MEDICAL SCHOOLS: PRODUCERS OF WHAT?

SELLERS TO WHOM?

by

Thomas D. Hall
University of Hawaii

and

Cotton M. Lindsay
University of California, Los Angeles

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ABSTRACT

This paper seeks to add to the literature on nonprofit institutions and at the same time shed light on the continuing controversy over the behavior of medical schools in the United States. It has long been maintained among economists that medical schools conspire with organized medicine to restrain the supply of practitioners. In this connection, however, no one has attempted to develop a competing hypothesis about expected behavior of medical schools in the absence of such a conspiracy. This paper seeks to do this by treating medical schools as examples of a "nonprofit enterprise" modeled in the paper. The model is used to generate comparative statics implications for changes in medical school output and tuition associated with changes in student demand for training, donor demand for trained students, and shifts in production technology. Empirical testing of the model strongly confirms these implications and is inconsistent with the hypothesis that medical schools collude to restrain output.

There is a certain irony in economists' treatment of medical schools. Economists have long professed knowledge of the motives and results of medical school enrollment policy. Indeed belief in some sort of conspiritorial alliance between medical schools and the AMA is probably more widely subscribed to than most of the principles alluded to be "fundamental" to the discipline. Little analysis of the behavior of these institutions has been done, however. Earlier studies of Friedman and Kuznets (1946), Kessel (1958) and (1970), and Rayack (1967) which are largely responsible for this belief, rely exclusively on a few pieces of "circumstantial evidence." None of these writers explicitly modeled the behavior of the colluding groups or that of the alternative "socially motivated" medical school to insure that the facts reported actually permit discrimination between the two views. Indeed, so far as we can determine, no one has yet stated a clear-cut empirically verifiable hypothesis that will confirm or deny the influence of the medical profession on enrollments.

Now is an especially important time to examine the workings of these institutions. It appears likely that Congress will legislate national health insurance of some form in the near future, and even the most modest proposals currently under consideration would significantly increase the demand for physician services. Unless medical schools respond differently than economists, if consistent, must expect them to, however, such a program will do nothing but increase the earnings of physicians. As the principal channels for expanding supply are these very medical schools, this conventional scenario offers little hope of substantial increases in access to medical care from this program.

A more direct way of increasing access to medical care is to subsidize the training of more doctors. This approach raises another question, however. How do medical schools respond to such subsidies? Medical schools may be as insensitive to changes in support levels as they are alleged to be to changes in demand. In principle, they may spend the extra government subsidies to train their students more intensively, to engage in more research, to reduce their demands on other funding sources, or even to purchase utility-improving inputs such as deeper carpets and more luxurious office accessories.[1] Without a model of the behavior of these institutions, we cannot predict how they will respond to subsidies.

Until such a model is developed, policy in these areas will be uninformed. We attempt here to fill this lacuna by explicitly modeling medical school decision-making which relates enrollments and tuitions to a variety of market variables including training costs, grants and donations, and applicant demand. We use multiple regression analysis to explain annual enrollment and tuition levels in terms of these variables for a sample of sixteen medical schools over the period 1959-1973. These results are consistent with the theoretical approach taken here, and call into question the popular view of medical schools as the vassals of organized medicine.

Another important application of the model is its ability to produce policy relevant measures of medical education costs. The standard method of calculating "the cost of a medical graduate" involves merely division of total educational expenditures by the number of graduates. The usual reasons for treating such an average cost estimate with suspicion are compounded here by the interpretation analysts seek to give to such estimates. We are led to believe that this estimate is an approximation of the cost to government of eliciting a marginal graduate from the industry. We will demonstrate here, however, that medical training can exhibit constant costs and yet produce sharply rising costs to government of producing an additional graduate. Our estimates of this cost are therefore substantially higher than previous results.

THE DEMANDERS OF MEDICAL TRAINING

Two facts are sufficient to establish that medical schools are not engaged in the competitive supply of medical education to would-be physicians. First the payment which schools actually accept from students is only a fraction of the cost of the training which they provide, typically less than twenty percent.[2] More importantly, these fees are substantially less than could be obtained for the same quantity of training. At observed tuition rates prospective students would willingly purchase far more training service than schools actually provide -- frequently more than 50 percent more in the aggregate.[3] Indeed, observation of persistent excess demand in this market has led many economists to conclude that medical schools conspire with organized medicine to restrain the number of graduates and thus the supply of medical practitioners.

Such an explanation is inconsistent with other findings, however. The "profits" associated with investing in a medical career have been shown to be negligible; see Lewis (1963), Hansen (1964), Lindsay (1973), and very flexible in a downward direction (Leffler and Lindsay, 1978a). Moreover, a simple stock-adjustment model of medical school behavior shows them to be highly responsive to conditions in the market for medical care, though less so to conditions in the market for medical education (Leffler and Lindsay, 1978b). Finally organized medicine's record in its other attempts to influence policy does not instill confidence in its ability to maintain a grip on medical school admissions. The AMA sponsored one of the most heavily financed lobbying efforts ever mounted in an attempt to defeat Medicare and Medicaid in the mid-1960s to no avail. Stiff resistance to professional standards review organizations in the 1972 Medicare amendments failed to stop their adoption. And, most notably, the profession has been spectacularly unsuccessful in preventing expansion of supply through immigration of foreign-trained physicians. The increase in FMGs licensed to practice over the past two decades exceeds the number of domestically trained licentiates in 1958. Under such circumstances controlling medical school admissions seems hardly worth the bother.

In the face of such contradictory evidence it seems reasonable to seek some alternative to this conspiritorial model of medical school behavior. We offer here a model of medical school behavior which is consistent with all of these findings. The key to understanding motives and behavior of medical school administrators (regents, trustees, deans) is not in the second of the anomalies noted above -- it is in the first. Economists have focused their attemtion on would-be physicians when the most important demanders of medical education are clearly those groups and agencies who provide the lion's share of medical school revenues. It seems to us that a much more logical way to approach these institutions is to treat them as suppliers of trained physicians who face some negatively priced inputs (i.e., medical students). The demanders of this output are the donors whose "sales," as already reported, constitute a far more important source of "revenues" than receipts from students. These demanders include alumni and other private individuals, business firms, not-for-profit organizations (e.g., trusts, research organizations, and even the AMA), and agencies of all levels of government.

