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ABSTRACT

A model in which nonprice rationing has two effects on the number of medical school applicants in the United States is specified and estimated for the 1951-76 period. The results indicate that low acceptance rates discourage many potential applicants and that a fairly large and constant percentage of rejected applicants can be expected to reapply. Four previous applicant studies are examined. The results also indicate that the rapid growth rates of applicants in recent years can largely be attributed to three factors: growth in women applicants, increases in resident salaries; and induced increases in repeat applicants. Medical school tuition, loan availability, and the attractiveness of science careers do not appear to have been important determinants of applicants over the sample period. (Author/SW)

MORE ON THE DEMAND FOR MEDICAL EDUCATION,

WITH SPECIAL ATTENTION TO THE EFFECTS

OF NONPRICE RATIONING.

By

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Discussion Paper No. 79-23

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MORE ON THE DEMAND FOR MEDICAL EDUCATION WITH SPECIAL ATTENTION TO THE EFFECTS OF NONPRICE RATIONING.

ABSTRACT

A model in which nonprice rationing has two effects on the number of medical school applicants in the U.S. is specified and estimated for the 1951 - 76 period. The results indicate that low acceptance rates discourage many potential applicants and that a fairly large and constant percentage of rejected applicants can be expected to reapply. Four previous applicant studies are examined in the light of these findings. The results also indicate that the rapid growth rates of applicants in recent years can largely be attributed to three factors: growth in women applicants, increases in resident salaries and induced increases in repeat applicants. Medical school tuition, loan availability and the attractiveness of science careers do not appear to have been important determinants of applicants over the sample period.

There have been four previous econometric studies of the demand for medical education: Sloan (1968, 1971), Esposito (1968), Leffler (1977) and Feldman and Scheffler (1978). The research reported on here brings the number to five. Interest in the subject has evolved in part from two concerns which have led to extensive government involvement in medical education: perceived, if not actual, physician shortages and the underrepresentation of minorities and women in the physician population. These studies have also been motivated by a more general interest in demand for higher education. Data on medical school applicants are of good quality and medical education has been a fairly homogeneous "commodity" over time relative to other types of education. The assumption is that inferences about the effects of tuition, loan and scholarship availability, and incomes of graduates on demand for higher education can be made from studying how these same variables affect the demand for medical education.

Our interest in the demand for medical education is mostly due to a well known characteristic of the medical school admissions procedure: many students who apply are not accepted at any school. In fact, only thirty-six percent of all applicants for entrance to U.S. medical schools in 1976 were admitted.* In economic terminology, the "market" for medical education is characterized by extensive nonprice rationing. Our results indicate that this rationing has two substantial effects on the demand for medical education.

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* Association of American Medical Colleges (1976). Throughout dates refer to academic years unless otherwise noted. Hence applicants for 1976 are those hoping to matriculate in the fall of 1975.

First, many potential applicants are discouraged by rationing. Application normally requires extensive premedical study and the possibility that the investment in premedical study will not payoff makes it less attractive.** This effect has been recognized in the four previous studies although only Feldman and Scheffler make a serious attempt at estimating its magnitude Second, a large number of applicants each year are applicants who have applied previously. Of all applicants for entrance in 1976, 23 percent had applied previously. We find that a model in which a constant proportion of rejected applicants reapply the following year fits the data very well, while ignoring the existence of repeaters -- as has been done in the previous studies -- seriously affects results. Our results should interest those studying demand in other rationed markets, where comparable effects may be observed.

In Section 1 we present the applicant data and discuss features of the data that are relevant in constructing our empirical model. The model is specified in Section 2 and results are discussed in Section 3. In Section 4 the previous studies are reconsidered. Remarks about future research on medical school applicants conclude the paper.

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* To complete a typical set of course requirements would require approximately two years of full-time undergraduate study. While an undergraduate premedical major is not required, a large number of courses in biology, chemistry and other sciences are usually specified. In addition, most schools require completion of a bachelor's degree. See Stapleton (1978, p. 31) for further details.

1. The Applicant Data

The Association of American Medical Colleges (A.A.M.C.) has gathered and published annual data on applicants to U. S. medical schools since 1927 except for the years 1944 through 1947. Data from individual schools are compared to eliminate double counting of applicants who apply to more than one school. Since 1951 the data have been published by sex. Since 1974 the A.A.M.C. has distinguished between first-time and repeat applicants; this distinction was also made in the period from 1952 to 1961.

We have chosen not to use the applicant data prior to 1951 both because data by sex are not available and because other data to be used in our model are not available. Applicant data for 1951 and later years are presented in the first four columns of Table 1. In the 14 years from 1954 to 1968 the number of applicants increased by only 32 percent while in the following seven years, to 1975, the number increased by 124 percent.

Two sources of growth in the later period will be considered in the model of the next section: increases in the number of male college graduates and in the attractiveness of becoming a physician. A third source which will not be considered is the larger rate of growth for female applicants. Throughout the 1950's fewer than seven percent of applicants were women. As late as 1969 this percentage was only 9.7. From that year on it grew rapidly, reaching 22.6 percent by 1976. While factors leading to growth in the number of male applicants in the 1970's undoubtedly affected the number of female applicants as well, it is unlikely that they can fully account for the growth in the latter series. This growth may in large part be due to a

TABLE 1

Medical School Applicants by Sex,
First-time and Repeat, 1951 to 1975

Year	Applicants		First-time Applicants*		Repeat Applicants*	
	Men	Women	Men	Women	Men	Women
1951	20,386	1,173	n.a.	n.a.	n.a.	n.a.
1952	18,245	1,040	12,513	783	5,732	257
1953	15,207	964	10,264	691	4,943	272
1954	12,931	908	9,709	721	3,222	187
1955	13,139	841	10,656	681	2,483	160
1956	13,301	939	10,631	789	2,670	150
1957	14,289	1,028	11,323	826	2,966	202
1958	14,290	920	11,470	745	2,820	175
1959	13,740	888	10,999	719	2,741	169
1960	13,504	974	10,769	805	2,735	169
1961	13,020	989	10,467	831	2,553	158
1962	12,930	1,126				
1963	14,340	1,149				
1964	15,914	1,356				
1965	17,095	1,677				
1966	16,661	1,614				
1967	16,206	1,605	n.a.	n.a.	n.a.	n.a.
1968	16,365	1,859				
1969	18,584	1,990				
1970	21,712	2,180				
1971	21,690	2,595				
1972	24,551	3,548				
1973	29,584	5,228				
1974	32,060	6,913	24,134	5,670	7,926	1,243
1975	32,440	8,364	23,387	6,546	9,053	1,818
1976	31,658	9,265	22,791	7,231	8,867	2,034

Source: Association of American Medical Colleges (1951-76).

* The decomposition by sex for 1956-58 was estimated by assuming that the proportion of repeaters who were male was the same as the average proportion for 1959-61 (.94).

breaking down of barriers to entry into medicine for women (either real or perceived).* Since it proved impossible to construct a meaningful empirical model to capture this change, the models presented below are fitted to data for men only.

