Trends in hospital labor and total factor productivity, 1981-86

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The per-case payment rates of Medicare's prospective payment system are annually updated. As one element of the update factor, Congress required consideration of changes in hospital productivity. In this article, calculations of annual changes in labor and total factor productivity during 1981-86 of hospitals eligible for prospective payment are presented using several output and input variants. Generally, productivity has declined since 1980, although the rates of decline have slowed since prospective payment implementation. According to the series of analyses most relevant for policy, significant hospital productivity gains occurred during 1983-86. This may justify a lower update factor.

Introduction

The introduction of Medicare's diagnosis-related group prospective payment system (PPS) in fall 1983 produced major changes in the productive efficiency of hospitals and the manner in which patients are treated. To preserve dynamic incentives for efficiency without overpaying for care, the Health Care Financing Administration (HCFA) has also implemented a methodology for updating payment rates on an annual basis that is based on a hospital input price index. The Prospective Payment Assessment Commission (ProPAC) has critically reviewed HCFA's methodology and offered suggestions for adjusting the update factor (called the discretionary update factor) in various ways. These include positive and negative adjustment for nominal versus real case-mix change, scientific advances in medicine, and productivity improvement. In this article, we are primarily concerned with the last issue. If hospitals have been enjoying productivity gains during the PPS period, society could rightfully share in those gains in the form of lower updates without financial harm accruing to the industry.

Although many productivity variants exist, two generic types are presented here: hospital labor productivity and hospital total factor productivity, including capital inputs. As long as capital is reimbursed by HCFA on a passthrough basis, a good argument can be made for using a labor productivity index to update rates. If labor productivity gains have been achieved through large capital investments, it is still proper to adjust operating costs for such gains because the capital costs that generate them are passed through. If at some time the Congress folds capital costs into the prospective payment, then a more global total factor productivity index would be the appropriate measure.

Three questions relating to productivity adjustments are addressed in this article. First, what have been the rates of growth in labor and capital inputs before and after PPS was implemented in 1983? Second, how are these trends affected by adjusting for changes in skill mix and capacity utilization? Third, using several output variants, what have been the overall labor and total factor productivity trends before and after PPS was implemented?

To the extent that hospital productivity is down because of declining volumes under PPS, policymakers may want to use a higher productivity growth index adjusted for capacity underutilization in setting the PPS update. Conversely, if hospitals have achieved higher productivity by hiring more expensive workers, a factor not routinely captured in the hospital market basket, policymakers may prefer to use a lower productivity index adjusted for skill mix.

The rest of the article is organized as follows. In the next section, we provide a theoretical context in which to measure and interpret productivity trends. This is followed by three sections in which we discuss the measurement of hospital output and labor and capital inputs. Next, we review the data sources, define PPS-type hospitals, and calculate several output and input series. In the following section, we provide empirical estimates of input and productivity trends using alternative output and input variants. The article concludes with a brief section on the implications and feasibility of using total factor or labor productivity measures in updating PPS rates.

Multifactor productivity model[1]

Both labor and total factor productivity change can be derived from a Hicks-neutral specification of the production function for output:

$$Q_t = A(t) f [K(t), L(t)], \qquad (1)$$

where $Q(t)$ is a measure of real output in year t, $K(t)$ is a measure of the flow of capital services during year t, $L(t)$ is the flow of labor services, and $A(t)$ is an index of multifactor productivity change during the year. Differentiating with respect to time and solving for the rate of output growth, we have

[1]Theoretical presentations similar to that given here can be found in Baily (1982), Darby (1984), and Mark and Waldorf (1983).

$$\frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + \frac{\partial Q}{\partial K} \frac{K}{Q} \frac{\dot{K}}{K} + \frac{\partial Q}{\partial L} \frac{L}{Q} \frac{\dot{L}}{L}, \qquad (2)$$

where dots indicate absolute changes with respect to time. $(\dot{A}/A)$ represents the rate of change in multifactor productivity, which is easily seen by rewriting equation (2) as

$$(\dot{A}/A) = (\dot{Q}/Q) - [W_K (\dot{K}/K) + W_L (\dot{L}/L)], \qquad (3)$$

where $W_K = (\partial Q/\partial K) (K/Q)$ and $W_L = (\partial Q/\partial L)$ (L/Q) are the elasticities of output with respect to capital and labor, respectively. Productivity change is derived as the difference in two percentage changes: $\dot{Q}/Q$ (the percent change in real output) and the weighted percentage change in capital and labor inputs.

