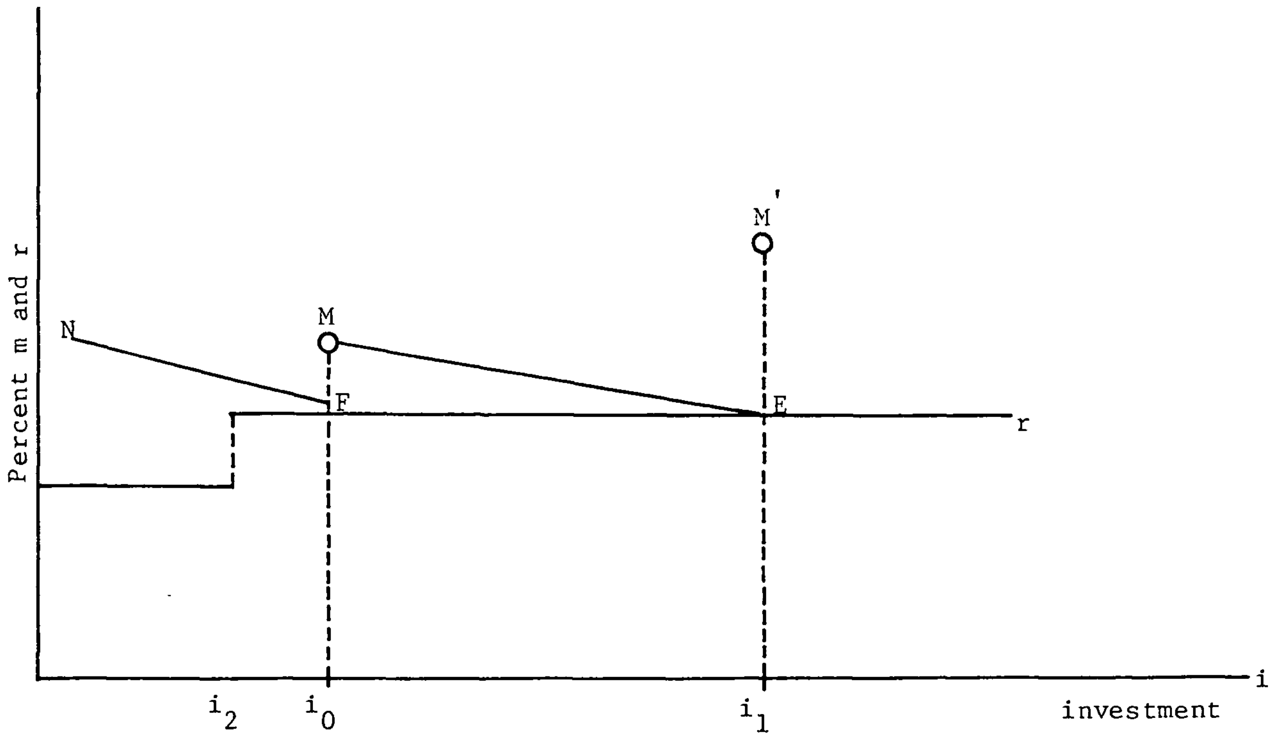

Figure 4. Investment demand and supply of funds schedules.

Figure 4 shows that up to a certain point the interest cost of financing investment is low and constant. As the size of investment increases beyond i_2, the cost of borrowing or the opportunity cost of using retained earnings also increases and remains constant for the rest of the investment level. Unexpected changes in the earning streams from graduate education may shift the demand function for investment.

The aggregation of all individuals for whom the market interest rate is less than or equal to the rate of return to investment in graduate education will provide the total number of graduate enrollments demanded.

Figure 5 is a graph of an aggregate demand for graduate enrollments, labeled d_0d_0. The vertical axis measures the expected rate of return (m). The horizontal axis gives the number of enrollments (E) demanded by college graduates with a given expected rate of return, or higher to graduate education. In the figure, if the interest rate is r_0, then the number of enrollments demanded will be equal to E_0. Variation in the cost of borrowing (interest rate) will lead to variation in the number of enrollments demanded.

The hypothetical demand function of Figure 5 relies on the assumption of the existence of adequate loan capital for education borrowing. Although the education loan market has been improving in recent years, it is still highly imperfect. In the absence of a highly developed capital market for investment in graduate education, the potential graduate students would rely partially on federally guaranteed loans and partially on individual or family sources for

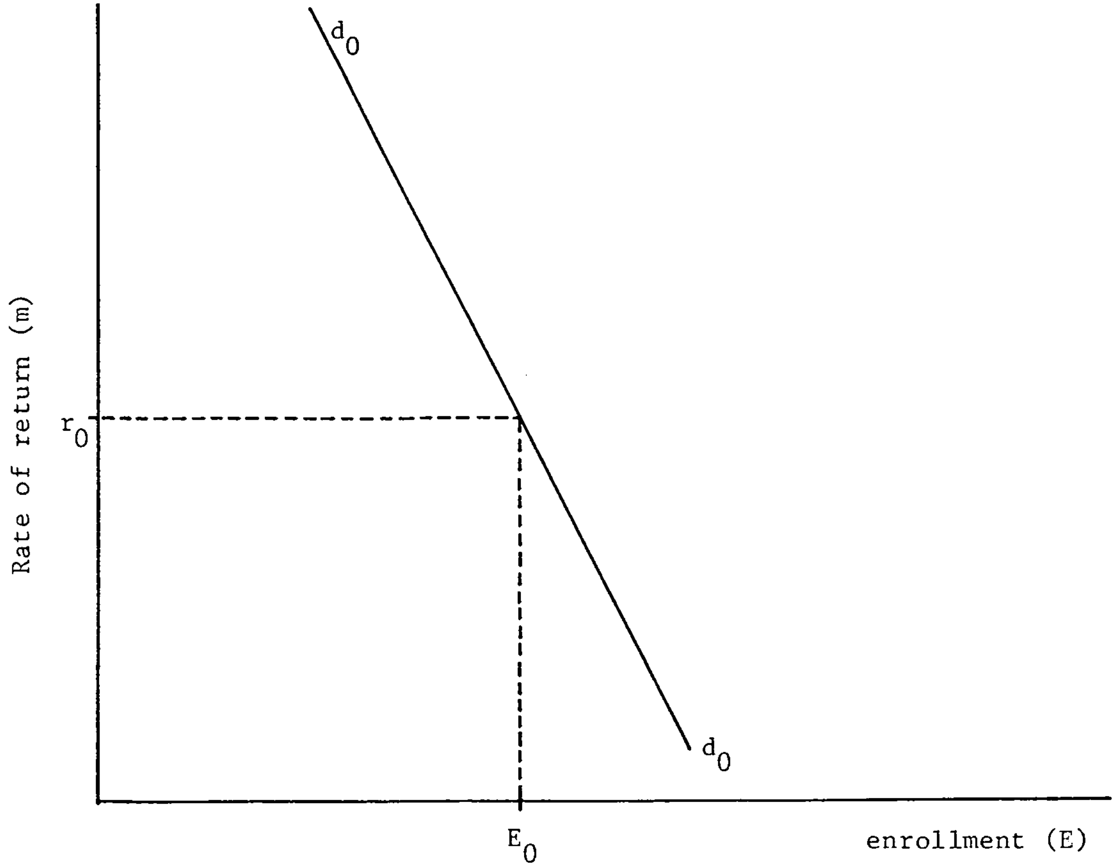

Figure 5. Relation between interest rate and demand for enrollment.

financing. However, assistanships (teaching or research) and tuition remission may mitigate this for a significant number of graduate students. Even when educational loans are made, a strong current family income and assets, rather than a highly anticipated future income, is likely to be the basis for obtaining a loan from a lending institution. Since much of the funds for investment in graduate education come from individual or family sources and assistantships, and because obtaining a loan will sometimes depend on a family financial position, we would expect the demand for enrollments to vary directly with family income, and the number and size of assistantships available to potential enrollees.

A shift in the rate of return line (d_0d_0) of Figure 5 may be caused by a change in the demand for graduates. For example, a decrease in the demand for individuals having graduate education, ceteris paribus, would decrease the expected income of these graduates, thus resulting in a decrease in everyone's expected rate of return. This would result in a shift to the left of the rate of return line as shown in Figure 6. Such a shift would discourage everyone from investing in graduate education at least in the short term. If we measure such a shift in the rate of return line to the average individual, then we would expect a direct relationship between the demand for enrollments and average rate of return. Campbell and Siegel (7) and Hight (28) assumed in their investigations that the rate of return to investment in college education did not change significantly for the four or five decades. Table 1 indicates a significant decline in the private rate of return to investment in college education.

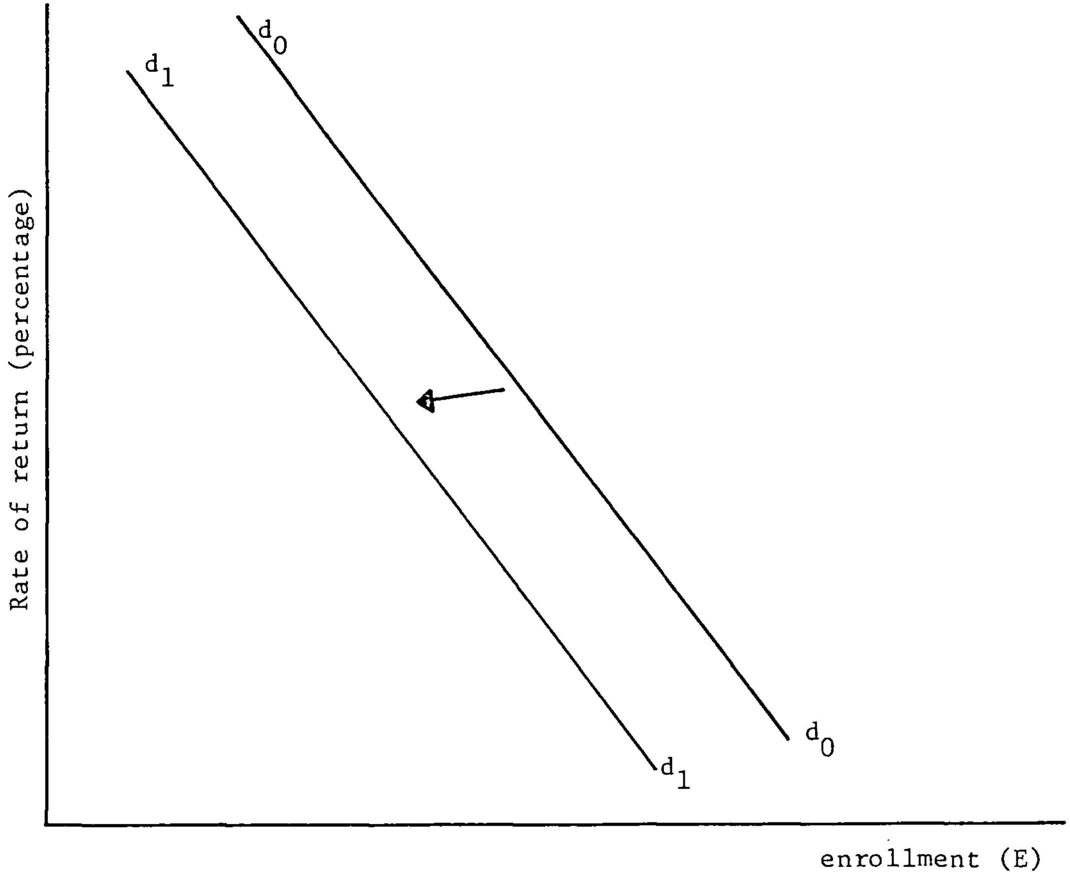

Figure 6. Relation between rate of return and demand for enrollment.

TABLE 1. PRIVATE RATE OF RETURN TO INVESTMENT IN COLLEGE EDUCATION FOR SELECTED YEARS.