In each of the 13 years for which repeat applicant data are available, repeaters account for at least 19 percent of all applicants. The maximum percentage is 31 (in 1952) and a good deal of variation in the number of applicants is evidently due to variation in the number of repeaters. We concentrate out attention on determinants of the number of first-time applicants rather than the total number. In part this is because the number of first-time applicants may be more relevant for policy purposes; the most important reason, however, is a practical one. The decision to reapply is fundamentally different than the original decision to apply since it is conditional on the original decision. It is likely that much of the premedical investment is a "sunk cost" when the decision to reapply is made. Therefore the number of repeaters is probably determined by different factors than the number of first-timers. Ideally separate models would be built for first-timers and repeaters, but since only total applicant data are available in many years, the two must

* Factors which may account for growth in women applicants are: 1) changes in medical school recruitment policies, in part due to federal affirmative action programs and legal actions against individual schools; 2) special loan and scholarship programs for women; 3) increased encouragement of women at the premedical level; and 4) changed aspirations of women in general. Discussion of recruitment programs can be found in recent A.A.M.C. Applicant Studies. Walsh (1977, p. 268) discusses legal action against schools and the effects of affirmative action requirements.

be combined. Because of limited degrees of freedom a very simple model for repeaters is hypothesized and the first-time model is developed in more detail.

2. Econometric Model

Since the model is to be estimated for males only, all references to applicants in this section are to male applicants only. The model consists of two equations, one for first-time ("New") applicants, A^n, and one for repeaters, A^r. First-time applicants are primarily third and fourth year college students, or students who have just completed their undergraduate education, and an important determinant of the number of applicants is expected to be the number of persons in this group or "applicant pool"*.

To measure the size of this pool we use the number of men graduating from college in the year prior to the year for which application is being made, C. Hence the pool for applicants wishing to enter in the fall of 1974 (or academic year 1975) is measured by the number of men graduating from college in the spring of the same year.

An individual in the pool is assumed to apply if the individual's expected utility from application exceeds the utility from pursuing the best alternative career, where the only uncertainty about the outcome of the decision

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* Of first-time applicants applying for admission in 1976, 54.8 percent were in their last undergraduate year, 4.6 percent were in their next to last year and 8.5 percent had been out of college for one year (A.A.M.C. 1976, p. 880).

is whether or not the individual will be admitted to medical school. Let $U(\underline{z})$ be the individual's utility function satisfying the axioms of Von Neumann and Morgenstein (1947), where $\underline{z}$ is a vector of career characteristics, and let P be the probability (as perceived by the student) of being admitted to medical school. The student will choose to apply iff:

(1) $P \cdot U(\underline{z}_m) + (1 - P)\, U(\underline{z}_c) > U(\underline{z}_a)$

where $\underline{z}_m$ is the vector of characteristics associated with successful pursuit of a medical career, $\underline{z}_c$ is the vector associated with a conditional alternative career if the student applies and is not admitted and $\underline{z}_a$ is the vector associated with the best alternative career.* Both $\underline{z}_m$ and $\underline{z}_c$ will include characteristics of premedical education while $\underline{z}_c$ and $\underline{z}_a$ may actually refer to the same career, although the characteristics will depend on whether the career is pursued initially or after failure to get into medical school.

It is assumed that $U(\underline{z}_a) \geq U(\underline{z}_c)$ and $U(\underline{z}_m) > U(\underline{z}_c)$: All students can achieve as much utility from a career pursued initially as from the same career pursued after failure to get into medical school. Further, all students are assumed to prefer application followed by admission over application followed by rejection. Hence the students will apply iff.

(2) $P > [U(\underline{z}_a) - U(\underline{z}_c)]/[U(\underline{z}_m) - U(\underline{z}_c)]$

For a given applicant pool, this model implies that more applicants will apply if: 1) there is an increase in the attractiveness of a career as a physician; 2) there is a decline in the attractiveness of alternative careers;

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* A similar application of this criterion may be found in Comay, Melnik and Pollatschek (1977).

3) there is an increase in the attractiveness of conditional alternative careers; and 4) there is an increase in the probability of acceptance*. Note that an increase in the attractiveness of an alternative career which is also a conditional alternative will have opposing effects on the number of applicants: the customary, negative "opportunity cost" effect and the positive conditional alternative effect.

In the econometric model, the proportion of the college applicant pool choosing to apply is determined linearly by a vector of predetermined variables, $\underline{x}$, which are presumed to affect student perceptions of admission probabilities and career attractiveness.

(3) $a_c = \underline{\beta}'\underline{x}$

where a_c denotes the proportion of college graduates applying and $\underline{\beta}$ is a

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* To verify the first three statements, let P* stand for the right-hand-side of (2). Increases in P* will reduce the number of applicants. Partial derivatives of P* with respect to utility from each of the three careers are:

$$\partial P^*/\partial U(\underline{z}_m) = [U(\underline{z}_c) - U(\underline{z}_a)]/[U(\underline{z}_m) - U(\underline{z}_c)]^2 < 0$$
$$\partial P^*/\partial U(\underline{z}_a) = 1/[U(\underline{z}_m) - U(\underline{z}_c)] > 0$$
$$\partial P^*/\partial U(\underline{z}_c) = [U(\underline{z}_a) - U(\underline{z}_m)]/[U(\underline{z}_m) - U(\underline{z}_c)]^2$$

The last derivative is negative for all those who would consider application for some value of P (i.e., those with $U(\underline{z}_m) > U(\underline{z}_a)$); an increase in $U(\underline{z}_c)$ will not affect the decision of those students for whom $U(\underline{z}_m) < U(\underline{z}_a)$.

parameter vector.* A time subscript is implicit for a_c and $\underline{x}$. The first element of $\underline{x}$ in every year is unity. Remaining variables in $\underline{x}$ are defined in detail in Table 2.

An increase in acceptance rates should increase the proportion of college graduates applying in the near future if students perceive their own chances of admission being increased. From 1951 to 1976 the acceptance rate for men has varied considerably, being as low as .33 in 1951 and .34 in 1975 and as high as .60 in 1961-62. Hence if low acceptance rates do discourage applicants it should be possible to measure this effect in this period.

An increase in resident income relative to that of male college graduates in the same age group should encourage more applicants. There was a sharp increase in the resident income variable in the late 1960's -- from .44 in 1964 to .80 in 1971. This increase may explain part of the growth in applicants in this period.

Higher medical school tuitions are expected to discourage applicants. Measured in 1967 dollars, mean tuition has increased from $790 in 1956 (the first year for which consistent data are available) to $1,483 in 1973. Although nearly doubling, tuition remained small relative to the opportunity costs

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* Explicit derivation of an expression for a_c as a function of $\underline{x}$ from the individual model is provided in Stapleton (1978, Chapter 4). A nonlinear empirical specification for a_c is also considered, but results do not differ in a fundamental way from the linear results presented here.

