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THE GROWING SUPPLY OF PHYSICIANS: HAS THE MARKET BECOME MORE COMPETITIVE?

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Both popular and professional writings suggest that the American Medical Association (AMA) no longer wields the authority that it held even 10 years ago. An apparent downward trend in real physician incomes attributed to their emptier offices is cited as the primary evidence. ". . . Competition is no longer a theory to many doctors . . . . It is a harsh reality--one they feel in the form of gaps in their appointment schedules and declines in their real incomes . . . ."[1] Moreover, the AMA's losing battle with the Federal Trade Commission concerning jurisdiction over physician business practices as well as the general increase in government intervention in the health industry is suggested to imply a weakening trade organization unable to defend its members'

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1 H. Schwartz (1982), p. 43.

interests. A falling membership in the AMA corroborates this notion.

Economists have long recognized that the market for physician-provided services cannot be described adequately by a purely competitive model. Rather, it is suggested that the supply of physicians permitted to practice in the United States has been restricted for the better part of the twentieth century. As Reuben Kessel (1958, 1970), Milton Friedman (1962), D. Hyde, P. Wolff et al. (1954), and others have noted, successful barriers to entry have been maintained through a combination of medical school accreditation with mandatory state licensing of individual physicians. That is, when only a specific number of medical school spaces are accredited,[1] the requirement that all candidates for medical licensure have graduated from accredited medical schools limits possible expansion to that permitted by the accrediting body. Since the American Medical Association was instrumental, during the first decade of this century, in establishing this system, and still now controls, through its Council on Medical Education, the school accreditation process, it is often regarded as the primary force determining physician supply in the U.S. Therefore, if the rumors of AMA demise have some validity, a lessening of these supply restrictions and, hence, a growth in the physician stock, should be manifest.

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[1] Schools are accredited on the basis of a specific student body size, thus internal expansion is also prevented.

It is important to recognize that evidence suggesting that physician supply has, at least in the past, fallen short of the level that would prevail under competitive market conditions does not imply a unique motivation for such restraint. Two theories prevail in the economics literature. The "cartel" rationale, credited originally to Friedman and Kessel, posits AMA behavior as that of a typical trade union, serving the economic interests of its existing membership through the successful erection of barriers against would-be entrants. Alternatively, Kenneth Arrow (1963) and Keith Leffler (1978) suggest that the licensing and school restrictions enforced by the AMA are demanded by consumers to assure quality since an informational asymmetry exists between the highly-trained physician and the ignorant public. The costs of choosing an incompetent physician may be viewed as high, both to the individual patient and to the general public (if there are externalities associated in the misdiagnosis/treatment of contagious diseases, for example). Thus, the "quality assurance" hypothesis suggests that the public may recognize that a restricted physician supply raises the price of medical care, and yet perceive this cost as lower than that of a lower average level[1] of care expected to prevail in the absence of licensing restrictions. Leffler does not predict positive returns to physician training; a quality assurance mechanism may lower

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[1] Or even if they do not expect a lower average level, the possibility of a minimum quality may be adequate to demand AMA monitoring if sufficient risk aversion is present.

supply by increasing the average cost of training. Thus, while supply may be lower than the quantity that would prevail in the absence of restrictions, economic rents to becoming a physician still may not exist. The "quality assurance" argument above is more general; it suggests that consumers may recognize that, by granting "organized medicine" the power of licensing, they give physicians the market power to raise prices by more than the amount by which their costs increase.

Both rationales for AMA existence thus imply that any deterioration of the AMA's authority will lead to (1) an expansion of physicians' supply, and (2) a decline in their real incomes. As Figure 1 clearly depicts, the physician-population ratio has grown substantially in the last 20 years, after falling for most of the first third of the century,[1] and then rising only slightly during the next 25 years. However, to test these propositions properly, it is necessary to take account of changes in the demand for medical services as well as in the cost of becoming a physician. The enactment of public health insurance programs (Medicare and Medicaid) in 1965, which subsidize consumption of medical services, surely extended demand greatly.

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[1] The large decline in the physician-population ratio during the first three decades of this century is generally attributed to the AMA's crackdown on medical schools. What gave the AMA the necessary authority to accomplish this mission at this time and not in its earlier attempts is less clear. It seems likely that a growing public awareness of the existence of "scientific medicine," primarily brought over by European physicians, created a demand for some standard of quality.

FIGURE 1

Physician - Population Ratio

1880 - 1981

Ratio of Physicians* to 1000 U.S. Resident Population

* 1880-1940 data represent total number of physicians

1946-1981 are only active physicians

(Thus earlier period data are higher than they would be if directly comparable to the latter period.)

Under most reasonable assumptions about the elasticities of supply and demand, even a perfectly functioning cartel responds to increases in demand by expanding output.[1]

Has physician supply risen beyond that attributable to the demand growth, leading to a more competitive market for physicians? Have returns to becoming a physician, hence, diminished? This paper develops a model of the stock of physicians which tests whether the market structure has, over time, become more competitive. Before developing that model, however, it is helpful to posit a hypothesis that suggests why changes in market structure may have occurred.

If market conditions have in fact become more competitive, the weakening of an entry barrier is suggested. Recall that the AMA's control over the number of medical school spaces is regarded as the primary barrier to entry into the medical profession. The number of medical schools has grown from 87 in 1963 to 126 in 1980, and the number of graduates has more than doubled, rising from 7,264 to 15,134 during the same period.[2] What caused this substantial increase in supply? Public concern about a "physician shortage" began in the late 1940's. Sensing an oncoming battle as early as 1946, the AMA claimed that "the

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[1] Still, it is not clear that an existing number of physicians (i.e., firms) would want to permit entry of new "firms." Such a desire can be rationalized as an attempt to prevent consumers from actively seeking substitutes.

[2] Journal of the American Medical Association (JAMA) 198, 21 November 1966, p. 196, and JAMA 246, 25 December 1981, p. 2917.

normal annual number of graduates from existing medical schools is adequate for the peacetime needs of the country . . . ."[1] The increased birthrate of the 1950's as well as expanded private insurance coverage furthered popular sentiment regarding the need for more physicians. Moreover, many medical colleges were suffering financially, leading groups such as the Association of American Medical Colleges to favor federal support. In 1959, the AMA, perhaps bowing to public pressure, also cautiously admitted that more doctors would be necessary in the future and that medical schools required one-time (only) federal support. Finally, in 1963, legislation providing federal funds to both medical schools, for construction and improvement, and to students, in the form of subsidized loans and scholarships, was enacted. In 1965, simultaneous to the passage of Medicare and Medicaid, the "manpower training" programs were expanded.[2] In 1971 the Comprehensive Health Manpower Training Act was passed which also provided "capitation grants" to medical schools, per student bonuses that clearly encouraged expansion of enrollments. Federal support of medical research also blossomed in the 1960s and provided medical schools with incentives to expand their

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1 JAMA, quoted in Paul Feldstein (1977, p. 62).

2 Indeed, the AMA's puzzling opposition to the demand-enhancing Medicare and Medicaid programs perhaps becomes more understandable if these insurance programs are viewed as one part of a package deal along with supply-increasing manpower training funds. That is, the AMA may have recognized that the government-induced entry barrier weakening would insure that only short-term rents would accrue from the increase in demand.

research efforts. Since research and teaching are generally considered joint products by medical schools, it is not surprising that student enrollments also rose. It appears, therefore, that in the 1960s, the increase in federal funding for physician (as well as other medical) services subsidized not only demand, but supply sources as well.

During the 1960's, it also became easier for foreign medical graduates to practice in the U.S. The immigration law was eased in 1968, and throughout the sixties state licensing laws requiring citizenship were dropped. Expansion in the number of medical school spaces as well as the relaxation of many entry restrictions on foreign medical graduates can be viewed as weakening the medical profession's barrier to entry. It does not explain why the AMA may have weakened: rather it should be viewed as evidence of such deterioration.

Section II examines trends in physician incomes as well as measures of training costs to determine whether the return to becoming a physician has declined in recent years. In Section III a model that describes the determinants of the physician stock is developed. A weighting parameter, measuring the degree of actual competition in the market for physicians as an average of the pure monopoly and perfect competition equilibria, is explicitly incorporated to permit testing of the proposition that market structure has changed. Section IV discusses empirical tests of the model. Section V provides a summary.

II. THE RETURN TO BECOMING A PHYSICIAN

Many economists have examined the return to medical training.[1] All use a similar methodology to estimate this return: the cost of becoming a physician is measured as the opportunity foregone by not pursuing the next best possible employment plus any direct costs associated with medical training such as tuition. Because of data limitations, opportunity cost is measured with respect to earnings of college (bachelor degree) graduates, adjusted for the additional time necessary to go to medical school (four years) and complete a (lowpaying) residency program (one-five years).

No universal conclusion regarding the profitability of medical school attendance emerges from the literature. Slightly varying any of several assumptions about the elements of the opportunity cost stream (such as the discount rate, average training time, or hours worked) substantially alters the resulting calculation. Thus the studies by Friedman and Kuznets, Sloan, and Fein and Weber suggest "abnormal" (non-competitive) rates of return while the others do not.[2]

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[1] See, for example, Milton Friedman and Simon Kuznets (1945), H. Gregg Lewis (1963), Frank Sloan (1970), Rashi Fein and Gerald Weber (1970), Cotton Lindsay (1973, 1976) and Keith Leffler (1977, 1978).

