Volume Title: Doctors and Their Workshops: Economic Models of Physician Behavior

Volume Author/Editor: Mark Pauly

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-65044-8

Volume URL: http://www.nber.org/books/paul80-1

Publication Date: 1980

Chapter Title: Physician Influence on the Productivity of Hospitals: Empirical Results

Chapter Author: Mark Pauly

Chapter URL: http://www.nber.org/chapters/c11523

Chapter pages in book: (p. 25 - 42)

3 Physician Influence on the Productivity of Hospitals: Empirical Results

Do physicians in fact choose the level of their own inputs and the inputs provided by the hospital in the way described in the preceding chapter? Do they cause the overuse of hospital inputs relative to physician inputs? This chapter presents the results of an empirical estimation of a hospital production function for a set of hospitals in the United States. The data contain a measure of physician inputs, and make possible some answers to these questions.

The Sample

A sample of 165 predominantly rural counties in 9 midwestern states was selected. Each of these counties had just one short-term general hospital with more than 50 beds throughout the period 1966–72. It is reasonable to suppose that the great bulk of hospital care provided by physicians in each county was provided at the sample hospital. The intent was to choose approximately 50 hospitals in each of four categories: not-for-profit, 50–100 beds in 1966; governmental 50–100 beds in 1966; not-for-profit, over 100 beds; and governmental, over 100 beds. There was not a sufficiently large number of hospitals with reasonably complete data in the third and fourth categories to permit 50 observations, the second category was slightly oversampled, and later editing reduced the sample size in all categories. However, since the sample was nonrandom to begin with, these characteristics did not seem to justify a complex procedure of stratifying or replacing observations excluded by editing, which would have required adding observations from non-midwestern states. The editing consisted of removing hospitals for which data were missing, and removing one hospital which, although classified in 1966 as short-term, changed to long-term in subsequent years. Data on these hospitals for 1966–72 were obtained from the American Hospital Association *Annual Survey of Hospitals*. In order to obtain a proxy measure for the amount of physician input in hospitals for each of these counties, the American Medical Association's Distribution of Physicians data were used to list the number of patient care physicians of various types in each county. The measure of physician input used was therefore a measure of the number of physicians available for patient care in the county. This was obviously not the measure of physician input most desirable for production function estimates. However, it is *the level of input that is likely to be manipulable by policy*. That is, public policy has been and is generally directed at getting more physicians to locate in rural areas. It is not directed at controlling the allocation of their time. The results show what may be expected in terms of hospital output by adding or removing physicians who treat their patients at that hospital.

Hospital staff appointments are not at present a matter of public policy, but the development of policy on such matters is not inconceivable. For a single year (1972), I obtained data from the Social Security Administration's "Provider of Services" file on the number of staff physicians at each of the sample hospitals, and on a finer breakdown of nonphysician personnel into categories. These data are provided periodically by all participating hospitals as part of the Medicare certification program.

Functional Forms

A Cobb-Douglas function is probably the most convenient functional form to use in estimating production functions. Whether it is appropriate is another matter. One problem that arose in Reinhardt's study of physician input into the production of ambulatory care[1] is not present here. In the physician's office, output can be produced even if no aides are employed, but the Cobb-Douglas function requires that all inputs be positive if output is to be positive. The four inputs that are used in most of the estimates are hospital beds, nonphysician hospital personnel (full-time equivalents), other nonlabor hospital inputs (meals, drugs, etc.) and physicians. Each of these would appear to be essential, and each is positive in all of the sample hospitals. Hence, the requirement of the Cobb-Douglas form that every input be positive is not onerous. A more serious restriction of the Cobb-Douglas form is that it constrains the elasticity of substitution to unity. Other forms are available which do not require this constraint, but their use raises more complex estimation problems. Since we do not know a priori whether the Cobb-Douglas form is reasonable or not, I have followed Feldstein in first estimating that form, and then considering alternative specifications only if the

Cobb-Douglas form appears "unreasonable." Judgment is obviously involved here.[2]

When physicians or personnel are disaggregated into specialty types, zero values for inputs do occur. Results are obtained both using the Cobb-Douglas functional form but with a positive constant (one) added to all values of these variables, and using the "transcendental" form suggested by Reinhardt.[3]

