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THE SUPPLY OF SURGEONS AND THE DEMAND FOR OPERATIONS

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ABSTRACT

This paper presents a multi-equation multi-variate analysis of differences in the supply of surgeons and the demand for operations across geographical areas of the United States in 1963 and 1970. The results provide considerable support for the hypothesis that surgeons shift the demand for operations. Other things equal, a 10 percent increase in the surgeon/population ratio results in about a 3 percent increase in per capita utilization. Moreover, differences in supply seem to have a perverse effect on fees, raising them when the surgeon/population ratio increases. Surgeon supply is in part determined by factors unrelated to demand, especially by the attractiveness of the area as a place to live.

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Inequality in the distribution of physicians across the United States and the possible influence of physician supply on the demand for their services are subjects of continuing interest to economists and health policy makers. If physicians choose their locations partly for reasons unrelated to demand, and, if, given their locations, they can increase or decrease the demand for their services independently of changes in price, the implications for economic analysis and for public policy are profound. Some economists [Fuchs-Kramer 1972; Evans 1974] have reported evidence in support of the demand-shifting hypothesis, but others are skeptical [Sloan-Feldman 1977]. Many physicians believe that they have almost unlimited power to shift demand. This belief is based on introspection, clinical experience, and the correlation between supply and utilization, but skeptics offer several alternative explanations for the correlation.

The principal purpose of this paper is to shed some light on this question through a multi-equation, multi-variate analysis of differences in the supply of surgeons and the demand for operations across geographical areas of the United States. In-hospital operations seem particularly well suited for analysis of demand-shifting because several of the problems that have hampered previous studies can be avoided or minimized. The following section discusses the hypothesis of demand-shifting and indicates why this study provides a good test of it. The analytical framework and data are then described, followed by

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a section reporting the empirical results and a concluding section which considers some implications.

The "Demand-Shifting" Hypothesis

Standard economic analysis assumes that the supply and demand schedules in any market are independent. Given an exogenous increase in supply, a new equilibrium is reached by moving down the (constant) demand curve, as shown in Figure 1A. The demand-shift hypothesis asserts that "given an exogenous shift in the supply of physicians from S_1 to S_2, the physicians induce a shift in demand from D_1 to D_2" (see Figure 1B).

Another way of viewing demand-shifting is presented in Figure 2. The benefits from increases in the quantity of medical care, either to an individual patient or to a population, can be assumed to increase at a decreasing rate, hence the falling marginal benefit curve MB. For simplicity, let us assume that the cost of medical care to the patient (financial cost, time costs, risks, etc.) increases at a constant rate, shown by the marginal cost curve MC. If patients had full information and full control over the quantity of care, they would choose quantity Q. The fact that the quantity may be determined by the physician does not in itself imply demand-shifting. The physician, acting as an unbiased agent of the patient, may also choose quantity Q. If, however, the physician chooses and the patient accepts a quantity of care greater than or less than Q, we would say that there has been demand-shifting.

Note that demand can be shifted either up (to the right) or down (to the left). Let us assume that, other things equal, physicians prefer to come as close to Q as possible, i.e., they derive utility from ordering the amount of care which equates marginal cost and marginal benefit for their patients.[1] Let us also assume that physicians derive utility from income and that work (at least beyond some level) is a source of disutility. If the physician/population ratio is relatively high in an area (for reasons unrelated to demand) they may push quantity to the right of Q in order to keep prices and incomes from falling drastically. If there are relatively few physicians in an area, and if they cannot or do not raise price to an equilibrium level, they may push quantity to the left of Q in order to avoid excessive work. This latter situation, sometimes characterized as "excess demand," has been offered as an explanation for the observed correlation between supply and utilization [Feldstein 1970]. It would be described in Figure 1A by a price which is <u>below</u> the intersection of S_1 and demand. A shift of supply to the right results in higher utilization because it takes care of some of the excess demand.

Note that the presence of demand-shifting should not be equated with "unnecessary care." If "necessary care" is defined as Q in Figure 2, demand-shifting to the <u>left</u> implies that some patients are not getting the care they should, and does not imply that any patients are getting unnecessary care. Moreover, necessary care may be defined differently than the quantity that maximizes the patient's utility (i.e., Q). If, for instance, it is defined as the quantity that maximizes the patient's health regardless of cost, the optimum would clearly be to the right of Q and such demand-shifting would not necessarily imply "unnecessary care."

This study of in-hospital operations provides a sharp test of demand shifting for several reasons. First, operations are typically well-defined procedures; it is, therefore, possible to get a direct measure of quantity. There is some variation in average complexity of operations (as measured by the California Relative Value Scale) across geographical areas; the coefficient of variation for 11 frequently performed procedures is 6 percent. A count of operations, however, is likely to be a much better measure of quantity of medical care than a count of office visits, which may vary greatly with respect to length, number of tests and X-rays, etc. Furthermore, variations in average complexity can be studied separately.