[2] Potential objections to each of the studies exist: Friedman and Kuznets assume a discount rate of only 4 percent; they also, as does Lewis, use dentists, why themselves may be earning rents, as the comparison benchmark. Sloan uses median rather than mean earnings and does not adjust for taxes. Lindsay assumes a 62

(footnote continued)

A more competitive market for physicians should be evidenced by a downward trend in their relative incomes. Figure 2 depicts the ratios of physician income (MDINC) to a measure of the total opportunity cost (TOC) of becoming a physician.[1]

If measured opportunity cost completely accounts for all the costs associated with becoming a doctor, then a physician income to opportunity cost ratio of one implies a competitive market for physicians. There are several reasons why our measure of opportunity cost is incomplete. For example, a premium may be necessary to compensate for any greater uncertainty associated with medical training. Also, physicians may be of "higher quality" on average than the standard college graduate to whom they are compared. Moreover, if there are such quality, and hence, opportunity cost, differences across physicians, then only

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(footnote continues)

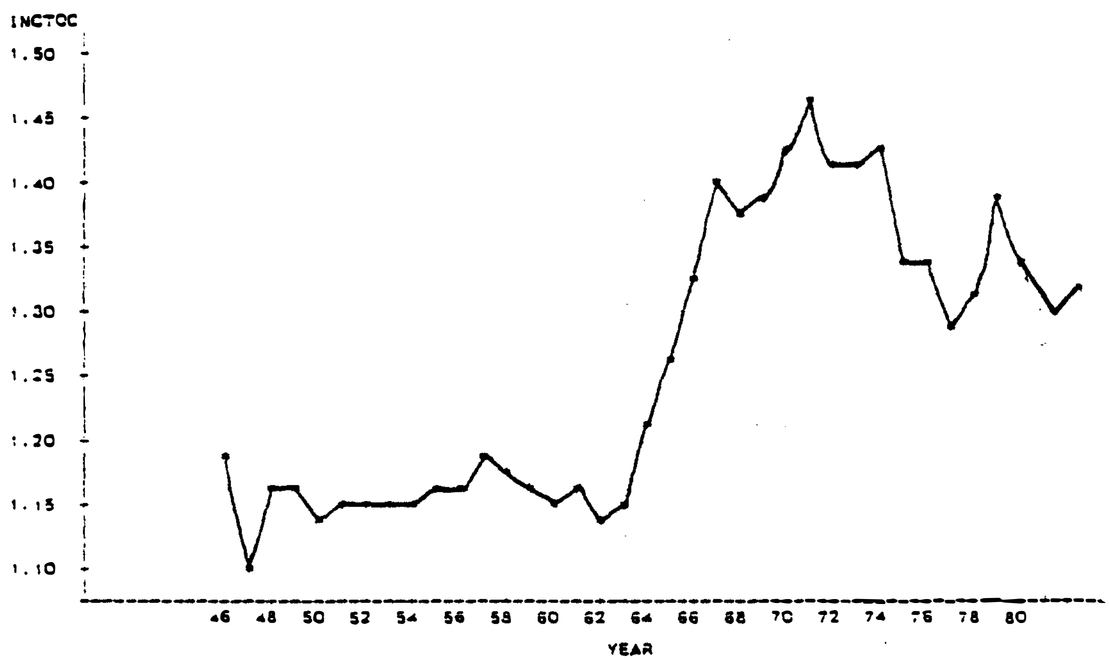
hour physician work week while most studies suggest 40-53 hours to be appropriate. Fein and Weber compare physician earnings to those of Ph.D. biologists, who, like dentists, may not be earning competitive returns. Leffler studies only general practitioners' earnings despite the fact that by 1970 GPs comprised only 17 percent of the physician population.

[1] Both are measured in 1972 after tax dollars. Data sources are listed in Appendix A. The physician income series is spliced from Department of Commerce, IRS, AMA and Medical Economics data. No single source provides accurate numbers for all years (e.g., recent IRS data are biased downward since it has become common for higher income physicians to incorporate), but sufficient overlap exists to make the elements of the series comparable. TOC is constructed similarly to those series of the studies described above and is outlined in Appendix B. Mean full-time worker incomes of college graduates over age 25 are used as the base.

FIGURE 2

Physician Income - Opportunity Cost Ratio

1946 - 1982



the marginal physician earns no economic rents. Since we are measuring averages of both income and opportunity cost, it is not clear what equilibrium ratio we should expect. The interesting question of whether the measured return has changed over time remains; if we assume that the measurement error in our calculated opportunity cost has not changed significantly, we can still examine the time path of returns.[1]

From the figure, it is evident that throughout the period studied, the measured return to physician training is positive. The ratio has ranged from a low of 1.10 (a 10 percent average premium over measured opportunity cost) to a high of almost 1.5 in 1971. After remaining fairly stable for several years following World War II at an average level of 1.16 from 1948-1963,[2] the income-opportunity cost ratio began to climb in 1964, when a precursor to Medicare/Medicaid was enacted, and continued to rise to its 1971 peak of 1.47. For the decade following enactment of Medicare/Medicaid its average level equaled 1.4. Since 1971, however, the return to physician training has diminished steadily, although it still exceeds that experienced

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[1] Increased entry of physicians in recent years has lowered their average age, thus the equilibrium measured average income may have fallen. However, the age distribution of the entire civilian labor force has also shifted downward: in 1970, 42 percent of the labor force was under 35; by 1982 this percentage had increased to 51 percent.

[2] The data underlying the 1946 and 1947 measures of TOC are questionable.

before 1966. Whether it has leveled off or will continue to plummet is unclear.

What does this pattern indicate? Certainly, the evidence suggests that, to date, physicians have not suffered as a result of increased federal spending for medical care; their long-term profits from it, however, appear to be slight.[1] Thus, while short-term gains certainly existed because of slow and incomplete adjustment to a large (unexpected?) increase in demand when Medicare/Medicaid were enacted, as supply adjusted both through the importation of numerous foreign medical graduates (FMG) and the substantial growth in U.S. medical school slots, the return diminished.[2] It seems unlikely that demand will experience another large surge in the foreseeable future since the vast majority of the population is already insured (about 95 percent); therefore, if the physician-population ratio continues to rise, the physician income-opportunity cost ratio may fall further.

The evidence depicted in this section is certainly consistent with increasing competition in the market for physicians

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[1] In 1965, the year immediately preceding extensive public health insurance funding under Medicare and Medicaid, the physician income-opportunity cost ratio equaled 1.32; the 1964-65 average was 1.30. During the last three years, 1980-82, the average ratio has been 1.32.

[2] Given the size of the short-term rents, however, it is still difficult to explain AMA opposition to Medicare and Medicaid.

leading to decreasing rents. However, the data can also be explained as portraying a price response to a temporary stock disequilibrium caused by a sudden growth in demand and costly supply adjustment. If, in the next several years, the return continues to fall (below the 1965 level), a stronger case can be made for the increasing competition theory. At present, however, it is necessary to examine directly the stock of physicians to determine whether the increase in supply has surpassed that induced by expanded demand.

III. A MODEL OF THE PHYSICIAN STOCK

Is the evident growth in the number of physicians attributable to a more competitive medical market? To answer this question we need first to account for equilibrium adaptation of the stock to changes in demand and/or opportunity cost, and then to measure any change in market structure that may have occurred. First, by modeling the equilibrium number of physicians, at any point in time, as a weighted average of the stock that would prevail under conditions of pure monopoly and that would exist if the market were perfectly competitive, we can examine changes in the weight over time. If the weight, as a function of time, moves closer to the competitive extreme, then we can conclude that entry barriers have become less effective.[1] This section

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[1] Alternatively, we can model directly the causes of a market structure change and view the stock of physicians as composed of a dominant firm of AMA-sanctioned physicians and a competitive (footnote continued)

will develop the framework necessary to estimate the effects of changing market structure.

A. Equilibrium Physician Stock

At any point in time, the equilibrium supply of physician services and fees charged are determined by current demand and production functions as well as by the prevailing market structure. From exogenous demand conditions for physician services and the technology that relates the number of physicians to the number of services provided, a demand curve for the physician stock can be derived assuming the proportions are constant at the optimum. Thus, demand for a stock of physicians in year t, MDS_t, is positively related to a vector of demand shifters, $\underline{Z}_t$, including population characteristics such as number, personal income, insurance coverage, age distribution and other health status determinants, as well as the price of substitutes. It is negatively related to the "price" of physicians, their real earnings, $MDINC_t$.[1]

(footnote continues)

fringe. If market competition has increased, we should be able to observe an outward shift in the competitive fringe supply curve. Monica Noether (1984) estimates directly the effect on physician stock and income of various entry barrier relaxations and subsidy programs.

[1] It is also determined by the technology implicit in the production function for physician services as well as the degree of market power exercised by each individual physician in providing services. Changes in technology can have various effects on the demand for physicians. If, through the invention of sophisticated medical equipment, the efficient production of medical (footnote continued)

In this simplest case, then, a linear market demand curve for a stock of physicians can be written as:

$$(1)\quad MDS_t = a_0 + a_1 MDINC_t + \underline{a}_2' \underline{Z}_t$$

where $\underline{a}_2'$ is a row vector with all elements greater than zero (the elements of $\underline{Z}_t$, the demand determinants, have been so

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(footnote continues)

services becomes more capital intensive, all else constant, the demand for physicians declines. On the other hand, advances in medical knowledge have greatly widened the scope of conditions that are considered treatable. To the extent that physicians are responsible for overseeing the implementation of such therapies, derived demand for them may increase. Since both of these considerations are probably relevant and, hence, at least partially offset each other, and since accurate measurement of their effect is problematical, it will be assumed in this work that the technological relation between services and stock is fixed.