Variables

For the cross section 1966–72, and for the pooled cross sections, values of both beds and personnel were taken from the American Hospital Association's *Guide Issue.* A variable to represent nonlabor inputs other than beds was constructed by subtracting from nonlabor expense the product ($BEDS \times 1000$), where \$1000 is an estimate of the annual depreciation expense per bed on beds alone. Sensitivity of the results to this assumption will be discussed below. Output was defined as the number of cases treated, as measured by the number of admissions. While it would have been desirable to have an explicit measure of casemix, such data were not available. Because the sample hospitals are the sole hospitals serving relatively similar populations and are not major teaching hospitals, variation in casemix is not likely to be great. The output of the hospital is assumed to be a "treated case." Each case, it is assumed, is treated to the same degree; quality is assumed to be unrelated to input mix, and days of stay are assumed *not* to be of value in themselves. Fuchs has noted that it is not even clear whether additional days of stay should be treated as beneficial, because they mean more bed and board, or as detrimental, because they delay the patient's resumption of normal activities.[4] The actual estimating equations were of the form

$$lnADMISSIONS = a_o + \beta_1\, lnBEDS + \beta_2\, lnPERSNL + \beta_3\, lnMD + \beta_4\, lnNLIP + \gamma\, TIME + u$$

where *ADMISSIONS* is inpatient admissions per year;

BEDS is short term beds available;

PERSNL is full-time-equivalent nonphysician personnel;

MD is medical staff measures;

NLIP is a nonlabor inputs measure; and

TIME is time, measured from 1 to 7.

Results

Table 3.1 indicates the results using total patient care physicians (*MD*) as a measure of physician input, and hospital full-time-equivalent nonphysician personnel as a measure of the nonphysician labor input. The coefficient on the physician input, the elasticity of admissions with respect to the number of physicians in the county, is always significant, at the 0.01 level or better, and in the range of 0.11 to 0.17.[5] Personnel and nonlabor expense are likewise always significant. Measured hospital productivity decreased during this period at a rate of about 3% per year. It is likely that this decline in measured productivity captures increases in the service intensity or style of care, especially since actual admissions were increasing on average at these hospitals. The *BEDS* variable is significant only for nonprofit hospitals; except for this difference, the production function does not appear to differ across hospital types. Not-for-profit hospitals above 100 beds and large hospitals overall display approximately constant returns to scale, while for all other hospital

Table 3.1 **Production Function Estimates: All M.D.'s Dependent Variable: Admissions**

Sample	Constant	Beds	Personnel	M.D.'s	Nonlabor input	Time	Σ Coeffs.	n	$\bar{R}^2$
Full Sample	3.9	.086 (2.7)	.52 (16.4)	.15 (10.7)	.15 (8.7)	−.029 (7.7)	.904 (41.1)	1145	.864
Beds>100	3.7	.16 (3.3)	.49 (10.2)	.16 (3.3)	.14 (4.9)	−.030 (5.1)	.941 (29.2)	421	.857
Beds: 50–100	4.2	.002 (0.1)	.53 (12.1)	.13 (6.0)	.15 (7.3)	−.027 (5.3)	.810 (32.7)	724	.658
Governmental	3.9	.00 (0.01)	.57 (11.0)	.14 (6.2)	.17 (5.2)	−.031 (6.2)	.873 (19.7)	615	.807
Not-for-profit	3.8	.18 (4.0)	.45 (11.2)	.17 (10.0)	.13 (6.7)	−.030 (6.1)	.934 (40.0)	530	.907
NFP, Beds>100	3.6	.28 (4.5)	.37 (6.0)	.16 (6.8)	.16 (4.2)	−.032 (4.3)	.979 (33.8)	240	.877
NFP, Beds 50–100	4.1	.091 (1.6)	.50 (9.5)	.17 (5.8)	.12 (5.3)	−.027 (4.0)	.878 (32.0)	291	.700
Govt. Beds>100	3.9	.004 (0.0)	.62 (8.5)	.15 (3.7)	.11 (2.2)	−.026 (2.9)	.888 (16.3)	181	.800
Govt. Beds 50–100	4.3	−.057 (0.9)	.53 (8.0)	.11 (3.9)	.19 (5.2)	−.032 (4.3)	.778 (13.1)	434	.637
Occup. >75%	3.9	.065 (1.4)	.47 (9.2)	.17 (7.4)	.19 (6.1)	−.032 (4.8)	.898 (49.9)	463	.887
Full Sample	3.5	.088 (2.6)	.64 (19.3)	— —	.18 (7.2)	−.041 (10.0)	.904 (60.0)	1145	.849

NOTE: t ratios in parentheses.