Year	Rate of return
1939	14.5
1949	13+
1956	12.4
1958	14.8
1959–1961	slightly higher than in 1958
1969	11.5
1972	10.5
1975	8.5

Sources: For the years 1939-1961 (1), 1969-1975 (20)

Schultz (45) suggested that the rate of return to investment in college education is approximately equal to the rate of return to investment in school education. If we assume that the rate of return associated with graduate education followed the same trend as rate of return to investment in college education then a declining trend has existed in the rate of return to investment in graduate education since about 1960. Since data on the rate of return to graduate education over time are not available, one could incorporate variables in the model which, it is believed, affect the expected rate of return. A general rise in the expected money income from graduate education investment should increase the rate of return and therefore, increase the demand for graduate enrollments. An increase in the cost of graduate education, either in the form of increased direct money outlays or an increase in the opportunity cost of graduate education should decrease the rate of return and will, in turn, decrease the demand for enrollments. The opportunity cost of joining graduate school depends upon the unemployment rate prevailing in the country for college graduates. The higher the unemployment rate for potential enrollees, the fewer will be the number of job openings for college graduates and the lower will be the opportunity cost associated with graduate education. On the other hand, a higher unemployment rate for master's and doctoral degree holders will result in lowering the earnings for these individuals and, hence, the expected earnings of new enrollees in graduate programs. We would expect an inverse relationship between the unemployment rate for technical and professional workers holding advanced degrees and demand for enrollments. Similarly a direct relation will exist between the demand for enrollments and the unemployment rate for college graduates.

The investment approach leads one to expect that, for a given population of college graduates: 1. Demand for enrollments[6] should vary directly with the expected monetary gains and inversely with the opportunity costs and direct monetary outlays. 2. An inverse relation should exist between the level of the unemployment rate for technical and professional workers and the demand for enrollments. A positive relation exists between the demand for enrollments and the unemployment rate for college graduates. 3. A direct relation exists between the real family income and the demand for enrollments.

The Consumption Approach

In addition to being a durable good in the sense of bringing future benefits, graduate education also brings current consumption benefits from cultural, intellectual, and athletic activities available to a graduate student. If consumption services from graduate education are normal or superior goods, then an increase in income will result in an increased demand for the number of enrollments.

The law of demand applies to all normal or superior goods. Unless a graduate education is a Giffen good, an increase in costs (price) of graduate education will decrease the number of enrollments demanded. These costs are the same costs as were discussed when we considered graduate education as a durable good.

6/ Demand for enrollments implies here the number of individuals wanting to enroll in graduate education.

Finally, considering graduate education as a consumption good, an increase in the price of a good complementary in consumption with graduate education will decrease the demand for enrollments. An increase in the price of a substitute good leads one to expect an increased demand for graduate education (15, 27). However, we were not able to identify any commodities that are complementary with graduate education. Food, clothing, and shelter will be purchased whether an individual enters the graduate school or joins the labor force. However, the quality of these goods may not be the same. Nevertheless, we assume that a college graduate maintains his/her living standard whether or not he/she joins the graduate school. Books and supplies are part of education and are not complementary to it. Therefore, the prices of these items are costs of education. If the above explanation is correct then we are in a position to eliminate the prices of the complementary consumption goods from our model. However, demand theory allows us to argue that demand for enrollments is sensitive to its money cost relative to the prices of current consumption goods. An increase in the prices of current consumption goods means a reduction in the cost of future benefits relative to the cost of current consumption. Such a reduction will encourage the individuals to divert their expenditure from current consumption goods to future consumption goods (i.e., increased enrollments).

Summarizing the consumption approach, we would expect, for a given number of potential enrollees, the demand for enrollments to vary positively with real family income, positively with the prices of consumer goods, and inversely with the costs of graduate education.

Demand Rationing

The existing literature has given little attention to the demand rationing forces which play an important role in determining college enrollments. With respect to the admission process, it was assumed that every recent graduate can find some in-state public institution in the region or, within the country, a private institution which will accept him, if he wants and can afford to enroll (3, 7, 11, 14, 28, 32, 41). Such an assumption is not a realistic one when enrollment demand for graduate education in a public institution is under investigation. Graduate education is supplied by publicly supported universities as well as by private non-profit institutions. For publicly supported institutions, pricing decisions are in the hands of public officials such as legislators, boards of higher education and state executives. This suggests that prices (tuition and fees) in higher education will be largely supply determined. Very often admission requirements are established at a fixed nominal price for all college graduates who are willing to enter the graduate school. The admission requirements into graduate schools vary considerably, but generally there is a university-wide minimum based on the holding of a bachelor's degree and a good record of academic accomplishment as an undergraduate. The various departments add their own additional requirements, so that in reality an applicant has not only to satisfy the graduate school or registrar's office but also to meet the requirements set by a particular department in which he proposes to do his study. In addition to the undergraduate grade point average, the departmental requirements may include the reputation of the institution which granted the college graduate his/her undergraduate degree, the quality of any practical experience the student attained after college graduation, and the quality of letters of recommendation from employers and undergraduate faculty members.

The setting of admission standards for entrance to the graduate school is often a more crucial component of public policy than the price charged by the institution to the graduates, which is usually nominal in nature. Figure 7 represents a graduate enrollment demand schedule, labeled d_0d_0, faced by a department or by an institution when the minimum entrance requirement is possession of an undergraduate degree. Any additional admission requirement will generate a new demand curve. The new demand curve will give the quantity of enrollments associated with each tuition level by all those meeting the new admission requirements. The new demand curve d_1d_1 will be to the left of d_0d_0 because the institution is considering a subset of original potential enrollees. Different entrance requirements will generate many such demand curves each corresponding to different admission standards. The more restrictive the admission requirements, the further to the left of the original demand curve will be new demand curve with each curve representing, therefore, a different population of enrollment demanders. To estimate the impact of entrance requirements on enrollment demand at the institutional level, one can think of the minimum entrance requirements as some sort of average entrance

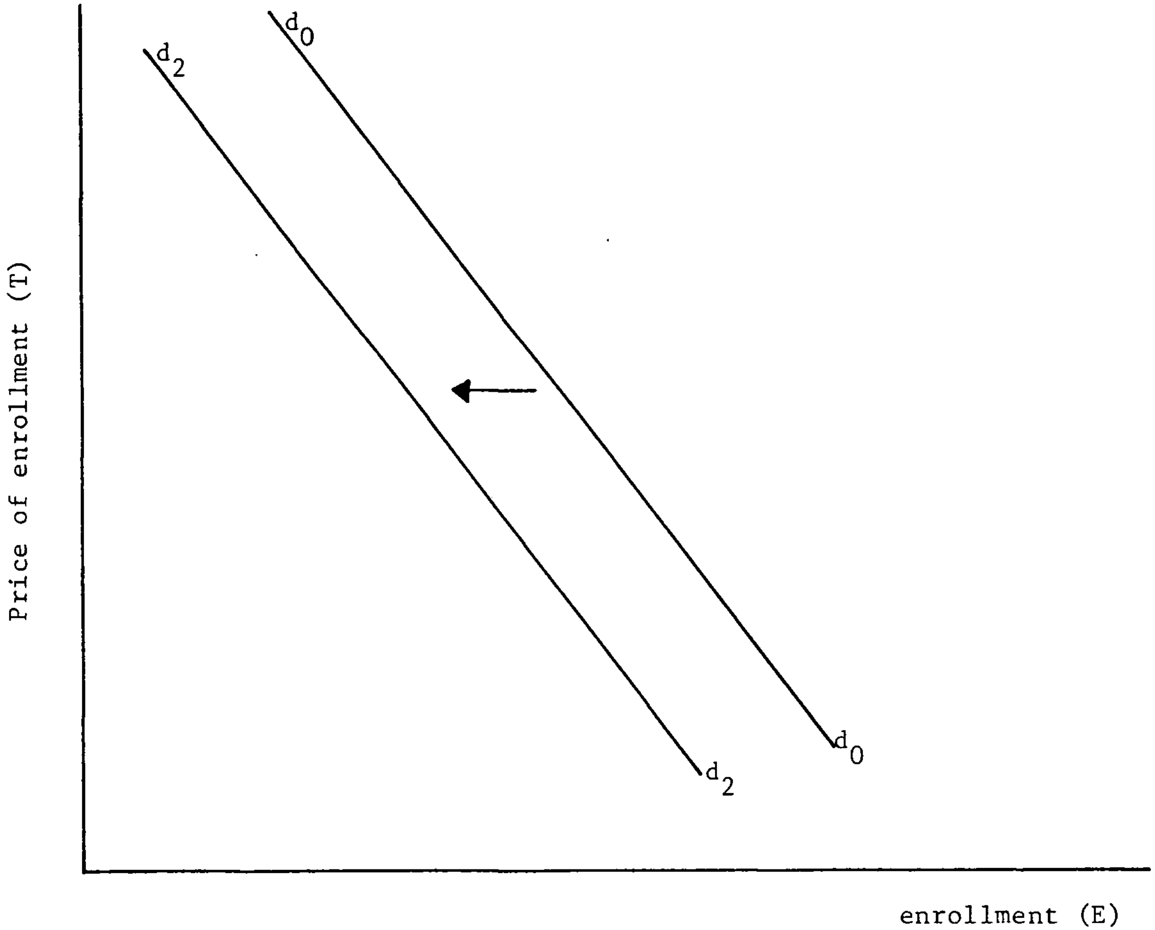

Figure 7. Relation between admission requirements and demand for enrollment.

requirement averaged over all departments within the institution, e.g., grade point average for undergraduate work.

Other Variables of Interest

Location of an institution can be an important variable affecting one's decision to join a particular graduate school if he/she has the choice of two or more. Since forty percent of the cost of financing graduate students comes from their own earnings or from the earnings of their spouses, a college graduate would like to join the institution located in a town which can provide part-time or full-time job opportunities for him (her) or his (her) spouse (47). We should expect a direct relation between the size of the town and the number of enrollments demanded. However, we are investigating the enrollment demand for graduate education at a single institution as well as at the national level and we can eliminate this variable from the demand function.

Similarly, the reputation of an institution of higher education would have an influence on the decision of a college graduate to join a particular institution. The reputation of graduate programs varies among departments. The reputation of a particular department will depend upon the quality of its graduate faculty, the curricula, the instructional and research facilities and the quality of graduate students. The number of articles published by the faculty members in the nationally-known journals may be considered as one of the criteria in its evaluation. The quality of the graduate students will depend upon the admission requirements set by each department.

Higher admission standards should improve the quality of graduate students and, in turn, improve the reputation of an institution. Since data on the publications by faculty members over time are not available, the quality of graduate students (admission requirements) may be considered as a proper representation of the reputation of a department or an institution of higher education. We would expect a positive relation between the reputation of a department or an institution and the demand for enrollments.

The Demand Function

A formal statement of enrollment demand at the national level that includes investment and consumption aspects of graduate education as well as demand rationing is given by the following equation:

$$E_t = f\,(Y_t,\ T_t',\ G_t,\ S_t,\ C_t,\ AR_t,\ U_t,\ F_t,\ P_t) \tag{2.8}$$

where ... E_t is the number of new students admitted in the graduate program in calendar year t, Y_t is the mean real family income in the United States in year t. T_t' is the average financial cost of graduate education incurred by new enrollees. G_t represents the expected monetary gains associated with graduate education in year t[7].

7/ It is assumed that a potential enrollee compares his earnings with those of the Ph.D. degree holder at the time he decides to join the graduate program. The starting real salary difference between a Ph.D. degree holder and a B.S. degree holder is used as a proxy for the real monetary gains associated with a graduate program.

S_t is the expected economic value from the direct consumption benefits resulting from graduate education as viewed by new enrollees of year t. AR_t represents the minimum admission requirements set by the administration and also represents the quality of the graduate program offered by an institution in year t. C_t represents the average price of consumer goods in general in year t. U_t is the unemployment rate for technical and professional workers in the United States in year t. The majority of the bachelor's degree holders join the graduate school at the end of September of year t. The information on the unemployment rate for technical and professional workers is released by the federal administration at the beginning of the next year. However, we assume that a potential enrollee has some feeling of that unemployment rate at the time he makes his decision regarding graduate education. F_t represents the number of assistantships and fellowships available to new graduate students in year t and P_t is the number of persons graduating from college during the fall term of year t-1 and the winter, spring and summer term of year t.

If we assume that psychic gains (S) from the direct consumption of graduate education do not change over time, then we can eliminate this variable from our model. In addition, if we assume that consumption demand depends upon the cost of graduate education relative to the cost of other consumer goods, then we can rewrite the demand function as:

$$E_t = f\ (Y_t,\ T_t,\ G_t,\ AR_t,\ U_t,\ F_t;\ P_t) \qquad (2.9)$$

where ... T represents the average financial cost associated with graduate education relative to the average price of the current consumer goods.[8]

New enrollment data provide the most obvious source of information on demand. This information is available for only 12 years (1960-1971) at the national level and for ten years (1966-1975) at the institutional level.[9] The small number of observations on the endogenous variable limits the number of exogenous variables which can be used in the estimation process. A large number of explanatory variables in the equation would reduce the confidence in our parameter estimates by reducing the number of degrees of freedom. Also the available data on the exogenous variables are not strictly comparable.[10] In addition,

---

8/ Since tuition is the main component of financial cost of education, then T represents the real size of the tuition.