TABLE 2

PREDETERMINED VARIABLES*

Name	Definition
acceptance rate	accepted male applicants divided by total male applicants
resident income	mean first-year resident (i.e., intern) salaries relative to mean income of male college graduates, age 25 - 34
tuition	tuition revenue per student (in thousands)**
loan index	maximum federally supported loans available to medical students (in thousands)**
Ph. D. fellowships	proportion of all graduate students receiving federal fellowships and traineeships
Ph. D. unemployment	unemployment rate of new bioscience Ph. D.'s

* Sources of data as well as interpolation and adjustment methods are given in the appendix.

** Deflated by the 1967 Consumer Price Index.

and income benefits of a medical career. It also appears to be highly correlated with a variable that has been omitted for lack of data: tuition at graduate schools.* It is therefore unlikely that it will capture any effect of higher tuition on the number of applicants. Nevertheless it is included as the obvious price variable in this market and because it is an important policy instrument.

The loan maximum index is intended to measure the availability of loans to medical students from the federal government. A main reason for its inclusion is that capital markets for educational loans in general are thought to be imperfect because students can't offer their future "human capital" as collateral. One might think that this would not be a problem for medical students who have a very high probability of becoming doctors and seem unlikely to default.** Nevertheless few medical students receive

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* Medical and graduate school tuition for selected years are compared in Stapleton (1978, p. 45). Tuition ratios at public and private schools remained fairly constant in the eight years from 1963 to 1975 for which data were available; medical tuition was roughly 60% higher than graduate tuition at public schools and 20 percent higher at private schools.

** Historically attrition rates at medical schools have been under 10% (Johnson and Hutchins, 1966, p. 1116).

private bank loans and these are usually for small amounts.* If the market for student loans is imperfect, an increase in loan availability should encourage applicants. Further, even if capital market imperfections are not substantial, government loans offer more favorable terms than could be expected in the private sector, again making medical education more attractive. Before 1959 the index is zero, increasing to 4,700 (in 1967 dollars) in 1976, with major increases occurring in the early 1960's.

The Ph.D. unemployment and fellowship variables are intended as measures of the attractiveness of the alternative careers most often considered by potential applicants. Many potential applicants consider professional careers in the sciences (particularly biomedical sciences) as an alternative to becoming a physician. Some of these may actually choose a science career in preference to medicine while others may view science as a conditional

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* In 1975, four percent of students received bank loans (excluding those with government guarantees) with an average value of $2,095; in 1968, nine percent received loans with an average value of $1,400 (U.S. Public Health Service, 1974 and 1975).

alternative if they are unable to get into medical school.* The attractiveness of a science career may therefore have both an opportunity cost and a conditional alternative effect on the number of applicants. Both of these opposing effects may be important: Medical educators in the early 1960's believed that graduate science programs were attracting many potential medical school applicants (see the A.A.M.C. Applicant Studies in these years). On the other hand, Freeman (1977) found that the number of rejected medical school applicants is an important determinant of the number of enrollments in Ph.D. Biological Science programs.

While the fellowship variable includes federal fellowships to all Ph.D. students, by far the largest share of these were received by science students. A negative coefficient indicates that the opportunity cost effect dominates the conditional alternative effect. The unemployment variable is specifically for biological scientists and a positive coefficient indicates that the opportunity cost effect dominates the conditional alternative effect. Both

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* The conclusion that biological science is the most important alternative is based on an analysis of two large surveys of college students in which students considering becoming doctors at some point in their college career are identified. The first survey was conducted by the National Opinion Research Center in 1961 and is described in Davis (1965). The second was conducted by the American Council of Education in 1966, with 1970 and 1971 follow-ups, and is described in El-Khawas and Bisconti (1974). Two studies of unsuccessful applicants indicate that the careers most frequently actually pursued by unsuccessful applicants are in the sciences (Becker, Kalatsky and Seidel, 1973, and Levine, Weisman, Sack and Morlock, 1974).

variables indicate major increases in the attractiveness of science careers in the post-Sputnik years and declines in the late 1960's. A negative coefficient on the fellowship variable and a positive coefficient on the employment variable would confirm the fears of medical educators during the period.

In determining the lag-length for each variable a two-year decision-lag was first assumed. Since applicants must complete studies in specific subjects requiring approximately two years of course work, one would expect most decisions to be made at least two years before planned entry into medical school. Several studies of medical students confirm that most made the decision in their first or second undergraduate years, if not earlier (Thielens, 1957; Rogoff, 1957; and Becker, et. al., 1961). Information lags were also taken into consideration in determining lag-lengths. Published data for some variables are more current than for others and some data are readily accessible to medical students while other data are not.

Many models with different lag-lengths (and some with additional variables) were estimated besides the one reported here. This was done to check for robustness of results with respect to small changes in lag-length. In general results were disturbingly unrobust, as will be discussed further below. The specification presented here was chosen because, of all specifications estimated, it best conformed with our expectations. Of course this procedure invalidates the use of t-statistics in testing hypotheses about population coefficients.

First-time applicants from the college graudate pool are given by the product of a_c (the proportion of the pool which applies) and C (the size of the pool). Of course not all first-time applicants come from the college graduate pool. In 1975, for instance, 32 percent of first-time applicants had been out of college for more than one year at the time they applied (A.A.M.C., 1976, p. 880). Presumably, many of these are graduate students in the sciences who are discouraged by poor job prospects. Attempts at measuring this pool and including this pool explicitly in the first-time equation were unsuccessful. In recognition of this unmeasured pool we include a constant in the first-time applicant equation; hence first-time applicants are determined by the sum of the constant, a_0, the term for first-time applicants from the college graduate pool, $a_c C$, and a disturbance, ε^n:

(2) $A^n = a_0 + a_c C + \varepsilon^n = a_0 + \underline{\beta}'\underline{x}C + \varepsilon^n$

The disturbance term is assumed to be distributed independently of C and $\underline{x}$, with zero mean and constant variance, σ_n^2.

Repeat applicants come from the pool of previously unsuccessful applicants. As a measure of this pool we use the number of unsuccessful applicants in the previous year, U, under the assumption that most unsuccessful applicants reapply in the next year if at all. It is assumed that a constant proportion of unsuccessful applicants reapply. No constant term is included in the repeat equation since all repeaters by definition are from the unsuccessful applicant pool:

(3) $A^r = a_u U + \varepsilon^r$

where a_u is the proportion of unsuccessful applicants reapplying. The disturbance, ε^r, is assumed to be distributed independently of U, $\underline{x}$ and C, with zero mean and constant variance σ^2. Also ε^n is assumed to be independent of U and to have constant covariance with ε^r, σ_{nr}.