Table 3.2 **Sample Means and Standard Deviations**

Sample	Hospitals	Beds	Personnel	M.D.'s	NLIP ($ thou.)	G.P.'s	Surg. spec.	Med. spec.	Other spec.	Hosp. based phys.
Full Sample	165	108	190	17.4	491	9.3	3.7	1.8	1.8	0.7
		(60)	(127)	(15.4)	(435)	(5.1)	(4.9)	(3.3)	(3.1)	(2.1)
Beds >100	60	158	292	28.3	777	11.8	7.3	4.0	3.7	1.5
		(70)	(154)	(20.4)	(561)	(6.5)	(6.4)	(4.5)	(4.3)	(3.2)
Beds 50–100	105	78	131	11.1	325	7.9	1.6	0.5	0.7	0.3
		(24)	(46)	(4.9)	(202)	(3.3)	(1.5)	(0.9)	(1.1)	(0.7)
Govt.	88	97	171	15.3	432	9.3	2.9	1.2	1.4	0.6
		(45)	(45)	(10.7)	(335)	(4.6)	(3.2)	(2.2)	(2.3)	(1.2)
Not-for-Profit	77	119	212	19.8	560	9.4	4.7	2.5	2.3	0.9
		(72)	(153)	(19.2)	(519)	(5.6)	(6.2)	(4.1)	(3.8)	(2.8)
NFP Beds: >100	35	168	315	30.8	860	11.4	8.4	4.9	4.3	1.7
		(80)	(174)	(23.9)	(621)	(7.0)	(7.5)	(5.1)	(4.8)	(4.0)
NFP Beds: 50–100	42	79	127	10.8	312	7.8	1.6	0.5	0.7	0.3
		(22)	(42)	(4.6)	(194)	(3.3)	(1.5)	(0.7)	(1.0)	(0.5)
Govt. Beds >100	26	143	262	25.1	666	12.4	5.9	2.8	3.0	1.1
		(48)	(117)	(13.7)	(449)	(5.8)	(4.2)	(3.2)	(3.2)	(1.4)
Govt. Beds 50–100	62	78	133	11.2	334	8.0	1.7	0.6	0.7	0.3
		(26)	(48)	(5.1)	(206)	(3.2)	(1.5)	(1.0)	(1.2)	(0.9)
Occ. > 75%	66	120	229	22.1	596	10.3	5.3	2.9	2.6	1.0
		(76)	(161)	(20.3)	(524)	(5.9)	(6.4)	(4.3)	(4.1)	(2.9)

NOTE: Standard deviations are in parentheses.

subsamples, and for the full sample, the sum of coefficients is significantly less than unity, indicating decreasing returns.

The most likely reason for the insignificance of beds is the high correlation of this variable with personnel ($r = .91$). High multicollinearity is to be expected in production function estimates; perhaps its existence might also explain why Feldstein's results for British hospitals were "unreasonable," with low or insignificant coefficients for such obviously important inputs as nurses. Heteroskedasticity was anticipated, but did not occur; error variances were almost identical for each quartile.

There is a potential problem in the estimates because of the possibility of excess capacity. The possibility of excess capacity in any of the inputs is disturbing in any production function study. It is even more disturbing here because the measured amount of the physician input may well be correlated with the extent of excess capacity in the other inputs. If it is supposed that hospitals may have excess capacity in the hospital inputs (beds, personnel, and other nonlabor inputs), and if physicians can in part create or activate demand for hospital care, then it is possible that any observed increase in output related to the presence of larger numbers of physicians, observed hospital inputs held constant,

Table 3.3 Population Rates: Sample Means and Standard Deviations

Sample	Population (00)	Adm. Pop.	M.D. Pop.	Personnel Pop.	Beds Pop.	G.P.'s Pop.	Surg. Pop.
Full	283	14.4	0.060	0.75	0.45	0.036	0.012
	(185)	(6.5)	(0.025)	(0.35)	(0.23)	(0.013)	(0.012)
Beds	402	16.0	0.072	0.85	0.48	0.031	0.019
>100	(238)	(7.3)	(0.029)	(0.40)	(0.27)	(0.011)	(0.015)
Beds:	214	13.5	0.054	0.69	0.43	0.039	0.008
50–100	(94)	(5.8)	(0.019)	(0.31)	(0.21)	(0.013)	(0.009)
Govt.	271	13.7	0.057	0.70	0.41	0.036	0.010
	(164)	(6.5)	(0.022)	(0.33)	(0.19)	(0.011)	(0.011)
Not-for-	297	15.2	0.065	0.80	0.49	0.035	0.014
profit	(208)	(6.4)	(0.027)	(0.37)	(0.27)	(0.014)	(0.013)
NFP Beds:	403	17.2	0.076	0.93	0.53	0.030	0.021
>100	(251)	(7.6)	(0.032)	(0.42)	(0.31)	(0.012)	(0.015)
NFP Beds:	208	13.5	0.055	0.69	0.45	0.040	0.008
50–100	(99)	(4.6)	(0.016)	(0.27)	(0.21)	(0.014)	(0.008)
Govt. Beds:	399	14.3	0.066	0.74	0.42	0.033	0.016
>100	(220)	(6.6)	(0.024)	(0.33)	(0.18)	(0.010)	(0.013)
Govt. Beds:	218	13.4	0.053	0.68	0.41	0.038	0.008
50–100	(90)	(6.4)	(0.020)	(0.33)	(0.20)	(0.012)	(0.010)
Occ. >	336	14.8	0.064	0.76	0.42	0.034	0.014
75%	(233)	(7.3)	(0.029)	(0.37)	(0.20)	(0.011)	(0.015)

NOTE: Rates are rates per 100 persons.

may not in fact reflect physician input productivity. Instead, we may only be observing more intensive use of previously underutilized hospital inputs. As noted in the preceding chapter, this problem cannot be fully resolved without direct measurement of underused inputs. Even if physician inputs actually rise, the total change in hospital output would be the sum of the direct effect of physician inputs, holding the utilization or service flow of hospital inputs constant, *plus* the increase in output arising from the greater flows of productive services from the hospital inputs. There is, of course, some ambiguity in the notion of excess capacity, and some question of how to measure it and incorporate it into production function estimates.