9/ It was my intention to compare the demand for graduate enrollments among various institutions of higher education in the State of Oregon. But the non-availability of enrollment data from other institutions (University of Oregon and Portland State University) limited the investigation to Oregon State University.

10/ The data on mean real family income (Y) and unemployment for technical and professional workers (U) are aggregate in nature at the national level. The grade point average representing admission requirements (AR) and the real size of tuition (T), are available only for Oregon State University. Data on the starting real salary difference (G) between Ph. D. and B. S. degree holders are available only by profession. Also the periods for which data on these variables as well as on the endogenous variable are available at the national and the institutional level are not the same.

a high degree of multicollinearity exists between the national and institutional variables.[11]

The few observations on the endogenous variable and the high degree of multicollinearity between national and institutional explanatory variables suggest that the demand for graduate education at Oregon State University and at the national level may be better estimated separately, utilizing the institutional and the national data, respectively.

The Institutional Demand Function

A formal statement of the institutional model is given in equation (2.10).

$$E_{ti} = f\ (T_t,\ AR_t,\ G_t,\ D_i),\ t = 1966,\ 1967,\ \ldots,\ 1975 \qquad (2.10)$$

where ... E_{ti} is the number of new graduate students who joined the graduate program in department i at Oregon State University in year t. T_t represents the real tuition cost in year t, and G_t represents the monthly starting real salary difference between Ph.D. and B.S. degree holders as viewed by the potential enrollees of year t. AR_t is the

11/ A high correlation exists between the real tuition level at Oregon State University and the unemployment rate for technical and professional workers in the United States, ($r = 0.804$); and between real tuition at Oregon State University and real mean family income in the United States, ($r = 0.838$). The data for the period 1966-1975 were used to calculate the correlation between these variables.

minimum grade point average required for admission in the graduate program and D_i is the binary variable representing department i.

The number and the size of available assistantships and fellowships to potential enrollees vary substantially among disciplines. The "financial support" variable was eliminated from the model due to the non-availability of discipline-wide information on assistantships and fellowships. However, the binary variables representing various disciplines will embody the effect of available financial support to new graduate students.

Difficulties were encountered in defining the population of potential enrollees who can enroll, if they can afford it, in the graduate program at Oregon State University. The difficulty arises because only 16 percent of the college graduates from Oregon State University join the graduate program on their own campus (23). College graduates from the entire United States and even from all over the world are, in fact, the potential enrollees.[12] However, we do not expect that any change in the number of college graduates at the national level will have any significant effect on the enrollment demand at an institution of higher education where enrollment can be constrained by entrance requirements beyond the minimum requirement of holding a college degree (as discussed earlier in this chapter). If the above explanation is correct then it is appropriate to exclude the potential enrollee variable in equation (2.10).

12/ In fall, 1976, more than 50 percent of the graduate students in the School of Engineering were foreign students (17).

The National Demand Function

A formal statement of the national model is given by equation (2.11).

$$E_t = f\ (U_t,\ Y_t,\ P_t),\ t = 1960,\ 1961,\ \ldots,\ 1971 \qquad (2.11)$$

where ... E_t represents the first year enrollment for all master's and doctoral programs in the United States in year t. U_t represents the unemployment rate for technical and professional workers in year t. Y_t is the real mean family income in the United States in year t, and P_t is the number of bachelor's degrees awarded in the United States in the months of September to December of year t-1 and January to August of year t.

For equation (2.11) to provide a test of our demand model, we assume that every recent college graduate can find some public or private institution in the United States that will accept him, if he is willing and can afford to enroll.[13]

In the previous studies (7, 11, 14, 32) it was assumed that the "potential enrollees" variable has a multiplicative relationship with the rest of the explanatory variables. There is no *a priori* evidence to justify such interaction. However, in this study the first year graduate enrollment was deflated by the number of college graduates

13/ For supporting views see Blaug (3), Osthiemer (41), Hopkin (32).

to reduce the expected severe multicollinearity. The demand function of equation (2.11) may be rewritten as:

$$E_t/P_t = N_t = f\ (U_t,\ Y_t) \qquad (2.12)$$

where ... N_t is the first year enrollment ratio and U_t and Y_t are unemployment rate and mean family income variables as defined earlier.

III. THE ECONOMETRIC MODELS

Model 1

After providing the conceptual framework, it is now possible to set forth the econometric model (as specified model is equation 3.1).

$$
\begin{aligned}
E_{it} = \beta_0 &+ \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + \beta_5 X_{5t} \\
&+ \beta_6 X_{6t} + \beta_7 X_{7t} + \beta_8 X_{8t} + \beta_9 X_{9t} + \beta_{10} X_{10t} \\
&+ \beta_{11} X_{11t} + \beta_{12} X_{12t} + \beta_{13} X_{13t} + \beta_{14} X_{14t} \\
&+ \beta_{15} X_{15t} + \beta_{16} X_{16t} + \beta_{17} X_{17t} + \beta_{18} X_{18t} \\
&+ \beta_{19} X_{19t} + \beta_{20} X_{20t} + \beta_{21} X_{21t} + \beta_{22} X_{22t} \\
&+ \beta_{23} X_{23t} + \beta_{24} X_{24t} + \beta_{25} X_{25t} + \beta_{26} X_{26t} \\
&+ \beta_{27} X_{27t} + \beta_{28} X_{28t} + \beta_{29} X_{29t} + \beta_{30} X_{30t} + e_t
\end{aligned}
$$

where ... $t = 1966, 1967, \ldots, 1975$; $i = 4, 5, \ldots, 30$; i represents the department.

Variable number	Variable name	Measurement of variable
E_t	New graduate enrollment in (winter + spring + summer + fall)$_t$	Number of students
X_1	Tuition level at Oregon State University	Real dollars
X_2	Grade point average for admission requirement and representing quality of graduate program	Actual numbers (0-4)
X_3	Monthly starting salary difference between Ph.D. and B.S. degree holders	Real dollars
X_4	Agricultural and Resource Economics	1 if yes, 0 otherwise
X_5	Agronomic Crop Science	1 if yes, 0 otherwise
X_6	Animal Science	1 if yes, 0 otherwise
X_7	Fisheries and Wildlife	1 if yes, 0 otherwise
X_8	Food Science and Technology	1 if yes, 0 otherwise
X_9	Horticulture	1 if yes, 0 otherwise
X_{10}	Poultry Science	1 if yes, 0 otherwise
X_{11}	Rangeland Resources	1 if yes, 0 otherwise
X_{12}	Soil Science	1 if yes, 0 otherwise
X_{13}	School of Pharmacy	1 if yes, 0 otherwise
X_{14}	Forest Management	1 if yes, 0 otherwise
X_{15}	Forest Products	1 if yes, 0 otherwise

Variable number	Variable name	Measurement of variable
X_{16}	Botany and Plant Pathology	1 if yes, 0 otherwise
X_{17}	Biochemistry and Biophysics + Chemistry	1 if yes, 0 otherwise
X_{18}	Business Administration	1 if yes, 0 otherwise
X_{19}	Geography	1 if yes, 0 otherwise
X_{20}	Geology	1 if yes, 0 otherwise
X_{21}	Microbiology	1 if yes, 0 otherwise
X_{22}	Physics	1 if yes, 0 otherwise
X_{23}	Entomology	1 if yes, 0 otherwise
X_{24}	Mathematics	1 if yes, 0 otherwise
X_{25}	Statistics	1 if yes, 0 otherwise
X_{26}	Zoology	1 if yes, 0 otherwise
X_{27}	Civil Engineering	1 if yes, 0 otherwise
X_{28}	Electrical Engineering	1 if yes, 0 otherwise
X_{29}	Chemical Engineering	1 if yes, 0 otherwise
X_{30}	Mechanical + Nuclear + Industrial + Metalurgical Engineering	1 if yes, 0 otherwise

e_t is the disturbance term

Based on a priori expectation that the demand for graduate education was different for each profession, dummy variables were used representing each department or profession to illustrate and check for significant differences among departments. The coefficients for the dummy variables will indicate variation with respect to demand for graduate education after account is taken of the set of explanatory variables.[14]

Profession-wise new enrollments (E) were calculated under the assumption that the total number of dropouts from the graduate program equals zero or that the number of dropouts remained constant over the period considered in this study.

In recognition of the danger of allowing the data to dictate procedure, the following analytical procedure was established beforehand:

Step 1: Using ordinary least squares, estimate the parameters of equation 3.1 with all variables in the model.

Step 2: In empirical work one sometimes faces the problem of selecting a subset of independent variables from a given set according to some criterion. One objective that is commonly used is the maximization of $\bar{R}^2$, the square of the multiple correlation coefficient adjusted for the number of degrees of freedom. It has been noticed that discarding an independent variable with t-value less than unity (24) or F-value less than unity (30) in magnitude generally increases

---

14/ It is assumed that β_1, β_2 and β_3 are the same for all disciplines.

the $\bar{R}^2$ of the multiple regression equation. Thus Step 2 calls for eliminating the variables from equation 3.1 whose estimated coefficients have t-value less than unity and call this equation 3.2.

Step 3: Compare the results of Step 1 and Step 2, and examine these equations, for the significance of the estimated coefficients, for evidence of multicollinearity, autocorrelation and other statistical problems and select the one which minimizes the statistical problems and also provides the higher $\bar{R}^2$.

Hypotheses

Numerous hypotheses were generated during the development of the conceptual framework and in the testing of the model. The relevant hypotheses in this investigation are related to the coefficients of the explanatory variables. The null hypotheses (H_0) and the alternative hypotheses (H_a) in terms of equations 3.1 and 3.2 are[15]:

Coefficient	H_0	H_a
β_1	$=0$	<0
β_2	$=0$	$\neq 0$
β_3	$=0$	>0
β_4	$=0$	$\neq 0$

15/ As it turned out, the variables X_6, X_8, X_9, X_{12}, X_{20} of Equation 3.1 were eliminated from Equation 3.2 by the criterion of maximization of $\bar{R}^2$.

Coefficient	H_0	H_a
β_5	=0	$\neq 0$
β_6	=0	$\neq 0$
β_7	=0	$\neq 0$
β_8	=0	$\neq 0$
β_9	=0	$\neq 0$
β_{10}	=0	$\neq 0$
β_{11}	=0	$\neq 0$
β_{12}	=0	$\neq 0$
β_{13}	=0	$\neq 0$
β_{14}	=0	$\neq 0$
β_{15}	=0	$\neq 0$
β_{16}	=0	$\neq 0$
β_{17}	=0	$\neq 0$
β_{18}	=0	$\neq 0$
β_{19}	=0	$\neq 0$
β_{20}	=0	$\neq 0$
β_{21}	=0	$\neq 0$
β_{22}	=0	$\neq 0$
β_{23}	=0	$\neq 0$
β_{24}	=0	$\neq 0$
β_{25}	=0	$\neq 0$
β_{26}	=0	$\neq 0$
β_{27}	=0	$\neq 0$
β_{28}	=0	$\neq 0$

Coefficient	H_0	H_a
β_{29}	=0	≠0
β_{30}	=0	≠0

The null hypotheses (H_0) are that the coefficients β_2, β_4-β_{30} equal to zero. The alternative hypothesis for coefficient β_1 (tuition level) indicates that it is less than zero. The alternative hypothesis for the coefficient of X_2, which represents the minimum admission requirements and also the quality of graduate programs, suggests that it is not equal to zero. The alternative hypothesis for β_3 indicates that coefficient is greater than zero, while the alternative hypotheses for the coefficients of the binary variables (β_4, ..., β_{30}) indicate that the coefficients are not equal to zero.

Model 2

The national model is specified as:

$$E_t/P_t = Y_t = \alpha + \beta_1 U_t + \beta_2 (RI)_t + e_t \tag{3.3}$$

where ... $t = 1960, 1961, \ldots, 1971$

Variable number	Variable name	Measurement of variable
Y	First year graduate enrollment ratio	Actual numbers
RI	Mean family income in the United States	Real dollars
U	Unemployment rate for technical and professional workers	Actual numbers (percentage)

Hypotheses

The relevant hypotheses for the national model are:

Coefficient	H_0	H_a
β_1	=0	<0
β_2	=0	>0

The null hypotheses are that the coefficients (β_1, β_2) are equal to zero. The alternative hypotheses are that β_2 is greater than zero and β_1 is less than zero.