Seemingly perverse aspects of observed medical school behavior appear more reasonable when viewed from this perspective. The unresponsiveness of medical school capacity to demand conditions among would-be trainees seems quite reasonable if demands of this group are not highly correlated with demands of donors. Failure to raise tuition to the level which clears the market for students is no more unreasonable than the failure of firms to lower wages of top management positions to the point where the number of applicants falls to the number of such posts. The National Football League annually faces a potential player pool many tens of times larger than the number of players it ultimately employs. It contemplates neither expansion to the size at which the player pool would be cleared at current salaries nor reduction of salaries until the number of people willing to accept employment as players has fallen to the current number employed. Just as it is ticket buyers who ultimately determined the size and character of the NFL, it is donors who do the same for the medical education industry. And just as the Rams do not limit their search for quarterbacks to those willing to play the position for the lowest price, medical schools have good reason to exercise discretion in their admissions policies.[4]

We believe this approach has wide applicability to institutions in the not-for-profit sector. Conventional treatment of these organizations too often assumes a broad range of opportunities for the gratification of managerial tastes without making clear the sources of this latitude. We believe that it is more fruitful to assume that organizational resources and managerial behavior are not independent -- that the budgets of these institutions in many cases may fruitfully be treated as "revenues" associated with the sale of a product. The fact that the organization is quite often (as is the case with medical schools) engaged in the explicit sale of some other product should not divert attention away from the most important market in which it is involved, that between the organization and its donors. Once that market has been effectively identified, such institutions may be analysed effectively with the standard theory of the firm.

Medical schools' attitudes toward the admissions process give the clearest picture of donors' intentions. Evidence supports schools' claims to search for students with very specific attributes. For example, every school sets and adheres closely to standards related to applicants' grades in pre-medical courses and performances on standardized tests. In addition, schools consider age (applicants over 25 years old are rarely accepted), concern themselves with applicants' desired choices of specialty, and sometimes search for assurance that applicants intend to practice in the schools' home state.[5] Discrimination criteria differ widely across schools, but in each case one thing is clear -- administrators of schools do not consider all demanders to be "appropriately qualified" to receive the benefits of donor-sponsored medical training. We hypothesize that it is the specific admissions policy which completes the definition of the output which administrators sell to donors. The product is a particular brand of medical training administered to "appropriately qualified" students, and donors entrust school administrators to maximize output each year, subject to a given annual flow of donations.[6] This hypothesis leads to a very simple description of decision-making which related medical school tuition and enrollment to exogenous factors describing costs and incomes.

THE SUPPLY OF QUALIFIED MEDICAL GRADUATES

If medical schools are competitively engaged in the production and sale of trained graduates to donors, we should be able to model this supply behavior quite straightforwardly. At a minimum such a development should predict response of supply in this market to changes in costs of training and shifts in demand on the part of donors. We hope to use such a model to illuminate behavior in the market for training, however. It is therefore useful to incorporate features which allow us to simultaneously determine price (tuition) in the training market. Our approach is outlined with reference to Figure 1.

Figure 1 depicts the factors which affect the first-year enrollment selected by a medical school which can educate medical students at a marginal cost of C per student per year. A is the demand curve by all applicants for first-year training and D is the demand curve by that subset of applicants which is deemed "appropriately qualified." We assume that the medical training process requires four years to complete, and that when a school selects its first-year class it commits itself to training the class for the entire four years. Thus, if a school chooses a first-year class size of N, it is selecting a total school enrollment of 4•N in flow equilibrium.[5] We further assume that it is equally costly to train each of the four classes each year, so that the annual flow of resources necessary to maintain a first-year class of N is four times the cost of training the N for a year. Under these assumptions, a school will select first-year class size N if it can attract annually a sum of tuition and donation income equal to the annual cost of training 4•N students. As an example in Figure 1, total donations in the amount of 4•BFEC annually allow a school to set