The marginal products of capital and labor, $\partial Q/\partial K$ and $\partial Q/\partial L$, are not directly observable, so economists usually rely on the competitive market assumption that marginal products equal real input prices. This allows us to assume that W_K and W_L are equal to the shares of costs attributable to capital and labor, respectively, which are observable (e.g., the 80-20 percent labor-nonlabor split used in PPS, excluding building and movable equipment capital costs).[2]

Disembodied technical progress, $\dot{A}/A$, has a special meaning for price setting in any industry. It represents the additional output, and hence, revenue, that is enjoyed by producers once they have paid for any additions to their capital and labor inputs. Regulators could reduce the rate of price increase resulting from economy-wide inflation by the percent change in total factor productivity and not damage the financial position of producers, including their capital costs.

Sometimes, it is useful to consider a partial productivity measure for labor alone. This can be derived from equation (2) by subtracting the growth rate of labor from both sides of the equation and assuming that $W_L = 1 - W_K$:

$$(\dot{Q}/Q) - (\dot{L}/L) = \dot{l}_L =$$
$$(\dot{A}/A) + W_K [(\dot{K}/K) - (\dot{L}/L)] \qquad (4)$$

Labor productivity change alone is decomposed into the rate of disembodied technical change and the growth in the capital-labor ratio, weighted by capital's share. Labor can become more productive in any period either because it shares in technical progress generally or because it has more capital to work with.

So far only disembodied technical progress has been considered. Yet, gains in productivity generally do not fall like manna from Heaven but rather are embodied in new equipment or better trained workers who cost money. Moreover, we have not considered the possible underutilization of fixed capital stocks and

fixed administrative labor. All three can be incorporated into the productivity equation, thereby eliminating the abstract, disembodied technical change term.

Assuming a constant returns-to-scale Cobb-Douglas production function, disembodied technical change can be decomposed as follows (Mark and Waldorf, 1983).

$$\frac{\dot{A}}{A} = W_K(n + u) + W_L s, \qquad (5)$$

where W_K and W_L are the shares of capital and labor, respectively, in total costs; n is the rate of growth in capital productivity resulting from technical change; u is the rate of change in the rate of capacity utilization (which can be proxied for hospitals by changes in the occupancy rate); and s is the rate of growth in labor productivity resulting from better qualified workers. The measured rate of productivity growth using unadjusted capital stocks and full-time equivalent employees, $\dot{A}/A$, can be considered to derive from capital-embodied technical change, n, adjusted downward, if necessary, for less capacity utilization, u, and from an improved labor force, s, each weighted by the corresponding capital and labor shares. Thought of another way, if raw capital and labor inputs were augmented to account for their improved quality, no measured productivity change would occur, unless, of course, some residual, disembodied, technical progress were also taking place that was not allocatable to either input. This is because the actual productivity gain has been included (embodied) in inputs by raising their effective levels.

Explaining productivity change by embodying it in hospital inputs does not eliminate the rationale for reducing the update factor for productivity gains. On the contrary, what is sought by the regulator is a better understanding of where the productivity change, positive or negative, is coming from, as different sources require different adjustments. If society did not want to shelter producers from any of the utilization decline, then a higher rate of productivity gain would be used that ignored the decline. Deriving an estimate of u and applying it to equation (5) allows us to make such an adjustment. Conversely, if protecting hospitals against utilization declines were deemed socially desirable, then the observed productivity trend would be more appropriate (and less stringent). The same is true of a skill-mix adjustment, s, which would raise measured labor inputs and reduce the rate of productivity growth, thereby reducing the debit to the update factor. This is desirable if it is presumed that hospitals have had to pay higher salaries for these higher skilled workers.