A second related consideration in translating service demand into stock demand is the role that the individual physician has in determining his or her output. In this model services are assumed proportional to the stock. This may be a good or poor assumption. Labor-leisure tradeoffs are one relevant factor affecting the production function. Another is the degree of market power exercised by each individual physician. That is, while the stock of physicians may be tightly controlled, each individual physician can "cheat on the cartel" by, for example, overutilizing complements, such as hospital beds, in the provision of services. See Sol Shalit (1977) for an elaboration of this theory. Once again, however, it is not clear what the net effect of such individual physician labor supply decisions is on the stock-service relation. Disutility from working lengthy hours will offset the incentive to cheat by providing more services. Thus, while an assumption of a fixed association between the derived demand for physicians and the underlying demand for medical services is an obvious over-simplification, many of the considerations which invalidate it may be offsetting. Moreover, it can be argued that demand for medical services is also derived from an underlying demand for health which can be achieved in various combinations of medical services, exercise, diet and other preventive measures, some of which involve consumption and others investment. See Michael Grossman (1972) for a discussion of investment and consumption in health care.

defined) and _' indicates a row vector, while _ denotes a column vector.

As discussed in Section II, the marginal cost of supplying an additional physician can be viewed as the total opportunity cost (TOC) of that individual not pursuing a next best career and can be measured as that income at which he/she is indifferent between becoming a physician or pursuing the alternative career. The shape of this curve depends on the quality (opportunity cost) pattern across the pool of applicants to medical school. If, in increasing the stock of physicians, it is necessary to draw in higher opportunity cost individuals, the marginal cost curve slopes upward.[1] However, since, by most accounts, many "highly qualified" applications are rejected each year, and since medical students represent such a small proportion of all college graduates, it seems reasonably accurate to posit the marginal cost curve as horizontal in the relevant range, that is:

(2) $MC_t = TOC_t$

where TOC_t is not a function of the number of physicians.

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[1] An upward sloping supply curve would be generated by the necessity to attract individuals whose utility is less enhanced by becoming a physician, that is if TOC reflects different tastes as well. It could also result from increasing quality in the potential physician pool. The AMA's contention that increases in supply result in reduced quality actually suggests a falling cost curve, assuming that physician quality is closely correlated with ability in alternative occupations.

The marginal cost curve nevertheless should reflect any existent barriers to entry, due, for example, to restrictions on the number of medical school spaces. If the barrier to entry is totally binding, the cost curve becomes vertical when the constraint is reached. If the entry barrier raises the opportunity cost of substitutes (such as Foreign Medical Graduates), then it becomes steeply upward sloping and/or jumps to a higher level. Increasing competition therefore can be viewed as a rightward movement of the marginal cost curve. Figure 3 illustrates equilibria under the extreme regimes of perfect competition (MDS^{*c}) and pure monopoly (MDS^{*m}) with the simplest case of linear demand and horizontal marginal cost curves. As shown, the actual equilibrium may lie anywhere between the two extreme conditions. One such example is given by MDS^{*i}. For a less than competitive solution to result, the MC curve becomes vertical at some capacity constraint. Figure 3 also portrays movement from a profit-maximizing cartel constraint to one leading to greater competition, from MDS^{*m} to MDS^{*i}, due to a shift from MC^m to MC^i.

Under competition, physician earnings simply equal the opportunity cost of becoming a physician so that the competitive equilibrium stock is:

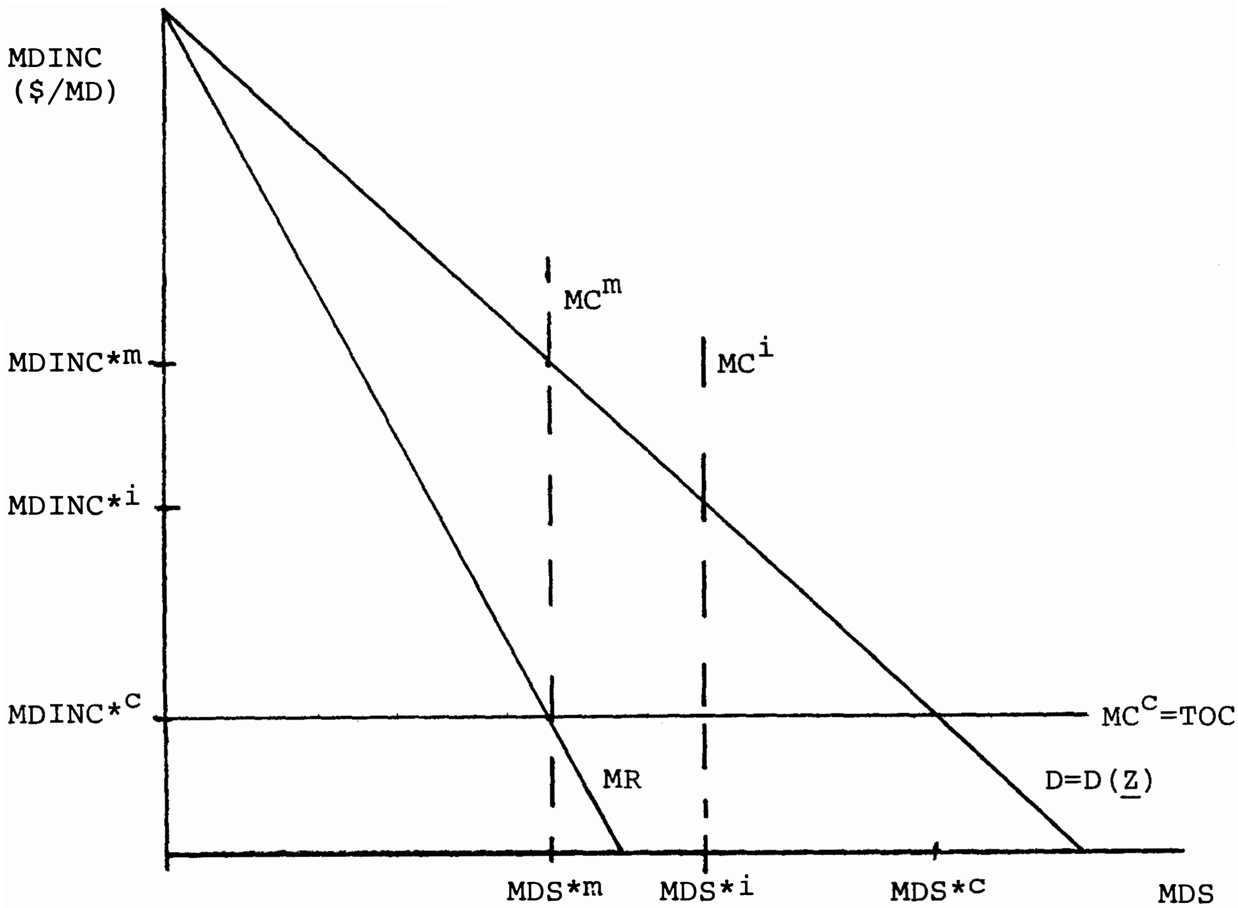
$$(3) \quad MDS_t^{*c} = a_0 + a_1 TOC_t + \underline{a}_2' \underline{Z}_t$$

where the * denotes an equilibrium value and the c a competitive market.

FIGURE 3

Equilibrium Physician Stock and Income

with Various Market Structures



With vertical entry barrier (capacity constraint) between MC^m and MC^c: $MDS^{*i} = \omega MDS^{*c} + (1-\omega) MDS^{*m}$

m: Pure Monopoly
c: Perfect Competition
i: Intermediate

Solving for marginal revenue and setting it equal to marginal cost yields the equilibrium pure monopoly stock:

(4) $MDS_t^{*m} = a_0/2 + (a_1/2)TOC_t + (\underline{a}_2/2)'\underline{Z}_t$

which is, given the linear demand and horizontal cost curve, just half the competitive solution.

As discussed above, we can describe the actual equilibrium stock as a weighted average of the competitive and monopolistic extremes, as shown in equation (5) below, where ω as the weight represents the degree of competition in the market:

(5) $MDS_t^{*} = \omega\, MDS_t^{*c} + (1 - \omega)MDS_t^{*m}$, where $0 \leq \omega \leq 1$,

which, given (3) and (4), implies

(6) $MDS_t^{*} = 1/2(1 + \omega)\ \{a_0 + a_1 TOC_t + \underline{a}_2'\underline{Z}_t\}$.

If $\omega = 1$ then the equilibrium physician stock is competitive, while if physicians function as a perfect cartel, $\omega = 0$.