For 13 years data on first-time and repeat applicants are available so that, for these years, the equations could be estimated straightforwardly. However, since there are 8 parameters in the first-time equation, this would leave just 5 degrees of freedom for that equation. In fact, the situation is even worse since for the first 7 of these years, 1952 - 58, data for several of the predetermined variables in $\underline{x}$ are not available (after taking into account the lag-lengths). Hence only 6 observations are left for the first-time equation. In order to have enough information to estimate the model, the total applicant data for 1962 - 73 must be employed. Specification of a total applicant equation is straightforward since the sum of first-time and repeat applicants yields total applicants, A:

$$(4)\quad A = A^n + A^r = a_0 + a_c C + a_u U + \varepsilon^n + \varepsilon^r$$
$$= a_0 + \underline{\beta}'\underline{x}C + a_u U + \varepsilon$$

where $\varepsilon \equiv \varepsilon^n + \varepsilon^r$.

Since given any two of equations 2, 3 and 4, the third is redundant, for estimation purposes we can ignore any one of the three in years where data on A^n and A^r are available. For convenience we omit the first-time equation, equation 2, in these years. Hence the total applicant equation is to be estimated for the 18 years 1959 - 76 and the repeat equation is to be estimated for the 13 years 1952 - 61 and 1974 -76. They are first estimated separately by least squares and then jointly using Zellner's "seemingly unrelated regressions" technique. Modifications similar to those discussed by Schmidt (1977) are necessary in the latter procedure since the sample periods for the two equations do not coincide.*

3. Results

The model is first estimated under the assumption that the proportion of college graduates applying, a_c, is fixed, rather than varying with $\underline{x}$. Results are presented in Table 3. Results in lines 1 and 2 of the table are for the total applicant equation estimated by itself. In line 1 the coefficients of C and U imply that 3 percent of college graduates apply and that 68 percent of unsuccessful applicants will reapply. Both coefficients are significantly different from zero at conventional confidence levels. In line 2 unsuccessful

* Our procedure differs from Schmidt's only in the method used to construct the block diagonal variance-covariance matrix of the disturbances. This was done as follows: First the residuals from the separate regressions were used to estimate the variance of ε, σ^2, and of ε^r, σ_r^2, in the conventional way. The estimate of σ_r^2 was used for the block corresponding to the years 1952 - 58, for which only the repeat equation is estimated, and the estimate of σ^2 was used for the block corresponding to 1962 - 73, when only the total equation is estimated. For the third block, corresponding to 1959 - 61 and 1974 - 76, when both equations are estimated, different estimates of σ^2 and σ_r^2 were used. These, as well as an estimate of the covariance of ε and ε^r, σ_r, were constructed using the 6 residuals for these years from the two separate regressions. This procedure ensured that this block of the matrix was positive definite while using as much information as possible in the other blocks. Fortunately differences in the two sets of estimates were minor. Interestingly, Schmidt finds that statistical properties of parameter estimates in small samples are reasonably invariant to the choice of the four procedures for estimation of variances and covariances he considers.

TABLE 3

RESULTS WITH THE COLLEGE GRADUATE COEFFICIENT FIXED [1]

Dependent Variable	Constant	College graduates (-1)	Unsuccessful applicants (-1)	R^2
	Predetermined Variables			
1. Total Applicants	2622 (2.3)	.030 (4.7)	.680 (4.8)	.970
2. Total Applicants	-48 (0.0)	.057 (14.7)	——	.924
3. Repeat Applicants	——	——	.426 (137)	.997
4. Repeat Applicants	54.1 (.7)	——	.422 (63.8)	.997
5. Total Applicants	1812 (.2)	.038 (8.7)	.485 (4.8)	
6. Repeat Applicants	——	——	.431 (71)	
7. Total Applicants	1651 (1.9)	.040 (16.2)	.428 (128)	
8. Repeat Applicants	——	——	.428 (128)	

Absolute t-statistics are in parentheses.

applicants are omitted, resulting in a near doubling of the college graduate coefficient. The implications of this result will be discussed in the next section.

Single equation estimates of the repeat equation are given in lines 3 and 4. In line 3, the coefficient of U implies that 42.6 percent of unsuccessful applicants reapply. The conventionally constructed .05 confidence interval for a_n is very narrow -- from .420 to .432. This is not surprising since in the 13 years for which data are available the smallest ratio of A^r to U is .406 (in 1959) and the largest is .471 (in 1953). Further no trends in the ratio are observed. In line 4 a constant is included and its small value and t-statistic indicate that the omission of a constant is appropriate. The excellent fit of the repeat equation to the data suggests that this simple model adequately captures one of the effects of rationing on applicants.

In lines 5 through 8 results from joint estimation of the applicant and repeat equations are presented. For lines 5 and 6, the coefficients of U in the two equations were allowed to differ, although according to our model they should be the equal. In comparing line 5 to line 1 an interesting result emerges: There is an 85 percent increase in the t-statistic for the coefficient of C, due in part to a 27 percent increase in the value of the coefficient and in part to a 31 percent reduction in the standard error. While joint estimation is expected to reduce standard errors, the reduction here is surprisingly large. The apparent explanation is that implicitly the six years of first-time applicant data are now being used. That is, the results are identical to those that would be obtained from an estimation procedure in which the total equation was replaced by the first-time equation in the six years for which first-time data could be used.* On the other hand, the first-time data were ignored in estimating the equations separately. The result suggests that availability of first-time data for all years would allow substantially better inferences about the behaviour of first-time applicants.

The difference between the coefficients of U in the two equations is .054 and the t-statistic for this difference is only .6, leading us to accept the hypothesis that the population coefficients in the two equations are the same. While this hypothesis may appear unimportant, its validity implies that ignoring other determinants of repeaters will not bias the coefficient of C in the applicant equation.** Put another way, inclusion of U in the applicant equation adequately controls for all factors affecting repeat applicants. The above test indicates that this is the case.

When the restriction is imposed in lines 7 and 8 there is a further large increase in the t-statistic for the coefficient of C, primarily due to an

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* To obtain identical results estimates of σ_n^2, σ_{nr} and σ_r^2 in the six-year block must satisfy certain "singularity" requirements in relation to the estimated values of σ^2, σ_r^2, and $\sigma_{r.}$ used in the original procedure. These require that the same estimate of σ_r^2 be used and, denoting parameter estimates with "hats", that $\hat{\sigma}^2 = \hat{\sigma}_n^2 + \hat{\sigma}_r^2 + 2\sigma_{rn}$ and $\hat{\sigma}_{r.} = \hat{\sigma}_{nr} + \hat{\sigma}_r^2$.

** See Stapleton (1978, 197 - 99) for a proof.

additional 43 percent drop in its standard error. Overall there is a 61 percent drop in the standard error of the coefficient of C from line 1 to line 7. It is clear that incorporation of the first-time and repeat data provides substantial information about applicant behavior.

Results from estimation of the full model -- with the coefficient of C being determined by $\underline{x}$ -- are presented in Table 4. Each line of the table represents a different set of results; in the first nine columns are parameter estimates for the applicant equation and the last number is the estimate of the single parameter in the repeat equation. Estimates of the elements of β are in columns 2 through 9 (note that each element of β is a coefficient of the product of C and one of the predetermined variables, including unity in column 2).