A second reason why operations should provide an interesting study of demand shifting is that we can rule out "excess demand" (i.e. demand shifting to the left) as an important explanation for any observed relation between supply and utilization. Excess demand may exist for house calls and other types of services rendered by general practitioners, where price seems to be below its equilibrium level and non-price rationing is observed, but such phenomena are rare in surgery. Economists and physicians who have studied surgical markets have reported that the average number of operations per surgeon (150 to 200 per year) is far below the level that surgeons consider a "full workload" (about 400 to 500 per year) [Fuchs, 1969; Hughes, Fuchs, Jacoby and Lewit, 1972; Watkins, Hughes and Lewit, 1975]. The average workload is less than half that recorded in group practice settings such as the Group Health Cooperative (Seattle) and the Mayo Clinic (Rochester, Minnesota), and below the quantity that surgeons would be willing and able to perform at the going price. The data used in this paper reveal that even in non-metropolitan areas where the surgeon/population ratio is very low, the average surgeon performs only about 250 operations per year. A recent SOSSUS report noted, ". . . we have failed to identify large or small areas of this country that are significantly under-supplied with personnel suitably qualified to carry out surgery" [SOSSUS, 1976].

The "cost of time" explanation is also likely to be less relevant for operations than for physician office visits. This explanation for the correlation between supply and utilization asserts that equilibrium is achieved by a change in the total price to the patient, including the cost of time. Where the physician population is higher, the time costs to the patient of search, travel, and waiting are all reduced, which is equivalent to a decline in price. Thus figure 1A is said to adequately describe the market for physician services if price is correctly specified. There is, therefore, no need to introduce demand shifting as an explanation. Time costs are undoubtedly important for the average ambulatory visit, but are likely to be less relevant for in-hospital operations because the psychic costs of surgery and the time costs of hospitalization are likely to be large relative to the time costs of search, travel, and waiting. Thus, this study avoids an ambiguity inherent in many previous studies of demand shifting.

Finally, given widespread insurance coverage for in-hospital surgery (about 80 percent of the population), the absence of accurate price data may cause fewer problems than in studies of demand for outpatient services which have lower insurance coverage.

Although an inter-area analysis focused on surgical operations seems to offer several advantages, there are potential problems as well. First, there is probably a significant amount of "border crossing" by surgical patients. Whereas most outpatients obtain care from nearby physicians, it is not unusual for patients to travel considerable distances for in-hospital surgery. Such "border crossing" is likely to be particularly relevant for residents of nonmetropolitan areas who frequently go to metropolitan areas for their operations. According to American Hospital Association data (1972), the rate per thousand population of operations (excluding births) in metropolitan area hospitals was 1.75 times the rate in nonmetropolitan area hospitals. Health Interview Survey Data (1970) based on the residence of the patient rather than the location of the hospital, indicates a (non-obstetrical) operation rate for metro residents only 1.10 times the rate for nonmetro residents. Using this information plus the metro/nonmetro population ratio of 2.33, we can calculate that nonmetro residents obtain about 30 percent of their operations in metro areas (assuming no movement of metro residents to nonmetro areas for in-hospital surgery).[2] Thus, if there is an effect of supply on demand, the demand in nonmetro areas may be affected by the supply in the adjacent metro area as well as by the supply in the nonmetro area itself.

There is probably much less unreciprocated border crossing from one geographical division to another. A comparison of the surgical utilization rates in the HIS data for 1970 with AHA data for 1972 shows four divisions (New England, East North Central-East, South Atlantic-Upper, and Pacific) with rates above the U.S. average for both measures, and five divisions (East North Central-West, South Atlantic-Lower, East South Central, West South Central, Mountain) with rates below U.S. average, according to both measures. There are two divisions (Middle Atlantic and West North Central) which show rates above the U.S. average by location of hospital (AHA data), and below U.S. average by residence (HIS data). This suggests that there may be some unreciprocated border crossing into those two divisions for surgery. However, it should be noted that both those divisions had rates above the U.S. average in the

HIS data for 1963, so it may be that some of the discrepancy in 1970 is the result of sampling variability.[3]

Another possible source of difficulty is that a significant amount of surgery (fragmentary data suggest about 20 percent)[4] is performed by physicians who are not "surgical specialists"--primarily general practitioners and surgical residents. The location of surgical residents is highly correlated with that of surgeons, but the location of general practitioners is not, and some attempt will be made to take account of their supply in the analysis.

Not only are some operations performed by "non-surgeons," but surgical specialists typically do not limit their practice to performing operations. Thus, this study is concerned with only a portion (albeit the major portion) of the demand for "surgeons' services," and would result in an understatement of "demand shifting" if, as seems likely, it is easier and more attractive for surgeons to shift the demand for office procedures and tests than for in-hospital operations.[5]

One problem which is perennial in attempts to estimate demand shifting is that of simultaneity. Strong demand for surgery in an area may attract surgeons, rather than the surgeons stimulating demand. I will attempt to deal with this problem by using "predicted" physician supply rather than actual supply. The predictions will be based on a regression that incorporates "taste" variables that affect surgeon location.

The Analytical Framework and Data Base

The general framework of this paper is similar to that used by Fuchs and Kramer to analyze inter-area variations in the demand for, and supply of, physicians' services. A demand equation is specified which includes variables usually thought to determine demand (e.g., demographic characteristics, income, price), and then "predicted" physician supply is added. This predicted supply is obtained by regressing the surgeon/population ratio on a set of variables believed to determine physician location. The physician location decision is of interest in its own right, given the wide variation in the physician/ population ratio across areas.