Sources and Nature of the Data

To test the effectiveness of the institutional model, observations on individual college graduates who enrolled in graduate programs were desired. Enforcement of confidentiality regulations eliminated the possible use of individual observations. Due to the non-availability of data on yearly new enrollments for each discipline, the new enrollments for each discipline were calculated by the following formula:[16]

$$\text{New graduate enrollments}_{(W,Sp,Su,F)_j} = \text{Total graduate enrollment}_{(F)_j}$$

$$- \text{ total graduate enrollment}_{(F)_{j-1}} + [\text{No. of graduate degrees awarded}]_{F_{j-1} + W_j + Sp_j + Su_j}$$

$$+ [\text{No. of dropouts}]_{F_{j-1} + W_j + Sp_j + Su_j}$$

where ... j = 1966, 1967, ..., 1975, and W = winter, Sp = spring, Su = summer, F = fall.

The new enrollment data used to test the hypothesized relationships were limited to those who were regular students, thus excluding special and unclassified graduate students. From the available total enrollment data it was not possible to calculate the new enrollments for the departments of Mechanical Engineering, Nuclear Engineering, Industrial Engineering, and Metallurgical Engineering separately. For this reason these departments were considered as one discipline. Similarly, the present department of Biochemistry and Biophysics used to be a part of the Chemistry department and new enrollments in these two departments were summed for the purpose of this study. New enrollments for 25 other disciplines excluding the disciplines of the School of Education

---

16/ Data on dropouts were not available and the assumption of zero dropouts introduces a measurement error in the dependent variable.

and also the disciplines of the School of Home Economics were calculated[17]. To reflect the influence of these disciplines on enrollment demand binary variables indicating particular disciplines were used. The tuition variable is the amount of money a graduate student pays per term in real dollars. The data on tuition for various years were obtained from the Oregon Department of Higher Education (39) and then deflated by the respective consumer price index. The year 1967 was the base year.

The grade point average requirement set by the administration was considered to be a demand rationing device. Also, a potential enrollee may have considered it as a measure of the quality of the graduate program offered by the institution. The data on minimum grade point average were found in various graduate school bulletins (40).

For a particular discipline, the starting salary difference between doctoral and bachelor's degree holders in the same discipline was considered as a proxy for the monetary gains associated with graduate education. It was assumed that the salary difference among all the disciplines of the School of Agriculture and biological sciences in the School of Science was the same for the years 1966-1975. Salary data for the agricultural disciplines were available in various proceedings of the conferences of deans and directors of resident instruction (46).

17/ The School of Education offers the teacher's certification program, which is different from the master's and doctoral program. Also, a large number of graduate students enroll in the School of Education and in the disciplines of the School of Home Economics for summer term only. The new enrollments calculated by the formula for these schools would have bias in it. We have not included the School of Education and the School of Home Economics in our study.

The differential salary data for the disciplines in the School of Engineering and for the physical sciences were calculated from the salary statistics obtained from the CPC Salary Surveys (10) with the permission of the College Placement Council, Inc. who were the copyright holders.

For the national model, the data on first year graduate enrollments and the number of bachelor's degrees awarded in various years were obtained from various publications of the U.S. Department of Health, Education and Welfare (50).

The real size of the mean family income was calculated by obtaining the data on mean family income from the publications of the U.S. Department of Commerce (49) and deflating the data by the Consumer Price Index.

The information on the unemployment rate for technical and professional workers was obtained from the Manpower Report of the President (51).

IV. RESULTS

Institutional Model

Using the 270 observations obtained through the process described in Chapter III, the parameters of equations 3.1 and 3.2 were estimated (Tables 2 and 3). The objective was to select one of these two equations which minimizes the statistical problems, for example, multicollinearity, serial correlation, heteroskedasticity and also gives the highest $\bar{R}^2$ (multiple coefficient of determination adjusted for degrees of freedom).

A guide to the possible problem of multicollinearity has been to observe the individual elements of the simple correlation matrix, the r_{ij}'s, $i \neq j$. An arbitrary rule of thumb is: if the individual r_{ij} (the simple correlation coefficient between X_i and X_j) exceeds 0.8 or 0.9, one should begin to worry about multicollinearity at least as far as those variables are concerned (25). The largest r_{ij} in the matrix of equation 3.1 and equation 3.2 was 0.706, which equals 0.499 when squared. Based on this information it was assumed that severe multicollinearity was not a problem in model estimations.

Multicollinearity is a problem sometimes difficult to detect by observing simple correlation coefficients (r_{ij}'s). Some researchers have uncovered instances of serious multicollinearity where simple correlation coefficients (r_{ij}'s) gave little indication of the situation (4). Brown (5) has illustrated this in an example where the

TABLE 2. EMPIRICAL RESULTS OF EQUATION 3.1.

Variable		Regression coefficient ($\hat{\beta}_i$)	Standard error	t-value
	Constant	-77.973	21.097158	-3.69**
X_1	Size of the tuition	- 0.05396	0.019999	-2.69**
X_2	Grade point average	32.247	7.156245	4.50**
X_3	Monetary gains	0.0135	0.007823	1.73*
X_4	Agricultural and Resource Economics	7.6000	3.354490	2.26**
X_5	Agronomic Crop Science	6.0000	3.354490	1.78*
X_6	Animal Science	- 0.8000	3.354490	-0.23
X_7	Fisheries and Wildlife	11.3000	3.354490	3.36**
X_8	Food Science and Technology	0.5000	3.354490	0.14
X_9	Horticulture	- 3.2000	3.354490	-0.95
X_{10}	Poultry Science	- 7.1000	3.354490	-2.11**
X_{11}	Rangeland Resources	- 5.7000	3.354490	-1.69*
X_{12}	Soil Science	1.4000	3.354490	0.41
X_{13}	School of Pharmacy	- 5.2998	3.378786	-1.56
X_{14}	Forest Management	3.6000	3.354490	1.07
X_{15}	Forest Products	- 5.2998	3.378786	-1.56
X_{16}	Botany and Plant Pathology	6.6000	3.354490	1.96**
X_{17}	Chemistry, Biochemistry and Biophysics	19.1000	3.378786	5.65**
X_{18}	Business Administration	34.7510	3.369826	10.31**
X_{19}	Geography	7.2000	3.354490	2.14**
X_{20}	Geology	0.6000	3.354490	0.17

TABLE 2 - continued

Variable		Regression coefficient ($\hat{\beta}_i$)	Standard error	t-value
X_{21}	Microbiology	5.3000	3.354490	1.58
X_{22}	Physics	- 4.0366	3.381399	-1.19
X_{23}	Entomology	---	---	---
X_{24}	Mathematics	8.4666	3.484823	2.42**
X_{25}	Statistics	3.6666	3.484823	1.05
X_{26}	Zoology	8.0000	3.354490	2.38**
X_{27}	Civil Engineering	15.9940	3.358787	4.76**
X_{28}	Electrical Engineering	10.7660	3.441991	3.12**
X_{29}	Chemical Engineering	- 4.0379	3.368865	-1.19
X_{30}	Mechanical, Nuclear, Industrial and Metallurgical Engineering	16.0150	3.377765	4.74**

$R^2 = 0.636^{++}$, $\bar{R}^2 = .592$, $F = 14.481$, $N = 270$, $\bar{E} = 14.256$

* Significant at the .1 level ($t_{.05,\ 240} = 1.645$)

** Significant at the .05 level ($t_{.025,\ 240} = 1.960$)

++ Significant at the .01 level ($F_{.01,\ (29,\ 240)} = 1.70$)

\+ Significant at the .05 level ($F_{.05,\ (29,\ 240)} = 1.46$)

TABLE 3. EMPIRICAL RESULTS OF EQUATION 3.2.

Variable		Regression coefficient ($\hat{\beta}_i$)	Standard error	t-value
	Constant	-78.2230	20.8708	-3.74**
X_1	Size of the tuition	- 0.05396	0.0199	-2.71**
X_2	Grade point average	32.2470	7.1171	4.53**
X_3	Monetary gains	0.0135	0.0078	1.73*
X_4	Agricultural and Resource Economics	7.8500	2.5480	3.08**
X_5	Agronomic Crop Science	6.2500	2.5480	2.45**
X_7	Fisheries and Wildlife	11.5500	2.5480	4.53**
X_{10}	Poultry Science	- 6.8500	2.5480	-2.68**
X_{11}	Rangeland Resources	- 5.4500	2.5480	-2.13**
X_{13}	Pharmacy	- 5.0498	2.5796	-1.96**
X_{14}	Forest Management	3.8500	2.5480	1.51
X_{15}	Forest Products	- 5.0498	2.5796	-1.96**
X_{16}	Botany and Plant Pathology	6.8500	2.5480	2.68**
X_{17}	Chemistry, Biochemistry and Biophysics	19.3500	2.5796	7.50**
X_{18}	Business Administration	35.0010	2.5676	13.63**
X_{19}	Geography	7.4500	2.5480	2.92**
X_{21}	Microbiology	5.5500	2.5480	2.17**
X_{22}	Physics	- 3.7866	2.5829	-1.46
X_{23}	Entomology	---	---	---
X_{24}	Mathematics	8.7166	2.7155	3.20**

TABLE 3 - continued

Variable		Regression coefficient ($\hat{\beta}_i$)	Standard error	t-value
X_{25}	Statistics	3.9166	2.7155	1.44
X_{26}	Zoology	8.2500	2.5480	3.23**
X_{27}	Civil Engineering	16.2440	2.5536	6.36**
X_{28}	Electrical Engineering	11.0160	2.6609	4.13**
X_{29}	Chemical Engineering	- 3.7879	2.5667	-1.47
X_{30}	Mechanical, Nuclear, Industrial and Metallurgical Engineering	16.2650	2.5782	6.30**

$R^2 = .633^{++}$, $\bar{R}^2 = .597$, $F = 17.594$, $N = 270$, $\bar{E} = 14.256$

* Significant at the .1 level ($t_{(.05,\ 245)} = 1.645$)

** Significant at the .05 level ($t_{(.025,\ 245)} = 1.960$)

+ Significant at the .05 level ($F_{.05,\ (24,\ 245)} = 1.52$)

++ Significant at the .01 level ($F_{.01,\ (24,\ 245)} = 1.88$)

individual r_{ij}'s did not reveal the presence of severe multicollinearity, even though the simple correlation matrix was singular.

Since pairwise-simple correlation coefficients (r_{ij}'s) sometimes fail to detect the presence of severe multicollinearity, a more rigorous technique was used to judge the degree of multicollinearity. This technique involves analyzing the diagonal elements, R_{jj}, of the inverse simple correlation matrix. These diagonal elements are referred to as "variance inflation factors" (V.I.F.), since they indicate the degree to which the variance of the estimated regression coefficients are inflated due to multicollinearity (13). The factors for the estimation are listed in Tables 4 and 5.

As a general guide, if the V.I.F. values are relatively large, then care should be taken in judging the significance of the regression coefficients from the calculated t-values. The V.I.F. value for the grade point average variable was 3.2256, which was the highest in both of the equations.

TABLE 4. VARIANCE INFLATION FACTORS FOR EQUATION 3.1 ESTIMATION.

Variable		Variance inflation factors
X_1	Size of the tuition	1.7450
X_2	Grade point average	3.2256
X_3	Monetary gains	2.9409
X_4	Agricultural and Resource Economics	1.9259
X_5	Agronomic Crop Science	1.9259
X_6	Animal Science	1.9259
X_7	Fisheries and Wildlife	1.9259
X_8	Food Science and Technology	1.9259
X_9	Horticulture	1.9259
X_{10}	Poultry Science	1.9259
X_{11}	Rangeland Resources	1.9259
X_{12}	Soil Science	1.9259
X_{13}	School of Pharmacy	1.9539
X_{14}	Forest Management	1.9259
X_{15}	Forest Products	1.9539
X_{16}	Botany and Plant Pathology	1.9259
X_{17}	Chemistry, Biochemistry and Biophysics	1.9539
X_{18}	Business Administration	1.9433
X_{19}	Geography	1.9259
X_{20}	Geology	1.9259
X_{21}	Microbiology	1.9259
X_{22}	Physics	1.9569
X_{23}	Entomology	--

TABLE 4 - continued

Variable		Variance inflation factors
X_{24}	Mathematics	2.0785
X_{25}	Statistics	2.0785
X_{26}	Zoology	1.9259
X_{27}	Civil Engineering	1.9309
X_{28}	Electrical Engineering	2.0277
X_{29}	Chemical Engineering	1.9425
X_{30}	Mechanical, Nuclear, Industrial and Metallurgical Engineering	1.9527

TABLE 5. VARIANCE INFLATION FACTORS FOR EQUATION 3.2 ESTIMATION.

