Prospective payment for Medicare hospital capital: Implications of the research

by Philip G. Cotterill

The special characteristics of capital have an important effect on the cross-section variation in hospitals' capital costs. Variables reflecting capital age and financing differences perform as expected and add substantial explanatory power to capital cost models. However, even with the inclusion of these variables, the capital-cost models perform poorly compared with total-cost models. The empirical findings of this article support using the total-cost models to develop a common set of adjustment factors for capital and operating payment amounts in the Medicare prospective payment system.

Introduction

The 1983 Amendments to the Social Security Act (Public Law 98-21) enacted the Medicare prospective payment system (PPS) for the payment of hospital inpatient operating costs, but pending further study, continued cost-based payment of capital costs until October 1, 1986. On June 3, 1986, the U.S. Department of Health and Human Services (DHHS) issued proposed regulations for incorporating capital payments into PPS. In July 1986, legislation (Public Law 99-349) was passed that extended the exclusion of capital from PPS until October 1, 1987. In May and September 1987, DHHS issued proposed and final regulations to fold capital payments into PPS. However, in October 1987, enactment of Public Law 100-119 prevented the final regulation from taking effect. The Omnibus Budget Reconciliation Act of 1987 (Public Law 100-203) subsequently required DHHS to implement prospective payment for capital starting October 1, 1992. In February and August 1991, DHHS once again issued proposed and final regulations for a third attempt to incorporate capital payments into PPS. The August 1991 capital regulation took effect October 1, 1991, thus initiating a 10-year transition to full prospective payment of Medicare's share of inpatient capital-related costs.

Congressional persistence attests to the widespread belief that change was needed in Medicare capital payment policy. In particular, there was recognition that to encourage efficient resource use, Medicare payment policy should not influence hospitals' choices of how to combine capital and operating inputs. There was also the understanding that with capital paid on a cost basis and operating costs on a prospective basis, Medicare provided hospitals the incentive to substitute capital for operating cost.

Under these circumstances, why did it take so long to incorporate capital into PPS? Both the special nature of capital and the tradition of cost-based payment inhibited change.

The durability and "lumpiness" of capital distinguishes it from other inputs. Capital tends to be purchased in larger, less divisible quantities at less frequent intervals than operating inputs. The lumpiness of capital creates the need for long-term financing and the contractual commitments that accompany debt financing. Debt obligations make it more difficult to change Medicare capital-payment policy without imposing major adjustments on hospitals with very large debt service costs.

Another consequence of the lumpiness of capital is that, relative to its size, capital cost per discharge varies more among hospitals than does operating cost per discharge. As a result, a prospective payment based on the average capital cost will tend to have a greater relative impact in redistributing payments than was the case for operating cost.

Finally, the tradition of cost-based payment for hospitals has created a tendency to accentuate the uniqueness of capital in people's thinking about Medicare payment policy. Neither the variability nor the lumpiness of capital are unique to hospitals. Only the tradition of cost-based payment is unique to hospitals. Certainly, in the private sector, it is almost impossible to think of a good or service for which the unit of payment separately identifies capital from the other inputs used in producing the good or service. Even in highly capital-intensive publicly regulated industries such as electric power, the return on capital is incorporated into a rate structure based on the unit of service[1] (e.g., dollars per kilowatt hour).

The experience of other industries clearly demonstrates that hospital capital can be paid on a per discharge basis and need not be paid separately from other input costs. However, a shift to prospective payment for hospital capital requires consideration of how to minimize the negative effects of transitional payment redistributions and how to structure the longrun prospective payment for capital.

The next section of this article addresses the issue of payment redistributions by presenting descriptive data on the variation of capital and operating costs. This information quantifies the extent to which capital costs are more variable than operating costs. The effect of capital-cost variability on total-cost variability is also assessed. The specifics of transitional payment mechanisms are beyond the scope of this article, but the details of the policy being implemented are described in the August capital regulation (*Federal Register,* 1991).

The opinions expressed in this article are the author's and do not represent the official position of the Health Care Financing Administration.

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[1] Industries with regulated rates of return on capital have their own problems in establishing incentives for efficient resource use (Averchand Johnson, 1962).