Let us now turn to a discussion of the proper measurement of output and inputs.

Nature of hospital product

Many candidates have been proposed for defining the hospital product, including patient discharge,

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[2]Whether capital and labor shares are truly indicative of relative marginal products in the hospital industry is debatable. Nonprofit institutions may have a technology bias that results in the MP_K being less than W_K through overinvestment in beds and equipment. Lee (1971), Salkever and Bice (1976), and Cromwell (1987), among others, have discussed this issue.

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patient day, service mix, treatment of the illness episode, health outcomes, intermediate inputs, and composite units. (A detailed review and critique of this literature can be found in Berki, 1972.) The first of these, the discharge, stratified by diagnosis-related group, is now the operational unit of PPS payment. Employing the economic paradigm of treating the product itself as a variable (Hirshleifer, 1980), we can express total hospital output as

$$Q_h^* = Z_h \cdot ADM_h, \qquad (6)$$

where Q_h^* = content-adjusted total hospital output in hospital h; ADM_h = total admissions; and Z_h = average product content per admission in the hth hospital. The Z_h term has been commonly used in economics to reflect product quality, as in the quality grade associated with a given raw output rate (e.g., miles per gallon of regular versus premium gasoline). It includes attributes of the admission—ultimately, improvements in health status. If health outcomes are unmeasured, the intermediate services used in treatment can be taken as hospital output, and Z measures the intensity of services per admission.

Taking the logarithms of equation (6) and differentiating with respect to time decomposes the temporal growth in the hospital's ultimate product into two terms:

$$\frac{\dot{Q}^*}{Q} = \frac{\dot{Z}}{Z} + \frac{\dot{ADM}}{ADM} \qquad (7)$$

The first term on the right-hand side reflects the growth in quality, or improvements in health outcomes or service intensity for the average patient; the second is simply the raw change in admissions. Only if quality growth is zero ($dZ/dt = 0$) does admissions growth provide a true measure of the change in hospital output. For $dZ/dt > 0$, true hospital output can rise without any admissions growth.

Changes in per-admission content can result from the rate of technical (medical) innovation, but also relevant are changes in average health status. If admitted patients were becoming sicker over time, then real output (in Q^* terms) could rise even though ADM fell. This could occur because of the greater resources necessary to treat sicker patients. It is the reason that case-mix severity trends should be presented together with admissions trends.

Ideally, hospital output should be measured as content-adjusted admissions, as indicated in equation (6). Unfortunately, content per admission, Z_h, is extremely difficult to observe directly. However, content-adjusted hospital output can be measured indirectly by using hospital revenues and prices. If the amount hospitals are paid (or bill) is based on the content of their admissions, then hospital revenue R is

$$R_h = P_c \cdot Q_h^* = P_c \cdot Z_h \cdot ADM_h, \qquad (8)$$

where R_h = total revenue of hospital h, and P_c = price per content unit of hospital output.

Hospital revenue deflated by the price per content unit therefore yields a measure of content-adjusted hospital output:

$$R_h/P_c = Z_h \cdot ADM_h = Q_h^*. \qquad (9)$$

The deflated revenue measure of hospital output incorporates changes in hospital case mix and intensity of treatment. If the content of hospital admissions Z_h is rising because hospitals are treating a more severe case mix or treating the same patients more intensively, billed charges increase to reflect the greater services per admission, even if admissions are constant.