Variable		Variance inflation factors
X_1	Size of the tuition	1.7450
X_2	Grade point average	3.2256
X_3	Monetary gains	2.9409
X_4	Agricultural and Resource Economics	1.1235
X_5	Agronomic Crop Science	1.1235
X_7	Fisheries and Wildlife	1.1235
X_{10}	Poultry Science	1.1235
X_{11}	Rangeland Resources	1.1235
X_{13}	School of Pharmacy	1.1913
X_{14}	Forest Management	1.1235
X_{15}	Forest Products	1.1913
X_{16}	Botany and Plant Pathology	1.1235
X_{17}	Chemistry and Biochemistry and Biophysics	1.1913
X_{18}	Business Administration	1.1408
X_{19}	Geography	1.1235
X_{21}	Microbiology	1.1235
X_{22}	Physics	1.1944
X_{23}	Entomology	--
X_{24}	Mathematics	1.2760
X_{25}	Statistics	1.2760
X_{26}	Zoology	1.1235
X_{27}	Civil Engineering	1.1284

TABLE 5 - continued

Variable		Variance inflation factors
X_{28}	Electrical Engineering	1.2252
X_{29}	Chemical Engineering	1.1400
X_{30}	Mechanical, Nuclear, Industrial and Metallurgical Engineering	1.1503

This value of the V.I.F. indicates that the variance of the estimated coefficient of grade point average variable was inflated by a factor of 3.2256. However, the estimated coefficient remains significant at the .10 level and at the .05 level. Based on these results, severe multicollinearity was not judged to be a problem in either of the equation estimations. The values of the V.I.F.'s for the binary variables are less, approximately by 0.8, in equation 3.2. This rule favors the selection of equation 3.2 over equation 3.1.

The usual contention is that the assumption of nonautoregression is more frequently violated when the relations are estimated from time series data than in the case of relations estimated from cross-sectional data. To check the presence of autocorrelation, the Durbin-Watson test has been used[18]. The d statistics for equation 3.1 and equation 3.2 were 2.20 and 2.18, respectively. These values lead to rejection of the presence of serial correlation in both of the regression equations (34).

The assumption of the linear regression model which implies that the variance of the error term is constant for all observations is not usually violated when time series data are used to estimate the relationships. Plots of residuals against the estimated endogenous variable ($\hat{E}$) indicated the absence of specification bias or heteroskedasticity in both of the equations.

18/ To apply this test the value of the statistic d was calculated by:

$$d = \sum_{t=2}^{n} (e_t - e_{t-1})^2 \Big/ \sum_{t=1}^{n} e_t^2$$

The other criterion for selecting one of the two equations was the size of the term $\bar{R}^2$ (multiple coefficient of determination adjusted for degrees of freedom)[19]. It is desirable for this value to be as close to unity as possible. Generally even fairly low values of R^2 would be statistically significant, which would imply that a relationship existed between the endogenous and exogenous variables. However, the purpose of the $\bar{R}^2$ is to facilitate comparison of the "goodness of fit" of several regression equations that may vary with respect to the number of explanatory variables or the number of observations. The $\bar{R}^2$ value from equation 3.1 was .592 whereas equation 3.2 gave an $\bar{R}^2$ of .597. Although both of the regression estimations were significant at the .10 level and at the .05 level, yet the "goodness of fit" test favors the selection of equation 3.2.

The $\bar{R}^2$ statistic for the equation 3.2 was .597. The estimated coefficients of the size of tuition and the monetary gains associated with graduate education variables have the expected negative and positive signs, respectively, and are statistically significant (one-tailed test at the .05 level). The positive sign and the statistical

---

19/ $\bar{R}^2$ was calculated as:

$$\bar{R}_k^2 = R_k^2 - \frac{K}{n - k}(1 - R_k^2)$$

where ... R_k^2 is the multiple correlation coefficient, $\bar{R}_k^2$ is the multiple coefficient of determination adjusted for degrees of freedom, K is the number of explanatory variables and n is the total number of degrees of freedom.

significance of the estimated coefficient associated with the monetary gain variable supports the human capital view of the demand for graduate education. Because tuition is viewed as part of the cost, the negative sign and significance of its estimated coefficient confirms both the consumption and investment aspects of the demand for graduate education. The coefficient of the grade point average (GPA) variable has a positive sign and is statistically significant (two-sided test at the .05 level). This implies that the potential enrollees consider the minimum grade point average as a measure of the quality of the graduate program offered by the institution. This would distinguish it from being a "demand rationing" variable. The selected equation also leads one to suggest that the new enrollment demand is price-inelastic and that a ten percent increase in real tuition would decrease the new graduate enrollment by six percent[20]. Hoenack (31) and Campbell-Siegel (7) found an estimate of the tuition elasticity of -.85 and -.44, respectively, at the undergraduate level. Both of these studies are consistent with my results that the demand for education is price (tuition) inelastic.

The estimated coefficients of the binary variables pertaining to the OSU Department of Agricultural and Resource Economics, Agronomic Crop Science, Fisheries and Wildlife, Botany and Plant Pathology, Chemistry plus Biochemistry and Biophysics indicate that the demand for

---

20/ From equation 3.2, $\frac{\partial E}{\partial X_1} \cdot \frac{\bar{X}_1}{\bar{E}} = -.623$, this elasticity figure is calculated at the mean values of the relevant variables.

graduate enrollments in these disciplines is significantly higher than the demand for graduate enrollment in Entomology. Also the graduate enrollment demand for Business Administration, Geography, Microbiology, Mathematics, Zoology, and for all of the disciplines in the School of Engineering, with the exception of Chemical Engineering, is significantly (at the .05 level) greater than is the case for Entomology. However, the demand for graduate enrollments in the disciplines of Poultry Science, Rangeland Resources, Pharmacy, and Forest Products is significantly (at the .05 level) lower than the demand for graduate enrollments in the discipline of Entomology.

The estimated regression coefficients of the "discipline" variables do not provide direct interdisciplinary demand comparisons with the exception of comparisons with Entomology. A simple method used in this study for making such demand comparisons is to test the hypothesis that $\hat{\beta}_j = \hat{\beta}_k$, $j \neq k$. To test these hypotheses the test statistic, t, is calculated as:

$$t = \frac{\hat{\beta}_j - \hat{\beta}_k}{S_{(\hat{\beta}_j - \hat{\beta}_k)}} \sim t_{(n - m)}$$

where ... $\hat{\beta}_j$ is the estimated coefficient of discipline j,

$\hat{\beta}_k$ is the estimated coefficient of discipline k,

$S_{(\hat{\beta}_j - \hat{\beta}_k)}$[21] is the standard error of the difference between $\hat{\beta}_j$ and $\hat{\beta}_k$.

n is the total number of degrees of freedom

m is the number of explanatory variables in the model,

(n - m) is the number of degrees of freedom.

At a given significance level, if the t-value is in the critical region, then one rejects the null hypothesis and concludes that a significant difference in demand exists between disciplines "J" and "K."

Variation in Enrollment Demand

In general, the variation in demand for enrollment among disciplines may result from one or several of the following factors:

Non-pecuniary benefits: The investor in human capital earns income in his career by devoting time to his work. Since graduate education brings both present and future psychic gains, these psychic factors will be important in his discipline selection decision. Other things being equal, a college graduate will join that particular graduate program which brings the most psychic gains during the years he spends in the graduate school and afterward. As Marshall (35) observed, "The seller of labor must deliver himself...So it matters a great deal...whether or not the place (of work) is wholesome or pleasant...while it matters little to the seller of bricks whether they are used in building a palace or a sewer."

21/ The standard error of the difference between two estimated coefficient is calculated as:

$$S_{(\hat{\beta}_j - \hat{\beta}_k)} = \sqrt{S^2_{\hat{\beta}_j} + S^2_{\hat{\beta}_k} - 2 \text{ Est. cov } (\hat{\beta}_j, \hat{\beta}_k)}$$

Wealth endowment: Family wealth may be another important factor influencing the decision of a potential enrollee to join the graduate program and select a particular discipline. Bachelor's degree holders from wealthy families are most likely to enroll in disciplines which provide more psychic gains and potential enrollees from less wealthy families would probably assign greater weight to the monetary rewards (18).

Financial support: Direct financial support to graduate students may be classified in the following broad categories: Fellowships and scholarships that do not require work by recipients, research and teaching assistantships, and low interest educational loans. During the 1960's graduate students received extensive direct financial support. In 1967-68 and the following year, one out of every six full-time graduate students received a federally supported traineeship or fellowship. The total number of such rewards fell from 51,000 for 1967-68 to 29,000 for the 1971-72 academic year (53). The proportion of students supported and the value of stipends varied among specialties. Because financial support reduces the private direct cost of a graduate program, the availability of more assistantships and fellowships in a specific discipline relative to the other disciplines may increase the enrollment demand for that discipline.

Employment opportunities: Several factors in specific occupations affect the demand for graduates (master's and doctoral degree holders). The two most important work activities of the graduates are teaching and conducting research. In the educational institutions, graduates teach and advise students and conduct research. In institutions of higher education the demand for graduates depends, at least in part, upon the level of undergraduate enrollment. During the 1961-70 period college and university enrollments more than doubled. The size of the university faculties also grew with similar rapidity during the same period. The growth rate slowed down in 1971-72 as compared with that of the 1960's (21). Because a high percentage of doctorate holders were employed by institutions of higher education, a declining growth rate in undergraduate enrollment for certain disciplines would have reduced the employment opportunities in those disciplines relative to the others.

A major factor in determining the demand for master's and doctoral degree holders in sectors other than institutions of higher education is the amount of research and development activity which is performed by scientists and engineers. The dramatic shift in the demand for Ph.D. degree holders in the 1969-72 period was a direct result of the reduction in national public research and development expenditures (21). The decrease in real expenditures from this source reduced the employment opportunities for scientists and engineers in research and development. Also, it reduced the financial support to the colleges and universities, resulting in decreased demand for new faculty. The disciplines conducting basic research were affected the most. These disciplines may have faced a reduction in demand for enrollments as compared with disciplines engaged in applied research.

Table 6 provides the demand comparison between various disciplines at Oregon State University[22]. Several comparisons appear to be important, for example, the enrollment demand for the Master of Business Administration (MBA) program (variable X_{18}) is significantly different from the enrollment demand for any other discipline. The size of the estimated coefficient of the binary variable representing the MBA program suggests that the demand for enrollment in MBA program is greater than that for any other discipline. Higher enrollment demand for the MBA program may be attributable to better employment opportunities for MBA degree holders. These graduates may end up as business executives of some kind, salesmen and teachers. The diversified job opportunities for graduates with MBA degrees during the 1960's and 1970's may be the cause of higher enrollment demand for MBA programs.

A perusal of Table 6 leads to the conclusion that the demand for enrollment in the disciplines of the School of Engineering, with the exception of Chemical Engineering, is significantly different than the demand for enrollment in most of the other disciplines. The estimated coefficients suggest that the demand for enrollment in these fields was greater than for most of the others. Among the reasons for the higher demand for enrollment in these disciplines may be the foreign demand. Demand for enrollment by foreign students varies among disciplines. For example, the percentage of foreign students in the School of

---

22/ The numbers in Table 6 are the calculated t-values for the difference between $\hat{\beta}_j$ and $\hat{\beta}_k$. The lower half of the table may be read as the negative of the upper half.