In order to determine whether the estimates presented above might be affected by this excess capacity effect, it is useful to determine whether the measured effect of physicians on output varies with the level of hospital excess capacity. The lower the level of excess capacity, the closer the coefficient on physicians will approximate the true output elasticity. The average occupancy rate of all hospitals in the sample is about 70%. A subsample of these hospitals with occupancy rates (in any year) greater than 75% was selected.[6] The estimated production function is shown in the second to last line of table 3.1. The values of coefficients on all variables, including physicians, are practically unchanged from the full sample results. These results suggest that the presence of excess capacity does not bias the coefficient estimates. Of course, if additional physicians mean *no* physician input, or if none of the hospitals ever reaches a capacity constraint at any time during the year, then this argument does not hold. Neither of these suppositions seems plausible.

Finally, comparison of the first and last lines in table 3.1 indicates that omission of the physician input did not bias estimates of returns to scale. Omission of the physician input does, however, lead to an overestimate of both the effect of personnel on output and of the rate of decrease in productivity over time. Adding the physician input makes only a modest contribution to the explanatory power of the regression, as might be expected given the high multicollinearity of the input variables.

Table 3.4 shows the result of a similar estimate using disaggregated measures of physician input. (For each of these physician measures, a constant (1) was added to prevent zero observations). The explanatory power of the regression is not appreciably improved by this change, but the results do shed some light on the way hospital output responds to subspecialties.[7] (The coefficient on the time variable is almost the same as in table 3.1, and so is omitted.) Not surprisingly, hospital based specialists, uncommon in hospitals under 100 beds anyway, tend to depress output there, probably because their presence is a proxy for case complexity. Similarly, medical specialists (internists, pediatricians, etc.) tend to affect output only in the large hospitals. Both surgical specialists and G.P.'s have positive output elasticities everywhere. Interpretation of the coefficients on G.P.'s and surgeons can be simplified by converting the elasticities into marginal products per physician. Table 3.5 shows that the marginal product of a physician is about 35 admissions per year, or about 3 per month. As might be expected, the marginal product is higher for surgeons than G.P.'s, and the difference tends to widen in the larger hospitals and counties where specialization by surgeons may occur to a greater extent. The purely hospital based physicians have a high marginal product in the larger hospitals.

Since many of the measures of input used here are obviously very crude, it seems appropriate to test the sensitivity of the results to alternative measures. Table 3.6 presents the results of such tests.

Output has been measured by the admission or case treated. I have argued that "quality" or casemix is not likely to differ in a systematic way across the sample hospitals, since the hospitals are stratified by size and since the populations served are all from relatively rural midwestern counties. One attempt to control for "quality" would be by introducing the number of approvals (of education programs) and accreditations, as well as the number of facilities at the hospital as independent variables

Table 3.4 **Production Function Estimates: Disaggregated Physicians (Logarithmic Specification)**

Sub-sample	Con-stant	Beds	Persnl.	Non-labor input	G.P.'s	Sur-geons	Med. spec.	Other spec.	Hosp. based'	n	$\bar{R}^2$
Full	4.1	.068	.53	.13	.088	.059	.028	.037	−.001	1145	.869
Sample		(2.1)	(16.1)	(8.1)	(6.1)	(4.9)	(2.1)	(3.4)	(0.1)		
Beds>100	4.3	.14	.45	.11	.049	.080	.034	.038	.033	421	.856
		(3.0)	(9.1)	(3.7)	(2.6)	(3.8)	(2.0)	(2.4)	(3.7)		
Beds:	4.1	−.001	.56	.14	.11	.055	.001	.029	−.043	724	.662
50–100		(0.2)	(13.0)	(6.9)	(5.6)	(3.7)	(0.2)	(1.9)	(2.1)		
Govern-	4.0	−0.0	.56	.16	.10	.071	.032	.003	−.016	615	.810
mental		(0.0)	(11.2)	(5.3)	(4.3)	(3.8)	(0.1)	(0.1)	(0.8)		
Not-for-	4.1	.13	.47	.12	.082	.046	.025	.078	.012	530	.910
profit		(3.1)	(10.2)	(8.2)	(4.6)	(2.9)	(1.6)	(5.2)	(0.9)		
Not-for-profit	4.4	.25	.34	.11	.043	.055	.068	.068	.028	240	.888
Beds>100		(4.0)	(5.8)	(3.2)	(2.1)	(2.0)	(3.4)	(3.4)	(1.6)		
Not-for-profit	4.1	.036	.55	.12	.14	.065	−.057	.067	−.019	291	.709
Beds 50–100		(0.0)	(10.0)	(5.0)	(4.7)	(3.3)	(1.9)	(2.9)	(0.5)		
Govt.,	4.2	.00	.60	.12	.063	.087	.008	.00	.026	181	.800
Beds>100		(0.0)	(7.5)	(2.0)	(1.6)	(2.6)	(0.1)	(0.0)	(0.9)		
Govt., Beds	4.3	−.053	.53	.19	.093	.058	.021	−0.0	−.044	434	.643
50–100		(0.8)	(7.7)	(4.9)	(3.3)	(2.6)	(0.8)	(0.0)	(1.6)		
Occu.	4.2	.017	.49	.18	.097	.12	−.004	.036	−.005	463	.893
>75%		(0.3)	(9.1)	(6.1)	(4.7)	(6.0)	(0.2)	(1.9)	(0.1)		