Deflated revenues have been widely used by economists as a measure of real output. For example, Denison (1979) and others have produced estimates of the economy-wide effectiveness of human capital improvements using real gross national product as an output measure. It should be remembered that, in the hospital sector, revenues measure only the production of intermediate services, not the final output, health. If a hospital produces and bills for more tests, days, and services with the same inputs of capital and labor, it appears more productive on a deflated revenues basis. However, if the added tests, days, and services do not augment patient health status at discharge, the hospital is not more productive in bringing about health. This limitation is shared by admissions and days output measures. Indeed, they are worse because they err on the other side in reflecting no increases in intensity. Measuring productivity regarding health will be possible only when measures of health outcome become available or when hospitals are paid on the basis of their increments to health status rather than the services they produce. The best we can do at present is measure productivity in the production of intermediate services that go into the production of health outcomes.

Given the limitations of either admissions or revenues alone as a hospital output measure, we use both in our empirical work. Hospital outpatient output is accounted for by converting outpatient services to inpatient equivalent admissions (American Hospital Association, 1985) or by adding outpatient to inpatient revenue. Because the admissions output measure does not fully reflect all growth in output, negative productivity growth may be indicated in some of the calculations using admissions as an output measure.

Measuring labor inputs

In addition to capital, the other major input needed to calculate a total factor productivity measure is labor. Labor can be measured in a number of ways, or, alternatively, a number of adjustments can be made to an initial labor measure. For example, labor can be measured in terms of hours of input or number of employees. Measuring hours would be preferable to measuring employees in most situations, because a measure based on employees will not take

into account changes over time in the average number of hours worked per employee. Even if the employee measure is expressed in full-time equivalents, an employee measure will not fully capture changes in hours worked because of secular trends in the work week. Consequently, hours of labor input are utilized in most studies if such data are available. For example, Mark and Waldorf (1983), Baily (1982), and Darby (1984) all calculate productivity in terms of hours, although Darby also presents results per employee. However, in some instances, the only data available are for numbers of employees.

When using hours as the measure of labor input, one usually must work with data that represent hours paid, not hours actually worked. To the degree that the ratio of hours worked to hours paid changes over time, paid hours will be an inaccurate measure of the actual level of labor input used in the production process.

In addition to adjustments concerning the quantity of labor services, adjustments can also be made for the quality of the labor input. Producers may be able to obtain more output from a given unit of labor input by increasing the quality of the labor employed. In this situation, a raw measure of input, such as total paid hours, will indicate an increase in observed productivity. However, in order to hire the higher quality labor, the employer will most likely have to pay more per unit of labor. If the purpose of the productivity measure is to indicate those changes in output that are not reflected in changes in the real resource costs of inputs, then ideally the labor input should be quality adjusted.

A number of adjustments can be made for labor quality. For example, Darby (1984) adjusts for age, sex, education, and immigration status. After adjusting for these characteristics, he calculates that the average annual growth rate in hourly labor productivity increased from 2.27 to 2.34 percent for 1965-73 and from 0.64 to 0.72 percent for 1973-79. These small changes are indicators that quality adjustments to labor services in the hospital industry might not be an important factor, at least over short periods. National figures, on the other hand, may not be representative of any single industry. The issue of labor quality adjustments is also mentioned in the work of Mark and Waldorf (1983), who present new Bureau of Labor Statistics multifactor productivity measures. (However, no such adjustments are actually made to the Bureau of Labor Statistics measures.)

Adjustments for employee characteristics are usually based on the relative wages paid to these groups. Wage levels largely reflect productivity differences. However, they may also reflect discrimination for or against the characteristics possessed by the group (for example, older females). To the degree that wage differences reflect discrimination rather than differences in the ability to produce output, quality adjustments based on wage levels will distort measures of productivity. This issue is explored briefly by Darby (1984).

Another approach to account for changes in labor quality is to track the changing occupational mix of the labor input. This approach is not particularly appropriate for aggregate productivity measures because occupational titles may not be comparable across industries. However, adjustments based on occupation could be appropriate for a more narrowly defined sector, such as the hospital industry.