TABLE 6. DEMAND COMPARISON BETWEEN VARIOUS MAJORS AT OREGON STATE UNIVERSITY $(\hat{\beta}_j - \hat{\beta}_k)^{23}$.

j/k	$\hat{\beta}_4$	$\hat{\beta}_5$	$\hat{\beta}_7$	$\hat{\beta}_{10}$	$\hat{\beta}_{11}$	$\hat{\beta}_{13}$	$\hat{\beta}_{14}$	$\hat{\beta}_{15}$	$\hat{\beta}_{16}$	$\hat{\beta}_{17}$	$\hat{\beta}_{18}$	$\hat{\beta}_{19}$	$\hat{\beta}_{21}$	$\hat{\beta}_{22}$	$\hat{\beta}_{24}$	$\hat{\beta}_{25}$	$\hat{\beta}_{26}$	$\hat{\beta}_{27}$	$\hat{\beta}_{28}$	$\hat{\beta}_{29}$	$\hat{\beta}_{30}$
$\hat{\beta}_4$	--	0.48	-1.11	4.41**	3.99**	3.84**	1.20	3.84**	0.30	-3.42**	-8.10**	0.12	0.69	3.46**	-0.25	1.13	-0.12	-2.51**	-0.92	3.47**	-2.51**
$\hat{\beta}_5$		--	-1.59	3.93**	3.51**	3.36**	0.70	3.36**	-0.18	-3.90**	-8.58**	-0.36	0.21	2.98**	-0.71	0.67	-0.60	-2.99**	-1.39	3.00**	-2.98**
$\hat{\beta}_7$			--	5.52**	5.10**	4.94**	2.31**	4.94**	1.41	-2.32**	-7.00**	1.23	1.80*	4.56**	0.82	2.20**	0.99	-1.41	0.16	4.58**	-1.40
$\hat{\beta}_{10}$				--	-0.42	-0.54	-3.21**	-0.54	-4.11**	-7.80**	-12.49**	-4.29**	-3.72**	-0.91	-4.49**	-3.11**	-4.53**	-6.91**	-5.22**	-0.91	-6.88**
$\hat{\beta}_{11}$					--	-0.12	-2.79**	-0.12	-3.69**	-7.38**	-12.07**	-3.87**	-3.30**	-0.49	-4.09**	-2.70**	-4.11**	-6.49**	-4.81**	-0.50	-8.81**
$\hat{\beta}_{13}$						--	-2.65**	0.00	-3.54**	-7.31**	-11.74**	-3.72**	-3.15**	-0.79	-4.07**	-2.65**	-3.96**	-6.29**	-4.79**	-0.38	-6.39**
$\hat{\beta}_{14}$							--	2.65**	-0.90	-4.61**	-9.30**	-1.08	-0.51	2.27**	-1.40	-0.02	-1.32	-3.71**	-2.09**	2.28**	-3.70**
$\hat{\beta}_{15}$								--	-3.54**	-7.31**	-11.74**	-3.72**	-3.15**	-0.79	-4.07**	-2.65**	-3.96**	-6.29**	-4.79**	-0.38	-6.39**
$\hat{\beta}_{16}$									--	-3.72**	-8.40**	-0.18	0.39	3.16**	-0.54	0.85	-0.42	-2.81**	-1.22	3.18**	-2.80**
$\hat{\beta}_{17}$										--	-4.59**	2.54**	4.11**	6.94**	3.15**	4.57**	3.30**	0.92	2.48**	6.93**	0.92
$\hat{\beta}_{18}$											--	8.22**	8.79**	11.35**	7.37**	7.98**	7.98**	5.62**	6.84**	11.43**	5.49**
$\hat{\beta}_{19}$												--	0.57	3.34**	-0.37	1.02	-0.24	-2.63**	-1.04	3.35**	-2.62**
$\hat{\beta}_{21}$													--	2.78**	-0.91	0.47	-0.81	-3.20**	-1.60	2.79**	-3.19**
$\hat{\beta}_{22}$														--	-3.70**	-2.28**	-3.58**	-5.91**	-4.41**	0.001	-6.01**
$\hat{\beta}_{24}$															--	1.44	0.13	-2.14**	-0.69	3.68**	-2.23**
$\hat{\beta}_{25}$																--	-1.25	-3.51**	-2.13**	2.27**	-3.65**
$\hat{\beta}_{26}$																	--	-2.39**	-0.81	3.59**	-2.39**
$\hat{\beta}_{27}$																		--	1.51	5.94**	-0.01
$\hat{\beta}_{28}$																			--	4.40**	-1.56
$\hat{\beta}_{29}$																				--	-6.01**
$\hat{\beta}_{30}$																					--

23/ $\hat{\beta}_j$ is the parameter estimate of the coefficient of X_j, where j, k = 4, 5, 7, ..., 30, j ≠ k, j is the row variable, k is the column variable.

For the key, see Table 3. * Significant at the .10 value $[t_{(.05,\ 269)} = 1.645]$ ** Significant at the .05 value $[t_{(.025,\ 269)} = 1.960]$

Engineering rose from 8.8 in the fall of 1970-71 to 43.9 in the fall of 1975-76. In the School of Agriculture this percentage dropped from 29.5 to 25.8 during the same period, while the percentage remained constant in the School of Science (39). An increased demand for graduate enrollment by foreign students in engineering relative to other disciplines might have brought an overall increase in enrollment in the disciplines of engineering.

Another interesting point to note is that the demand for enrollment in physics is significantly less than for all the disciplines in the School of Science. Also, it is lower when compared with most of the fields in the Schools of Agriculture and Engineering. One of the several factors accounting for a lower enrollment demand for physics may be a substantial change in the flow of students into the field at the undergraduate level. The number of bachelor's degrees in physics relative to the total number of bachelor's degrees awarded dropped substantially in the 1970's relative to the early 1960's (19). This relative decrease in the number of bachelor's degrees awarded in physics at the national level might have a depressing effect on the demand for enrollment in physics at Oregon State University.

The other reason for a lower demand for physics at Oregon State University (OSU) may be the availability of a close substitute at the University of Oregon (U.O). To illustrate this point, one may consider a hypothetical situation in which a college graduate decides to pursue his graduate program in physics in the State of Oregon. He may enroll either at OSU or the U.O. A number of college graduates may enroll in physics at the University of Oregon who otherwise would have joined the graduate program in physics at Oregon State University. However, the engineering and agricultural disciplines have no close substitutes available at the University of Oregon or Portland State University. Thus college graduates who are interested in graduate programs in these disciplines and who wish to study in Oregon do not have any choice other than joining Oregon State University. One would expect the enrollment demand for those disciplines for which close substitutes are available in other institutions of higher education in the State of Oregon, *ceteris paribus*, to be less at Oregon State University. Physics was one of the fields which was hit hard by the substantial cut in the national research and development expenditures and by the reduction in the space program. These cuts reduced the employment opportunities for holders of master's and doctoral degrees and also severely affected the financial support to college graduates who intended to join a graduate program in the discipline. These effects in turn might have brought about a decrease in enrollment demand for physics.

Since this institutional model represents the enrollment demand at Oregon State University, generalization of these results to other institutions of higher education may be misleading. However, these results generate interesting hypotheses which could be tested using a larger sample.

National Model

Using the 12 observations on the new graduate enrollment ratio (y), the unemployment rate for technical and professional workers (U) and real mean family income (RI) equation 4.3 was estimated [24,25]

$$E_t/P_t = \hat{y} = 0.4736 - 0.076236\ U_t + 0.0000381\ (RI)_t \qquad (4.3)$$

$$(3.777)\quad (-2.6445)\qquad\qquad (2.752)$$

$$R^2 = .6109$$

$$N = 12,\ F = 7.0665$$

Autoregressive structure of the disturbance terms, $\hat{\rho} = 0.29095$ [26]

The numbers in the parentheses are t-statistics

Durbin-Watson d test = 1.09348 [27].

In the demand equation the signs of the regression coefficients were as expected from the discussion in Chapter II. Both of the coefficients were also significantly different from zero (one-sided test at the .025 level). The F value indicated that all of the

---

24/ A linear relationship was specified among the variables. The analysis was limited to the 1960-71 period because the information on first year graduate enrollment was available only for that period.

25/ Relevant data appear in Appendix Table 4.

26/ $\hat{\rho} = \Sigma(\hat{e}_t \hat{e}_{t-1}) \,/\, \Sigma \hat{e}_t^{\,2} \quad (t = 2, 3, \ldots, n)$

27/ The Durbin-Watson d-statistic was calculated as:

$$d = \sum_{t=2}^{n} (\hat{e}_t - \hat{e}_{t-1}) \,/\, \sum_{t=1}^{n} \hat{e}_t^{\,2}$$

explanatory variables as a whole contributed significantly to explaining the total variation in demand for enrollment (enrollment ratio). The t-values on the individual estimates also revealed that corresponding variables were also important in explaining the variation in the demand for graduate enrollments. Plots of the residuals against the endogenous variable and each exogenous variable suggested the absence of systematic bias from specification error and heteroskedasticity. A check of the simple correlation matrix (r_{23} = .031) did not reveal any evidence of severe pairwise multicollinearity. The low value of the Durbin-Watson statistic (d = 1.09348) may create suspicions in one's mind about the violation of one of the crucial assumptions that successive disturbances are drawn independently of the previous values.[28,29]

28/ To check for the presence of autoregression in the econometric model the investigator should have at least 15 observations. This study has only 12 observations, which are not enough to check the d-statistics from the table. The values of lower bound (d_L) and upper bound (d_u) Durbin-Watson statistics become smaller and smaller as the number of observations decrease. At a given level of significance, if we reject the hypothesis of the presence of autocorrelation with 15 observations, then at the same level of significance the assumption of independence of error terms may also be valid in case of 12 observations.

29/ At the .05 level the $d_L<d<d_u$, the test is inconclusive and the researcher is not in a position to accept or to reject the hypothesis of no autocorrelation.

This is an important and necessary property of the ordinary least square (O.L.S.) procedure. It also implies that y_i and y_j, $i \neq j$, are uncorrelated. Under the violation of the above assumption ordinary least squares is not entirely appropriate for use with economic time series data (48). The least squares estimators of the regression coefficients are unbiased and consistent but they are not efficient. Kmenta (34) has pointed out that the variances of the estimated coefficients obtained through O.L.S. are biased when the disturbances are autoregressive.

An alternative estimation procedure for estimating a regression equation with the presence of autoregression is an iterative method (9). This method consists of the following steps:

1. Obtain ordinary least square estimates of the parameters of

$$y_t = \propto + \beta_1 U_t + \beta_2 (RI)_t + e_t,$$

and calculate the residuals, $\hat{e}_1$, $\hat{e}_2$, ..., $\hat{e}_t$.

2. Calculate the estimate of ρ, $\hat{\rho}$ from the residuals,

$$\hat{\rho} = \Sigma_t \hat{e}_t \hat{e}_{t-1} \;/\; \Sigma \hat{e}_t, \quad (t = 2, 3, \ldots, n)$$

3. Transform the original variables by using $\hat{\rho}$ as

$$(y_t - \hat{\rho} y_{t-1}),\ (U_t - \hat{\rho} U_{t-1}),\ [(RI)_t - \hat{\rho}(RI)_{t-1}],\ \ldots,$$

$$(y_n - \hat{\rho} y_{n-1}),\ (U_n - \hat{\rho} U_{n-1}),\ [(RI)_n - \hat{\rho}(RI)_{n-1}]$$

This procedure will result in loss of an observation. While the loss of one observation does not matter in a large sample, it may make a significant difference when the size of the sample is small (43).

4. To avoid the loss of one observation, transform the observations on each variable by the method suggested by Prais and Winston as follows (42):

$$\sqrt{1-\hat{\rho}^2}\; y_1,\quad \sqrt{1-\hat{\rho}^2}\; U_1,\quad \sqrt{1-\hat{\rho}^2}\;(RI)_1,\; \ldots,$$

$$(y_n-\hat{\rho}y_{n-1}),\; (U_n-\hat{\rho}U_{n-1}),\; [(RI)_n-\hat{\rho}(RI)_{n-1}]$$

5. Repeat steps 2 to 4 until the coefficients are stabilized or until the Durbin-Watson test rules out the presence of autoregressive disturbances.

Following the above generalized least squares (G.L.S.) procedure the estimated equation was:

$$\hat{y} = 0.465^{30} - 0.062\, U + 15(10)^{-6}(RI) \qquad (4.4)$$

$$(5.252) \quad (-3.030) \quad (1.062)$$

$R^2 = .523$

$N = 12$, $F = 4.9419$

Autoregressive structure of the disturbance term $\hat{\hat{\rho}} = 0.086$

30/ $\overset{*}{\alpha} = (1-\hat{\rho})\hat{\alpha}$, $\hat{\alpha} = \overset{*}{\alpha}/1-\hat{\rho} = 0.6563$

Durbin-Watson d test = 1.7928. Values of the t statistic are given in the parentheses below their respective coefficients.