B. Actual Physician Stock

Due to uncertainty about future demand and/or cost conditions, possible shifts in the market structure, combined with costly adjustment due to the length of training time required to become a physician, it is likely that the observed stock of physicians differs from the equilibrium value at any given point in time. As in other work studying the determinants of an occupation's supply,[1] we can posit a partial adjustment model where the change in actual stock from one year to the next represents only part of the difference between this year's equilibrium value and last year's actual stock. Moreover, since training requires four years of medical school and one to five more of a graduate program (usually five years until licensure from the beginning of medical school and then one to four more of residency training once licensed), adjustment to any changes in the equilibrium stock in year t that were not perceived in year t-5 can only be made by the importation of more previously-trained foreign medical graduates or through a slowing in the retirement of the existing stock. Thus, it is possible that there are two different rates of adjustment, one to changes in the equilibrium in year t that were perceived in year t-5 and another to those changes which become known after t-5. That is, the difference between the actual stocks in years t-1 and t may have two components:

$$(7) \quad MDS_t - MDS_{t-1} = \gamma_1 (MDS^*_{t|t-5} - MDS_{t-1|t-5}) + \gamma_2 (MDS^*_t - MDS^*_{t|t-5})$$

where MDS_t = actual stock in year t

MDS^*_t = actual equilibrium stock in year t

[1] See B. Peter Pashigian (1977).

$MDS_{t-1|t-5}$ = prediction made in t-5 of actual stock that will exist in t-1

$MDS^*_{t|t-5}$ = prediction made in t-5 of equilibrium stock for year t

γ_1, γ_2 = adjustment rates to changes in equilibrium perceived in year t-5 and those unexpected as of t-5 but realized between t-5 and t, respectively. Presumably, $\gamma_1 \geq \gamma_2$.

If we assume that predictions of the optimal stock, MDS^*_t, from t-5, based only on forecasts of demand and cost variables, are unbiased, then $(MDS^*_t - MDS^*_{t|t-5})$ is distributed with mean zero and $\gamma_1 = \gamma_2 = \gamma$.[1] How much uncertainty exists in year t-5 about the actual stock that will exist in year t-1? Appendix C outlines how this uncertainty can be reduced to ignorance about the exact number of FMG's entering in the intervening four year period.[2]

Incorporating these simplifications into (7), the actual physician stock can be expressed as:

$$(8)\quad MDS_t = \gamma MDS^*_t + (1-\gamma)\ MDS_{t-1} + \gamma e^F_t + u^1_t$$

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[1] Preliminary tests using Box-Jenkins forecasts to estimate prediction errors showed insignificant differences between the estimated γ_1 and γ_2.

[2] Aloysius Siow (1984) addresses the problem of measuring occupational choice under uncertainty by assuming rational expectations on the part of potential entrants to a profession. While this framework is not explicitly incorporated into the derivation of physician opportunity cost (TOC), the 5-year expectations framework used here to describe entry reflects the same notion.

where e_t^F represents uncertainty over FMG entry and is defined as

$$e_t^F \equiv \sum_{i=1}^{4} (1-d)^{i-1} \, (FMG_{t-1} - FMG_{t-i|t-5})^{1}$$

where FMG = number of foreign medical graduates obtaining new U.S. medical licenses in year t

and d = yearly depreciation rate of licensed physicians and students, assumed to be constant over time.

u_t^1 represents the random error in predictions of the optimal stock.[2]

Substituting for MDS_t^* from (6) yields

$$(9) \quad MDS_t = \frac{\gamma}{2} (1+\omega)\{a_0 + a_1 TOC_t + \underline{a}_2' \underline{Z}_t\} + (1-\gamma) MDS_{t-1}$$

$$+ \gamma \, e_t^F + u_t^1.$$

The preceding discussion suggested that, due to sluggish adjustment, the actual stock of physicians may not equal its equilibrium value at any given time. Therefore, if the market is

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[1] $E(e_t^F \, e_{t-i}^F)$, $i \neq 0$ is not necessarily zero if, for example, government policies with respect to immigration are not perfectly predicted and are autocorrelated (more than one period long) once enacted. More generally, e_t^F can be thought of as the result of any prediction errors in year t; for example, unexpected variations in the depreciation rate may also yield forecast errors.

[2] Actually it could be autocorrelated for up to five periods if information about permanent changes in demand or cost is released between t-5 and t.

to clear, earnings must adjust to make current demand equal existing supply. Therefore, using (9) and (1) results in:

$$(10)\quad MDINC_t = \{\tfrac{\gamma}{2}(1+\omega)-1\}(a_0/a_1 + \underline{a}_2'\underline{Z}_t/a_1) + \tfrac{\gamma}{2}(1+\omega)\ TOC_t + \big((1-\gamma)/a_1\big)MDS_{t-1} + (\gamma/a_1)e_t^F + u_t^2.$$

C. Changes in Market Structure

The primary motivation behind examining the determinants of physician stock is to test the hypothesis that the observed growth in supply in recent years cannot be attributed wholly to increases in demand (or cost reductions), and therefore is also due to increasingly competitive market conditions for physicians. As discussed in the introduction, substantial subsidization of the supply of as well as the demand for physician services began in the mid-1960's.

ω is the parameter that measures the extent to which supply is restricted; as ω decreases toward zero, a pure monopoly outcome is approached. Increasing competition over time implies that $\omega = \omega(t)$ with $\partial\omega/\partial t > 0$ (t=time). More precisely, we would like to reject a null hypothesis of no change in ω during the time period studied ($\partial\omega/\partial t = 0$). A more specific functional form for $\omega(t)$ is also suggested by the events of the 1960's as well as the model. Since the physician training process is lengthy, supply increases will occur only slowly. Medicare/Medicaid funding began in 1966; the first manpower training bill preceded it by three years; the immigration law was eased in 1968. Thus, while some supply adjustment may have preceded 1966 in anticipation of Medicare/Medicaid, the bulk occurred later and slowly. Therefore, we expect ω to be flat until the mid or late 1960's and rise gradually thereafter until it ultimately levels off either at 1 (perfect competition) or some lower point if some restrictions remain.

D. Summary

This section has developed the framework to test whether the market for physicians has become more competitive through time. It determines an equilibrium stock of physicians, based on demand and cost conditions, and measures changes in the degree of market competition as changes in the equilibrium, after taking account of slow adjustment to new demand and cost conditions. A function denoted ω measures where between the extremes of monopoly and competition the actual equilibrium moves over time. Estimatable equations describing the stock and income of physicians are derived. The next section will discuss the empirical results of estimating these equations.

IV. EMPIRICAL TESTS

This section presents estimates of growing competition in the physician market using the ω-weighted average model developed in Section III. After controlling for shifts in demand and marginal cost, we isolate the effect of any change in the degree of market competition on the stock and income of physicians. In the model estimated in this chapter, the actual equilibrium stock, and hence income, is hypothesized to be a weighted average of the number of physicians that would exist with free entry and under pure monopoly (a perfect cartel) with weights of ω and $(1-\omega)$ respectively. ω is defined as a function of time. Using the estimated time path for ω we will be able to evaluate the importance of a changing market structure. Equations (9) and (10) form the system of stock and income equations to be estimated. The time period analyzed in all the empirical work is from 1946 to 1981.

A. Discussion of the Variables

The active physician-population ratio (MDSP) is used as a dependent variable where population is denoted in thousands. Regressions using the level number of physicians produced similar results.

Several variables are used as components of $\underline{Z}$, the vector of demand characteristics. The health economics literature suggests that personal income, insurance coverage, education, and various measures of health status, such as the age distribution of the population, influence the demand for and expenditures on physician services, in addition to both their money and time prices.[1] Insurance coverage increases utilization. An elderly or more highly educated individual also consumes more services. Finally,

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[1] See Odin Anderson and Ronald Andersen (1967, 1972), Ronald Andersen and Lee Benham (1970), Karen Davis (1976), Paul Feldstein (1961), Joseph Newhouse and Charles Phelps (1976), among many others. See American Medical Association (1978) for a summary.

if the quality of medical care has increased over time, demand may have increased. Therefore Z includes personal income (INCM), percent of the population covered by public insurance--Medicare and Medicaid (PUBINS),[1] median years of education (EDUC), and percent of the population over age 65 (G65). It also includes the deathrate per 100,000 population from all diseases (DEATHR)[2] as a crude proxy for the perceived quality of medical care. It is anticipated that all of the population characteristics will positively affect demand, while the deathrate will have a negative impact since a lower deathrate implies higher quality.[3]

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1 Initially, a variable measuring the extent of private insurance was also used. It was expected to have either a positive or negligible effect, insignificant if private insurance premiums just displace private consumer payments with no wealth redistributions to high users. Both the percent of the population covered by various types of policies, and the proportion of all health care expenditures contributed by private insurance were tried. However, the variables' coefficients were consistently negative and significant. While the simple correlation between the rise in private insurance coverage and growth in MDSP is negative, there is no reason for the partial effect also to be negative. Therefore it appears that private insurance proxies for some other measure. PUBINS, since it redistributes income to the poor and elderly who tend to be sicker and have lower time costs, should have a positive impact.

2 Homicide, suicide and accidents are omitted because of the lesser influence medicine may have on their incidence.

3 The effect of substitutes and complements on the demand for physicians is not included in this analysis. Since the two groups have opposing influences on demand, the net bias due to their omission may not be large. Whatever bias does exist will be incorporated either by the coefficients on the included demand variables, or through our estimated time path of ω. In the latter case, we misestimate the actual change in the degree of competition: if complements provide the stronger omitted effect we under-estimate growth in demand and hence overestimate the
(footnote continued)

The opportunity cost variable (TOC) is that used in Section II (along with physician income) to measure the return to physician training.[1] Sources for all the variables used in the estimation are listed in Appendix A.