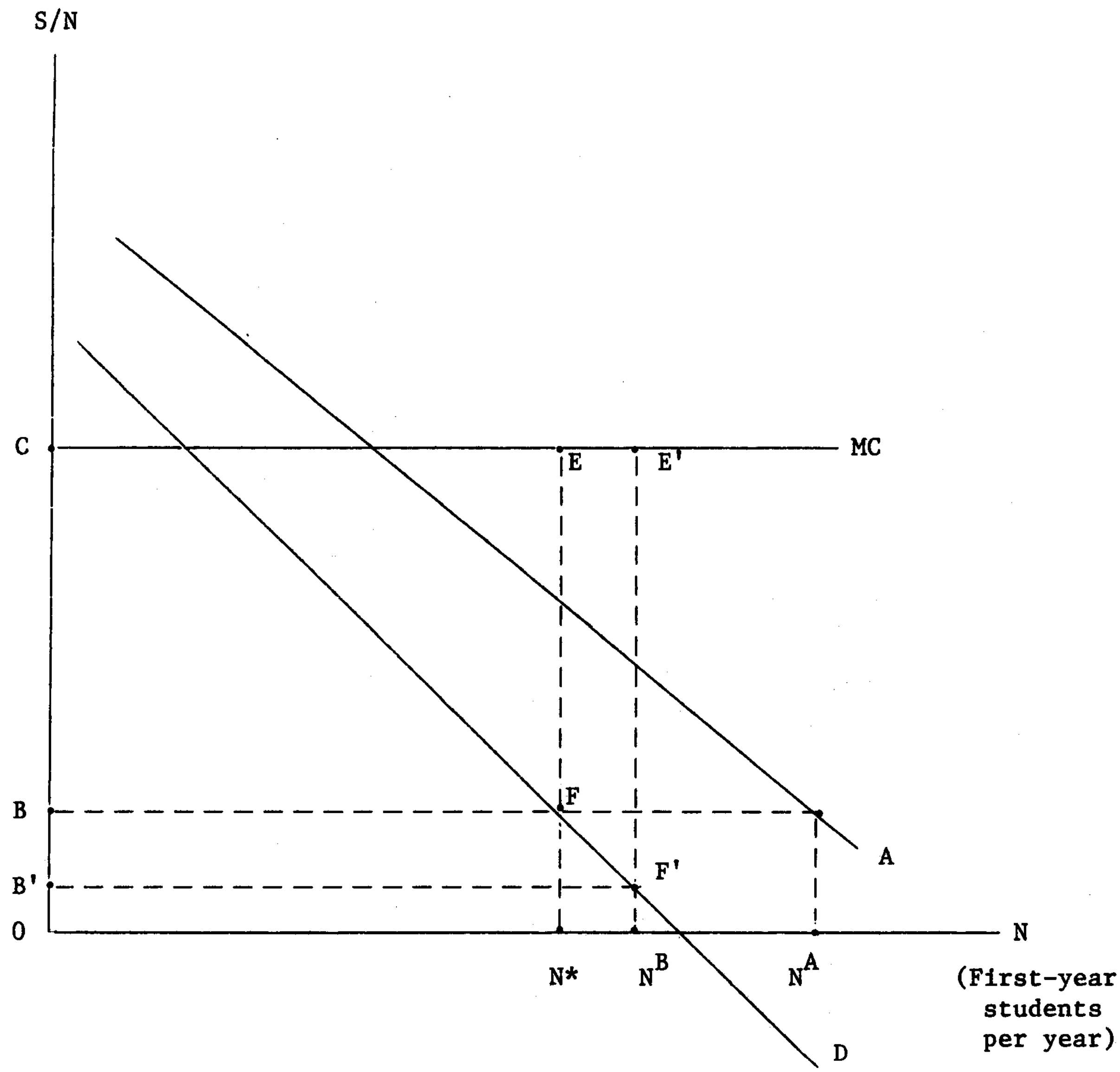

FIGURE 1

tuition at B per student per year, a level sufficient to attract N^* new first-year students per year. The school's annual training costs equal $4 \cdot N^* \cdot C$, which equal $[4 \cdot N^* \cdot B + 4 \cdot BFEC]$. This equilibrium is, as we designed it to be, of course, consistent with our original observations that tuition recovers only a small fraction of training costs $(B < C)$ and that large numbers of students are rationed on other-than-price bases $(N^* < N^A)$. However, if we assume that schools do not redefine their outputs frequently, the hypothesis also has comparative statics implications. Increases in donations (such as to $4 \cdot B'F'E'C$ annually, in Figure 1) encourage administrators to increase enrollment and lower tuition (to N^B and B^1 in Figure 1). Increases in demand by appropriately qualified students (outward shifts in D in Figure 1) yield similar results. And, increases in training costs schedule (upward shifts in MC in Figure 1) cause contractions in enrollment and increases in tuition.

We can view the decision process more generally in mathematical form. Let training costs be a function of total enrollment, $C = C(4 \cdot N;c)$, and demand for first-year admission by appropriately qualified students c and t summarize exogenous shift factors for the cost and student demand functions, respectively; $D_t > 0$, $C_c > 0$.[6] Then if donations in a year equal s, administrators face a budget constraint $s \geq C(4 \cdot N;c) - T \cdot 4 \cdot N$. Maximization of N (and thus $4 \cdot N$) subject to this constraint requires that equality $s = C(4 \cdot N;c) - T \cdot 4 \cdot N$ be satisfied. Since dependent variables T and N are related by the appropriate student demand function, we can rewrite this constraint in terms of only one unknown, T, to get equation (1) below. By solving (1) for T we obtain the reduced form equation (2) which identifies equilibrium tuition. We then define the reduced form function which identifies equilibrium first-year enrollment by evaluating D at T^*, as in equation (2').

$$s = C(4 \cdot D(T;t);c) - T \cdot 4 \cdot D(T;t) \quad (1)$$

$$T^* = T(s,c,t) \quad (2)$$

$$N^* = N(s,c,t) = D(T^*;t) = D(T(s,c,t);t) \quad (2')$$

The forms of T and N depend directly on the forms of the structural equations $C(4 \cdot N;c)$ and $D(T;t)$. The assumptions $D_T < 0$, $D_t > 0$, $C_c > 0$, and $C_N > 0$ are sufficient to imply that $T^*_t > 0$, $T^*_c > 0$, and $T^*_s < 0$, and therefore that $N^*_t > 0$, $N^*_c < 0$, $N^*_s > 0$.

ENROLLMENTS AND TUITION

In this section we show empirically that observed behavior in medical training markets since 1959 is consistent with the behavioral hypothesis developed above, and estimate the magnitudes of the effects which market forces have had on medical schools' tuitions and enrollments. We are unable to directly estimate the reduced form equations $N^* = N(s,c,t)$ and $T^* = T(s,c,t)$ since even the simplest assumptions about the structural equations D and C necessitate functional forms for N and T which are empirically unmanageable.[7] Alternatively we first estimate two simple linear equations which relate enrollments and tuitions to donations, training costs, and student demand variables, and then separately estimate the structural equation $D(T;t)$, appropriate student demand for medical training. We then use the coefficients of that structural equation to approximate the partial derivatives (N_s, N_c, T_s, and T_c) of the reduced form equations N and T.

First we specify regressions of the forms (i) and (ii).

$$N^* = \beta_0 + \beta_1 s + \beta_2 c + \beta_3 t + e \quad (i)$$

$$T^* = \alpha_0 + \alpha_1 s + \alpha_2 c + \alpha_3 t + u \quad (ii)$$

These do not yield unbiased estimates of the partial derivatives of functions N and T since the functional forms are likely to be misspecified, but they do allow us to test hypotheses concerning the signs of those derivatives. Our behavioral hypothesis leads us to expect that regressions of (i) and (ii) will yield positive signs for β_1, β_3, α_2, and α_3, and negative signs for β_2 and α_1.