Cross-section regressions are run for 1963 and for 1970 and in a few instances the observations for the two years are pooled. The Health Interview Survey (HIS), which is the source for the surgical utilization data, provides information for 22 areas (metropolitan and nonmetropolitan areas in each of 11 divisions)[6] that cover the entire population. These areas are the units of observation for some of the regressions. Other regressions are run on a more detailed breakdown of the HIS data in which individuals are cross-classified by age (six classes), sex, race (white and nonwhite), and education of head of family (five classes), and the 22 areas. Regressions across these cells permit much finer control of demographic variables and also permit testing of Pauly's suggestion that demand shifting might be more important for some groups (e.g., the poorly educated) than for others [

The possibility of border crossing from nonmetro to metro areas is allowed for by including an additional predicted supply variable for each of the nonmetro areas. This variable is based on the ratio of the number of surgeons in the adjacent metro area to the total population of the division. Also, some regressions are run across only the metro areas or only the nonmetro areas. Per capita income and surgical prices are deflated by a general price index for each division, adjusted for metro-nonmetro differences, and all nominal dollar values for 1963 are inflated to 1970 price levels.

The utilization rates were calculated from the Health Interview Survey (for 1963 and 1970) conducted by the National Center for Health Statistics. The data represent a probability sample of households including all living civilian noninstitutionalized individuals. In 1970 interviews were conducted with approximately 37,000 households containing about 116,000 individuals, and in 1963 with 42,000 households containing 134,000 individuals. Surgical rates were obtained in response to the following questions: "Was the respondent hospitalized at any time during the last 12 months?" and, if an operation was performed, "What was the name of the operation?" For each hospitalization, only first operations were included; the number of second and third operations was small. Deliveries, abortions and other obstetrical procedures were excluded from the analysis because they are primarily a function of conception rates.

Although the Health Interview Survey data are representative of the nation's population, they are subject to recall error by the individual or proxy respondent. Hospitalizations and operations are reported with greater accuracy than simple episodes of illness, but an overall rate of under-reporting of 10 percent remains. Moreover, this under-reporting is not uniformly distributed among the population. Whites tend to report hospitalization more accurately than nonwhites; higher education is also associated with more accurate reporting, as is higher income (controlling for education).

The physician supply data come from the AMA Distribution of Physicians in the U.S. and are reasonably accurate. Most of the other data come from the Bureau of the Census and the Bureau of Labor Statistics. The principal variables (summary statistics in Table 1) are:

Endogenous

Q* Number of operations per 100,000 population.

S* Number of surgical specialists per 100,000 population. These are office-based patient-care physicians, both board certified and nonboard-certified. The M.D. supply is adjusted to take account of doctors of osteopathy.

METS* This variable is used only for the nonmetro areas and takes a value of zero for the metro areas. It is based on the predicted number of surgeons in the metro area divided by the total population of the division. It is included to allow for the possible effect of the surgeon supply in a metro area on the demand in the nonmetro area in the same division.

Exogenous

INC* Real income per capita (in thousands of dollars). The income data were obtained from Distribution of Physicians in the U.S. 1969 data were used for 1970, and 1965 data for 1963. Nominal per capita income was deflated by a divisional price index derived by Jeffrey Williamson [1977] from BLS data for large metro areas. Prices in nonmetro areas were assumed to be .87 of the prices in the metro areas (the cost-of-living differential reported by the BLS). The all-commodity CPI was used to adjust for intertemporal change.

HOTEL* Per capita receipts (dollars per person) of hotels and motels in the division.[7] The same value was used for the nonmetro and metro areas in a division. This variable is used as a measure of the "attractiveness" of the area. The "services" component of the CPI was used to adjust for intertemporal change.

NONMET A dummy variable denoting nonmetro areas.

NRMET The fraction of the population in a nonmetro area living in counties that were designated as "potential" SMSA's or that had population in excess of 50,000. This variable took a value of zero for the metro areas.

%WYTE Percent of the area's population that is white.

GP* Number of general practitioners per 100,000 population.

In addition to the above variables some attempts were made to use an endogenous price of surgery variable. This was based on American Medical Association data for nine divisions in 1970 reporting the average price of an initial office visit, a follow-up office visit, and a follow-up hospital visit (all for surgeons). An average of these three prices was calculated and then deflated by the Williamson-BLS divisional price index for all commodities. The surgical price index never had any effect in either the demand or location regressions.

A variable measuring the percent of the division's population with surgical insurance was also tried without any appreciable effect. This variable, obtained from the Health Insurance Institute, is probably not measured accurately.[8]

In the regressions across the cells, dummy variables are included for the demographic characteristics--age, sex, race, and education of head of family--that are used to form the cells.

Regression Results

Surgeon location. Table 2 presents the results for the surgeon location regressions.[9] Representative runs for each year across the 22 areas are shown. The fits are extremely good ($\bar{R}^2$ as high as .96) and the coefficients are relatively insensitive to changes in specification. The principal conclusion is that the "taste" variables have a very strong influence on surgeon location.

The NONMET dummy variable is highly significant in all runs with a value usually close to -25. The preference for metropolitan-like areas is also revealed by the NRMET variable, with a coefficient of about 14. This indicates that nonmetro areas with 100 percent of their population in counties that are nearly like metropolitan counties have, ceteris paribus, 14 more surgeons per hundred thousand than nonmetropolitan areas with no population in such counties. The preference of surgeons for metropolitan living may reflect the professional attraction of the "medical environment" as well as their preference as consumers. Potential demand, however, as measured by predicted utilization ($\hat{Q}^*$) has virtually no effect on location.