A skill-mix-adjusted employee count can be derived from

$$L_t^* = \sum_j (W_j/W_o)L_{jt} , \qquad (10)$$

where L_t^* is the number of occupationally adjusted workers; W_j is the wage of the jth occupational group; W_o is the wage of the numeraire, or base, category; and L_j is the number of full-time equivalents in the jth occupation in year t. Relative wages are used as occupation weights to reflect relative marginal products of inputs, again assuming competitive wage determination.[3] The ratio of $L_t^*/\Sigma_j L_{jt}$ is the index of labor quality, and $(\dot{L}/L)^* = s + (\dot{L}/L)$ is the rate of change of labor in efficiency units.

Measuring capital inputs

Capital inputs present a special measurement problem because—unlike labor—machines, beds, and buildings are usually purchased, not rented. The annual flow of capital services, therefore, is not observable, as labor man-hours are, but must be imputed. In earlier studies of industry productivity (Kendrick, 1961), it was assumed that changes in net capital stocks were proxies for changes in their flow of services as well. In more recent studies (Jorgenson, 1963; Feldstein, 1982; Auerbach, 1984; Mark and Waldorf, 1983), the concept of user cost of capital has been incorporated. When the user cost is rising, it is assumed that the flow of services is also rising, explaining the retention of capital in a given mode of production; that is to say, the flow of capital services in production in any period is approximated by the rental cost of capital. (A considerably more complicated version of the cost of capital in which hospital cost-based reimbursement as well as taxes are considered can be found in Wedig, Hassan, and Sloan, 1985.)

Capital theorists like Jorgenson have argued for the explicit recognition of imputed interest rates and asset appreciation as well as simple asset depreciation. If long-term interest rates have averaged 5 percent, then capital services must return at least 5 percent over and above depreciation to justify the marginal investment. A debit to the imputed interest rate is also made for capital appreciation. Lower operating returns are acceptable to investors if asset values are appreciating.

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[3]Some debate exists in the literature on philanthropic wage setting by hospitals (e.g., Feldstein, 1970, versus Sloan and Steinwald, 1980). Nonprofit maximizing behavior, however, should have less effect on relative wages.

Jorgensonian capital theory would require that real capital stocks be adjusted upward or downward each period for changing interest rates. However, if interest and appreciation rates that appear in the implicit rental price are unchanged across the period of analysis, the capital input index (or ratio of annual flows) becomes only a function of changes in deflated stocks, greatly simplifying the analysis. In fact, stable long-run values of all three components of the user cost of capital (i.e., interest rates, depreciation, and asset appreciation) are preferred. Short-run changes in interest rates or asset appreciation probably do not reflect real input changes because of the lack of time for investors to reallocate capital. Because we are interested in measuring real input growth to derive productivity trends, we deflate the annual increase in unit purchase prices from changes in the hospital net asset series. An implicit adjustment for depreciation is made by relying on the net book value of assets, which is defined as the difference between original purchase prices and accumulated depreciation. Without additions to capital stocks, existing buildings and equipment will depreciate, which will lower their productive capacities.

Data sources and empirical methodology

The principal data source for the analysis was the Annual Survey of Hospitals of the American Hospital Association (AHA). The AHA provided an aggregated tape of utilization, capital, and labor data for the years 1980-86. The data items included admissions and inpatient days (both unadjusted and adjusted for outpatient activity), gross and net plant and equipment assets, annual capital expenditures by type (buildings or movable equipment), and full-time equivalent (FTE) workers in 29 occupational categories, e.g., doctors of medicine, registered nurses, licensed practical nurses, dietitians, and radiographers.