Results in line 1 are from separate estimation of the applicant and repeat equations.* In line 2 results are from joint estimation but without the restriction on the coefficient of U. The restriction is imposed in line 3. Comparisons across the three sets of estimates are similar to comparisons made when the coefficient of C was fixed, although less striking. Joint estimation yields general reductions in standard errors and imposition of the restriction leads to further reductions. The restrictions again can not be rejected; in fact, the unrestricted coefficients of U in line 2 are almost equal. The remainder of the discussion will refer to the results in line 3.

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* The repeat equation coefficient is the same as that reported in line 3 of Table 2.

RESULTS WITH THE COLLEGE GRADUATE COEFFICIENT VARYING

	Predetermined Variables									
		college graduates (-1) times:							Unsuccessful applicants(-1)	
Specification	constant	constant	acceptance rate(-2)	resident income(-3)	tuition(-3)	loan index(-1)	Ph. D. fellowships(-3)	Ph.D. unemployment(-3)	applicant equation	repeat equation
1. Equation-by-equation estimates	7500 (1.5)	-.044 (1.4)	.097 (4.0)	.10 (2.2)	-.023 (1.2)	.0012 (1.3)	-.019 (0.1)	-.13 (1.5)	.523 (2.7)	.426 (137)
2. Joint estimates, unrestricted	7862 (1.6)	-.041 (1.4)	.095 (3.8)	.10 (2.5)	.025 (1.5)	.0015 (1.9)	-.020 (0.2)	-.11 (1.4)	.428 (5.9)	.426 (127)
3. Joint estimates, restricted	7811 (1.7)	-.041 (1.5)	.095 (4.4)	.10 (2.6)	-.025 (1.6)	.0015 (2.0)	-.020 (0.2)	-.11 (1.5)	.426 (133)	.426 (133)

Absolute t-statistics are in parentheses.

Of the coefficients of the variables in $\underline{x}$, three are significantly different from zero if the t-statistics are interpreted in the conventional way. However, as mentioned previously, this interpretation is inappropriate because of the sequential estimation procedure used to arrive at the final specification. The robustness of each coefficient with respect to minor specification changes must also be considered.

The acceptance rate coefficient is reasonably robust. In all specifications in which this variable was included with a two year lag, the smallest coefficient was .066 and the largest was .15. The smallest t-statistic was 3.2. When either a one or two-year lag was used the coefficient was still positive, although smaller and with t-statistics less than 2. One explanation of the small t-statistics at adjacent lags is this: Since the denominator of the acceptance rate is the number of applicants, cycles in the applicant series are generated (holding other variables constant) if the lagged acceptance rate does affect applicants. Suppose that an increase in the acceptance rate does generate more applicants, with a lag. This lowers the acceptance rate, subsequently reducing applicants, again increasing the acceptance rate, etc. If a two-year lag is appropriate, specification of a four-year lag would likely yield a negative coefficient and specification of one or three-year lags may yield coefficients near zero of either sign. Hence the result might be interpreted as confirming that a two-year lag is appropriate.

The acceptance rate coefficient is .095. This value implies a very large effect of a change in the acceptance rate on applicants. To illustrate, a reduction of 100 in the number of places available in 1976 would have reduced the number of 1978 applicants by 145, other things constant.* In the long run, after induced changes in the acceptance rate and the number of repeaters had worked themselves out (holding other variables constant at 1976 values) applicants would be reduced by 97 annually.** While long-run responses of other variables have not been considered, the discouraging effect of low acceptance rates appears to be substantial. As further illustration, the estimated coefficient implies that if the acceptance rate had remained constant at the 1965 value of .471 rather than dropping to .345 by 1974, there would have been 6,100 more first-time applicants in 1976 than there actually were -- an increase of 27 percent.

The coefficient of resident income was usually, but not always, more than 2 standard errors greater than zero in specifications where it appeared

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* In 1976 there were 31,659 male applicants, of whom 11,302 were successful. A reduction of 100 places would have reduced the acceptance rate from .357 to .354. There were 508,424 male college graduates in 1975; in the calculation this same figure was used for 1977.

** Using the 1976 values for the variables, the estimated applicant equation reduces to $A_t = 506 + 550{,}720{,}000/A_{t-2} + .426A_{t-1}$. In the long-run equilibrium $A_t = A_{t-1} = A_{t-2}$ and the (locally stable) solution is 31,283. Reducing the number of places by 100 and solving again yields 31,186.

with a three-year lag. The maximum value for this coefficient in all models estimated was .13 and the minimum was .01. With a four year lag length the coefficient was smaller, but still positive, although with a two-year lag length it became negative. At either two or four-year lags the coefficient was less than two standard errors away from zero. Hence the statistical significance of the result reported here is in doubt.

A priori it seems unlikely that the substantial increases in resident salaries in the late 1960's would not attract more applicants. The point estimate of the resident income coefficient, .10, implies that the increase in relative income from 1964 to 1971 resulted in an increase in first-time applicants of over 18,000. Hence this may be the primary cause of the increase in applicants over this period.

Coefficients of the other variables in x were much less robust to specification changes, often switching signs in response to changes in specifications of lag-lengths of other variables. Therefore the coefficients and associated t-statistics for the tuition variable and loan maximum index should not be interpreted as demonstrating that higher tuition discourages applicants and greater loan availability encourages applicants. The tuition result is perhaps not surprising, for reasons previously discussed. That loan availability was not important is more surprising since the increase in the index was substantial during the sample period. While it may be that the index is not an adequate measure of availability, several attempts to model the effect of loans with dummy variables yielded similar results.

The coefficients of the Ph.D. fellowship and unemployment variables were usually less than two standard errors from zero and their signs varied from one specification to another. In the results reported, the signs are contradictory. The fellowship coefficient indicates that the attractiveness of science fields discourages applicants while the unemployment coefficient indicates the opposite. Since there was considerable variation in these variables over the period, it must be concluded that the two effects of science career attractiveness -- the opportunity cost effect and the conditional alternative effect -- are small and/or nearly offsetting. Medical educators' fears of competition from Ph.D. science programs in the early 1960's appear to be unjustified.

4. Earlier Studies

The results reported on here indicate that important specification errors are made in the models of Sloan, Esposito and Leffler. Similar errors may arise in modelling aggregate demand for any type of higher education -- as well as demand in some other markets. These errors are discussed in the first part of this section. The section is concluded with comments on the model of Feldman and Scheffler, which differs in a fundamental way from models of the other three studies as well as from this one.