That surgeons live in areas that most people consider desirable to visit and vacation in is demonstrated by the HOTEL* variable. This coefficient (usually highly significant) shows the increase associated with an increase of one dollar per capita in receipts of hotels and motels. The elasticity at the means is approximately .2.

The coefficient of %WYTE is always positive and usually statistically significant, but varies somewhat depending upon the specification. A value of .20 implies an elasticity of .6 at the means. The GP* coefficient is not significant and does not have any appreciable effect on those that are. Some attempts were made to incorporate predicted price into the location regressions. Its coefficient was always insignificant.

Demand. Table 3 presents the results for the demand regressions across the 22 areas. Table 4 presents similar runs across the cells. The latter regressions permit much finer control of the demographic variables but do not, of course, allow for any additional variation in those variables which are only available for the areas. The fits of the demand equations are not as good as those for the surgeon location equations, and the size and significance of the coefficients are more sensitive to variations in specification. In general, the results support the view that an exogenous change in surgeon supply does affect the demand for operations. Each additional surgeon in an area, ceteris paribus, is associated with an increase of between 40 and 60 operations per year. The elasticity at the means for a coefficient of 50 is about .28. Use of the two-stage procedure does reduce the relation between supply and utilization. In OLS regressions (shown at the bottom of Table 3), the surgeon supply coefficient is from 8 to 40 percent larger than in the two-stage runs.

The regressions in Part B of Table 4 were run across cells with 11 division values instead of 22 area values. The predicted surgeons were obtained from a regression across the divisions of $\bar{S}$* on HOTEL*, %WYTE and the percent of the division's population living in metropolitan areas (%MET). The fit was good ($\bar{R}^2 = .80$) and the coefficient for %MET (.24) was the equivalent of the NONMET dummy coefficient in the area location regressions. The relative price of surgery was included in the cell-division regressions, but was never significant.

The income coefficient is always positive in the demand equations, but usually not statistically significant unless predicted surgeon supply is omitted. One surprising finding is the statistically significant negative coefficient for GP* in 1970. One possible explanation is that where GP's are numerous they can provide continuing nonsurgical care for various conditions which might otherwise be treated by surgery. However, this variable was insignificant in 1963. The coefficients for the demographic characteristics are presented in Table 5. These are usually very significant and virtually unaffected by the inclusion or exclusion of the area variables.

It is possible that the effect of predicted supply on demand reported in Table 3 and Part A of Table 4 is really the effect of the metro-nonmetro distinction on both supply and demand. To test for this possibility, similar two-stage regressions were run for just the metro areas and just the nonmetro areas, with 1963 and 1970 pooled in order to have a reasonable number of observations.[10]

The results for the demand regressions across the areas are reported in Table 6 and those for the regressions across cells in Table 7.

The principal coefficient of interest is for predicted supply ($\hat{S}*$), and we see that this coefficient is generally larger and more statistically significant in these regressions than in those that included both metro and nonmetro areas. For the five metro regressions in the two tables, the median coefficient for $\hat{S}*$ is 82, and for the 10 nonmetro regressions the median is 80. These coefficients imply an elasticity at the means of approximately .53 for the metro areas and .27 for the nonmetro areas. The difference in elasticity reflects the much lower surgeon/population ratio in the nonmetro areas.

The nonmetro regressions were run with an exogenous METS* variable, as well as without; this coefficient was not statistically significant. A variable designed to measure the possible impact of border-crossing in metro areas also had no significant effect. The only variable except predicted supply which came close to consistently significant results is GP* in metro areas. The negative coefficient is similar in size to that reported in Tables 3 and 4 for 1970. In general, the separate regressions strongly support the demand shift hypothesis and reject the hypothesis that the metro-nonmetro distinction explains the observed relation between predicted supply and utilization.

Interaction with education. Mark Pauly has suggested that the ability of physicians to shift demand for their services might vary for different groups in the population. In particular, he hypothesized that the effect might be inversely related to the level of education. Table 8 reports the results of regressions directed to this question. The regressions are run across the cells grouped by education, with 1963 and 1970 pooled. The effect of predicted supply on demand does seem to be largest for the low education class and smallest for the high education class. The differences between the coefficients, however, are not statistically significant.

Complexity, urgency, and necessity. Eleven frequently performed procedures[11] that account for 42 percent of all nonobstetrical operations were scaled for "complexity," "urgency," and "necessity." The complexity scale is based on the California Relative Value Scale. The urgency and necessity scales are based on replies by physicians to a mailed questionnaire asking them to choose a statement which best characterizes their impression of the operations being performed in each category.[12]

Indexes of complexity, urgency and necessity were calculated for each cell and then regressed on the demographic dummy variables, income per capita, and predicted surgeon supply, with the results as shown in Table 9. There seems to be some positive relation between complexity and surgeon supply, but the coefficient is not statistically significant. The surgeon supply coefficient in the urgency index regression is large and statistically significant. Each additional surgeon per 100,000 in an area lowers the urgency index by one percent--a large change, given the relatively small variation in the urgency index across areas. The necessity index also shows an inverse relation with surgeon supply, but the effect is smaller than for the urgency index and not statistically significant.

The effect of supply on price. The effect of predicted supply on quantity (and complexity) provides some evidence in support of the hypothesis that surgeons shift the demand for their services. Confidence in this conclusion would be increased if changes in supply also resulted in changes in price in the same direction. This question is investigated with regressions across the 11 divisions.