The remainder of this article addresses the issue of the structure of the long-run prospective payment for capital by analyzing and comparing sources of variation in capital cost versus operating and total costs: The empirical models of capital- and total-cost variations that were estimated are described, and estimation results are presented. The article concludes with a discussion of the policy implications of this analysis.

The regression results reported in this article differ from those found in the August capital regulation in two ways. First, given the focus of this article on comparative analyses, it was necessary to limit the data set to hospitals for which all variables were available. This meant that fewer hospitals were included in the regressions reported here than in the regression actually used to determine the capital payment adjustments in the August capital regulation. Second, because the emphasis here is on understanding sources of cost variation rather than on determining specific payment adjustments, the variables included in the regressions are not identical to those reported in the August capital regression.

The article identifies several problems in accounting for capital-cost variation and concludes that it is preferable to use the analysis of total cost (the sum of capital and operating cost) to develop a common set of adjustments for the capital and operating prospective payments rather than to use the analysis of capital cost to develop separate capital payment adjustments.

It should be noted that this conclusion is not inconsistent with the August 1991 capital regulation, which establishes adjustment factors for the capital prospective payment based on analysis of total-cost variation. In the long run, it only makes sense to base the capital payment on total-cost variation if the operating payment is also based on total-cost variation. However, the Health Care Financing Administration (HCFA) currently lacks the statutory authority to modify the payment adjustments for the operating payment to conform with the capital adjustments. The logical conclusion is for legislative action to permit the use of the same payment adjustments for the operating and capital payments based on analysis of the combined capital and operating costs.

Capital- versus operating-cost variation

Data from Medicare cost reports on the distributions of Medicare inpatient capital and operating costs per discharge during the period 1985-89 are presented in Table 1. Medicare capital costs consist of Medicare's share of a hospital's depreciation and interest expenses, plus capital-related insurance costs, property taxes, leases, and rent. The main components of Medicare operating costs are routine and ancillary costs. Excluded are capital costs and the costs of approved graduate medical education programs. Table 1 contains only the portions of capital and operating costs that have been allocated to Medicare inpatient services.

Although capital and operating costs per discharge have risen during this period, there was little change in the shape of their distributions (Table 1). For example, the ratio of the interquartile range (the difference between the 75th and 25th percentile values) to the median has remained relatively constant for both capital and operating costs. The relative interquartile range for operating cost

Table 1

Medicare inpatient capital and operating costs per discharge: Selected distributional statistics, PPS-2 through PPS-6

Item	PPS-2 1985	PPS-3 1986	PPS-4 1987	PPS-5 1988	PPS-6 1989
Percentile		Medicare capital cost per discharge			
95 percent	$768	$852	$893	$1,006	$1,102
75 percent	431	481	521	571	608
50 percent	275	313	342	377	398
25 percent	171	197	220	240	241
5 percent	93	107	120	131	127
Mean[1]	$339	$379	$410	$448	$476
Standard deviation	257	271	279	307	336
Mean ÷ median	1.23	1.21	1.20	1.19	1.20
Interquartile range ÷ the median	.94	.91	.88	.88	.92
Percentile		Medicare operating cost per discharge			
95 percent	$4,963	$5,265	$5,693	$6,204	$6,890
75 percent	3,465	3,770	4,098	4,481	4,938
50 percent	2,661	2,898	3,160	3,454	3,823
25 percent	2,049	2,248	2,400	2,605	2,866
5 percent	1,453	1,589	1,708	1,841	1,986
Mean[1]	$2,877	$3,122	$3,369	$3,683	$4,067
Standard deviation	1,173	1,235	1,340	1,481	1,729
Mean ÷ median	1.08	1.08	1.07	1.07	1.06
Interquartile range ÷ the median	.53	.53	.54	.54	.54

[1] The mean and standard deviation are hospital weighted.

NOTES: PPS is prospective payment system. PPS-2 cost reports are for hospital accounting years beginning on or after October 1, 1984, and no later than September 30, 1985. The other years' reports are categorized analogously.