In Section 2 it was argued that the attractiveness of the alternative careers could have opposing effects on the number of applicants. If the acceptance rate is as important a determinant of applicants as our results indicate, it seems likely that the positive conditional alternative effect is important for some careers. Sloan and Esposito view variables representing the attractiveness of several careers, including science careers, as opportunity cost measures. Increases in their values are expected to reduce applicants' and the "conditional alternative" effect is ignored. Given this second possible effect, Sloan's marginally significant, negative coefficients for these variables are less convincing evidence of (net) opportunity cost effects. Esposito's failure to find opportunity cost effects may be explained by the modification of the theory.

Leffler constructs a physician profitability variable, π, which is a measure of the present value of monetary costs and benefits to studying medicine and becoming a physician, calculated at the point of entrance into medical school. In his econometric models different variants of this variable and the size of the college graduate pool determine the number of applicants. Our results indicate that if this approach is to be pursued, a more appropriate profitability variable would be expected profitability at the time the decision is made -- several years before entrance. Such a variable would take into account the probability of acceptance and the conditional alternative income stream as well as a basic alternative stream. Leffler's probability variable could be viewed as a component of the more appropriate variable. It is difficult to predict how this modification would affect the results, but since the acceptance rate appears to be so important in our model, it is likely the effect would be substantial.

All three authors ignore the existence of repeat applicants in their models. Our results indicate that variation in repeaters accounts for a good deal of the variation in total applicants. Further, failing to control for repeaters appears likely to bias coefficients of other variables. In line 2 of Table 3 the unaccepted applicant variable is omitted from the total applicant equation, resulting in a near doubling of the coefficent of college graduates. It is likely that omission of this variable or similar controls will bias estimates of effects of other variables away from zero: If an increase in a variable actually does induce more applicants it will also result in more unsuccessful applicants, *ceteris parebus*, and therefore more repeaters and total applicants in the subsequent year. This may also explain why Sloan's "partial adjustment" specification, with full effects occurring only after several years, appears to be more appropriate than his immediate adjustment specification.

All three studies attempt to explain variation in total male and female applicants combined. For most of their estimated equations they choose as their single applicant pool variable the number of male college graduates in the previous year. This is the same pool used here for first-time male applicants. Ignoring the female college graduate pool would probably be unimportant if the proportion of female applicants was fairly constant and small over the sample period. The sample periods of Sloan and Esposito both end in the mid-1960's and the only period they include where there was obvious variation in the percentage of women applicants is the early postwar years, when the percentage was unusually low. In the years in their samples for which data are available by sex the percentage of applicants who were women did not exceed 10. On the other hand, Leffler's sample ends in 1973, including four years in which the number of women applicants was growing the attractiveness of several careers, including science careers, as opportunity cost measures. Increases in their values are expected to reduce applicants and the "conditional alternative" effect is ignored. Given this second possible effect, Sloan's marginally significant, negative coefficients for these variables are less convincing evidence of (net) opportunity cost effects. Esposito's failure to find opportunity cost effects may be explained by the modification of the theory.

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Misspecification of repeat and women applicants may be regarded as special cases of a more general misspecification: misspecification of applicant pools. There are other examples as well. One is failure to recognize the impact of World War II veterans on applicants in all three of the studies being discussed. Two possible causes of the post-World War II swell are: 1. GI bill benefits made medical school exceptionally attractive and 2. veterans with medical experience in the war applied directly or after an exceptionally short period of premedical training. It is the latter effect which may be viewed as due to a change in the applicant pool. It may well be that failure to account for this effect is the source of Sloan's major result: the very significant negative effect of his net price variable on applicants. The price variable is tuition net of major scholarships, which during this period included GI bill benefits (both tuition benefits and living stipends). These are so large that net price is actually negative in 1947, 1948 and 1949; not until 1953 is it larger than the largest prewar value (for 1929). In Sloan's regression this variable accounts for most of the change in applicants in this period. If the veteran effect is important, it is likely that his price coefficient greatly overstates the true effect of net price. Esposito includes separate GI bill and tuition variables. In his results the GI bill variable appears to be important but tuition is not, indicating that Sloan's result may be due to the effect of the GI bill variable alone, which seems likely to be a good proxy for the veteran pool.

The last example of a misspecification of applicant pools is in the work reported on here: failure to measure the pool from which first-time applicants who have been out of college for more than one year come. Over 32 percent of first-time male applicants in 1976 had been out of college for more than a year. It is likely that a large number of these are students who are in or have completed science graduate programs and are discouraged by job market conditions in their fields. Attempts to account for this source of applicants were unsuccessful. If growth in applicants from this pool was a major source of growth in the early 1970's, it is likely that effects of other variables which grew rapidly in the same period are overstated. In particular this may be true of the resident salary variable.

Since variation in the size of major applicant pools is likely to be a major source of variation in demand for any type of education, the specification of applicant pools deserves considerable attention. Such attention is conspicuously lacking in the higher education demand literature. Usually only the most obvious pool is considered.* How major pools are to be included in the model also deserves careful consideration. The issue is one of functional form. The models estimated here are specified in such a way that the number of applicants from a pool is homogeneous of degree one in the size of the pool. For first-time applicants from the college graduate pool this means that the effect on applicants of a change in a predetermined variable is proportional to the size of the pool. Most of Sloan's specifications and all of Esposito's are linear in the pool variable, so that effects of predetermined variables are independent of pool size. Leffler's semi-logarithmic specification implies that effects of his profitability variable are proportional to the number of applicants and increase at an increasing rate with increases in the applicant pool. Clearly the absolute effects of predetermined variables should be related to pool size: more individual decisions are affected by the change in a variable the larger is the pool. The proportional specification used here is appropriate if in different time

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* Campbell and Siegel (1967), Hight (1975) and Freeman (1976) all estimate demand functions for undergraduate education in which only high school graduates or the "college age" population are used as pool measures. A secondary pool, new veterans, is considered by Galper and Dunn (1969) and found to be important. Also demand functions for particular graduate fields have been embodied in the "cobweb" models of Freeman (1971, 1972, 1975, 1975a) and others. Typically, undergraduate degrees granted in a particular field are the pools. Clearly other sources of applicants are important; while measurement may be difficult, at least careful consideration should be given to potential effects of the omitted variables.

periods applicants in the same pool faced with the same information included in the model (i.e., the variables in $\underline{x}$) would make the same decision (except, perhaps, for random errors); this is discussed further in Stapleton (1978, Chapter 6). While it may be that this assumption is violated, an alternative which would lead to a different specification is not obvious.*

The model of Feldman and Scheffler (1978) has the apparently great advantage of not requiring any specification of the applicant pool. They take a strict human capital approach to the demand for higher education and assume that competition for education in different fields equalizes expected rates of return across fields. For medical school applicants, the expected rate of return, $E(\overline{RR})$ in their notation, is given by a rate of return calculated for succesful applicants, RR, times the acceptance rate, defined as

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* In the higher education demand studies cited in the previous footnote, proportional specifications are used although justification is not given. Also Freeman usually uses a loglinear specification, with the log of the single applicant pool appearing on the right-hand-side of his equation. If the coefficient of the log of the pool variable is unity, the specification is homogeneous of degree one in the size of the pool. Usually this constraint is imposed, although Freeman does not provide justification. In the four cases we have discovered (Freeman, 1971, pp. 143 and 147) where the restriction is not imposed the coefficient estimate varies from 1.0 to 1.5 and only in one case is it significantly different from unity using the conventional test. This lends some support to the proportional specification.

the ratio of enrollments, ENROLL, to applicants, APP :

(5) $E(\overline{RR}) = RR \cdot ENROLL/APP$

This implies that a one percent increase in RR or ENROLL will lead to a one percent increase in APP in order to maintain equality of expected rates of return in all markets, presuming expected rates of return in other markets are unchanged. The obvious empirical specification arising from equation 5 is

(6) $\ln APP = \alpha + \beta \ln(ENROLL) + \gamma \ln(RR) + \delta \ln[E(\overline{RR})]$.