To estimate (i) and (ii) we have assembled observations of all of the necessary variables (or proxies) for each of sixteen U. S. medical schools for each of the academic years 1959-1960 through 1972-1973. Data for N* and t we obtained directly from annual publications of the Journal of the American Medical Association (JAMA) and the Journal of Medical Education (JME), while data for T*, s, and c were constructed using unpublished confidential responses to financial surveys which the AMA and the Association of American Medical Colleges (AAMC) administer annually to U. S. medical schools (hereafter referred to as the AMA-AAMC survey). To measure N* we use actual enrollments in individual schools' first-year classes annually. To measure T* we use total real tuition and fee payments actually collected by individual schools annually divided by the total number of students enrolled in all classes.[8] Using actual observations of enrollment and tuition to measure comparative statics equilibrium levels assumes both that changes in exogenous conditions are correctly anticipated and that adjustments to the changes are made fully in each academic year. We found that alternative assumptions about adjustment behavior did not prove superior to the full-adjustment specification.[9] To measure the donations variables we use the summation of real school flow incomes from all non-student sources which are not specifically earmarked for uses other than training medical students.[10]

The remaining variables, c and t, summarize shift factors too numerous and too difficult to directly measure. Since we are not interested in isolating the effects of individual factors which shift training costs schedules and student demand schedules, we use a collection of proxy variables which identify differences in cost and demand conditions. For the proxy for c we use the measure of average training cost itself -- total real school expenditures on medical training divided by the number of students enrolled in all classes. Use of this proxy of course requires the assumption of constant returns to scale in the production of training serivces. Available evidence supports this assumption for schools in our sample.[11]

To identify fluctuations in student demand schedules over time, we use two proxies for the variable t. The first, t1, is the aggregate number of applicants to all U. S. medical schools in the years of the observation. The second, t2, is a calculation of the optimal stock of physicians in the U. S. four years prior to the year of the observation. Though neither proxy is without its limitations, we feel that both successfully indicate changes in aggregate market demand for medical education from year to year. Variable t1, for instance, is a measure of current quantity demanded, and as such is a function of current tuitions as well as factors which shift demand curves. In most of our observation years, however, increases in t1 do identify (though understate) outward shifts in market demand because tuitions and applicants have increased simultaneously. Variable t2 is entirely free of this difficulty. "Optimal physician stock" is the number of practicing physicians in the U. S. which would be consistent with a normal rate of return on occupational investments for marginal entrants to medical schools, and is taken from calculations made in Lindsay, Hall and Leffler (1976). Optimal physician stock increases whenever the demand for physician services increases (as it has over most of our observation period), and thus should signal an increase in the demand for medical education. This presumes, of course, that changes in the physician services market elicit informed responses by students in the medical training market. Leffler and Lindsay (1978b) have found that prospective medical students do respond, though with a lag, to changes in the physicial services market. Our variable 52 and its four year lag specification are based on those findings.[12]

Using the individual school time series observations we estimated thirty-two regressions -- equations (i) and (ii) for each of the schools in our sample. The results are inconclusive in important respects. The coefficients of determination consistently exceed .88 for the enrollment regressions and .70 for the tuition regressions, and the F statistics are significant at the .01 level for 28 of the equations. The difficulty with those regressions is that severe collinearity between pairs of the independent variables in many of the time series inhibits judgment about t-statistics, especially those for the donations variables.[13]

As an alternative we estimate regressions of (i) and (ii) using the pooled time series observations for all of the individual schools. Pooling yields attractive large sample statistical properties; such as less pronounced collinearity between independent variables, greater variances in the observations of most variables, and increased degrees of freedom. The introduction of cross sectional variations into the regressions is consistent with the behavioral hypothesis of Section I. One can view administrators of different schools as the same decision-makers facing different exogenous conditions. However, our present collection of variables does not identify all differences in these exogenous conditions across schools. Specifically, we have been unsuccessful in identifying a priori the structure of appropriate student demand schedules, D(T;t), for individual schools. Though we have been able to capture shifts in levels of demand schedules for schools over time, our proxies t1 and t2 do not pick up differences in the magnitude D(T) or the slope D_T across schools. This is important since we expect that schools search for different types of students and thus face student demand curves with significantly different slopes and elasticities over historical ranges of tuition.

We try to diminish the significance of this pooling problem in two ways. We include dummy variables identifying individual schools, and we group our observations into smaller pools on the basis of one obvious indicator of differences in appropriate student demand schedules across schools -- quality of the training program. One can reasonably assume that schools which offer similar qualities of training services also search for students with similar academic abilities. We thus expect that the appropriate student demand schedules of these schools will have similar shapes and will comprise similar proportions of their total (i.e., unscreened) applicant demand. To investigate this possibility we have constructed and compared three objective indexes to proxy the qualities of educational programs across medical schools. Each index indicates that our sample of schools exhibits a wide range of qualities. However, the indexes also commonly suggest that within the range, schools cluster into three distinct groups.[14] We divide our observations into three cells according to the indexes and estimate separate regressions of the reduced form equations (i) and (ii) to test the hypothesis that the slopes and intercepts of the equations differ significantly with respect to school training program quality.

Table 1 displays the results of regressions of equations (i) and (ii) over the various subsets of pooled time series observations. The following list of variables and their definitions is repeated for the purpose of identification and interpretation in Table 1:

N = 1st year enrollments

T = tuition

s = educational subsidies per student

c = educational costs per student

t1 = total applicants

t2 = lagged optimal stock of physicians

G1 refers to observations for the four schools which fall into the highest training quality group, G2 refers to observations for the six schools in the second highest training quality group, and G3 refers to observations for the remaining six schools. The two regressions using all data are statistically powerful -- adjusted coefficient of determination is very high in each case and both of the F statistics are significant at the .01 level. The cross section dummies (not reported in Table 1) in these equations all enter significantly, but even without them the equations explain more than 50 percent of the variance in enrollments and tuitions. In addition, in all but one case, the t-statistics in the all-data equations are significant at the .01 level, and every coefficient has the predicted sign.