SOURCE: Health Care Financing Administration, Office of Research and Demonstrations: Based on data from the Medicare cost reports: Hospital Cost Reporting Information System.

only varied from .53 to .54 during the 1985-89 period. For capital cost, the same measure was higher and somewhat more variable, ranging from .88 to .94. Further, comparing the ratio of the mean to the median, it is clear that the capital-cost distribution is much more highly skewed to the right than the operating-cost distribution. For capital cost, the mean exceeded the median by 19-23 percent during this period. For operating cost, the mean was only 6-8 percent higher than the median. This greater relative variation and skewness illustrates that a capital payment system based on mean capital costs would tend to redistribute capital payments among hospitals to a greater extent than a comparable system for operating costs.

However, because capital cost is on average much smaller than operating cost, the actual number of dollars redistributed would be expected to be smaller than in the case of operating cost. As shown in Table 1, the mean capital cost in 1989 was $476, or about 11.7 percent of the mean operating cost ($4,067). The top 5 percent of hospitals had capital costs greater than $1,102, which is 27 percent of the mean operating cost but only 16 percent of the 95th percentile operating cost ($6,890). Although smaller in absolute dollars than in the case of operating cost, the redistribution of capital payments could be large, especially for hospitals in the tails of the distribution.

Another way to look at the impact of capital-cost variation is to consider its impact on total cost variation. On the one hand, the fact that capital cost represents only about 10.5 percent of total cost will limit its impact.

However, the correlation between capital and operating costs also plays a significant role. Capital and operating inputs may sometimes substitute for one another, which would tend to make them negatively correlated, and at other times may complement each other, which would tend to make them positively correlated. The Pearson correlation coefficients shown in Table 2 indicate that on balance capital and operating inputs are positively correlated. During 1985-89, the correlation varied from .47 to .55. This fact will tend to increase the impact of capital cost on total cost variation. It also suggests that payment policy needs to treat both cost elements jointly, because hospitals' decisions about capital and other inputs are related to one another.

To estimate the effect on the variation in capital cost of capital's relatively small share of total cost and the positive correlation between capital and operating cost, the increase in the standard deviation of total cost per discharge as a result of capital cost was calculated as follows: The variance (Var) of a sum of two variables equals the sum of the two variances plus twice the covariance of the variables. Noting that, by definition, the covariance is the product of the Pearson correlation coefficient (Rho) and the standard deviations (SD) of each variable yields:

$$\mathrm{Var(TOT)} = \mathrm{Var(CAP)} + \mathrm{Var(OP)} + 2*\mathrm{Rho}\ (\mathrm{CAP, OP})\ *\mathrm{SD(CAP)}*\mathrm{SD(OP)},$$

where TOT, CAP, and OP represent total, capital, and operating costs per discharge. Because the standard deviation (the square root of the variance) is measured in dollars per discharge, it provides a more interpretable measure of the increased variation than does the variance. If capital and operating costs were not correlated, the standard deviation of total cost would only be about 2 percent greater than the standard deviation of operating costs despite the much greater relative variation in capital cost. Two percent of the 1989 standard deviation of total cost ($1,928) is about $38. However, taking into account the positive correlation between capital and operating costs makes the standard deviation of total cost about 11.5 percent (or $200) greater than the standard deviation of operating cost.

Medicare cost report data confirm that capital cost exhibits much greater variability among hospitals than does operating cost or total cost. The positive correlation between capital and operating costs is responsible for greater variation in total cost than would be expected based on capital's relatively small share of total cost. The positive correlation between capital and operating costs also supports the view that Medicare hospital payment policy should not attempt to deal with capital cost independently.

Table 2

Simple correlation coefficients for Medicare inpatient capital and operating costs per discharge: PPS-2 through PPS-6

Accounting years	PPS-2 1985	PPS-3 1986	PPS-4 1987	PPS-5 1988	PPS-6 1989
PPS-2 1985	.47	.47	.48	.47	.48
PPS-3 1986	.46	.50	.50	.51	.51
PPS-4 1987	.44	.46	.51	.51	.51
PPS-5 1988	.42	.45	.48	.55	.52
PPS-6 1989	.41	.43	.46	.48	.53

NOTES: PPS is prospective payment system. PPS-2 cost reports are for hospital accounting years beginning on or after October 1, 1984, and no later than September 30, 1985. The other years' reports are categorized analogously.

SOURCE: Health Care Financing Administration, Office of Research and Demonstrations: Based on data from the Medicare cost reports: Hospital Cost Reporting Information System.