Table 3.5 Annual Marginal Admission Products, by Physician Specialty Type, Evaluated at Mean

Subsample	All M.D.'s	G.P.'s	Surg. Spec.	Med. Spec.	Other Spec.	Hosp. based
Full sample	35.8	31.3	46.0	36.7	48.4	——
Beds>100	33.3	21.2	53.5	37.7	44.8	73.2
Beds 50–100	34.8	31.8	54.3	——	——	——
Governmental	32.6	32.3	60.5	48.3	——	——
Not-for-profit	38.9	32.0	32.8	28.9	95.9	——
NFP, Beds>100	34.7	20.6	34.7	68.3	76.1	——
NFP, Beds 50–100	44.1	39.9	62.6	——	98.7	——
Govt. Beds>100	30.1	23.7	63.6	——	——	——
Govt. Beds 50–100	27.9	27.0	56.0	——	——	——
Occu.>75%	38.1	38.0	84.5	——	44.3	——

NOTE: —— = coefficient not significant or negative.

(line 1, table 3.6). While approvals were significant and positively related to admissions (somewhat unexpectedly), their inclusion did not affect the production function coefficients nor contribute appreciably to the explanatory power of the regression. The number of facilities was not significant.

Measuring hospital labor input with the number of full-time-equivalent personnel is obviously imperfect. One possible way to improve the measure of labor input is to follow Feldstein's procedure with British hospitals and use payroll expense. If personnel are heterogeneous, if relative wages reflect relative marginal products, and if absolute wage levels do not differ, the implicit weighting by wage rates should provide a better input measure than does just counting all employees equally. Even though there is no reason to suppose that quality-constant wage levels are identical, the variation among this set of geographically homogeneous hospitals may not be too severe. Line 3 of table 3.6 shows the result of replacing personnel with payroll. In general, using payroll instead of personnel did not improve, and sometimes worsened, the explanatory power of the regression. The only exception is in the case of smaller not-for-profit hospitals. One other change was an increase in the coefficient on beds.

A final test was to change the measure of annual bed cost used in calculating nonlabor expense from \$1000 to \$3500. Except for the expected change in the relative magnitudes of the *BED* and *NLIP* coefficients, the results were unaffected.

Since it is unclear whether hospital outputs respond immediately to the presence of all inputs, especially beds, medical staff, and specialized

Table 3.6 **Alternative Specifications of Production Function: Full Sample**

Line	Beds	M.D.'s	Time	Pay-roll	Per-sonnel	NLIP Beds-1000	NLIP Beds-3500	Ap-prov-als	Facil-ities	Avg. Stay	$\bar{R}^2$	n
1.	.064	.15	−.028		.53	.14		.043	−.00		.867	1145
	(2.1)	(10.1)	(7.8)		(12.0)	(8.7)		(4.1)	(0.0)			
2.	.48	.055	−.027		.34	.11				−.66	.947	1145
	(20.3)	(6.1)	(11.3)		(14.3)	(10.8)				(40.2)		
3.	.18	.16	−.061	.44		.10					.861	1145
	(6.2)	(10.5)	(15.4)	(18.7)		(5.8)						
4.	.17	.16	−.026		.55		.030				.863	1145
	(5.1)	(10.2)	(7.1)		(16.3)		(7.8)					
5.	−.04	.13	—		.69	.11						
	(0.1)	(4.1)			(7.0)	(2.2)					.906	168

facilities, since the precise dating of when an input was actually available in questionable in the data, and since standard errors may be understated owing to the presence of serial correlation in the pooled time-series cross section, results were also obtained using seven-year average values for each hospital for inputs and outputs. The results are shown on line 5, table 3.6. The results are again very similar to the pooled results of table 3.1, except that the beds variable is now insignificant.