With $\alpha = 0$, $\beta = \gamma = -\delta = 1$. They present least squares estimates of this equation, under the apparent assumption that $E(\overline{RR})$ is constant over time or varies independently of ENROLL and RR.* Estimates of RR are obtained from Sloan (1968) for 7 years between 1956 and 1966 and they themselves calculated a figure for 1970 following Sloan's procedure. In the empirical equations RR is lagged three years. Their estimates of β and δ are .922 and .822, with standard errors of .35 and .42, respectively; both are insignificantly different from unity. The implied value for $E(\overline{RR})$ is 2.2 percent, compared to estimates of RR ranging from 13.5 to 22.0.

The choice of a three-year lag for RR appears to be inconsistent with the theoretical equilibration process being assumed. They choose a three-year lag after experimentation with alternative lags and justify it by the decision lag previously mentioned here. If expected rates of return are equilibrated across education fields, a three-year decision lag implies that all potential applicants make individual decisions in such a way that

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* Estimates for linear and semilogarithmic versions of the equation are also presented. Results are very similar to those considered here.

the acceptance rate three years later will be just right to equalize expected rates of return. This seems implausible. It may well be that in the long run expected rates of return are approximately equalized, but the apparent existence of a long decision lag suggests that this is a poor short run assumption.

While this approach may have some merit, more consideration must be given to the equilibrating process. In this connection, the role of repeat applicants may be important since, for them, there may be no decision lag. Interestingly the idea that the number of applicants adjusts so that the acceptance rate obtains some equilibrium value has previously been considered in the medical education literature by Potthoff (1960), although no reason for equilibration is given.

5. Conclusion

Is further study of the determinants of medical school applicants warranted? Clearly important questions are still to be answered, but is there a reasonable chance that further research will provide answers?

Given the current availability of data further time-series analysis is perhaps not warranted. The results here indicate the importance of variation in different applicant pools, yet measures of some pools are not available. Further it would be desirable to have the applicant data disaggregated into applicants from reasonably homogeneous pools, as our experience with the limited data on first-time and repeat applicants indicates. One way to avoid these problems may be incorporation of an equilibrating mechanism like that of Feldman and Scheffler (1978) but a more reasonable specification than theirs is not obvious.

The lack of robustness of results with respect to fairly minor changes in specification is disturbing. This may in part be due to poor data on the determinants of applicants. As discussed in the appendix, several of these series required interpolation for some years and others required adjustments for definitional inconsistencies. Lack of robustness may also be due to insufficient variation in some determinants over the sample period, although with the exception of the tuition variable this does not appear to be the case. Perhaps the most serious problem is determination of appropriate lag-lengths. Since degrees of freedom are insufficient to allow multiple lag-lengths, hypotheses about effects of variables can not be tested unless lags can be specified a priori. This is a very difficult task, if not impossible.

Cross-sectional studies may provide a reasonable alternative. Esposito (1968) estimates applicant equations in which the unit of observation is the state. Unfortunately, he finds it difficult to interpret the results because it is unclear what his variables measure. Pooling state data for several years might also be considered. A problem is that a state may not be a reasonable unit of analysis since, especially among private schools, there is considerable movement of applicants across state boundaries. Further, the market for physicians is national in nature.

One might also examine determinants of medical school applicants at the individual level as Miller and Radner (1975) have done for undergraduate education. Surveys of individual college students may provide appropriate data.* Unfortunately it may be difficult to make reasonable inferences about effects of national medical education policies from either state or individual applicant studies. Nevertheless such studies may make a substantial contribution to our general understanding of the demand for higher education.

* See, for instance, the N.O.R.C. and A.C.E. studies discussed in Davis (1965) and El-Khawas and Bisconti (1974), respectively.

Appendix: Data Sources and Interpolation and Adjustment Methods

Male College Graduates: The source for original data is U.S. Office of Education (1957-76). For 1966-75 the series for bachelors degrees was used. This series was also available for 1961-65, but a definitional change was made in 1966. Figures for these years were multiplied by the ratio of new to old definition figures in 1966 (1.0388). Before 1961 the series reported is for bachelor's plus first-professional degrees. This series was deflated by the ratio of bachelors to bachelors plus first-professional degrees in 1961 (.9070).

Acceptance Rate: A.A.M.C. (1955-76).

Resident Income: For 1955-69, except 1960 and 1962, mean intern salaries as reported in Medical Education were used for the numerator of this series; figures for 1960 and 1962 were obtained by linear interpolation. For 1974-76 fir year resident salaries from the Council of Teaching Hospitals (1971-77) were used. 1970-73 both series were available; since discrepancies were minor, a simple average was used. The denominator, mean income of male college graduates age 25 - 34, is from U.S. Bureau of the Census (1958, 1960, 1961, 1964, 1967, 1967a, 1969, 1969a, 1970-71, 1973-76). Data for 1955, 1957, 1959, 1960, 1962 and 1965 are fitted values from a regression of the variable for years in which data are available on mean starting salaries of college graduates in engineering, general business, accounting and sales, reported by Endicott (1975).

Tuition: Tuition revenue and the number of medical students are reported separately in Medical Education.

Loan Index: The index was constructed by summing the annual maximums for all major national loan programs available to medical students in each years. The programs and maximums used are: National Defense Educational Assistance, $1,000 (1959-64); American Medical Association Educational Research Foundation, $1,500 (1963-76); Health Professions Educational Assistance Act, $2,000 (1965-66), $2,500 (1967-71), $3,500 (1972-77); Federal Guaranteed Student Loans, $1,500 (1967-72), $2,500 (1973-77).

Ph.D. Fellowships: Figures for 1961-74 were compiled by Freeman and Breneman (1974). For 1956-61 we were able to find data for three different fellowship programs: National Science Foundation, National Institute of Health and the National Defense Educational Assistance Act. For 1961 the total of these was 7,462, compared to a total of 11,591 for all programs (unfortunately not listed) included in the Freeman-Breneman variable. We therefore multiplied the sum of the figures for the three programs for 1956-60 by the ratio of the two 1961 figures, 1.55, before dividing by the number of graduate students. Graduate student data are from U.S. Office of Education (1967a, 1974a).