Modeling capital-cost differences

Past analyses encountered significant difficulty explaining capital-cost differences. For example, the variables used to explain operating-cost differences and/or to adjust the PPS operating payment (case mix, wage index, teaching, disproportionate share, etc.) explain more than 70 percent of the variation in Medicare operating cost (Pettengill and Vertrees, 1982; Anderson and Lave, 1986; Sheingold, 1990.) However, the operating characteristics appeared to account for far less of the variation in Medicare capital cost per discharge (Anderson and Ginsburg, 1983.)

Often observers lacked relevant data and merely assumed that the greater unexplained capital-cost variation was largely the result of capital's special age and financing characteristics, which was attributed earlier to its lumpiness. Two analyses (U.S. Congressional Budget Office, 1988; Prospective Payment Assessment Commission, 1987) used examples for individual hypothetical hospitals to demonstrate the effect of age or position in the "capital cycle" on capital cost.

Direct empirical evidence on the impact of capital's special characteristics has more recently begun to accumulate (American Hospital Association, 1990; Cleverly, 1986). This article and the AHA paper are among the first analyses to incorporate age and financing factors with the variables typically associated with operating-cost variation. This article differs from other work in its comparative analysis of the variation in capital and total costs.

The approach taken in this article was to first apply a typical operating-cost model to capital cost. A log-linear cost function was estimated that included the following variables:

- The Medicare case-mix index (CMI).
- The hospital wage index (WI).
- The level of teaching activity (measured by the ratio of interns and residents to the average daily census: RESDAY.)
- The proportions of poor Medicare and Medicaid patients (measured by the disproportionate-share percent with separate slopes for urban and rural hospitals with more and less than 100 beds: disproportionate share for urban hospitals with more than 100 beds (DSUL), with less than 100 beds (DSUS); disproportionate share for rural hospitals with more than 100 beds (DSRL), with less than 100 beds (DSRS). In addition, dichotomous variables were included for hospitals with at least 100 beds (BEDSGE100), hospitals in metropolitan areas with populations of at least 1 million (LARGE), hospitals in other metropolitan areas (OTHER), and type of ownership (proprietary: PROP or government: GOVT.) Rural hospitals and voluntary hospitals constitute the omitted categories.

Second, a capital-cost model was specified that added variables to the operating cost model that attempt to capture the distinctive features of capital. There were two steps in this process: Variables that reflect differences in the timing of capital spending were added first. These variables were generally proxies for the age of capital. Then another set of capital variables was added to the first set. The second set of capital variables reflects differences in financing, occupancy rates, and construction costs.

Third, the operating-cost model was applied to total cost, and finally, the full-capital model, consisting of all operating variables and both sets of capital variables, was estimated for total cost. Before proceeding to the estimation results, it is necessary to discuss the capital variables in some detail.

Capital variables

Because capital has a useful life measured in years, it tends to be purchased in relatively large amounts with less frequency than operating inputs. When new capital is put into service, capital costs rise sharply and then, in the absence of further major capital spending, gradually decline until the next major expenditure. When major projects come on line, a hospital can be expected to move up dramatically in the cross-sectional distribution of capital costs. Thus, two otherwise identical hospitals would have different levels of capital cost if the timing of their capital spending is not coincident. The term "capital cycle" was not used because there need not be regularity or uniformity among hospitals in the pattern of capital spending to produce this type of cost variation (*Federal Register,* 1991). To control for this effect requires a measure of differences among hospitals in the length of time between major capital expenditures. Hospitals with recent expenditures will have relatively high capital costs, and hospitals that have not made a major capital purchase for a long time will have relatively low capital costs.

Direct measures are not available. However, estimates of the age of a hospital's capital can serve as proxies. Three variables were used in this analysis: the ratio of accumulated depreciation to current depreciation (AGE), remaining depreciable asset life (the ratio of net asset value to current depreciation: RLIF), and the ratio of total fixed assets to total assets (TFATA.)

If a hospital had a single asset with a fixed useful life, RLIF would be highly negatively correlated with AGE because net asset value is the difference between gross asset value and accumulated depreciation. Hence, it would be sufficient to use only one of the two variables. Of course, hospitals have many assets of varying age and useful lives, and RLIF and AGE are in fact positively correlated. An old, mostly depreciated plant would tend to increase AGE, whereas RLIF might be more affected by recent equipment purchases. Both RLIF and AGE contributed to the explanation of capital-cost variation.