The surgical price index is derived from AMA data reporting average fees by specialty and division for initial and follow-up office visits and follow-up hospital visits in 1970. There is reasonably high correlation among these different fees.[13] An average of the three types of fees is taken to be representative of the relative price of surgery across divisions. This index is deflated by the Williamson-BLS divisional price index for all commodities, as shown in Table 10.

The surgical price index in both deflated and undeflated form is regressed on predicted surgeon supply and predicted demand and on the observed values of these variables. The predicted values of the endogenous variables are obtained from regressions with INC*, %MET, HOTEL*, and GP* as instruments.

The results (Table 11) reveal a positive effect of supply on price; this is clearly contrary to conventional market behavior. By contrast, the effect of demand on price is quite small. A coefficient of 1.5 for supply is equivalent to an elasticity of .5 at the means of the variables. Inasmuch as predicted price had no effect in the surgeon supply equation, we can reject the view that the high correlation between price and surgeon supply[14] reflects a causal relation running from price to supply.

Discussion and Summary

The small number of observations and potential measurement error in some of the data require us to regard the results reported in this paper as less than definitive. In particular, better price data and a more robust demand specification would serve to increase confidence in the findings. The shortcomings notwithstanding, the cumulative impact of the various statistical experiments casts serious doubt concerning the stability of the demand function for operations when there is an exogenous shift in the supply of surgeons. The hypothesis that an increase in the supply of surgeons results in an increase in demand is strongly supported by the following findings:

1. "Predicted" supply consistently has a positive effect on demand in a variety of specifications.

2. The effect is present in both 1970 and 1963 even though the quantity measure is subject to substantial sampling error and the correlation between years is not very high.

3. The effect is present and even stronger when metro areas and nonmetro areas are studied separately.

4. The supply effect on demand is inversely correlated with the level of education.

5. The supply effect is stronger for procedures deemed less urgent and less necessary by physicians.

6. Supply has a positive effect on price; not a negative one.

Can these results be reconciled with "normal" market behavior without recourse to demand shifting? They can, but it takes some straining to do so. One possible explanation is that surgeon quality is positively correlated with the surgeon/population ratio and that higher quality induces additional demand much as a decrease in price does.[15]

I agree that quality is probably correlated with quantity, but it seems doubtful that the quality effect would be strong enough to explain the observed differences in utilization or price. One indicator of "quality" is the percentage of surgeons who are sub-specialists, such as ophthalmologists, orthopedists, and the like, rather than general surgeons. This percentage is highly correlated with the surgeon/population ratio across divisions (r = .72), but the elasticity is only .15. Let us assume this captures only half of the quality difference so that the full elasticity of quality with respect to S* is .3. Let us also assume that the elasticity of demand with respect to quality is .3 (about triple the probable elasticity of demand with respect to price). The "quality effect" would then yield an elasticity of demand with respect to supply of .09, considerably less than the elasticity actually observed. Furthermore, it should be noted that "better quality" surgeons frequently recommend less surgery than do their colleagues with less training.

I believe that the "stylized facts" revealed in this paper can be summarized as follows: Surgeons have considerable discretion in choice of location and their distribution is determined partly by their preferences as consumers. Thus geographical areas differ in their surgeon/population ratio for reasons unrelated to the inherent demand for operations. Where surgeons are more numerous, the demand for operations increases. Other things equal, a 10 percent higher surgeon/population ratio results in about a three percent increase in the number of operations and an increase in price. Thus, the average surgeon's workload decreases by seven percent, but income per surgeon declines by much less.

These findings do leave one troublesome question. If surgeons can raise prices where they are more numerous, why don't they raise them even higher where the surgeon/population ratio is lower? One possible answer is that their incomes are already satisfactory because of their higher (but not excessively high) workloads, and they have less incentive to induce additional demand.

The implications for national policy of these results seem striking. If the surgeon/population ratio should increase (this seems likely if no action is taken), the result will probably be higher rather than lower fees, and also more operations. The marginal benefit of these operations relative to marginal cost is not addressed in this paper, but recent studies by physicians raise serious doubts, at least for some procedures [Paradise, et. al 1978; Bunker 1977].

One clear limitation of this study is the omission of that portion of surgeons' workload unrelated to in-hospital operations. As suggested previously, the surgeons' ability to shift the demand for out-patient services is probably greater than for operations. Thus the total impact of supply on demand may be larger, and the implied difference in income per surgeon smaller, than that observed in this study. Indeed, while the weakness of some of the data, and the tentative character of the conclusions need to be stressed, it should also be noted that some of these weaknesses probably serve to understate rather than exaggerate the extent to which surgeons can shift the demand for their own services.

Table 1. Summary statistics.

Symbol	Units	Mean 1963	Mean 1970	Standard deviation[a] 1963	Standard deviation[a] 1970	Coefficient of variation (%) 1963	Coefficient of variation (%) 1970
Q*	Operations per 100,000	4871	5558	668	567	13.7	10.2
S*	Surgeons per 100,000	26.9	30.5	10.0	9.5	37.2	31.1
INC*	$000 per capita	2.97[b]	3.35[c]	.36	.33	12.1	9.9
HOTEL*	Dollars per capita	37.4	47.3	10.9	15.1	29.1	31.9
NRMET	Fraction	.139	.129	.237	.232	171.2	179.8
%WYTE	Percent	88.5	87.8	7.6	6.6	8.6	7.5
GP*	GP's per 100,000	36.4	26.3	6.1	5.2	16.8	19.8

[a] Across 22 areas.