B. Estimation

The estimated stock and income equations are, respectively:

$$(11)\quad MDSP_t = \alpha_0 + \alpha_1\ TOC_t + \alpha_{21}\ INCM_t + \alpha_{22}\ PUBINS_t + \alpha_{23}\ EDUC_t + \alpha_{24}\ G65_t + \alpha_{25}\ DEATHR_t + \alpha_3\ MDSP_{t-1} + \alpha_4\ e_t^F + \varepsilon_t^1$$

and

$$(12)\quad MDINC_t = \beta_0 + \beta_1\ TOC_t + \beta_{21}\ INCM_t + \beta_{22}\ PUBINS_t + \beta_{23}\ EDUC_t + \beta_{24}\ G65_t + \beta_{25}\ DEATHR_t + \beta_3\ MDSP_{t-1} + \beta_4\ e_t^F + \varepsilon_t^2$$

(footnote continues)

increase in ω, while if substitutes dominate, the reverse holds. In recent years, it appears that many health professionals whose practices required direct physician supervision are now granted greater independence. It thus seems likely that substitutes exert the larger influence on physician demand. If this is true, our estimates of the magnitude of changes in the degree of competition will be conservative.

[1] If TOC is, in fact, upward sloping rather than constant as assumed in this analysis, we underestimate the effect of growth in competition because we underestimate the offsetting effect of increasing cost as supply increases. A separate consideration is the difference between short run and long run marginal cost. The partial adjustment framework takes account of the gradual attainment of a more elastic long run supply curve.

From (9) and (10) we know that:[1]

$\alpha_0 = \gamma/2(1+\omega)a_0$

$\alpha_1 = \gamma/2(1+\omega)a_1 < 0$

$\alpha_{2i} = \gamma/2(1+\omega)a_{2i} > 0, i=1 \ldots 4$; $< 0, i=5$

$\alpha_3 = 1 - \gamma > 0$

$\alpha_4 = \gamma > 0$

$\beta_0 = \{\gamma/2(1+\omega)-1\}a_0/a_1$

$\beta_1 = \gamma/2(1+\omega) > 0$

$\beta_{2i} = \{\gamma/2(1+\omega)-1\}a_{2i}/a_1 > 0, i=1 \ldots 4$; $< 0, i=5$

$\beta_3 = (1-\gamma)a_1 < 0$

$\beta_4 = \gamma/a_1 < 0.$

(11) and (12) have been estimated simultaneously using full information maximum likelihood (FIML). This enables us to impose all of the implied restrictions on the coefficients. Thus we identify separate estimates for a_1, the $\underline{a}_{2i}$ vector, γ and the parameters of the ω-function.[2] The coefficients reported are these separate estimates.

A cubic function of time will be used to describe the path of ω as follows:

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[1] In that the formulation of (11) and (12) uses the physician-population ratio, while the original model of (9) and (10) was expressed in levels, the a_i are not actually identical. However, the formulation of the initial model was meant to be general; therefore to avoid unnecessary confusion, the same symbols are used.

[2] The disturbance terms, ε^1_t and ε^2_t are due not only to possible omitted variables from $\underline{Z}_t$ which are assumed orthogonal to those included, but also to errors in all of the variables (with the exception of $MDSP_{t-1}$) since the true values (i.e., the 5-year predictions of variables influencing the optimal stock) are unobservable. The second factor biases estimates of the coefficients; the direction and magnitude of this bias is indeterminant since the errors may be correlated. If, however, the error variances are small relative to the variance of the true values, the bias will be slight (Maddala (1977), p. 294).

(13) $\omega = w0 + w1t + w2t^2 + w3t^3$.

t is centered around 1965; that is, it is defined to equal 0 in 1965, 1 in 1966, -1 in 1964, etc. Increasing physician competition implies estimated ω-coefficients that yield an upward sloping path for ω. Unfortunately this function is not constrained to lie between 0 and 1, and for large enough t, $|\omega|$ is certainly greater than one. Therefore, we cannot identify its level but only its time path. That is, we can determine whether ω has risen or fallen since 1965, but not from what point it started. Therefore, since the estimated level of the ω-function is not meaningful, we estimate regressions both with an unconstrained w0 intercept parameter and with w0 fixed at 1.[1]

Table 1 reports results with both an unconstrained w0-intercept parameter (columns 1 and 3) and with w0 fixed at 1 columns 2 and 4).

The first two equations reported use the entire vector of demand variables discussed above. The adjustment coefficient, γ, is estimated as .1015 and .0512 in the w0-free and w0-constrained regressions, respectively, suggesting that 5-10 percent of the total adjustment to any change in equilibrium stock is made in one year. The opportunity cost measure, TOC, is significant at

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[1] An alternative logistic formulation of ω such that $\omega = \frac{1}{1+e^{\lambda_0+\lambda_1 t}}$ has the convenient property of being resticted to the 0-1 range as the model suggests. Unfortunately, convergence was not achieved using this functional form for ω in the simultaneous estimation.

Table 1

SIMULTANEOUS ESTIMATION OF STOCK AND INCOME EQUATIONS
(11) AND (12), 1946-1981

	1	2	3	4
a_0	-.4634 (-.44)	-.5393 (-.62)	1.0136 (12.51)	1.0131 (13.57)
a_1 (TOC)	-.3237(-1) (-3.76)	-.3309(-1) (-3.56)	-.1763(-1) (-15.43)	-.1753(-1) (-15.55)
a_{21} (INCM)	.3894 (2.16)	.3866 (2.44)	.2930 (10.53)	.2925 (11.69)
a_{22} (PUBINS)	.8158(-2) (.91)	.8667(-2) (1.13)	.4308(-2) (1.73)	.4280(-2) (1.84)
a_{23} (EDUC)	.9129(-1) (1.48)	.9497(-1) (1.44)	--	--
a_{24} (G65)	-.8045(-1) (-.88)	-.8079(-1) (-.96)	--	--
a_{25} (DEATHR)	.1612(-2) (1.49)	.1691(-2) (1.85)	--	--
γ	.1015 (1.82)	.5123(-1) (2.84)	.1559 (3.46)	.9366(-1) (4.90)
w_0	.8452 (9.62)	1 (constrained)	.9149 (23.43)	1 (constrained)
w1 (t)	-.1788(-2) (-.12)	.1504(-1) (.67)	-.8227(-3) (-.12)	.7367(-2) (.74)
w2 (t^2)	.1056(-2) (3.41)	.1348(-2) (1.99)	.7064(-3) (4.01)	.7924(-3) (2.60)
w3 (t^3)	.7019(-4) (1.70)	.7688(-4) (.98)	.4648(-4) (2.28)	.4820(-2) (1.36)

Table 1--Continued

	1	2	3	4
log of the likelihood function	59.18	58.35	50.74	49.64
SSE-stock	.4360(-2)	.4384(-2)	.4332(-2)	.4255(-2)
SSE-income	38.18	39.62	62.93	66.90
Likehood ratio	36.32	34.66	40.74	38.54
$t(e_{t-1})$-stock	-1.12	-1.53	-.42	-.88
$t(e_{t-1})$-income	-.40	-.74	1.82	1.84

Notes: a-coefficients are those from demand curve, equation (1), variables to which they correspond are noted in parentheses: t-statistics in parentheses; (-n) on coefficient indicates that reported coefficient is 10^n times its actual magnitude; $t(e_{t-1})$ = t-statistic on lagged residual--test for residual autocorrelation (see text for explanation); likelihood ratio test measures significance of ω function in estimation. It is distributed χ^2 with as many degrees of freedom as there are ω parameters, i.e., 3 when w0 is constrained to equal 1 and 4 when it is free.

the .005 level, while INCM is at the .025 level (using one-tailed tests). The remaining demand variables are less significant, mostly not even reaching the .10 level. The coefficients on DEATHR and G65 also show the "wrong" sign. Substantial collinearity among the demand variables may be lowering their apparent significance.[1]

The implied time path for ω estimated from column 1 is depicted in Figure 4.[2] Two standard error confidence intervals are also shown. It suggests the predicted path: ω remains fairly flat until the late 1960's and then climbs quickly thereafter. Since even the unconstrained-w0 path does not remain in the 0-1 interval, no conclusions can be drawn about the level of ω, i.e., about the degree of competition. However, we can determine what effect the growth of ω has had on the stock and income of physicians. Using the estimated equations (11) and (12), we can predict what the stock and income would have equaled each year if ω had remained fixed at its 1965 level.[3] If we compare these predictions based on the constant 1965 degree of competition with the actual predictions, which incorporate the estimated time path

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[1] Estimated pairwise correlations range from -.40 between TOC and DEATHR to .96 between INCM and G65. Twelve (out of fifteen) exceed .75 in absolute value.

[2] The time path derived from the intercept constrained estimate (column 2 of Table 2) is very similar and therefore not shown. See Noether (1983) for greater detail.

[3] In these predictions, last year's predicted stock is used as the lagged stock in this year's prediction.