Ph.D. Unemployment is Freeman's (1977) SEEK variable. Freeman's series begins in 1958, when the National Research Council surveys on which it is based began. For 1956-57 fitted values from a regression of this variable on the contemporaneous values of the other variables in x were used. This is an *ad hoc* variation of Haitovsky's (1968) missing data method.

REFERENCES

Association of American Medical Colleges (1951-76). The Applicant Studies have appeared annually in the Journal of Medical Education under various titles and authors. A complete bibliography is available from the A.A.M.C.

Becker, H. S., Gees, B., Hughes, E.C. and Straus, A.L. (1961), Boys in White. Chicago: University of Chicago Press.

Becker, M.H., Kalatsky, M.E. and Seidel, H. (1973), "A Follow-up Study of Unsuccessful Applicants to Medical Schools", Journal of Medical Education. 48 (November) 991-1001.

Campbell, R. and Siegel, B.N. (1967), "The Demand for Higher Education in the United States", American Economic Review. 57 (June) 482-94.

Comay, Y.P., Melnik, A., and Pollatschek, M.A. (1977), "Option Values, Stipends and the Returns to Educational Investment", Journal of Econometrics. 6 (September) 243-260.

Council of Teaching Hospitals (1971-77) Survey of House Staff Policy. Washington, D.C.: Association of American Medical Colleges, annual.

Davis, J.A. (1965), Undergraduate Career Decisions. Chicago: Aldine Publishing Company.

El-Khawas, E.H. and Bisconti, A.S. (1974), "Five and Ten Years After College Entry: 1971 Follow-up of 1961 and 1966 College Freshmen", American Council on Education, Research Report, Vol. 9, No. 1.

Endicott, F.S. (1975), The Endicott Report: Trends in Employment of College and University Graduates. Evanston, Illinois: Northwestern University Press.

Esposito, L. (1968), "An Analysis of the Economic Factors Determining the Number of Applicants to Medical School", unpublished Ph.D. dissertation, Boston College.

Feldman, R. and Scheffler, R.M. (1978), "The Supply of Medical School Applicants and the Rate of Return to Training", Quarterly Review of Economics and Business 18 (March) 91-98.

Freeman, R.B. (1971), The Market for College Trained Manpower. Cambridge: Harvard University Press.

__________ (1972), "Labor Market Adjustments in Psychology", American Psychologist. 27 (May) 384-92.

_____________ (1975), "Supply and Salary Adjustments to the Changing Science Manpower Market: Physics, 1948-1973", American Economic Review. 65 (March) 27 - 39.

_____________ (1975a), "Legal Cobwebs: A Recursive Model of the Market for New Lawyers", Review of Economics and Statistics. 57 (May) 171-80.

_____________ (1976), The Overeducated American New York: Academic Press.

_____________ (1977), "Employment Opportunities in the Doctorate Manpower Market: Biosciences and Psychology", Report to the National Research Council in the National Academy of Sciences (unpublished).

_____________ and Breneman, D.W. (1974), Forecasting the Ph.D. Labor Market: Pitfalls for Policy. Washington, D.C.: National Board on Graduate Education, National Academy of Sciences.

Galper, H. and Dunn, R.M., Jr. (1967), "A Short-run Demand Function for Higher Education in the United States", Journal of Political Economy. 77 (September/October) 765-77.

Haitovsky, Y. (1968), "Estimation of Regression Equations When a Block of Observations is Missing", in 1968 Proceedings of the Business and Economic Statistics Section of the American Statistical Association. Washington, D.C.: American Statistical Association.

Hight, J.E. (1975), "The Demand for Higher Education in the United States 1927-1972: the Public and Private Institutions", Journal of Human Resources. 10 (Fall) 512-20.

Johnson, D.G. and Hutchins, E. B. (1966), "Doctor or Dropout: a Study of Medical Student Attrition", Journal of Medical Education. 41 (December) 1097-1269.

Leffler, K. (1977), "An Economic Analysis of Physician Licensure", unpublished Ph.D. dissertation, University of California, Los Angeles.

Levine, D.M., Weisman, C.S., Sack, D.G. and Merlock, L.L. (1974), "Career Patterns of Unaccepted Applicants to Medical School", Department of Health, Education and Welfare publication No. H12A, 75-29, Washington, D.C.,: U.S. Government Printing Office.

Medical Education (1955-76), Supplement to Journal of the American Medical Association. Annual.

Merton, R.K., Reader, G.G. and Kendall, P.L. (eds.) (1957), The Student-Physician. Cambridge, Mass.: Harvard University Press.

Miller, L. and Radner, R. (1975), Demand and Supply in U.S. Higher Education. New York: McGraw-Hill.

Potthoff, E. F. (1960), "The Future Supply of Medical Students in the United States", Journal of Medical Education, 35 (March) 223-37.

Rogoff, Natalie (1975), "The Decision to Study Medicine" in Merton, et al. (1957, pp. 109-30).

Schmidt, P. (1977), "Estimation of Seemingly Unrelated Regressions with Unequal Numbers of Observations", Journal of Econometrics. 5 (May) 365-77.

Sloan, F.A. (1968), "Economic Models of Physician Supply", unpublished Ph.D. dissertation, Harvard University.

__________ (1971), "The Demand for Higher Education: the Case of Medical School Applicants", Journal of Human Resources. 6(Fall) 466-89.

Stapleton, D.C. (1978) "Nonprice Rationing and the Demand for Medical Education", unpublished Ph.D. dissertation, University of Wisconsin-Madison.

Thielens, W., Jr. (1957), "Some Comparisons of Entrants to Medical and Law School", in Merton, et al. (1957), pp. 131-52.

U.S. Bureau of the Census (1958, 1960, 1961, 1964, 1965, 1967, 1967a, 1969, 1969a, 1970-71, 1973-76) Current Population Reports, Series P-60 Nos. 27, 33, 39, 43, 47, 51, 53, 60, 64, 66, 75, 80, 85, 90, 97 and 101. Washington, D.C.: U.S. Government Printing Office.

U.S. Office of Education (1957-76), Earned Degrees Conferred. Washington, D.C.: U.S. Government Printing Office, annual.

__________ (1967a), Projections of Educational Statistics to 1976-77. Washington, D.C.: U.S. Government Printing Office.

__________ (1974a), Projections of Educational Statistics to 1982-83. Washington, D. C.: U.S. Governemtn Printing Office.

U.S. Public Health Service (1974), How Medical Students Finance Their Education. Washington, D.C.: U.S. Government Printing Office.

__________ (1975), Survey of How Medical Students Finance Their Education. Washington, D.C.: U.S. Government Printing Office.

Von Neumann, J. and Morgenstern, O. (1947), Theory of Games and Economic Behavior, Second Edition, Princeton, N.J.: Princeton University Press.

Walsh, M.R. (1977), Doctors Wanted: No Women Need Apply. New Haven: Yale University Press.