Length of Stay

Holding beds constant, the only ways physician input (or any other input) can increase the number of cases treated are either by increasing the occupancy rate or by reducing length of stay. Feldstein's results for the United Kingdom strongly suggest that when output is increased by increased medical input (or any other input), average duration of stay declines but the occupancy rate is only slightly affected.[8] Does additional physician input in this sample of U.S. hospitals also increase output primarily by shortening stay? One way to tell is by including average stay directly in the production function. One can either interpret this as a "characteristic" of output which one may wish to hold constant, or as another output of a multiproduct firm.[9]

Line 2 of table 3.6 suggests that reductions in stay are an important part of the way in which physicians contribute to output. The coefficient of mean stay is negative and significant; its inclusion substantially improves the $\bar{R}^2$. The coefficient on *MD*'s falls to about one-third of its former value, the coefficients on personnel and *NLIP* fall by 25–35%, while the coefficient on beds increases substantially. One possible conclusion is indeed that an important way in which physicians "produce" admissions is by shortening the length of stay. It also appears that one of the reasons why the effect of beds on admissions was relatively slight is that beds produce bed-days, and that many of these additional days show up as extended stays rather than as new admissions.

There are, of course, some other explanations which are consistent with these results. One is that there are substantial differences in case complexity, and complexity tends to be positively related to the number of beds and negatively related to the number of physicians.

Another, perhaps more plausible explanation is indicated by Fuchs in his review of Feldstein's book.[10] He suggests that length of stay may vary for reasons other than medical input—regional differences in medical practice, socioeconomic characteristics of patients and area, and so on. If physician input primarily "produces" admissions, not days of stay, while beds and (to a lesser extent) personnel do produce days of stay, a consequence of reduced length of stay will be an increase in the ratio of medical staff to hospital inputs, but the increased ratio does nothing to *cause* the reduction in stay. This explanation would imply that there was, in some sense, an "excess" of days of stay (at least in the sense of their not being needed for the production of a treated case) when medical input was less; it suggests that some hospital inputs cannot be substituted for medical inputs in the production of treated cases. With the available data it is not possible to tell which interpretation is correct.

Optimal Input Ratios

If the hospital were to minimize cost for a given output, it would choose that mix of inputs at which the ratio of regression coefficients (output elasticities) just equalled the ratio of expenditures on the inputs. (This statement assumes that inputs are purchased at constant prices.) For those inputs for which dollar cost estimates are available—personnel, nonlabor inputs, and beds—the optimal ratios and the actual sample mean input expenditure ratios are shown in table 3.7. For physicians, the table shows the shadow price of a physician—the price per physician which would yield an actual ratio of inputs equal to the optimal one. A shadow price for physicians relative to all hospital inputs is also obtained by calculating the price per physician which would produce equality between the ratio of physician costs to hospital costs and the ratio of the coefficient on physicians to the sum of all hospital input coefficients.

There are two main messages from these computations. First, hospitals tend to underuse personnel relative to nonpersonnel inputs—either beds or other nonpersonnel inputs—in all but large nonprofit hospitals. Second, the shadow price of the physicians' annual input into the production of hospital output was in the neighborhood of $17,000 per year. It was higher for not-for-profit hospitals than for governmental hospitals.

There are other costs that should be considered, if only the data were available. To the extent that increased physician input shortens stays, one should add to the opportunity cost of physician input the explicit and implicit costs of home and other nonhospital inputs used to care for the patient during out-of-hospital convalescence, but subtract the opportunity cost of increased "sick time" that may accompany longer stays.

Physicians do not, on average, spend all of their working hours at the hospital. Instead, most physician working hours are spent in their offices, treating and diagnosing ambulatory patients. How does this fact affect the interpretation of the appropriate input mix?

Suppose for the moment that the ratio of average physician office hours to hospital hours is constant across the sample hospitals. If what the physician does in his office has no effect on the demand or supply of admissions, if physicians allocate their time to equate net income per

Table 3.7 **Optimal Input Ratios and Shadow Prices of Physician Inputs (Using Estimates of Table 3.1)**