The grouping procedure reveals differences in the equations for schools with different training qualities, and Chow statistics testing those differences are significant at the .01 level for both the enrollment and tuition equations. The group equation results generally remain consistent with our hypothesis. The performances of the average training cost variable in the G3 regressions comprise one exception -- the coefficients of c are insignificantly different from zero. This possibly reflects the fact that collinearity between c and each of the variables s, t2, and 53 is greatest in data group G3. The coefficients of t1 and t2 in the tuition regressions G1 and G2 respectively are other exceptions -- both are insignificantly different from zero. We offer no explanation of this result, but we note that the competing proxy in each equation performs strongly with the expected sign.

STUDENT DEMAND

When interpreted in a manner most favorable to our behavioral hypothesis, the regressions of the reduced form equations imply that medical schools do respond to market signals of several kinds: increases in donations and/or decreases in training costs encourage higher enrollments and lower tuitions, and increases in demand by prospective students encourage higher enrollments and higher tuitions. However, the regression estimates of the effects of these market forces are biased since the simple linear equations mis-specify the forms of the functions N(s,c,t) and T(s,c,t). We now estimate the appropriate student demand schedules D(T;t) which schools face and use the results to directly approximate unbiased partial derivatives of these equations.

To estimate the structural demand equation D, we use the same data used to estimate (i) and (ii). Observations on first-year enrollment N represent the quantity demanded by "qualified" students, observations on tuitions T represent the own-price of training seen by these students, and observations on the t proxies identify shifts in the student demand curves. We expect that medical schools behave as price (tuition) searchers and thus anticipate that the estimated demand curve slopes will be negative. The simple linear form of equation (iii) performs better than alternative specifications and is the only one we report.

$$N^* = D(T^*;t) = a_0 + a_1T^* + a_2t + w \qquad \text{(iii)}$$

Since estimating separate regressions for individual schools again yields inconclusive results, we estimate equation (iii) using the various pooled sets of time series data. Table 2 summarizes the results.

The equations perform strongly. The adjusted coefficients of determination are high and the coefficients have the correct signs. Except for t1 in the G1 equation the t-statistics are significant at the .01 level. A Chow test indicates significant differences between the group regressions, and differences in the coefficients across the equations are noticeable. The coefficient of the tuition variable in the G1 equation is over six times the size of that in the G3 equation, and similar dispersion occurs for the coefficients of the shift variables t1 and t2. The magnitudes of the estimated coefficients for the tuition variable T are reasonable. The tuition coefficient in the regression using the entire sample (-.0109) shows that it would take about a $92 increase in annual tuition to discourage application by just one appropriately qualified student. The separate group estimates are $33 for G1 schools, $67 for G2 schools, and $213 for G3 schools, and the implicit tuition elasticities of demand are -.479, -.149, and -.038 respectively, when evaluated at 1972-1973 sample means of observations on tuition and enrollment. These low elasticities are not surprising, especially considering the fact that tuition is a small fraction of students' training investments.

If we maintain the assumption that marginal and average training costs are constant over observed ranges of enrollments, then our estimates of the appropriate student demand schedules allow us to specify the forms of the reduced form functions N and T. With C(4•N;c) equalling 4•N•c, and D(T;t) taking the linear form estimated by equation (iii), the reduced form equation T (v) is obtained by solving the quadratic equation (iv) for T*. The reduced form equation N (vi) then is N(s,c,t) = D(T(s,c,t);t).

$$s = (c-T^*)\cdot 4\cdot N^* = (c-T^*)\cdot 4\cdot D(T^*;t)$$

$$= (c-T^*)\cdot 4\cdot (a_0 + a_1T^* + a_2t) \qquad \text{(iv)}$$

$$T^* = \frac{1}{2a_1}\cdot(ca_1-a_0-a_2t)-\frac{1}{2a_1}\cdot\sqrt{[(ca_1-a_0-a_2t)^2+4a_1\cdot(ca_0+ca_2t-\frac{s}{4})]} \qquad \text{(v)}$$

$$N^* = \frac{1}{2}\cdot(ca_1+a_0+a_2t)-\frac{1}{2}\cdot\sqrt{[(ca_1-a_0-a_2t)^2+4a_1\cdot(ca_0+ca_2t-\frac{s}{4}}} \qquad \text{(vi)}$$

The partial derivatives of N show the effects of incremental changes in flow donations, training costs, and student demand schedules on equilibrium enrollments. Since enrollments are adjusted necessarily in whole number increments, however, it is more empirically interesting to ask what changes in the exogenous variables would be required to encourage a school to expand equilibrium first-year enrollment by one student. Equations (vii) and (viii) show how to calculate the magnitudes of changes in flow donations (Δs) and changes in average training costs (Δc) necessary to induce one-unit increases in a school's equilibrium first-year enrollment.[15] The term a_1 is the slope of the

$$\Delta s = 4\cdot(c-T^*-1/a_1) - 4\cdot(N^*/a_1) \qquad \text{(vii)}$$

$$\Delta c = -(c-T^*)/(N^*+1) + 1/a_1 \qquad \text{(viii)}$$

appropriate student demand schedule described by equation (iii).

Table 3 lists calculations of Δs and Δc which use 1972 group means of the observed variables T*, N*, and c, and the group estimates of a_1 from the regressions in Table 2. The figures show that on average in 1972 either an increase in total donations income per year of about $135,000 or a reduction in training costs per student per year of about $240 would be required to encourage a school to expand its equilibrium first-year class size by one student (and its entire enrollment, therefore, by approximately four students). The figures in Table 3 also show similarities in Δs and Δc across groups, but this results mostly from the use of group averages of the enrollment, tuitions, and cost variables in the computations.