FIGURE 4

Estimated Time Path of ω

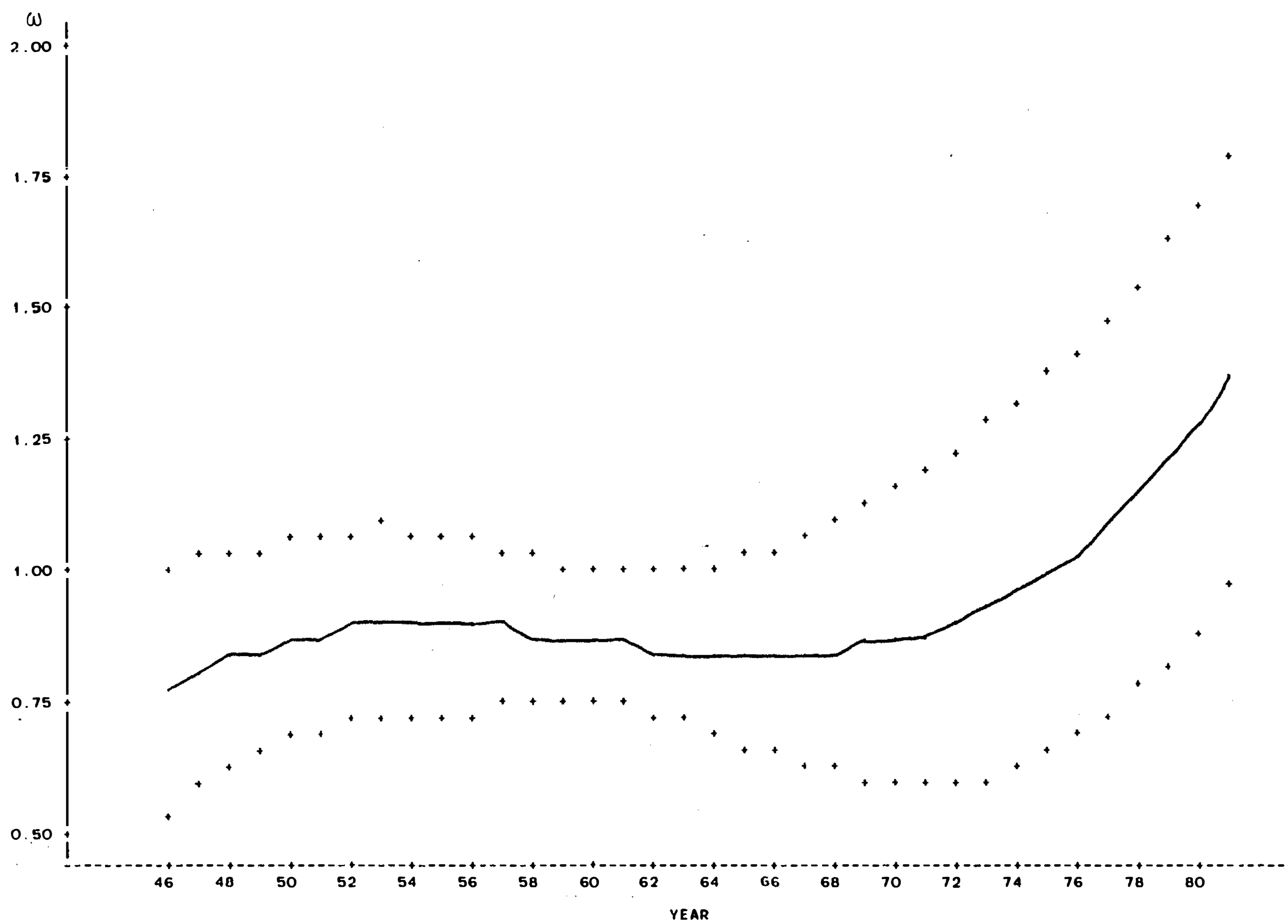

Table 1, column 1 estimates.
2 standard error confidence intervals denoted by +.

of ω, the difference between the two provides an estimate of the effect of changing competition on the market for physicians. According to these regressions, growing competition increased the stock by 44,000 (w0-free estimate) to 62,000 (w0-constrained to equal 1 estimate), between 1965 and 1981, or 10 to 14 percent, respectively, of the actual current stock of about 450,000. Similarly, physician incomes would be about $6,800 to $8,700, in 1972 after-tax dollars, higher, or about 24 to 30 percent above their actual 1981 level of $28,700. Figure 5 shows the "ω-constant" and actual predictions of stock and income, along with the true values of each variable for the column 1 regression.

The log of the likelihood ratio for the system and sum of squared error statistics for each equation (stock and income) suggest that the two regressions appear to fit about equally well. We can consider the null hypothesis which contains the same demand, cost, and adjustment constraints determining physician stock and income, but does not include a time-varying ω. We then can compute likelihood ratio statistics for each FIML regression from the log of the likelihood functions derived from the constrained estimation (LLR) which includes $\omega(t)$ and the unconstrained which does not (LLU). The statistic: -2(LLU-LLR) is distributed χ^2 with degrees of freedom equal to the number of restrictions imposed, in our case, 4 for the w0-free estimates

FIGURE 5

Predictions of Physician Stock and Income
Given Actual Degree of Competition (*)
and Assuming ω Held Constant at 1965 level (+)

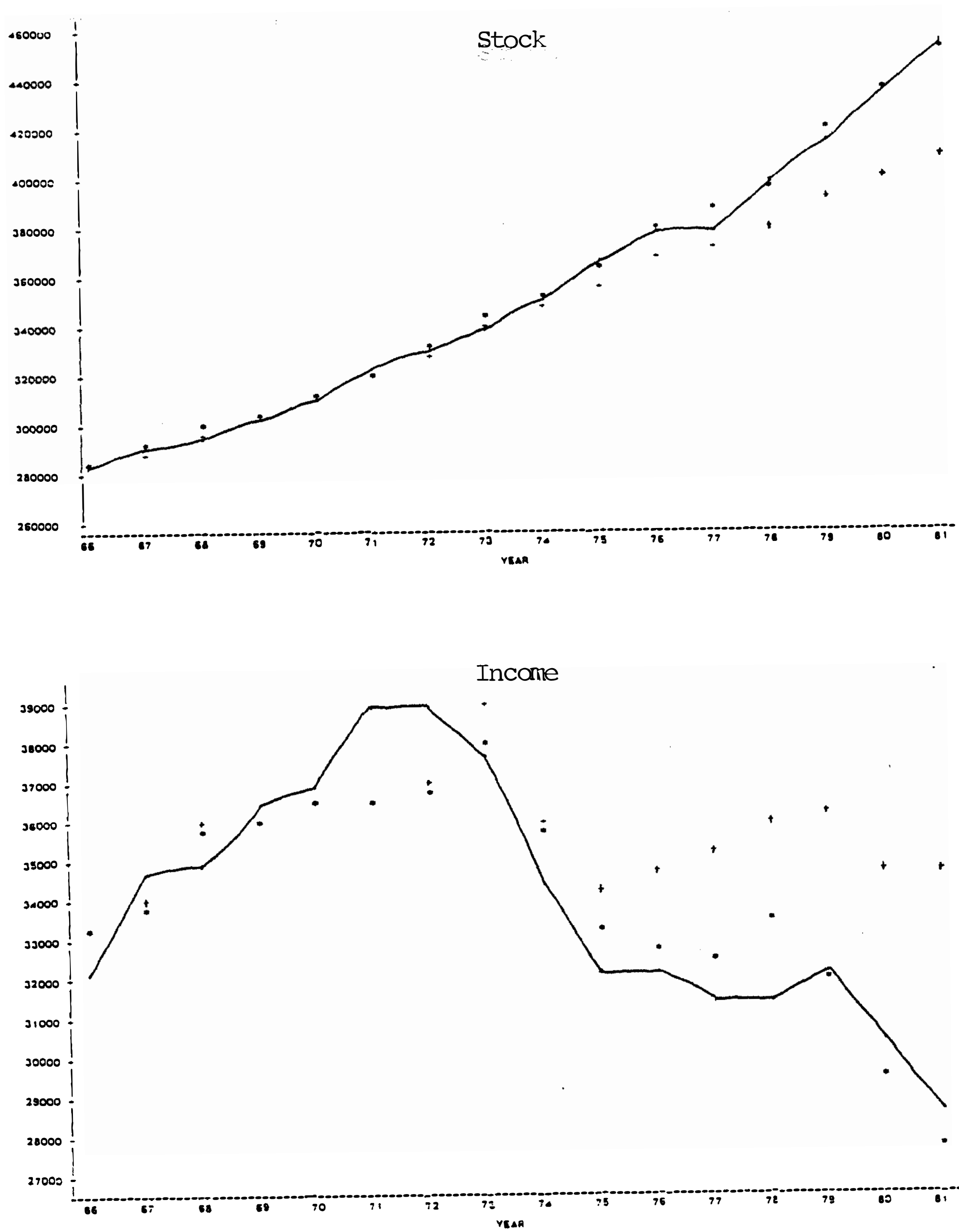

Table 1, Column 1 Estimates.
Solid line represents actual values.

and 3 for the w0=1 estimates.[1] These likelihood ratio tests are reported in Table 1. At the .005 level of significance, a χ^2 with 3 degrees of freedom equals 12.8, while one with 4 equals 14.9. Obviously, inclusion of the ω function in the stock and income equations is highly significant.[2]

As mentioned above, there is substantial correlation across the demand variables. To alleviate the apparent multicollinearity, some demand variables were dropped from the regressions. Since the positive coefficient estimates on DEATHR indicate that it may be a poor proxy for the quality of medical care,[3] it is omitted. G65 is also omitted because its effect may be measured by the PUBINS variable which includes the Medicare program of insurance for the elderly. INCM is kept since it seems clearly

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1 George Judge, et. al., 1980, p. 758.