Sample	BEDS/MDS		PERS/MDS		NLIP/MDS		BEDS + NLIP / MDS		All Hosp IP / MDS		PERS / NLIP + BEDS	
	Opt. Ratio	Price of M.D.	Opt. Ratio	Price of M.D.	Opt. Ratio	Price of M.D.	Opt. Ratio	Price of M.D.	Opt. Ratio	Price of M.D.	Opt. Ratio	Actual Ratio
Full sample	0.57	107	3.47	148	1.00	283	1.57	219	5.04	170	2.20	1.49
Beds>100	1.00	56	3.06	167	0.88	310	1.88	176	4.94	169	1.63	1.53
Beds 50–100	——		4.08	129	1.15	250	1.15	310	5.23	169	3.53	1.43
Governmental	——		4.07	126	1.21	233	1.21	286	5.29	162	3.35	1.48
Not-for-profit	1.05	56	2.65	194	0.75	374	1.82	189	4.47	191	1.45	1.50
NFP, Beds 50–100	0.54	136	2.94	182	0.71	407	1.24	291	4.18	215	2.38	1.48
NFP, Beds>100	1.75	31	2.31	220	1.00	280	2.75	122	5.06	166	0.84	1.52
Govt. Beds 50–100	——		4.82	107	1.73	172	1.73	212	6.55	136	2.73	1.41
Govt. Beds>100	——		4.13	122	0.73	364	0.73	442	4.87	170	5.64	1.57
Occ.>75%	0.38	143	2.76	177	1.12	241	1.47	221	4.24	192	1.88	1.50

NOTE: —— = coefficient not significant at 0.8 or better.

hour worked at every location, and if prices reflect consumer evaluations, an appropriate measure of the opportunity cost of the time spent per physician per year in the hospital would be average physician net income per year times the average fraction that hospital hours are of total working hours.

Even such measures are not easy to obtain, but the following calculations are probably reasonably accurate. Average physician net income in nonmetropolitan locations was about $39,000 in 1969. For nonmetropolitan physicians in 1969 hospital visits were about 25% of total patient visits. If one assumes equal time for hospital or office visits, this suggests that physicians spend, on average, about one-fourth of the work time at the hospital. If the average physician "wage" per visit is a legitimate measure of his opportunity cost, that cost is about $9750 per year, compared to a shadow price of $17,000 per year. The conclusion then is that there is overuse of hospital inputs relative to physician inputs in all hospitals taken together, and in all types of hospitals except small governmental ones. The actual savings from moving to an optimal physician-hospital input ratio in the average not-for-profit hospital in the sample would be $144,000, or about 8% of total hospital expenses. To this should be added the net costs (positive or negative) of convalescence out of the hospital owing to shorter stays. The relatively greater overuse in not-for-profit hospitals, as compared to governmental ones, is consistent with the notion that physicians may be able to control not-for-profit hospitals more effectively than they can control governmental hospitals, which at least have an identified political constituency.

Measures of Physician Input

As described above, the initial measure of physician input was the number of patient care physicians in the county. The ideal measure of physician input m_H that we seek could be defined as

$$m_H = h \cdot s \cdot M$$

where M is the number of physicians in the county, s is the hospital's staff of active physicians as a proportion of the total number of physicians in the county, and h is the average number of hours per week worked at the hospital by each staff physician. Since m_H is measured by M, there are several possible sources of error. I will argue that if the estimates above are in error, they will tend to underestimate physician productivity, and so tend to underestimate the overuse of hospital inputs.

Even if h, s, and M are uncorrelated, M will measure m_H only with an error. This raises the possibility of a standard errors-in-variables bias toward zero. Moreover, if either h or s is correlated with M, the coefficient on M will be a biased measure of m_H.

To adjust for such correlation, two things were done: first, data were obtained on the number of physicians with staff appointments at each of the 160 hospitals in late 1972 from the Social Security Administration's "Provider of Services" data. These data, obtained in the process of Medicare certification, list the number of medical staff appointments of various types. The Social Security Administration's survey also provides some more disaggregated measures of the type of personnel.

Physician staff members were divided into two groups: active staff members, and all other staff members (courtesy, honorary, etc.). A comparison of the results for 1972 using alternatively all county M.D.'s and hospital staff members is shown in table 3.8. The coefficient on physicians is only slightly lower when all county physicians are used than when active staff members are used. When the sample is disaggregated, it becomes apparent that, at least in 1972, there is considerable downward bias in the coefficient estimate for larger hospitals when physician input is measured by the total number of physicians in the county, but there was no bias for smaller hospitals. There does seem to be a little evidence, therefore, that overuse of hospital inputs may be somewhat more severe than indicated above.

Second, it may be hypothesized that physician hospital hours and numbers of physicians relative to hospital inputs might be inversely correlated. At least, with demand held constant, the number of hours worked in total by a physician may decline as the number of physicians increases (either because price declines or because of some pro-rata rationing effects). Moreover, as the number of physicians relative to hospital inputs increases, each physician may spend less time at the hospital. This is another reason to suspect that the estimates in table 3.7 may underestimate the overuse of hospital inputs.

One adjustment that can be made is to estimate the effect of physicians with the physician-population ratio held constant. Physicians may work shorter hours (at the hospital and in total) when they are plentiful relative to the population or, as suggested by Reinhardt, the pace of work may be less hectic. The physician-population ratio in this sense may serve as a proxy for hospital hours per physician. However, when the physician-population ratio (or its log) was entered in the regression, it had a significant coefficient only for the small nonprofit hospitals subsample, and the change there in the coefficient on *MD*'s, while positive, was small.