Both AGE and RLIF have several limitations. First, because a hospital balance sheet typically includes a variety of capital purchases made at different times, AGE and RLIF at best represent average values. Second, they are distorted by the fact that book value and depreciation reflect historical cost. Inflation in capital-goods prices means that assets purchased more recently will be more heavily weighted than older assets. As a result, AGE will tend to be understated and RLIF overstated. However, because depreciation is the largest single component of our capital-cost variable, the use of historical cost also affects our dependent variable. Although there may be some impact on the values of the coefficients for AGE

and RLIF, it is not clear what effect this measurement problem has on the explanatory power of the equation. Third, the ability to separate current depreciation from interest and other capital expenses in Medicare cost reports is subject to measurement error. Finally, TFATA also suffers from the use of historical cost accounting, but it is not affected by limitations in separating depreciation from the other components of capital cost.

It should be noted that including these variables will tend to control for differences in the relative frequency of capital spending, but they will not explain why differences in the frequency of capital spending occur. It is beyond the scope of this article to attempt to explain interhospital differences in the frequency of capital spending. The age variables are important because of their impact on the overall explanatory power of the model and the effects they may have on the coefficients of the other variables.

Consider the following cases:

- Two hospitals are identical except for the fact that one renovated its facility 2 years ago, and the other carried out a comparable renovation 10 years ago. In this case, controlling for age of capital would correctly treat the hospitals as having the same capital cost.
- A hospital that has been financially successful recently made a large capital expenditure last year because it needed to put its surplus to work. A financially strapped hospital has been unable to make badly needed capital repairs. In this case, controlling for age is also appropriate. The financially successful hospital's capital cost is in effect lowered, and the financially strapped hospital's capital cost is raised. The two hospitals are not treated as having different capital costs just because of differences in their financial circumstances. Further, if successful and strapped hospitals tend to consistently have certain characteristics found in the operating model, failing to control for age would indirectly attribute differences in financial status to those operating characteristics.
- A hospital located in a rapidly growing area has made large capital expenditures every year for the last 5 years in order to meet the needs of its population. Another hospital located in an area with three other hospitals has experienced declining occupancy for several years and has not made a major capital expenditure for many years. In this case, controlling for age differences will treat the hospitals as being alike, when it would be desirable to recognize the appropriateness of the higher cost of the first hospital. It will not be possible to do so unless other variables that distinguish these hospitals' circumstances can be identified. In this particular example, several possibilities may be available (occupancy rates, the rate of area population growth, degree of market competition, etc.). However, in general, it most likely will not be possible.

The second factor specific to capital-cost variation pertains to debt financing. Because Medicare capital cost includes interest expense, hospitals that borrow relatively heavily will have higher Medicare capital costs than hospitals that use more equity to finance their capital purchases. The ratio of total liabilities to total assets (TLTA) was included in the cost equation to control for this source of variation. This variable was included instead of the ratio of long-term liabilities to total fixed assets because TLTA was more highly correlated with capital cost. This result may occur because, on Medicare cost report balance sheets, total categories appear to be more accurately reported than their components. It should be noted that TLTA is included in the cost equation to account for variation in Medicare capital cost; no attempt is made to explain the variation in the relative use of debt financing. Questions of hospital capital structure are beyond the scope of this analysis.

Finally, two additional variables of special interest for capital were included: occupancy rate (OCCUP) and a capital construction cost index (CCI). The occupancy rate could have been included in the set of operating characteristics but given the more fixed nature of capital cost, OCCUP is expected to have a stronger effect on capital cost. It may also help identify situations such as the one previously discussed. The CCI was included to reflect locational differences in capital costs.

Estimation results

Table 3 presents estimation results for the capital- and total-cost models. The first three columns contain the capital models, and columns 4 and 5 show the total cost results. Column 1 includes only the variables commonly found in operating-cost models. In column 2 the three age-related capital variables intended to account for differences in the timing of capital spending have been added. Column 3 presents the full capital model including the effects of relative debt, occupancy, and construction costs. Column 4 shows the result of applying the operating model to total cost, and column 5 adds the full set of capital variables to the total-cost model.