2 Measures of residual autocorrelation are also presented. When the regression contains a lagged dependent variable as an exogenous variable, as does the stock equation, the Durbin-Watson test is biased. An alternative test regresses the estimated residuals on their lagged values and the exogenous variables, including the lagged dependent variable. Residual autocorrelation is measured by significance of the coefficient on the lagged residual. (Judge, et. al. p. 219). While the income equation does not contain a lagged income variable, it does include the lagged stock as an explanatory variable. Since the two equations are estimated jointly, the alternative residual autocorrelation test is used for the income equation as well. While the t-statistics on the income equations' lagged residuals are both less than 1, those on the stock equations are somewhat larger, but still not strongly significant.

3 The interesting alternative explanation, that the greater the level of health, the lower the demand for medical care, is also possible. However, without greater knowledge of what DEATHR actually measures, it is probably not wise to include it. It is also possible that DEATHR is endogenous, being determined in part by the available physician stock.

important in the initial regression. PUBINS is also maintained since it should measure the effect of a subsidization of the demand of lower income individuals[1] which would not be covered by the INCM variable. Moreover, since our primary focus concerns changes that have occurred in the medical care market since 1965, it seems necessary to account for programs as apparently important as Medicare and Medicaid. Finally, EDUC is dropped since many health demand studies find its effect to be similar to that of INCM (see the studies mentioned earlier). Column 3 and 4 of Table 1 report the results from these regressions.

The coefficients on the demand and cost variables are all as predicted, and those on TOC and INCM are now significant at the .0005 level, while PUBINS reaches the .05 level. The adjustment coefficient, γ, appears to have risen in each regression; in the w0-free equation it is now about .156, a 50 percent jump, while in the w0-constrained model, it has risen over 80 percent to .094. It has also increased in significance.

The implied time paths for ω are still rising, but not as quickly.[2] These regressions, with fewer demand parameters, suggest a less price elastic demand curve for physicians; at the

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1 It primarily includes persons enrolled in Medicaid (for the poor) and Medicare (for the elderly).

2 Since the estimated time paths and resulting "ω-constant" stock and income forecasts are similar to those estimated in the "complete demand" model, they are not shown. As the higher t-statistics on the ω coefficients imply, the resulting 2 standard error confidence intervals surrounding the estimated time paths are narrower for the "simple demand" estimations.

1981 level of output, elasticity here is about .24, while in the previous estimates it equaled approximately .4.[1] The effect of growing competition on the stock has lessened, to 39,000 for the w0 unconstrained model and 43,500 in the w0=1 model. At the same time, competition's impact on income appears stronger, ranging from about $10,300 to $11,400 or 35 to 40 percent of 1981 income in the two regressions.

The log likelihood ratios for the "simple demand curve" systems have fallen about 15 percent. The likelihood ratios, however, have risen over 10 percent, indicating that the ω function becomes more significant when fewer demand parameters are included. This could indicate that in the simple model we do not fully control for demand, but our estimates of ω's effect on the stock are larger in the more complete formulation of the $\underline{Z}$ vector. The sum of squared errors on the stock equations remain virtually unchanged, while the lagged residual t-statistics have fallen substantially and suggest no serious residual correlation. However, the fit of the income equations has worsened considerably: SSE's have risen over 60 percent and the lagged residual t-statistics are now significant at the .10 level using a 2-tailed test.[2]

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[1] These low estimates of elasticity are consistent with most found in the health economics literature.

[2] To correct the residual correlation, a Cochrane-Orcutt type first order autoregressive transformation was incorporated into the equations using the estimated residual correlation coefficients. Unfortunately, none of the models came close to convergence, so their results are not helpful.

V. SUMMARY AND CONCLUSIONS

The aim of this analysis has been to determine whether the market for physicians has become more competitive since the mid-1960's, and if it has, to measure what effect growing competition has had on the stock and income of doctors. Examination of the trend in the return to becoming a physician in Section II suggests that it has declined steadily over the last decade but still exceeds its pre-1965 level. However, this evidence is insufficient by itself to determine whether the degree of competition in the physician market has changed in recent years. Demand for physicians has expanded in the last 20 years, and even the equilibrium rents that accrue for a given market structure may have increased. Without other evidence about the physician market, it would be difficult to know whether to attribute part of the recent decline in physician incomes to increasing competition or solely to the return to equilibrium following a demand increase induced disturbance. The return data are consistent with both scenarios.

In order to isolate the impact of any increase in the degree of competition, a model is developed which accounts for the factors which affect the demand for and marginal cost of physician supply. Demand variables include personal income, the percentage of the population covered by public insurance, education, the percentage of the population who are over age 65, and a variable to proxy for the quality of medical care, the death rate. Marginal cost is measured as the opportunity cost of becoming a physician given the next best alternative of working immediately following four years of college. This opportunity cost includes the direct costs of attending medical school, tuition net of scholarships, and the income foregone by not working while in medical school. In addition to holding constant the demand and cost conditions we also incorporate a parameter which allows gradual adjustment of the stock to changes in its equilibrium level. After these factors are measured, any remaining growth in the stock of physicians is attributed to growth in the degree of competition. Changes in market structure are measured by positing the actual equilibrium stock of physicians as a weighted average of the competitive equilibrium and monopolistic (perfect cartel) outcomes and calculating changes in the weight over time. The results imply that increased competition has led to an expansion in the physician stock of 40,000 to 60,000 or 9-13 percent of the 1981 supply. The expansion that we attribute to increased competition represents 22-35 percent of total entry between 1965 and 1981. Likewise, income, measured in 1972 after-tax dollars, has fallen by $7,000 - $11,000 or 25-40 percent of its 1981 level.

Table 2 provides a summary of our estimates of the cumulative effect from 1966 through 1981 of growing competition on the stock and income of physicians. The stock effects range from 39,000 to 62,000, or 9-14 percent of the approximately 450,000 active physicians in 1981. Similarly, the estimates of competition's effect on income range from $7,000 to $11,000 in 1972

Table 2

COMPARISON OF DIFFERENT ESTIMATES OF THE AMOUNT OF THE 1981 PHYSICIAN STOCK AND INCOME DUE TO INCREASED MARKET COMPETITION SINCE 1965

Model	Stock	Income
Weighted Average Model		
Stock--Income System		
Complete demand, w0 unconstrained	44,741	- 6,786
complete demand, w0 ≡ 1	62,395	- 8,440
simple demand, w0 unconstrained	39,234	-10,333
simple demand, w0 ≡ 1	43,455	-11,358

after-tax dollars, or 24-38 percent of a 1981 actual income of just under $29,000.[1]

In which estimates are we most confident? As we discussed above the stock regressions which use the simple demand curve provide the best fit in terms of residual autocorrelation and are marginally better in terms of SSE. They suggest a 39,200-43,500 stock effect. The complete demand weighted average equations do a substantially better job at explaining physician income, both in terms of SSE and residual autocorrelation. They suggest a decline in income of $6,800 to $8,400. Even when relying on the most conservative of our estimates, the impact of a growth in the degree of competition among physicians has been substantial.

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[1] These results are comparable to those derived from estimating directly the effect of changes in government policy that relaxed entry barriers and created subsidies. Work reported in Noether (1984) suggests an expansion of the physician stock of 54,000 to 58,000 and a concomitant fall in income of about $10,000 due to policy changes.

APPENDIX A

DESCRIPTION OF THE DATA

This appendix describes the data used in estimating the model and depicted in the plots. It also cites their sources.

1. MDS: Stock of active U.S physicians.

Sources: American Medical Association (hereafter AMA), Distribution of Physicians in the U.S., annual; U.S. Bureau of the Census, Historical Statistics of the United States from Colonial Times to 1970 (hereafter Historical Statistics) and U.S. Public Health Service, Health Manpower Sourcebook, v. 20.

The number of active MD's is available only for selected years prior to 1963 (1950, 1955 and 1960). The other years' figures have been estimated by taking .95 of the total number of physicians, where .95 of the total number of physicians, where .95 is the average proportion that held for all years from 1950-1966 for which data were available.

(The variable used in estimation is deflated by the U.S. resident population.)

2. INCM: U.S. disposable personal income, in 1972 $.

Source: Historical Statistics and U.S. Bureau of the Census, Statistical Abstract of the United States (hereafter Statistical Abstract), annual.

3. PUBINS: Percentage of population enrolled in public insurance program; primarily composed of Medicare and Medicaid recipients.

Sources: U.S. House of Representatives, Data on the Medicaid Program (1977) and Health Care Financing Administration, The Medicare and Medicaid Data Book (1981).

4. EDUC: Median years of education completed by persons over 25.

Source: Historical Statistics and Statistical Abstract.

5. G65: Percentage of population age 65 and older.

Source: *Historical Statistics* and *Statistical Abstract*.

6. DEATHR: Deaths per 100,000 population from all causes except accidents, suicide and homicide.

Source: *Historical Statistics* and *Statistical Abstract*.

7. TOC: Total Opportunity Cost--the calculation of TOC is derived in Appendix B. Only its components are described here.

   a. College Graduate Earnings: To best hold quality constant, we look at earnings of full-time workers, with four years of college, over age 25, both sexes. (Mean, after tax, 1972 $.)