Table 3' lists calculations of Δs which use individual school observations N*, T*, and c for selected years, and the group estimates of a_1 from the regressions in Table 2. The figures in Table 3' provide a clearer picture of the variance in Δs both over time and across schools. The fact that student demand curves slope downward implies that Δs should be, _ceteris paribus_, positively related to the amount of donations received (and thus to the size of enrollments), and comparison of columns 1 and 5 is consistent with this. Enrollments in 1972-1973 are on average 58 percent higher than in 1959-1960, and Δs_{72} is greater than Δs_{59} for every school. However, _ceteris paribus_ conditions have not been met over time, so the differences in Δs across the columns also reflect outward shifts in student demand (which have tended to lower Δs) and upward shifts in training costs schedules (which have tended to increase Δs).

CONCLUDING COMMENTS

The results in Tables 3 and 3' offer several simple but important policy conclusions regarding the relationship between medical school finances and enrollments. The most significant conclusion is that the marginal cost to donors of stimulating enrollment expansions in most medical schools is very much higher than the average cost of training the additional students. Column 6 of Table 3' shows the additional training costs which schools would have incurred in 1972 if class sizes were increased by one student (four times our measure of c, the cost of training per student per year). Column 5 shows that the marginal first-year enrollment cost (Δs) in the same year is higher than $4 \cdot c_{72}$ for all but one school. The difference results from the fact that donors have not been paying the full costs of medical training. Even though students have financed only about 10 percent of schools' expenditures (by our measures of tuition and costs), on the margin their willingness to finance even more is very low (note the estimates of tuition-elasticity of demand in colummn 7 of Table 3'). Marginal cost to donors includes not only subsidization of the marginal student, but increases subdidization of infra-marginal students as well. This seems a simple point, but there is reason to believe that at least one donor to medical schools either has neglected or overlooked it. Since 1968, the federal government has annually awarded "capitation" grants to schools in an effort to subsidize health manpower investments. Under such grants, schools receive donations when they can promise increases in enrollments from year to year. However, schools have not found the terms of the grants to be exceedingly attractive since awards for marginal expansions have been nowhere near our estimates of Δs. Schools would accept the grants only if they were confident of receiving enough matching donations from other sources to make the required enrollment increases possible, or if they were willing to redefine their concepts of appropriately qualified students and become less selective in admissions. One suspects that other donors have also overestimated the productivity of marginal donations dollars since the best cost studies available have measured average training costs extensively but have not mentioned the marginal costs to donors of expanding enrollments.[16]

A second conclusion is that the quality of medical graduates seems unrelated to the marginal costs which donors have incurred to support their training. Table 3' calculations of Δs for 1972-1973 indicate that prospective donors would find it no cheaper to subsidize additional lower quality training than to subsidize additional higher quality training. In fact, everything else remaining the same, marginal donations costs for higher quality schools (G1) would increase at less rapid rates than the marginal donations cost for lower quality schools (G2 and G3) as more donations to schools are made.

A third conclusion is that schools with similar training quality show a significant variance in the marginal cost to donors of increasing enrollments. Table 3' shows that in every year, within each group of schools, Δs exhibits a wide range. The explanation of this (as well as the previous) conclusion is that many of the schools in our sample receive the bulk of annual donations from state government appropriations. One can understand that a state government would willingly subsidize additional training within its own school (or a private in-state school) even when equivalent (or higher quality) training is available at a lower (or comparable) marginal price in other schools. However, should the federal dollar become increasingly involved in the encouragement of medical eduation, our results indicate that national interests might best be served if federal grants are distributed very selectively -- to the higher quality schools when Δs's of schools are comparable, and to the cheapest Δs schools when training qualities are comparable.

Finally we ask whether our results shed any light on the question raised in the introduction of this paper. Have medical schools conspired with organized medicine to restrict the supply of practitioners? Our evidence suggests that they have not. Medical school output is positively related to demand by both donors and applicants. If the AMA wishes to maximize the welfare of its existing membership, then it should oppose expansion for either of these reasons. Of course, one may conjure up objective functions for AMA leadership which rationalize almost any behavior. In this connection, however, neither wage rate nor income maximization are consistent with expansion of physician supply.[17]

This is not to argue that the supply of medical practitioners is free from the influence of organized medicine. Two important avenues for such influence to be brought to bear remain. Leffler (1978) has examined licensure practices of individual states and considers whether recent experience is consistent with the hypothesis that standards have been raised to restrain entry. Kessel argued that the AMA has used its influence over accreditation to make medical education more costly for students (i.e., increase c in our discussions). He asserted that the AMA, through its power to accredit, forces schools to adopt training processes which are more time-intensive and more costly to administer per student per year than need be. Our results show that such techniques, if successful, would diminish the annual flow of graduates without increasing the quality of new physicians over time. Students who are appropriately qualified, both by school and AMA standards, would choose to forego training due to artificially high investment costs (longer investments at higher tuitions). We have no data showing the extent to which medical education production processes actually have been inefficient (or whether they have been at all).[18] If we did, however, Table 3 would allow us to calculate the resulting restrictive effects. The entries in the last column show that raising average training costs by approximately \$240 in 1972 would successfully shrink first-year enrollments (and thus annual graduates) by one student per school. This implies that at 1972 mean observations on average costs and enrollments, a 1 percent increase in average costs causes a .7 percent decrease in enrollments and medical graduates annually.

The focus of this paper has been medical schools, however, and their responsiveness to demanders of their output. The evidence which we have presented here is consistent with the hypothesis that they respond predictably to the set of parameters which define their economic environment. The model which we have used to predict this behavior is the standard theory of the firm operating in a competitive (non-collusive) setting. Although medical schools clearly are not proprietary firms in the conventional sense, they do engage in the sale of something, and the incentive structure faced by management seems likely to reward efficient organization of this activity, hence appropriate response to market signals.

This approach provides plausible explanations for two of the observations most frequently cited as evidence of collusive behavior by medical schools. Medical schools are not exclusively concerned with changes in the rate of applicants because they are not the principal market serviced by medical schools. Medical schools, though concerned about the supply of medical students, must in the final analysis adapt their plans to the demanders whose revenues cover more than two-thirds of their budgets. We have shown that medical schools respond significantly to changes in this market. Excess demand for medical education persists because not all individuals willing to matriculate satisfy standards imposed by these donors. Medical schools invest large amounts in the screening of applicants with the obvious intention of finding among them individuals who exhibit desired attributes. This may give the appearance of a restrictive practice. Such an interpretation of appearance is inconsistent with the undeniably vigorous competition which exists for those students found suitable, however, as well as the responses of output and tuition to increased demand by donors.