The data set comprises 2,859 hospitals whose capital variables passed a series of consistency edits. These hospitals cannot be regarded as representative of all U.S. short-stay hospitals. Although very similar in many ways, the greatest differences appear to be in urban-rural location and teaching status. Only 23 percent of the 2,859 hospitals are in metropolitan areas with a population of more than 1 million, compared with about 26 percent of all hospitals. Almost 50 percent of the sample hospitals are in rural areas, compared with less than 47 percent of all hospitals. Major teaching, proprietary, and government hospitals are also under-represented. There may be a systematic relationship between complexity or special features of corporate structure and the absence of usable balance sheets. The effects of this limitation on the cost models reported in this article could not be determined.

Two years of Medicare cost report data (PPS-5 and PPS-6)[2] were pooled, and a dummy variable was included for the PPS-6 year. All variables are derived from Medicare cost reports with the exception of the CMI, which is based on fiscal year (FY) 1988 and FY 1989 MedPAR; WI, which is constructed from the 1988 HCFA wage survey (excluding the effects of the 1990-91

[2]PPS-5 cost reports are for the hospital accounting year beginning on or after October 1, 1987, and no later than September 30, 1988. PPS-6 reports are for the hospital accounting year beginning on or after October 1, 1988, and no later than September 30, 1989.

Table 3
Medicare inpatient capital- and total-cost models[1]

Independent variables	Capital-cost model			Total-cost model	
	1	2	3	4	5
Intercept	5.509	6.493	6.338	8.099	8.243
	(250.098)	(116.265)	(110.374)	(871.932)	(296.546)
PPS-6	0.016	0.050	0.040	0.078	0.080
	(1.230)	(4.439)	(3.727)	(14.564)	(15.212)
ln CMI	1.519	1.327	1.475	1.019	1.057
	(24.489)	(23.898)	(26.396)	(38.956)	(39.078)
ln WI	0.080	0.216	0.022	0.714	0.598
	(1.298)	(3.920)	(0.289)	(27.515)	(16.045)
RESDAY	–0.104	–0.003	–0.005	0.250	0.266
	(–0.734)	(–0.053)	(–0.090)	(9.894)	(10.767)
DSUL	–0.008	0.064	0.004	0.077	0.077
	(–0.137)	(1.181)	(0.082)	(3.009)	(3.054)
DSUS	–0.347	–0.204	–0.271	–0.100	–0.087
	(–2.914)	(–1.914)	(–2.642)	(–1.990)	(–1.748)
DSRL	0.005	–0.359	–0.354	–0.234	–0.248
	(0.042)	(–3.221)	(–3.274)	(–4.444)	(–4.752)
DSRS	0.289	–0.433	–0.478	–0.306	–0.299
	(–4.296)	(–7.219)	(–7.798)	(–10.765)	(–10.075)
LARGE	0.299	0.161	0.191	0.081	0.086
	(9.147)	(5.519)	(6.532)	(5.853)	(6.078)
OTHER	0.164	0.036	0.060	0.016	0.022
	(5.670)	(1.374)	(2.274)	(1.352)	(1.770)
PROP	0.325	0.041	0.006	0.067	0.019
	(14.273)	(1.897)	(0.268)	(6.932)	(1.844)
GOVT	–0.086	–0.067	–0.037	0.006	0.016
	(–5.618)	(–4.928)	(–2.720)	(0.959)	(2.470)
BEDSGE100	0.137	0.144	0.161	0.087	0.099
	(4.929)	(5.848)	(6.620)	(7.468)	(8.397)
ln AGE		–0.398	–0.384		–0.053
		(–27.477)	(–26.548)		(–7.627)
ln RLIF		0.110	0.133		–0.009
		(5.919)	(7.416)		(–1.022)
ln TFATA		0.388	0.280		0.053
		(17.316)	(12.756)		(4.949)
ln TLTA			0.178		0.037
			(21.693)		(9.343)
ln OCCUP			–0.136		–0.048
			(–9.335)		(–6.828)
ln CCI			0.081		0.160
			(0.975)		(3.975)
Adjusted R^2	0.426	0.546	0.585	0.717	0.730

[1]The dependent variables are the logarithms of Medicare inpatient capital and operating cost per discharge. The regressions are based on pooled PPS-5 and PPS-6 Medicare cost report data for 2,859 hospitals.