      Sources: *Current Population Reports*, Series P-60, U.S. Bureau of the Census, various issues, and *Historical Statistics*.

   b. Tax Rates: To derive after tax incomes, marginal tax rates are calculated from data on tax payments by income bracket found in the Internal Revenue Service publication, *Statistics of Income, Individual Income Tax Returns*, U.S. Department of the Treasury, annual.

   c. Length of Medical Training Time, calculated as: four years of medical school + g years of graduate medical training - (4-c) years less than a full four years of college, where

      g_t is calculated as 4x(U.S. Residents & Interns$_t$/

      $$\sum_{i=0}^{3} \text{U.S. Med. graduates}_{t-i}$$

      c is the average number of years spent in college prior to medical school.

      Source: All data required for calculation of c and g are in annual Education number of the *Journal of the AMA*, (hereafter *JAMA*.)

d. Discount rate: .10 is used--the range of discount rates used in most studies is from .08 to .12.

e. Net Tuition: Calculated as (Total Tuition Payments to Medical Schools less Total Scholarships given to all Medical students from all sources)/number of students.

Source: Annual Education number of JAMA.

f. Income earned while in school: Following Gary Becker (1975) it is assumed that medical students earn 1/4 of what a college degreed worker would earn (by working summers and/or parttime). This assumption is also used for the residency training period. Actual residency salaries have, at least since 1970, been considerably higher than 1/4 of the college wage, but hours worked average over 70 per week, thus bringing the hourly wage to about $4.22 in 1979.[1] Actual data on residency stipends are only available annually beginning in the early 1960's; it is also difficult to discern how much in in-kind payments has been given to residents.

8. e^F: 5-year forecast errors of FMG entry, where

$$e_t^F = \sum_{i=1}^{4} (1-d)^{i-1} e_{t-i}^f, \text{ and}$$

$$e_t^f = FMGP_t - FMGP_{t|t-5}.$$

The 5-year predictions ($FMGP_{t|t-5}$) were calculated from Box-Jenkins AR1 models based on the 15 years of data ending 5 years before the prediction. d is the FMG depreciation rate, assumed to be a constant 2 percent.

9. MDINC: Mean U.S. physician income in after-tax 72 $. The series is spliced from the four series listed below since no single one provides consistent numbers for the entire period.

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1 Douglas Hough (1981).

Sources: AMA, *Profile of Medical Practice* and *Reference Data on Profile of Medical Practice*, various issues.
Medical Economics Company, *Medical Economics*, various issues.
U.S. Department of Commerce, *Survey of Current Business*, July 1951.
U.S. Department of the Treasury, Internal Revenue Service, *Statistics of Income, Individual Income Tax Returns*, various issues.

Tax data: see TOC.

Appendix B

DERIVATION OF THE TOTAL OPPORTUNITY COST (TOC) MEASURE

The following analysis closely follows that of Jacob Mincer (1974) or Becker (1975). The total present value of a physician's lifetime income stream can be divided into three parts. First, the present value of the stream of a physician's lifetime earnings viewed from the time he/she begins medical school, I_m, can be described as:

$$I_m = Y_m \int_{s}^{n+s} e^{-rt}dt \tag{1b}$$

where Y_m = yearly physician income

r = discount rate

t = time, measured in years

s = years of schooling

n = years of working.

Second, the direct costs to becoming a physician involve tuition net of scholarships received as well as books and other supplies for all years of schooling. These costs can be expressed as:

$$C_m = NT \int_{0}^{s} e^{-rt}dt \tag{2b}$$

where NT = net tuition. Finally, the student physician may earn some income while in school through summer and/or part time jobs and residency stipends. These earnings can be measured as:

(3b) $$SI_m = Y_s \int_0^s e^{-rt}dt$$

where Y_s = student income. Thus the total present value of the stream of incomes and costs accruing to a physician (V_m) can be calculated as

(4b) $$V_m = SI_m - C_m + I_m$$

(5b) $$= (Y_s - NT) \int_0^s e^{-rt}dt + Y_m \int_s^{n+s} e^{-rt}dt.$$

If it is assumed that the next best alternative to becoming a physician is to begin employment immediately following four years of college, then the return to medical training must be calculated by comparing V_m, the discounted net income stream a physician earns, to V_c the discounted stream accruing to a college graduate. V_c can be measured as

(6b) $$V_c = Y_c \int_0^n e^{-rt}dt$$

where Y_c = yearly college graduate earnings. The same discount rate and number of years worked is assumed to apply to physicians as to other college graduates.[1]

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[1] Since, when using any reasonable discount rate, the income received more than about thirty years in the future becomes trivial when discounted, the assumption regarding equal working lives is irrelevant practically and simplifies the resulting equation for the opportunity cost considerably.

To determine at what income an individual would be indifferent to being a physician, the two discounted earnings streams are set equal; that is:

(7b) $$(Y_s - NT) \int_0^s e^{-rt}dt + Y_m \int_s^{n+s} e^{-rt}dt = Y_c \int_0^n e^{-rt}dt.$$

Working through the integration and simplifying yields:

(8b) $$(Y_s - NT)(1-e^{-rs}) + Y_m(1-e^{-rn})e^{-rs} = Y_c(1-e^{-rn}).$$

Finally,

(9b) $$Y_m = e^{rs}Y_c + e^{rs}(NT - Y_s) \left\{\frac{1-e^{-rs}}{1-e^{-rn}}\right\}.$$

Since for any reasonable n, $(1-e^{-rn})$ is very close to 1, we can simplify to

(10b) $$Y_m = e^{rs}Y_c + (e^{rs} - 1) \{NT - Y_s\}.$$

Y_m in equation (9a) or (10a) represents that physician income at which a college graduate is just indifferent, given the required training time to become a physician, the direct costs associated with medical school, and the wage that he/she could earn without further schooling, between pursuing a career in medicine and obtaining a job available to a college graduate. This is the measure of total opportunity cost (TOC) used in the model.

This formulation does assume that there is no ability difference between those individuals who pursue a medical career and those who finish their schooling after four years of college. As Leffler (1977) notes, this assumption, if wrong (if physicians have greater ability), biases rate of return calculations upwards. However, it is difficult to find an alternative benchmark for which adequate income and schooling data are available. Another obviously incorrect assumption in the fomulation of this model is that yearly earnings do not vary over the lifetime stream. A comparison of age-earnings profiles with the averages showed remarkable stability over time for both physicians and college graduates, so this bias should at least be relatively constant throughout the period analyzed. For a detailed discussion of the problems inherent in rate-of-return-to-training-calculations, see Sherwin Rosen (1977).

Appendix C

PREDICTION OF MDS_{t-1} AS OF t-5

How much uncertainty exists in year t-5 about the actual stock that will exist in year t-1? If we assume that there is a known, constant annual depreciation rate, d, in all components of the stock, then only the number of new licensees, NL, between t-5 and t-1 is unknown; that is

$$(1c) \quad MDS_{t-1|t-5} = (1-d)^4 MDS_{t-5} + \sum_{i=1}^{4} (1-d)^{i-1} NL_{t-1|t-5}$$

where $NL_{t-i|t-5}$ is the forecast made in t-5 of new licensees to enter in t-i, and where it is assumed that the same depreciation rate applies to new licensees as to existing stock. Total new licensees, each year, comprise two groups, the first year students of five years ago who have not dropped out and the FMG's who successfully emigrate to the U.S. (or return in the case of Americans who studied abroad):

$$(2c) \quad NL_t = (1-d)^5 FYS_{t-5} + FMG_t$$

where FYS_{t-5} = first year students in year t-5

FMG_t = foreign medical graduates who successfully obtain U.S. licenses in year t

d = yearly depreciation rate, (1-d) is the year survival rate of U.S. students assumed here to be the same as that applying to the existing stock.

Since for any year t-i, i>0, the first year students from t-i-5 have been observed by t-5, uncertainty about new licensees entering in year t-i can be reduced to uncertainty about the number of FMG's who will enter. Thus:

$$(3c) \quad NL_{t-i|t-5} = (1-d)^5 FYS_{t-i-5} + FMG_{t-i|t-5}$$

and therefore, from (1b) and (3b)

$$(4c) \quad MDS_{t-1|t-5} = (1-d)^4 MDS_{t-5} + \sum_{i=1}^{4} (1-d)^{i+4} FYS_{t-i-5} + \sum_{i=1}^{4} (1-d)^{i-1} FMG_{t-i|t-5}$$

whereas realized physician stock in year t-1 equals

$$(5c) \quad MDS_{t-1} = (1-d)^4 MDS_{t-5} + \sum_{i=1}^{4} (1-d)^{i+4} FYS_{t-i-5} + \sum_{i=1}^{4} (1-d)^{i-1} FMG_{t-i}$$

and thus the prediction of MDS_{t-1} that is made in t-5 can also be written as [from (4b) and (5b)]:

$$(6c) \quad MDS_{t-1|t-5} = MDS_{t-1} - \sum_{i=1}^{4} (1-d)^{i-1} \{FMG_{t-1} - FMG_{t-i|t-5}\}$$

that is, as the actual stock minus a weighted sum of forecast errors about entering FMGs. Notice that this formulation makes no assumption about the determinants of FMG entry; it states only that their numbers may be predicted with some error.

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