APPENDIX

Equations (vii) and (viii) are derived as follows:

1. Solve the budget equation (1) for s (c).

2. Use the estimated form of D(T;t) from equation (iii) to solve for T* in terms of N*, then substitute this for T* into the equation for s (c) in step 1.

3. Differentiate the equation for s (c) with respect to N*.

4. Δs (Δc) equals the definite integral of ds/dN* (dc/dN*) over the range N* to N* + 1.

5. In the equation for Δs we use the substitution $(a_0 + a_2t) = N^* - a_1T^*$ for the intercept of the D(T;t) schedule with the enrollment axis, and in the equation for Δc we use the substitution $s = 4 \cdot N^* \cdot (c-T^*)$ for the sum of flow donations. The former substitution implicitly assumes that (N*,T*) is a point on the appropriate student demand schedule. The latter substitution is used rather than $\dot{s}$ itself so that our computations of Δs and Δc will be comparable. In the absence of perfect measures of s and c, we have to force the budget equation (1) to hold by assuming that one of the measures is correct and the other is incorrect. We chose to assume c is correct.

TABLE 1

Regressions of Reduced-Form Equations

Dependent Variable	Group/Observation	s[†]	c	t1[††]	t2[†††]	$\bar{R}^2$
N	ALL/224	.4027 (6.69)*	-.0022 (-7.64)*	.758 (2.54)*	.226 (4.36)*	.9504
N	G1/56	.3987 (4.95)*	-.0027 (-8.06)*	-.405 (-.79)	.422 (4.47)*	.9183
N	G2/84	.2532 (1.64)***	-.0027 (-5.16)*	.675 (1.33)	.438 (4.25)*	.9353
N	G3/84	.2137 (2.48)*	-.0057 (- .83)	1.410 (3.47)*	6.729 (.32)	.9780
T	ALL/212	-4.86 (-2.89)*	.0499 (6.47)*	2.000 (2.61)*	.767 (.57)	.9051
T	G1/53	-10.40 (-4.67)*	.0564 (6.21)*	1.210 (.93)	7.648 (3.15)*	.9386
T	G2/81	-10.32 (-2.50)*	.0783 (5.75)*	2.437 (2.17)*	-.092 (-.04)	.9025
T	G3/78	-5.60 (-2.01)*	-.0142 (-.77)	.508 (.43)	4.233 (2.09)*	.8898

† Constants and dummies were included but are not reported here. $\bar{R}^2$ is adjusted for degrees of freedom. t-statistics appear in parentheses.

†† Coefficients in this column should be multiplied by 10^{-5}.

††† Coefficients in this column should be multiplied by 10^{-3}.

* Significance at .01 level; ** significance at .05 level; *** significance at 0.1 level.

TABLE 2

Student Demand Equations

Dependent Variable	Group/Observation	T	t1	t2	$\bar{R}^2$
ENR1	ALL/212	-.0109	.0012	.00023	.9346
		(-4.01)*	(4.05)*	(5.27)*	
ENR1	G1/52	-.0302	.0004	.00056	.8957
		(-6.23)*	(.79)	(6.54)*	
ENR1	G2/81	-.0149	.0016	.00027	.9309
		(-3.46)*	(3.51)*	(3.97)*	
ENR1	G3/78	-.0047	.0007	.00011	.9894
		(-1.81)**	(2.98)	(3.43)	

* Significant at the .01 level.

** Significant at the .05 level.

TABLE 3

Exogenous Stimulants to Incremental First-Year-Enrollment Expansions

Group	A_1[1]	T^*_{72}[2]	N^*_{72}[2]	C_{72}[2]	E^T_{72}[3]	Δs_{72}[4]	Δc_{72}[5]
ALL	-.0109	$2248	140	$23,161	-.1750	$135,395	$-240
G1	-.0302	$3215	134	$31,528	-.7245	$131,132	$-243
G2	-.0149	$2038	147	$23,060	-.2065	$123,819	$-209
G3	-.0047	$1725	135	$17,685	-.0600	$179,584	$-330

[1] a_1 from regressions in Table 2.

[2] Group-means of observations, year 1972-1973 (1972 dollars).

[3] E^T_{72} is tuition-elasticity of demand, calculated from $E^T_{72} = a_1 \cdot T^*_{72}/N^*_{72}$.

[4] Δs_{72} is marginal enrollments-price (1972 dollars), calculated from equation (vii) in text.

[5] Δc_{72} is the average training cost reduction (1972 dollars) which would expand first-year enrollment by one, calculated using equation (viii) in text.

TABLE 3'

Δs for Individual Schools for Selected Years

Number	Group	Class[2]	(1) 59-60	(2) 62-63	(3) 65-66	(4) 70-71	(5) 72-73	(6) $4 \cdot c_{72}$	(7) E^T_{72}
1	G1	1	138870	140560	164530	149520	173440	157740	-.20
2	G1	0	63562	95238	111200	117430	107260	101050	-.72
3	G1	0	71789	104220	99729	142810	115770	114480	-.92
4	G1	0	54648	64322	96209	165940	128060	131200	-1.24
5	G2	1	72220	55062	84773	132200	154290	125900	-.16
6	G2	1	62090	74140	83929	105280	109750	84633	-.26
7	G2	1	79935	96125	107060	132780	128770	66493	-.07
8	G2	0	50157	45822	103640	141140	140300	129720	-.66
9	G2	1	38802	54863	69215	87615	89575	54881	-.07
10	G2	1	61489	69881	91831	135750	122950	91856	-.13
11	G3	0	77293	89074	93475	109130	115520	47541	-.15
12	G3	0	76312	85267	105670	134720	128960	50422	-.14
13	G3	1	215610	215990	227840	254920	*	83371	*
14	G3	1	91595	112230	127520	151800	169280	73675	-.01
15	G3	1	110190	113020	119850	169360	*	89606	*
16	G3	1	71085	79374	89730	140550	147330	79864	-.06

[1] All figures are in 1972 dollars. Δs is calculated using text equation (vii) with school observations for N, T, and c, and group estimates of $a_1 \cdot E^T_{72}$ is tuition elasticity of demand; $E^T_{72} = a_1 \cdot T_{72}/N_{72}$.