[b] 1965.

[c] 1969.

Sources: See text.

Table 2. Results of surgeon location regressions across areas, 1963 and 1970.

	$\bar{R}^2$	S.E.[a]	NONMET	NRMET	HOTEL*	%WYTE	$\hat{Q}$*	GP*
1970	.93	2.5	-25	14	.16	.24		
			(11.8)	(3.2)	(4.4)	(2.7)		
		3.0	-28	18	.17	.27	-.002	
			(4.8)	(1.9)	(3.6)	(2.2)	(.5)	
	.93	2.5	-25	13	.17	.26		-.05
			(9.3)	(2.8)	(4.1)	(2.3)		(.3)
1963	.96	2.1	-24	10	.12	.14		
			(12.7)	(2.7)	(2.7)	(2.2)		
		4.3	-28	14	.22	.29	-.005	
			(4.7)	(1.6)	(1.6)	(1.4)	(.9)	
	.95	2.2	-24	11	.12	.12		.03
			(11.4)	(2.6)	(2.4)	(1.3)		(.2)

Note: t statistics in parentheses.
Regressions weighted by population.
^ indicates predicted value.

[a]Standard error of the regression.

Table 3. Results of demand regressions across areas, 1963 and 1970.

	S.E.	$\hat{S}$*	METŜ*	INC*	%WYTE	GP*
1970	407	60 (3.1)	30 (2.0)	230 (.6)		
	419	60 (3.0)	30 (1.7)	223 (.5)	1 (.0)	
	536			753 (2.1)	2 (.1)	
	412[a]	54 (2.8)	26 (1.7)	263 (.7)		
	367[a]	43 (2.4)	44 (2.9)	801 (2.0)		-57 (2.5)
1963	523	44 (1.4)	41 (1.7)	768 (1.4)		
	539	42 (1.3)	37 (1.3)	705 (1.2)	5 (.3)	
	573			909 (2.5)	16 (.9)	
	524[a]	43 (1.4)	41 (1.7)	797 (1.5)		
	538[a]	42 (1.3)	43 (1.7)	856 (1.4)		-6 (.3)
<u>Addendum</u> OLS		<u>S*</u>	<u>METS*</u>			
1970	411	65 (3.8)	34 (2.4)	239 (.6)		
	368	55 (3.4)	51 (3.5)	756 (1.9)		-54 (2.3)
1963	520	59 (2.2)	51 (2.4)	633 (1.2)		
	535	59 (2.1)	52 (2.3)	676 (1.2)		-4 (.2)

[a]GP* added as an instrument.

Table 4. Results of demand regressions across cells, 1963 and 1970.[a]

	$\hat{S}$*	METS$\hat{}$*	INC*	GP*	PR$\hat{I}$CE
Part A (area values)					
1970	62	27	-83		
	(3.4)	(2.2)	(.2)		
	42	44	633	-68	
	(2.1)	(3.2)	(1.4)	(2.9)	
1963	49	34	300		
	(2.4)	(2.6)	(.8)		
	42	37	550	-18	
	(2.0)	(2.7)	(1.3)	(1.4)	
Part B (division values)					
1970	29		78		
	(1.2)		(.2)		
	33		68		-2 (-.03)[b]
	(1.0)		(.2)		(.2)
1963	56		-40		
	(2.1)		(.1)		
	80		-211		-9 (-.19)[b]
	(2.1)		(.5)		(.9)

[a]Age, sex, race, education dummy variables included; regression coefficients are presented in Table 5.

[b]Elasticities at means.

Table 5. Regression coefficients of demographic variables in demand regressions across cells (area values).[a]

	1970		1963	
	(1)	(2)	(1)	(2)
Female	710 (4.6)	704 (4.6)	476 (3.7)	475 (3.7)
Age 0-9	-1812 (7.3)	-1801 (7.3)	-1488 (7.2)	-1483 (7.2)
10-19	-2165 (8.8)	-2149 (8.8)	-1917 (8.8)	-1905 (8.8)
35-49	1490 (5.8)	1487 (5.9)	1202 (5.6)	1188 (5.6)
50-64	1290 (4.7)	1293 (4.8)	1291 (5.5)	1273 (5.5)
65+	2526 (7.9)	2512 (7.9)	1441 (5.3)	1432 (5.3)
Nonwhite	-1498 (6.2)	-1542 (6.4)	-1754 (8.6)	-1733 (8.4)
Education 0-8	-627 (2.1)	-472 (1.6)	-673 (2.5)	-510 (1.9)
9-12	162 (.6)	183 (.7)	-140 (.5)	-112 (.4)
15-16	-807 (2.3)	-813 (2.3)	-691 (2.1)	-705 (2.1)
17+	-642 (1.6)	-674 (1.7)	-804 (2.1)	-809 (2.1)

[a](1) No other right-hand-side variables.

(2) INC*, $\hat{S}$*, MET$\hat{S}$*, and GP* included as right-hand-side variables.

Table 6. Results of separate demand regressions across metro areas and nonmetro areas, 1963 and 1970 pooled.