NOTES: PPS is prospective payment system. For a complete definition of independent variables, see "Modeling capital-cost differences" in the text. *t*-statistics in parentheses. ln is natural logarithm.

SOURCE: Health Care Financing Administration, Office of Research and Demonstrations: Based on data from Medicare cost reports: Hospital Cost reporting Information System.

decisions of the Medicare Geographical Classification Review Board); and the CCI, which was developed for HCFA by the Center for Health Economics Research (Pope, 1991.) The functional form of all models is a hybrid log-linear-exponential function. The dependent-cost variables and all independent variables are in logarithms with the exception of the teaching variable (RESDAY), the disproportionate share variables (DSUL, DSUS, DSRL, and DSRS), and other dichotomous variables that are exponential in form. That is, the teaching and disproportionate share variables are not in logarithms.

Capital models

Table 3, column 1 shows that the operating-cost model explains 43 percent of the variation in capital cost. Case mix shows the strongest effect, followed by the urban dummy variables and the beds variable. There are several disturbing aspects to these results. For example, the CMI coefficient is much greater than 1, which implies that capital cost increases disproportionately with case mix. PPS operating payments are designed to increase proportionately with case mix, and operating-cost models have supported that relationship. In addition, the urban

variables typically are thought of as picking up residual unexplained locational effects not captured by the other key variables. Ideally, these unexplained effects would be small. Therefore, the large magnitude of the urban variables, combined with the statistically insignificant or marginally significant performance of the wage index, teaching, and disproportionate-share variables, is particularly troublesome. The coefficient of PROP indicates that proprietary hospitals' capital costs are 38 percent higher and (GOVT) hospitals' costs are 9 percent lower than those of voluntary hospitals.[3]

Table 3, column 2 indicates that adding the age of capital variables to the model improves the explanatory power noticeably (the R^2 increases to .55). All of the age variables have the expected signs and are highly statistically significant. Also, the behavior of the operating variables resembles somewhat more closely their behavior in operating-cost regressions (Sheingold, 1990.) The wage index is now positive and significant, and, as might be expected, its coefficient is much smaller than in operating-cost regressions. The disproportionate-share variables are qualitatively similar to the typical operating-cost model. Though not significant, the large urban disproportionate-share variable is now positive, and the small urban and rural variables are negative and generally significant. However, the CMI coefficient still greatly exceeds 1, and the teaching variable is very close to zero. Interestingly, the urban and proprietary hospital dummy variables are reduced dramatically, and only the large urban variable remains statistically significant at the .05 level. This result implies that to a large extent, urban and proprietary hospitals' higher capital costs result from their greater recent spending. In contrast, the coefficient of the bed-size variable is hardly affected by the addition of the age variables.

The results for the full-capital model appear in column 3 of Table 3. There is a small improvement in explanatory power compared with the age-only capital model (the R^2 is .59). With the exception of the construction-cost index, all the capital variables are strongly statistically significant. The only operating variable that changes much is the wage index, which becomes statistically insignificant. The small, statistically insignificant coefficients of the wage- and construction-cost indexes suggest effects of multicollinearity. Indeed, the two indexes are highly positively correlated (.80). However, regressions not reported in Table 3 indicate that merely dropping one of the indexes does not strengthen the remaining index. The interrelationships appear to be more complicated and involve the combination of age and financing variables.

To further explore the issue of multicollinearity, the Klein test was performed for the full-capital model (Maddala, 1977.) Each independent variable was regressed on the remaining independent variables. The R^2 of each independent variable regressions was then compared with the R^2 of the full-capital model. Under the Klein test, multicollinearity is likely to create problems when the R^2 of an independent variable regression exceeds that of the main regression. Only the wage- and construction-cost indexes fail the strict application of the Klein test for all three capital models estimated. However, the CMI also fails the test for the model with only operating variables, and the occupancy rate would fail for similar models. Unfortunately, the Klein test does not provide a prescription for curing the ills of multicollinearity. A major econometric advantage of the total-cost models is that their higher overall explanatory power reduces the impact of the collinearities.