The estimated coefficients have the expected signs, confirming our hypotheses. The comparison of equations 3 and 4 dictates that there was a slight change in the value of the regression coefficient associated with the unemployment rate. The estimated coefficient of the family income variable which was significant (one-sided test at the .05 level) in equation 4.3, became insignificant (one-tailed test at the .05 level) in equation 4.4.

Usually the O.L.S. underestimates the true variance of the regression coefficients when the error terms are autoregressive (33). A comparison between the O.L.S. and G.L.S. estimating procedures will give the readers some idea of the extent of underestimation by O.L.S. as the G.L.S. estimates provide unbiased estimates of variances (52). Table 7 shows the diagonal elements (C_{ii}) of the $(X'X)^{-1}$ matrices associated with the O.L.S. and the G.L.S. equations.

Table 7 shows the bias introduced in the variances of the estimated coefficients due to the underestimation of the diagonal elements of $(X'X)^{-1}$ matrix by O.L.S. The value of the total sum of squares (Σy_i^2) for O.L.S. in Table 8 is almost 2.905 times larger than that of the Σy_i^2 for the G.L.S. in Table 9.

The critical F-value for (2,9) degrees of freedom at the .05 level is 4.26. The calculated F-values in Tables 8 and 9 are significant. The overall F statistic for O.L.S. is 1.43 times larger than that of the G.L.S. The high value of F for O.L.S. is the result of auto-correlated disturbances. It is interesting to note that the value of

TABLE 7. C_{ii} VALUES FROM THE INVERTED MATRICES AND BIAS IN THE O.L.S. ESTIMATION OF VARIANCE OF $\hat{\beta}_i$.

Elements	O.L.S. (C_{ii})	G.L.S. (C_{ii})	Ratio of the main diagonal elements O.L.S./G.L.S.	Underestimation of O.L.S. variance due to $(X'X)^{-1}$
C_{11}	0.4170656	0.5046495	0.8264	1.22
C_{22}	$9.619793.10^{-8}$	$23.89344.10^{-8}$	0.4026	2.48

TABLE 8. ANALYSIS OF VARIANCE: O.L.S. REGRESSION.

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F
Total	11	$4.60838270.10^{-2}$	$4.1894388.10^{-3}$	
Regression	2	$2.81546723.10^{-2}$	$14.0773362.10^{-3}$	
Residual	9	$1.79291547.10^{-2}$	$1.9921283.10^{-3}$	7.0665

TABLE 9. ANALYSIS OF VARIANCE: G.L.S. REGRESSION.

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F
Total	11	$1.58613931.10^{-2}$	$1.44194483.10^{-3}$	
Regression	2	$0.83018348.10^{-2}$	$4.15091740.10^{-3}$	
Residual	9	$0.75595583.10^{-2}$	$0.839950922.10^{-3}$	4.9419

F from O.L.S. regression overestimated the real F value by 3.39 times[29]. This suggests that when disturbances are autoregressive and O.L.S. procedures are used, the analysis of variance may be misleading and F statistics are not statistically valid.

The residual sum of square $\Sigma(y_t - \hat{y}_t)^2$ for the O.L.S. regression equation is 2.37 times higher than for the G.L.S. equation, indicating a much better fit of the data by the G.L.S. equation. Murphy has pointed out that, in the presence of positive autocorrelation, the estimated variance of residuals ($\nabla^2 e$) from O.L.S. generally is biased downward (37). In this particular case the assertion of underestimation by O.L.S. does not hold true.

As stated earlier the O.L.S. underestimated the diagonal elements C_{11}, C_{22}, of $(X'X)^{-1}$. Even though the C_{11} for G.L.S. was higher than that of the O.L.S., the much lower value of MSE for the G.L.S. resulted in a higher absolute t-value associated with the estimated coefficient of the unemployment variable[30]. The C_{22} for the O.L.S. matrix $(X'X)^{-1}$ must necessarily be much lower in value to offset the much higher value of the MSE, resulting in an underestimation of the variance of $\hat{\beta}_2$ and overestimation of its t-value.

29/ The factor of overestimation of the real value of F by O.L.S. is calculated by:

$$\text{Overestimation of real value of F} = \frac{F(O.L.S.)}{F(G.L.S.)} \cdot \frac{\nabla^2 e(O.L.S.)}{\nabla^2 e(G.L.S.)}$$

where $\nabla^2 e$ are the mean square error elements from the analysis of variance Table 8 and 9.

30/ A t-value for a regression coefficient consists of the following elements:

$$t = \hat{\beta}_i / s^2 C_{ii}, \quad \text{where } \nabla^2 e \doteq s^2$$

The increase in the t-value associated with the estimated coefficient of the unemployment rate variable and a substantial reduction in the t-value associated with the estimated coefficient of mean family income for G.L.S. may be caused by the severe change which occurred in the simple correlation coefficients (r_{ij}'s) of the transformed data. The values of the simple correlation coefficients are given in Table 10.

TABLE 10. SIMPLE CORRELATION COEFFICIENTS FOR THE O.L.S. AND G.L.S. EQUATIONS.

Correlation coefficient	O.L.S.	G.L.S.
r_{12}	-0.532	-0.681
r_{13}	0.555	0.193
r_{23}	0.031	0.075

Table 10 shows that the simple correlation between the enrollment ratio and real mean family income decreased substantially for G.L.S. The absolute value of the simple correlation coefficient between the enrollment ratio and the unemployment rate increased from .532 for O.L.S. to .681 for G.L.S.

From the previous discussion we saw that the $\overline{V}^2e$ for the O.L.S. equation was 2.37 times larger than the $\overline{V}^2e$ for G.L.S. In the case of O.L.S. the real F value was overestimated by 3.39 times. Also the O.L.S. regression underestimated the variances of $\hat{\beta}_1$ and overestimated the variance of $\hat{\beta}_2$. On the other hand, the estimated regression coefficient of the family income variable was reduced significantly, suggesting that this coefficient is very sensitive to small changes in the data.

For these reasons one should be very careful in choosing one estimated equation over the other, because these estimated equations may lead to different policy implications.

V. SUMMARY AND POLICY IMPLICATIONS

Summary of Results

In Chapter 1 we noted that nationally the first year graduate enrollment formed an upward trend during the years 1960-1971. However, the enrollment ratio of first year graduate students to the number of bachelor's degrees awarded has formed an upward trend until 1965, showed a slight decline in 1966, peaked in 1967, then formed a declining trend which continued for the rest of the period under study. The fall term new graduate enrollments at Oregon State University for the period 1966 to 1975 showed fluctuations.

For the years 1967-1970, first year graduate enrollment and the enrollment ratio at the national level formed opposing trends whereas the fall term new graduate enrollments at Oregon State University showed fluctuations for the same period.

The primary objective of this study has been to determine the reasons for variation in graduate enrollment demand at Oregon State University as well as at the national level. Our demand model for graduate education relies on the well developed investment and consumption theories existing in the literature. However, some important variables, e.g., monetary gains associated with higher education and the minimum grade point average for admission, neglected in the previous studies of demand for college education, were included in the institutional model.

From the estimated coefficients of the institutional model, it was concluded that the demand for new graduate enrollment varies significantly among most of the disciplines. It was also concluded that the graduate enrollment demand is price (tuition) inelastic and that monetary gains associated with graduate education is an important factor influencing one's decision to enter a graduate school. The positive sign and the significance of the estimated coefficient of the grade point average variable suggests that any attempt to reduce graduate enrollment pressure by increasing the G.P.A. requirement for admission may not succeed. Potential enrollees may regard high admission requirements at a given institution as evidence of a high quality program and thus increase the demand for graduate education at that school. The study also revealed that the demand for enrollments varies significantly among most of the disciplines at Oregon State University.

When estimating a demand function, economists usually use the least square procedure that assumes the disturbances from regression to be independent. At the national level, ordinary least squares (O.L.S.) regression coefficients of variables representing mean family income and the unemployment rate had the expected signs and also were significant. However, the Durbin-Watson test was inconclusive. The method used to correct for autocorrelated observations is the one suggested by Prais and Winston (42). This method did not result in the loss of any observation and was able to eliminate the undesirable effect of autocorrelation. Basically, the corrected method used was the generalized least square (G.L.S.) procedure for eliminating the first order autoregressive error term structure.

The estimated coefficient of the family income variable was significant in the O.L.S. equation but became non-significant in the G.L.S. equation. The estimated coefficient of the unemployment rate variable in both of the equations was significant.

Policy Implications

This study supports the general contention that tuition and quality of graduate programs may be relevant variables in explaining the demand for new graduate enrollments. Any attempt by a university administration to increase tuition levels should be associated with improvement in its graduate program to maintain a specific level of enrollments. A recent declining trend in undergraduate enrollments at the national level may reduce the number of potential enrollees interested in joining the graduate program at Oregon State University. An improvement in the quality of its graduate program may mitigate, if not eliminate, the effect of decreased potential enrollees on the demand for graduate enrollments at Oregon State University. If an institution is faced with a ceiling on its graduate enrollment, any attempt by the administration to increase the minimum grade point average requirement may place additional pressure on the institution to live within enrollment ceilings imposed by the administration of the institution or by the Oregon State Board of Higher Education. On the other hand, data limitations precluded examining the possibility that, for some disciplines and for some institutions, the demand-rationing aspect of the minimum grade point average requirement will overwhelm the "quality of the program" component. For such cases an increase in the grade point average requirement may, in fact, reduce enrollment demand.

At the national level, the ordinary least squares regression coefficient of the mean family income variable supports the general contention that family income is an important factor in determining who enrolls in graduate school. Higher family income serves, at least in part, as an effective bypass to the imperfection of the capital market whereas potential enrollees from low-income families may not be able to advance for graduate education. However, the estimated coefficient of the income variable from the generalized least square regression suggests that family income is not an important factor influencing the decision of a college graduate to enroll in a graduate school. Thus one should be very cautious in recommending some kind of income enhancing program and/or low interest loan programs as vehicles for increasing the enrollment ratio. However, because it was not possible to measure the effect of direct financial assistance on enrollment demand, one cannot infer that increasing the availability of financial assistance for graduate study would not increase the enrollment demand.

Both of the equations indicate that the unemployment rate for technical and professional workers is an important factor in explaining the variation in the enrollment ratio. Improved employment opportunities for master's and doctoral degree holders may be considered a stimulus for increasing graduate school enrollments.

BIBLIOGRAPHY

1. Becker, Gary S. Human capital: A theoretical and empirical analysis, with special reference to education. New York, National Bureau of Economic Research, 1964.

2. Blaug, M. "The rate of return on investment in education in Great Britain." Manchester School, vol. 3:205-251. September, 1965.

3. __________. "An economic interpretation of the private demand for education." Economica, vol. 33:166-182. May, 1966.

4. Bowles, Samuel S. and Henry M. Levin. "More on multicollinearity and the effectiveness of schools." Journal of Human Resources vol. III:393-400. Summer, 1968.

5. Brown, William G. Oregon State University, AREc 568 (Econometrics) lecture notes. Spring, 1975.

6. Brown, William G. and David Fawcett. "Estimated economic losses by Oregon sheep growers associated with restricted predator control, 1965-1972: Some preliminary findings." Agricultural Experiment Station Special Report 418, Oregon State University, Appendix C-41. September, 1974.

7. Campbell, Robert and Barry N. Siegel. "The demand for higher education in the United States." The American Economic Review 57(3):482-494. June, 1967.

8. Christensen, Sandra, et al. "Factors affecting college attendance." Journal of Human Resources 10(2):174-188. Spring, 1975.

9. Cochrane, D. and G. H. Orcutt. "Application of least square regression to relationships containing autocorrelated error terms. Journal of the American Statistical Association vol. 44:32-61. 1949.

10. College Placement Council, Inc. "CPC Salary Survey." The Association for Career Planning, Recruitment and Placement. Bethlehem, Pennsylvania.

11. Corazzini, A. J. et al. "Determinents and distributional aspects of enrollment in U.S. higher education." Journal of Human Resources 7(1):39-59. Winter, 1972.

12. Education and Economic Systems, Inc. "College enrollments in U.S." Boulder, Colorado. 1975.

13. Farrar, Donald E. and Robert R. Glauber. "Multicollinearity in regression analysis: The problem revisited." Review of Economics and Statistics 49(1):91-107. 1967.