	S.E.	$\hat{S}$*	INC*	YEAR	%WYTE	GP*	METS*
Metro areas	463	76 (2.1)	259 (.5)	404 (1.4)			
	466	91 (2.3)	478 (.9)	258 (.8)	-20 (1.0)		
	444	116 (2.8)	1111 (1.6)	-521 (.9)		-47 (1.8)	
Nonmetro areas	466	85 (3.0)	1187 (2.7)	-223 (.9)			
	468	84 (3.0)	745 (1.1)	-56 (.2)	16 (.9)		
	477	82 (2.7)	1311 (2.2)	-330 (.7)		-9 (.3)	
	476	79 (1.9)	1107 (2.0)	-189 (.6)			9 (.2)
	468	65 (1.5)	424 (.5)	84 (.2)	21 (1.1)		24 (.6)
	489	78 (1.8)	1223 (1.7)	-285 (.6)		-8 (.2)	7 (.2)

Table 7. Results of demand regressions across cells, separate for metro areas and nonmetro areas, 1963 and 1970 pooled.

	$\hat{S}$*	INC*	YEAR	GP*	METS*
Metro areas	25 (1.0)	98 (.3)	612 (3.2)		
	82 (2.6)	1087 (2.3)	-477 (1.1)	-54 (2.9)	
Nonmetro areas	90 (3.5)	481 (1.3)	35 (.2)		
	82 (3.0)	760 (1.5)	-202 (.6)	-21 (.8)	
	65 (1.5)	310 (.7)	142 (.6)		25 (.7)
	58 (1.3)	587 (1.0)	-93 (.2)	-20 (.8)	24 (.7)

Table 8. Results of demand regressions across cells by education, 1963 and 1970 pooled.[a]

	$\hat{S}$*	MET$\hat{S}$*	INC*	Year
Part A (area values)				
Education 0-8	73 (3.0)	41 (2.5)	-155 (.3)	442 (1.9)
9-14	54 (2.9)	28 (2.3)	98 (.3)	497 (2.8)
15+	25 (.7)	14 (.6)	462 (.7)	226 (.7)
All	56 (4.2)	30 (3.5)	95 (.4)	433 (3.5)
Part B (division values)				
Education 0-8	41 (1.2)		253 (.5)	434 (2.0)
9-14	49 (2.0)		-97 (.2)	587 (3.5)
15+	8 (.2)		247 (.4)	365 (1.2)
All	41 (2.3)		68 (.2)	503 (4.2)

[a]Dummy variables for age, sex, race, and education (where applicable) included; coefficients not shown.

Table 9. Results of regressions of indexes of complexity, urgency, and necessity across cells (area values), 1970.[a]

	$\hat{S}*$	$MET\hat{S}*$	INC*
Complexity	.31 (1.4)	.24 (1.6)	1.3 (.3)
Urgency	-.98 (2.2)	-.12 (.4)	12.8 (1.5)
Necessity	-.26 (1.3)	-.01 (.0)	4.9 (1.3)

Note: All three indexes were rescaled to have means of 100. The standard deviations across areas (controlling for age, sex, race, and education) are:

complexity	6.1
urgency	13.8
necessity	4.7

[a]Dummy variables for age, sex, race, and education included; coefficients not shown.

Table 10. Divisional price indexes: surgical visits and all commodities (U.S. = 100).

	Surgical price index[a] (1)	Williamson-BLS index[b] (2)	Deflated surgical price index (1) ÷ (2) (3)
New England	108.1	107.9	100.2
Middle Atlantic	121.9	107.8	113.1
East North Central	87.5	101.0	86.6
West North Central	86.5	100.2	86.3
South Atlantic	94.2	94.8	99.4
East South Central	83.1	92.6	89.7
West South Central	89.6	91.1	98.4
Mountain	77.8	99.5	78.2
Pacific	111.1	100.9	110.1

Sources: [a]American Medical Association, Profile of Medical Practice, 1972, pp. 81, 83, 85.

[b]Jeffrey G. Williamson, "Unbalanced Growth, Inequality and Regional Development: Some Lessons from American History," 1977, mimeo, pp. 79-80. Division values are population weighted means of Williamson's state data.

Table 11. Regressions of surgical price on supply and demand across divisions, 1970.

2SLS	$\hat{S}*$	$\hat{Q}*$
Deflated surgical price	1.47 (1.2)	.01 (.3)
Surgical price	1.55 (.9)	.02 (.6)
OLS	**S***	**Q***
Deflated surgical price	2.01 (2.7)	-.01 (.6)
Surgical price	2.83 (3.5)	-.01 (.9)

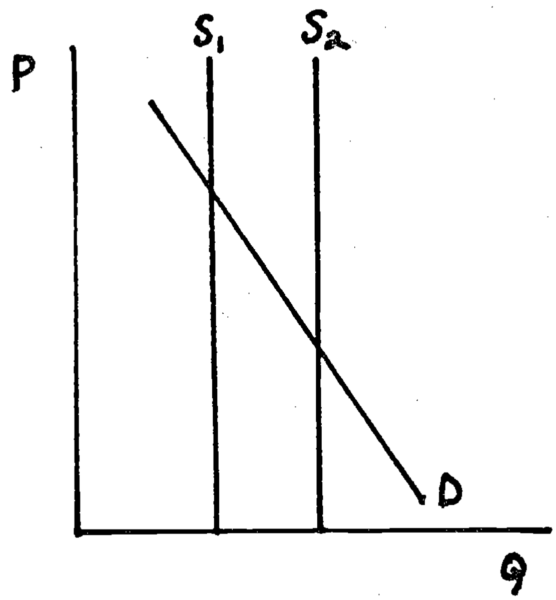

Figure 1A. No demand shifting.