[2] Class refers to ownership category. 1 signifies public, 0 signifies private.

* Insufficient data to calculate Δs. (Observation for this year and school was omitted from regression sample.

FOOTNOTES

1/ See Alchian and Kessel (1962).

2/ In the sample of schools which we observed, the percentage never exceeded 20 for any school in any year. Previous studies, such as Fein and Weber [5], have shown that in the aggregate tuitions average only about 4 percent of medical schools' overall expenditures. Our figures appear somewhat higher since we have divided tuition payments by expenditures on basic medical training only.

3/ Non-price rationing by medical school admissions committees is commonly known. Aggregate applicant-to-acceptance ratios have remained above 1.6 traditionally, even in years when demand for training has been relatively stable, e.g. from 1959-1963.

4/ The fact that the NFL is indeed a cartel should not be allowed to cloud the issue. This example was chosen to illustrate that apparent excess supply in an input market need not imply that the market is not cleared. As long as the "quality" of the input varies across suppliers, it is neither unusual nor necessarily inefficient for employers to pay more for the more qualified suppliers than less qualified suppliers would command.

5/ This assumes that all students complete the training program. This is not exactly true, but it is a very close approximation since attrition rates in medical schools have averaged less than 4 percent for many years. In 1974-75, for example, attrition was 1.31 percent. See JAMA, Education Number, annually.

[6] Variable subscripts indicate partial derivatives in this paper.

[7] Our hypothesis suggests forms of N and T which have second partial and cross partial derivatives which are functions of all of the exogenous variables. Unfortunately the usual functional forms which allow this and which are conveniently estimated via linear regression place constraints on some partials which are inconsistent with our hypothesis.

[8] An alternative to using this measure of tuition is to use stated tuition rates. We choose to use our measure for two reasons. First of all, stated tuitions are difficult to interpret across schools, as they sometimes include fees which are paid to parent universities rather than to the medical colleges. Secondly, schools may tuition discriminate to different degrees through the use of waivers, etc., and we have no knowledge of the extent to which they do.

[9] The full-adjustment assumption asserts only that expansion in first-year enrollment is a signal that desired school enrollment has increased. Schools may take years to adjust fully to the new capacities -- such as by spreading construction over time and increasing sizes of upper classes more slowly than first-year classes -- but we have not investigated the nature of the adjustment process since we have been unable to obtain the necessary data on capital expenditures (or financing) for individual medical schools.

[10] Our measure of s is the cleanest description of annual flow financing from donors which has been constructed. Because we had access to the AMA-AAMC survey responses we were able to significantly disaggregate previously published figures on finances, and therefore to get a more accurate picture of the degree to which certain funds are earmarked. Also we located sources of funds which some schools label as subsidies to finance "deficits" which actually are

annually expected flow donations for normal operating expenses. Though it is the cleanest data available, s is not free of measurement error. We checked schools' reported total incomes against reported total expenses and found that occasionally they do not match. Some survey entries used to construct s thus be in error. Where discrepancies in some year indicate the possibility of very large measurement errors for s, we have omitted the observation for that school for that year.

11/Our data revealed that all schools' real average costs rose sharply as outputs increased over the observation period, suggesting that significant economies of scale are unlikely, or at least that their effect on output is small relative to shifts in cost schedules. At the same time, our individual school regressions show a significant negative relationship between average cost and school class size, suggesting that strong diseconomies of scale also are unlikely, or that their effect is negligible compared to shifts in cost schedules.

12/The usefulness of both proxies t1 and t2 relies on two further assumptions which reflect our inability to adequately characterize student demand conditions on an individual school basis. One is that demand by appropriately qualified students correlates positively with general market demand. The other is that demand for each school correlates positively with nationwide student demand. Data on annual applications to individual schools is not meaningful for our purposes. Number of applications per applicant varies to such an extent over time that applicants cannot be interpreted as quantity demanded to individual schools.

[13] In fourteen of the time series (twenty-eight regressions) the variable s correlates strongly with either the student demand shifters t1 and t2 or with the average costs variable c. This creates uncertainty in evaluating results of 9 equations in which the coefficients on s are of the predicted signs and of anticipated magnitudes but in which the t statistics are too low to be judged significant. Other equations present the same problem for other independent variables, and as a result we can neither accept nor reject our hypotheses about the variables in equation forms (i) and (ii).

[14] Our three indices of school quality were calculated as follows: to construct one index we measured real sponsored research grants awarded to the medical school by external foundations and government agencies. We intended this to proxy the quality of faculty members. We called the time series average of this variable for each school the school's quality. To construct the second index we measured full-time faculty per undergraduate medical student and took the time series average for each school. To construct the third index we calculated the time series average for each school of our variable c, the real average training expenditures per student per year. The three indexes do not yield identical rankings of the schools. However, such index does show identical distinct clustering of the quality measures across indexes -- that is, each index shows three clusters and every school appears in the same cluster under each of the indexes.

[15] See the Appendix for derivation of equations (vii) and (viii).

[16] See Lindsay, et al. (1976), Chapter 8, for a summary and critique of this research.

17/ In connection with recent medical school expansion, the analogy has been made to monopolists increasing output in response to rightward-shifting demand. Even if total rather than average physician income is the appropriate maximand, a rightward-shifting demand curve is insufficient to warrant output expansion. Demand repeatedly has been shown to be price inelastic, hence total physician income will not be increased by output expansion.

18/ Indeed, the willingness of the great majority of medical graduates to undertake lengthy and far more costly postgraduate training programs after their tenure in the accreditation-influenced portion of their preparation suggests that supply restraint from this source is not a serious problem.

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