14. Feldman, P. and S. A. Hoenack. "Private demand for higher education in U.S." in U.S. Congress, Joint Economic Committee. The economics and financing of higher education in U.S. compendium of papers, 91st Cong., 1st sess., Washington: 375-395. 1969.

15. Ferguson, C. E. Microeconomic theory. Homewood, Illinois, Richard D. Irwin, Inc. 1972.

16. Fisher, Irving. The nature of capital and income. New York. 1906.

17. Foreign Students' Advisor's Office. "Out-of-state tuition differential for graduate student." Unpublished material. Oregon State University. February, 1977.

18. Freeman, Richard B. The market for college trained manpower: A study in the economics of career choice. Massachusetts, Harvard University Press. 1971.

19. __________. "Supply and salary adjustment to the changing science manpower market: Physics, 1948-73." The American Economic Review LXV(1):27-39. March, 1975.

20. __________. "Overinvestment in college training?" Journal of Human Resources X(3):287-311. Summer, 1975.

21. Freeman, Richard B. and David W. Breneman. "Forecasting the Ph.D. labor market: Pitfalls for policy." Technical report No. 2. National Board on Graduate Education, Washington, D.C. April, 1974.

22. Galper, H. and R. M. Dunn, Jr. "A short-run demand function of higher education in the U.S." Journal of Political Economy 77(5):765-777. September, 1969.

23. Graduate School. "Graduate School registration: Fall term, 1965-1975." Corvallis, Oregon State University.

24. Haitovsky, Y. "A note on the maximization of $\bar{R}^2$." The American Statistician 23(1):20-21. February, 1969.

25. Hammonds, T. M. Oregon State University AREc 567 (Applied Econometrics) lecture notes. Winter, 1974.

26. Handa, Michael L. and Michael L. Skolnik. "Empirical analysis of the demand for education in Canada." in Canadian higher education in the seventies. Edited by Sylvia Ostrey. Ottawa: Economic Council of Canada: 5-44. 1972.

27. Henderson, James M. and Richard E. Quandt. Microeconomic theory: A mathematical approach. New York. McGraw-Hill Book Company. 1971.

28. Hight, J. "Supply, demand, and enrollment ratio in the U.S. higher education." Brown University. Unpublished doctoral dissertation. 1971.

29. Hirshleifer, J. Investment, interest and capital. Englewood Cliffs, N.J. Prentice-Hall, Inc. 1970.

30. Hocking, R. R. "Misspecification in regression." The American Statistician 28(1):39-40. February, 1974.

31. Hoenack, S. A. "Private demand for higher education in California." University of California. Unpublished doctoral dissertation. 1967.

32. Hopkin, Thomas D. "Higher education enrollment demand." Economic Inquiry 12(1):53-65. March, 1974.

33. Johnston, J. Econometric Method. New York. McGraw-Hill Book Company. 1972.

34. Kmenta, Jan. Elements of econometrics. New York. The Macmillan Company. 1971.

35. Marshall, Alfred. Principles of Economics. New York. The Macmillan Company. 1936.

36. Mayhew, Lewis B. and Patrick J. Ford. Reform in graduate and professional education. San Francisco, California. Jossey-Bass Publishers. 1974.

37. Murphy, James L. Introductory econometrics. Homewood, Illinois. Richard D. Irwin, Inc. 1973.

38. Newburg, R. W. "Graduate education -- Yesterday, today and tomorrow at O.S.U." Corvallis, Oregon State University. Unpublished paper. 1977.

39. Oregon Department of Higher Education. "Analysis of tuition and fees -- Graduate studies, fiscal year 1964-65 through fiscal year 1975-76." Eugene, University of Oregon. 1976.

40. Oregon State University. Graduate School Bulletins 1966-67 to 1975-76. Corvallis, Oregon State University.

41. Osthemer, R. H. Student charges and financing higher education. New York. 1953.

42. Prais, S. J. and C. B. Winston. "Trend estimator and serial correlation." Chicago, Unpublished Cowles Commission discussion paper. Stat. No. 383. 1954.

43. Rao, Potluri and Zvi Griliches. "Small-sample properties of several two-stage regression methods in the context of auto-correlated errors. American Statistical Association Journal 64(325):253-272. March, 1969.

44. Rivlin, Alice M. et al. "The demand for higher education in micro-analysis of socioeconomic system: A simulation study." New York. Harper and Brother Publishers. 1961.

45. Schultz, T. W. "Investment in human capital." The American Economic Review XLIX(1):1-17. March, 1961.

46. Spring Conference Resident Instruction in Agriculture. "Summary of placement of survey of colleges of agriculture in the western region." Proceedings of the Spring Conference, deans and directors of Resident Instruction, Division of Agriculture, 12 Western States. 1967-1976.

47. Tevitan, Sar A. Human resources and labor market: Labor and manpower in the American economy. New York. Harper and Row Publishers. 1972.

48. Tintner, Gerhard. Econometrics. New York. John Wiley and Sons, Inc. 1952.

49. U.S. Department of Commerce. "Money income in 1974 of families and persons in the United States." Series P-60, No. 101:37. 1976.

50. U.S. Department of Education. "Projections of educational statistics to 1982-83: 1973 edition. Washington. 1974.

51. U.S. Department of Labor. "Manpower Report of the President." Washington, D.C. April, 1975.

52. __________. "Manpower issues in the profession and higher education: A reprint from Manpower Report of the President." 1972.

53. VonThünen, H. Der isolierte staat. 3rd ed., vol. 2, 1875. Transl. by B. F. Hoselitz, reproduced by the Comp. Educ. Center, Univ. Chicago.

54. Weisbrod, Burton A. "Preventing high school dropouts in measuring benefits of government investment." Robert Dorfman, ed. Published by the Booklings Institute:117-171. 1965.

APPENDIX

APPENDIX TABLE 1. FALL TERM M.S. AND Ph.D. ENROLLMENT IN VARIOUS DISCIPLINES AT OREGON STATE UNIVERSITY, 1965-1975[a].

Discipline	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Agricultural and Resource Economics	28	34	42	58	57	59	59	44	40	45	58
Agronomic Crop Science	24	38	39	33	33	33	32	16	27	32	41
Animal Science	20	21	23	26	30	26	20	22	19	25	24
Fisheries and Wildlife	61	53	66	68	64	67	69	76	77	75	83
Food Science and Technology	26	30	27	23	28	20	21	23	21	18	29
Horticulture	11	9	10	17	12	14	12	14	12	21	31
Poultry Science	1	1	4	5	3	4	3	4	3	5	4
Range Management	7	4	8	10	6	3	9	6	13	13	12
Soil Science	17	27	33	30	33	34	30	31	32	30	28
School of Pharmacy	13	17	15	15	13	15	17	16	14	12	14
Forest Management	23	25	34	32	37	27	30	34	30	38	47
Forest Products	3	4	2	12	15	21	20	16	20	12	15
Business Administration	21	41	65	80	93	89	87	64	52	96	105
Botany and Plant Pathology	58	67	76	59	55	56	49	41	55	50	61
Chemistry, Biochemistry and Biophysics	157	155	153	141	140	127	128	121	124	119	127
Geography	14	13	13	16	30	40	46	51	59	61	68
Geology	27	18	27	31	23	20	31	36	43	38	45
Mathematics	84	92	90	90	82	87	80	49	38	39	34
Microbiology	57	63	64	62	51	50	52	40	42	36	41
Physics	53	48	51	44	45	35	27	27	24	22	24
Statistics	25	32	30	41	38	41	39	28	39	47	50

APPENDIX TABLE 1 - continued

Discipline	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Zoology	60	58	73	77	75	70	66	65	58	49	51
Civil Engineering	20	35	43	43	48	51	43	33	61	58	53
Electrical Engineering	56	51	51	47	52	52	44	46	60	64	82
Chemical Engineering	23	20	22	25	19	16	13	13	14	18	21
Mechanical, Industrial and Nuclear Engineering	33	43	48	61	61	53	64	64	74	66	88
Entomology	28	37	41	33	27	30	30	24	21	34	32

a/ The enrollment data do not include persons seeking the Master of Agriculture, Master of Forestry, Master of Engineering and Master of Ocean Engineering degrees.

APPENDIX TABLE 2. GRADUATE DEGREES AWARDED IN VARIOUS DISCIPLINES AT OREGON STATE UNIVERSITY, 1966-1975[b,c].

Discipline	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Agricultural and Resource Economics	10	12	8	15	19	19	14	17	14	8
Agronomic Crop Science	9	11	16	14	14	15	6	14	11	14
Animal Science	10	9	6	4	15	8	6	8	8	5
Fisheries and Wildlife	14	14	13	20	23	17	8	25	22	26
Food Science and Technology	13	10	13	10	8	9	8	7	10	5
Horticulture	3	6	0	7	3	3	3	4	6	4
Poultry Science	3	1	1	1	2	1	1	0	3	2
Range Management	5	1	2	2	3	1	2	1	7	2
Soil Science	8	9	7	9	12	9	10	12	7	11
School of Pharmacy	6	4	2	3	4	4	5	4	8	4
Forest Management	5	15	11	7	10	7	10	15	15	8
Forest Products	2	0	0	0	3	2	3	5	8	7
Business Administration	8	19	27	25	53	53	56	37	32	39
Botany and Plant Pathology	16	15	22	19	15	12	13	14	15	13
Chemistry, Biochemistry and Biophysics	40	27	43	42	25	30	35	29	27	21
Geography	8	13	5	6	10	5	9	12	27	14
Geology	2	7	5	10	9	5	7	6	12	9
Mathematics	35	23	34	27	32	18	35	20	8	10
Microbiology	15	20	26	12	20	11	15	16	16	9
Physics	4	10	13	9	11	9	9	8	6	7
Statistics	3	8	9	9	11	9	17	12	11	20

APPENDIX TABLE 2 - continued

Discipline	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Zoology	22	18	13	17	29	10	22	18	18	13
Civil Engineering	14	7	20	17	18	23	20	36	25	35
Electrical Engineering	17	16	24	26	16	12	23	19	17	26
Chemical Engineering	5	8	3	4	5	8	6	8	4	5
Mechanical, Metallurgical, Industrial and Nuclear Engineering	10	19	15	13	21	21	22	22	37	23
Entomology	7	10	7	15	12	4	7	14	4	6

b/ Master of Agriculture, Master of Forestry, Master of Engineering and Master of Ocean Engineering degrees are not included.

c/ The number of degrees awarded in any year covers the time period of fall term of the previous year and the winter, spring and summer terms of the same year.

APPENDIX TABLE 3. SIZE OF GRADUATE TUITION AND MINIMUM GRADE POINT AVERAGE REQUIRED FOR ADMISSION IN THE GRADUATE PROGRAM AT OREGON STATE UNIVERSITY, 1966-1975.

Year (Fall)	Size of tuition $	Minimum grade point average required for admission
1966	110.00	2.75
1967	143.00	2.75
1968	143.00	2.75
1969	162.00	2.75
1970	162.00	2.75
1971	220.00	2.75
1972	250.50	2.75
1973	265.50	3.00
1974	279.00	3.00
1975	317.00	3.00

APPENDIX TABLE 4. FIRST TERM GRADUATE ENROLLMENT, BACHELOR'S DEGREES AWARDED, MEAN FAMILY INCOME, CONSUMER'S PRICE INDEX AND UNEMPLOYMENT RATE FOR TECHNICAL AND PROFESSIONAL WORKERS IN THE UNITED STATES, 1960-1971[d].

Year	First term graduate enrollment (thousands)	Bachelor's degrees awarded (thousands)	Mean family income ($)	Consumer's price index (1967 = 100)	Unemployment rate for technical and professional workers. (percentage)
1960	197	368.323	6227	88.6	1.7
1961	217	368.857	6471	89.6	2.0
1962	240	387.830	6670	90.6	1.7
1963	271	416.421	6998	91.7	1.8
1964	318	466.484	7336	92.9	1.7
1965	359	501.248	7704	94.5	1.5
1966	371	520.248	8395	97.2	1.3
1967	428	557.075	8801	100.0	1.3
1968	458	631.923	9670	104.2	1.2
1969	494	728.167	10577	109.8	1.3
1970	528	791.510	11106	116.3	2.0
1971	525	839.730	11583	121.3	2.9

d/ See footnote c.