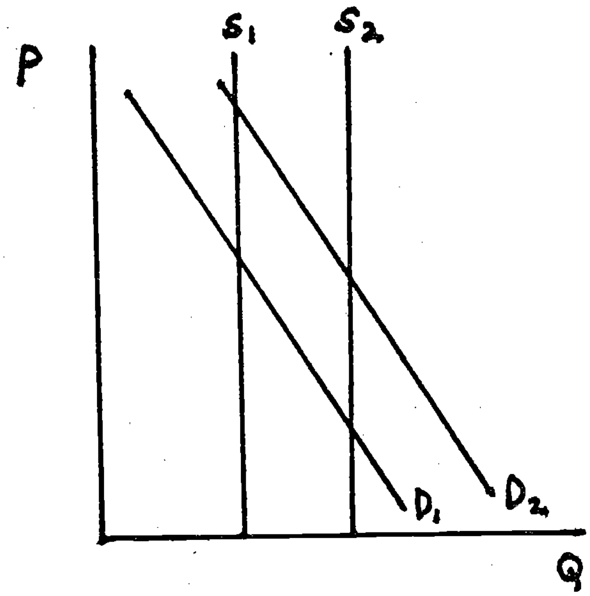

Figure 1B. Demand shifting.

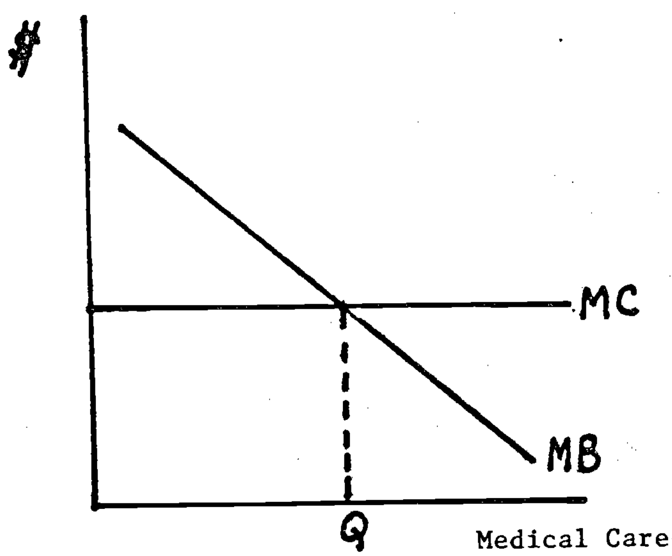

Figure 2. Alternative way of viewing demand shifting.

FOOTNOTES

1. For fuller discussions of physician-maximizing behavior, see Evans (1974), Sloan-Feldman (1977), Reinhardt (1977), and Green (1978).

2. Let

X_n = number of operations performed <u>in</u> nonmetro areas

R_n = number of operations performed <u>on residents</u> of nonmetro areas

P_n = population of nonmetro areas

X_m, R_m, P_m = the same for metro areas.

$$X = \frac{X_m}{P_m} \div \frac{X_n}{P_n} \qquad R = \frac{R_m}{P_m} \div \frac{R_n}{P_n} \qquad P = P_m \div P_n,$$

given X = 1.75 R = 1.10 P = 2.33, and assuming that no metro residents are operated on in nonmetro areas.

Solve for $\frac{X_n}{R_n}$

$$\frac{R_m}{R_n} = RP$$

$$\frac{X_m}{X_n} = XP$$

$$\frac{R_m + R_n}{R_n} = 1 + RP$$

$$\frac{X_m + X_n}{X_n} = 1 + XP$$

$$\frac{X_n}{R_n} = \frac{1 + RP}{1 + XP} = \frac{1 + 2.563}{1 + 4.078} = .70.$$

3. The coefficient of rank correlation of surgical utilization (adjusted for demographic characteristics) between 1963 and 1970 across the divisions is only .42.

4. SOSSUS Summary Report, Table 13, p. 39.

5. In-hospital procedures are typically monitored by hospital audit committees. Also, such procedures expose the patient to much greater risk.

6. The East North Central area is divided into an eastern section (Ohio and Michigan) and a western section (Indiana, Illinois and Wisconsin). The South Atlantic is divided into an upper section (Delaware, Maryland, District of Columbia, Virginia, and West Virginia) and a lower section (North Carolina, South Carolina, Georgia, and Florida).

7. Nevada was excluded because its huge gambling-based receipts did not seem relevant.

8. The number shown for the Middle Atlantic division is larger than the division's population.

9. All regressions use population weights.

10. Equality of slope coefficients between 1963 and 1970 was tested for both S* and Q* regressions and the null hypothesis was not rejected in any equation.

11. The 11 selected operations are: appendectomy, cataract removal, cholecystectomy, dilatation and curettage (excluding abortions), hemorrhoidectomy, hernia repair, hysterectomy, lumbar laminectomy for disc, prostatectomy, tonsillectomy, and varicose-vein stripping.

12. See Bombardier, Fuchs, Lillard and Warner (1977).

13. The coefficients of rank correlation across the nine divisions are: IOV and FOV .77; IOV and FHV .67; FOV and FHV .90.

14. r = .78 for undeflated price, and .71 when the surgical price index is deflated by the Williamson-BLS index.

15. This explanation was suggested by Sherwin Rosen.

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