Total cost models

Table 3, column 4 shows the results of applying the operating-cost model to total cost. The R^2 is .72, and all but two variables are statistically significant at the .05 level.[4]

The CMI coefficient is not statistically different from 1. The wage index behaves as expected; there is a positive, highly significant teaching effect. The disproportionate share effect for large urban hospitals is positive, but small. The disproportionate-share variables for small urban and rural hospitals are negative and statistically significant. Both the dummy variables for large metropolitan areas and large hospitals are positive and significant. The higher costs of proprietary hospitals compared with voluntary hospitals are statistically significant, but government hospitals' costs do not differ significantly from those of voluntary hospitals.

Column 5 of Table 3 presents the total-cost results using the full-capital model. Although the addition of the capital variables increases the overall explanatory power only slightly (the R^2 is .73), all of the capital variables are statistically significant with the exception of the variable RLIF. However, the elasticities of the capital variables are no larger than .05, except for the construction-cost index, whose elasticity is .16. Few of the operating-cost variables are affected by the addition of the capital variables, and their coefficients are very similar to those in column 4. The largest change is the wage index, whose coefficient declines from .71 in column 4 to .60 in column 5. The addition of the capital variables reduces the coefficient of PROP, which is no longer significantly different from 0 at the .05 level. The coefficient of GOVT rises slightly and becomes statistically significant.

Discussion

The results previously described demonstrate that the special characteristics of capital have an important effect on the cross-section variation in hospitals' capital costs. The capital variables perform as expected and add substantial explanatory power to the capital-cost models. The chief implication of this finding is that hospitals' past capital spending and financing decisions deserve serious attention in working out the transition from cost-based payment to prospective payment. In the long run, a

[3]The coefficients of the variables PROP (.325) and GOVT (–.086) in column 1 of Table 3 are transformed to percent differences by exponentiating them, subtracting 1, and multiplying by 100.

[4]The higher explanatory power of the total-cost model is hardly surprising given operating cost's dominant weight in total cost. Further, the higher explanatory power of the total-cost model in no way implies that the total-cost equation explains more capital-cost variation than the capital-cost equation. Although the age and financing variables included in the capital-cost models added significantly to the explanatory power of these models, there clearly is much that remains to be learned about capital cost variation.

hospital's Medicare prospective payment should, like market prices in general, be independent of the hospital's capital timing and financing decisions. In this context, the age and financing variables are appropriately used as control variables, serving to prevent their effects from being attributed to other factors that may be used to adjust the long-run payment.

However, other problems encountered in estimating the capital-cost models limit their usefulness for prospective payment. First, the Medicare balance sheet data required for the construction of the key age and financing variables are unusable for a large number of hospitals. Of special concern is the apparent systematic under-representation of certain types of hospitals, such as hospitals from large urban areas, major teaching hospitals, and proprietary hospitals. These types of hospitals may be more likely to have unusual capital items that complicate their balance sheets and result in their failing simple reasonableness screens.

Second, although the capital variables performed well in the capital-cost models, the key payment variables performed poorly compared with the total-cost model. The coefficient of the case-mix index was greater than 1, which implies that payments and costs would not be consistent with one another across the range of case-mix values (as previously discussed). Also, multicollinearity made it impossible to obtain reasonable estimates of the effects of the wage- and construction-cost indexes.

In addition to these limitations of the capital-cost models, there is another reason for preferring to base the long-run capital prospective payment on the total-cost model. In the total-cost model, the capital variables have little impact on the coefficients of the key operating variables. As a result, the capital variables could be ignored in designing payment adjustments based on total cost. Assuming that this result holds more generally, the ability to estimate the total-cost model using all hospitals also offers a solution to the problem of sample unrepresentativeness encountered with the capital-cost model.

As noted at the beginning of this article, capital's special characteristics are not unique to hospitals. A single price covering both capital and operating inputs is the norm for most enterprises. A single price or, equivalently, a common set of adjustments for capital and operating payments is also the simplest way to make hospitals indifferent to Medicare payment policy in choosing how to combine capital and operating inputs. The empirical findings of this article support using the total-cost models to develop a common set of adjustment factors for capital and operating prospective payment amounts.

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