Conclusion

The empirical results presented in this chapter suggest that, once a patient is hospitalized, there will be some overuse of hospital inputs relative to physician inputs. It would be possible to maintain the pro-

Table 3.8 1972 Production Function Estimates Using Physician Staff and Disaggregated Labor

Line	Personnel	NLXP	Beds (AHA)	M.D.'s	Active Staff M.D.'s	Other Staff M.D.'s	Beds (SSA)	R.N.'s	L.P.N.'s	Other Profs.	Other Personnel	n	$\bar{R}^2$
FULL SAMPLE													
1.	.57	.20	−.01	.10								160	.908
	(6.6)	(3.8)	(0.1)	(3.2)									
2.	.55	.20	−.02		.13	.019							.911
	(6.3)	(4.0)	(0.3)		(3.8)	(1.3)							
3.		.21	−.06		.080	.00		.076	.056	.045	.40		.905
		(3.6)	(0.0)		(3.6)	(1.3)		(2.3)	(3.6)	(1.6)	(5.6)		
4		.18			.12	.018	.19	.040	.046	.045	.32		.915
		(3.6)			(3.3)	(1.4)	(2.8)	(1.2)	(2.9)	(1.7)	(5.7)		
BEDS: 50–100													
1.	.55	.21	−.09	.088								101	.792
	(5.1)	(3.3)	(1.0)	(2.1)									
2.	.55	.22	−.10		.084	−.00							.788
	(4.9)	(3.4)	(1.1)		(1.9)	(0.0)							
3.		.21	−.06		.808	.00		.092	.059	.035	.38		.786
		(3.3)	(0.8)		(1.7)	(0.0)		(1.9)	(2.7)	(0.9)	(4.2)		
4.		.21			.076	.00	.12	.058	.051	.032	.30		.789
		(3.4)			(1.7)	(0.0)	(1.4)	(1.1)	(2.8)	(0.9)	(4.1)		

Table 3.8—*continued*

Line	Personnel	NLXP	Beds (AHA)	M.D.'s	Active Staff M.D.'s	Other Staff M.D.'s	Beds (SSA)	R.N.'s	L.P.N.'s	Other Profs.	Other Personnel	n	$\bar{R}^2$
							BEDS>100						
1.	.50	.27	.11	.066								59	.892
	(3.3)	(2.7)	(1.0)	(1.2)									
2.	.50	.16	.08		.22	.045							.913
	(3.3)	(1.6)	(0.6)		(3.2)	(2.1)							
3.		.16	.09		.23	.047		.038	.038	.031	.37		.908
		(1.7)	(0.7)		(3.2)	(2.1)		(0.8)	(1.6)	(0.7)	(3.1)		
4.		.13			.21	.043	.27	.019	.031	.042	.32		.919
		(1.3)			(3.2)	(2.2)	(2.7)	(0.4)	(1.4)	(1.1)	(3.7)		

duction of hospital admissions, even while reducing the level of hospital inputs, if additional physicians' time were added. The reduction in cost of the hospital inputs thus saved would *exceed* the increase in costs attributable to the additional physician inputs, at least if the social costs are measured by the portion of physician net income coming from time spent at the hospital. Whether these costs equal the social costs of providing physician services is, of course, very uncertain, given the way in which physician training is financed. Nevertheless, if these output elasticities are accepted as measures of the effect of physician hospital hours, and if the cost measure is taken as appropriate, the conclusion is that the given stock of physicians could be used more efficiently if physicians spent more time at the hospital and hospitals eliminated some personnel and nonlabor inputs.

This is inefficiency in the direction opposite from that found by Reinhardt for office practices. However, it is by no means obvious that a shift toward more physician-intensive production of hospital care would raise physician utility, even though it would lower hospital and total costs. Reductions in hospital costs reduce hospital insurance benefits. Depending upon the amount and type of physician fee insurance, the result may be a decrease in physician utility. Here, at least, we have a *reason* why resource misallocation occurs.

One message for policy is that what is likely to be important is the relatively low marginal product of specialists, especially of surgeons. Given the high cost of training surgeons, one may wonder whether the hospital output, even if that output is thought to be appropriate in some sense, justifies those costs. Of course, in practice, increases in physicians are likely to be accompanied by increases in hospital inputs; the hospital inputs mean more output, but also more cost.

Another message is that even primary care physicians—G.P.'s and medical specialists—have a significant positive effect on hospital admissions. If the goal is to increase the number of primary care physicians *without* increasing the hospitalization rate, the analysis above suggests that an appropriate strategy is to couple physician increases with hospital input decreases.