To approximate PPS-included hospitals, the AHA aggregated data on all short-term, general, non-Federal hospitals (AHA service code 10) plus non-Federal obstetrics-gynecology, rehabilitation, orthopedic, chronic, children's, and other specialty hospitals (AHA codes 11, 12, 44-51, and 55-59). Unfortunately, rehabilitation, chronic, and children's hospitals are not covered by PPS. However, all hospitals with average lengths of stay greater than 29 days were excluded from the AHA data. This eliminated all chronic, the majority of rehabilitation, and about two-fifths of children's hospitals from our sample. Altogether, out of a total of 5,800 hospitals, roughly 100 PPS-excluded hospitals, or less than 2 percent, were inadvertently included. The AHA will not release asset data for individual hospitals. However, a compromise resulted in the aggregation of data for each hospital type by State by region. This allowed us to cross-sectionally deflate the investment series by State before further aggregating to all U.S. hospitals. The AHA provided the number of reporting hospitals by State to assure us that any unexpected increases or decreases in the aggregates did not result from nonreporting. We used the AHA tape that had missing data imputed because our goal was to analyze industry totals, not individual hospitals. Missing data would have been treated as zeroes otherwise, biasing output or input estimates downward.

To incorporate changes in hospital skill mix, we constructed an occupation-adjusted labor index using the general methodology described earlier. The adjusted labor input index was created by weighting raw AHA figures for FTE's across the 29 hospital occupations by their relative wages and then summing.[4]

A measure of hospital capital inputs was derived from net plant and equipment assets aggregated to the State level. A base national 1980 value of net plant and equipment assets was computed by adjusting the value for each State for cross-sectional differences in the price of capital, using the Dodge Construction Cost Index, and then summing across States. To measure intertemporal changes in capital input, State-level, year-to-year changes in net fixed assets were deflated by cross-sectional and intertemporal capital price indexes to put them in cross-sectionally adjusted 1980 dollars; they were then cumulatively added to the 1980 base. Ideally, we would have adjusted the 1980 base net asset figures for different capital ages in different States, but we lacked the data to make such an adjustment. However, as our main focus is on real capital growth since 1980, this should not be a serious problem. The price indexes used were the Dodge Index, weighted 75 percent, and the Marshall and Swift hospital equipment price index, weighted 25 percent.

Our measure of capital growth may be biased upward. This is because, although we put post-1980 changes in hospital net assets in 1980 dollars, the base 1980 net asset figure to which they are added is in historical, not 1980, dollars; that is, the 1980 net asset figure is an accounting number, with the value of assets presumably entered at their original purchase price. Given price inflation, the historical purchase price (less historical depreciation) is an understatement of the value of the assets in 1980 dollars. Hence, our calculated capital growth rates may be somewhat too high, turning total factor productivity growth rates negative. To the extent that the calculated capital growth rates are biased, more weight should be given to the labor productivity growth rates we present.

A total factor input index was constructed by weighting capital and labor growth rates by their expenditure shares (as explained earlier) and then summing. We did not calculate a growth rate of inputs that were neither labor nor plant and equipment. This category consists mostly of supplies such as drugs, food, chemicals, and instruments, but it also includes energy and business and other services. Some rough calculations of real input growth in this

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[4]An appendix containing details of how this weighting process was accomplished is available from the authors on request.

category were performed using deflated AHA nonlabor expenditure data, PPS market-basket cost shares for 1982, and market-basket price proxies. According to these calculations, the growth rate of these inputs approximated the growth rates for plant and equipment over the period 1980-86. Therefore, the plant-and-equipment growth rates were weighted by the share of all nonlabor inputs. From rebased 1982 market-basket weights, including capital, given in the *Federal Register* (1986), the labor-related share is 67.33 percent and the non-labor-related share is 32.67 percent. These shares were used to combine the various labor and capital indexes.

A revenue-based hospital output measure was developed from the annual data on inpatient and outpatient revenue of community hospitals reported in the AHA's *Hospital Statistics*. The AHA reports both gross and net revenues. Gross revenues are what hospitals charge. Net revenues are gross revenues less deductions for contractual adjustments, bad debts, and charity care. Because gross revenues are more consistent with our charge-based price deflator (as discussed in the next paragraph) and reflect actual services rendered to patients (including uncompensated care), our revenue-based output measure is deflated gross, rather than net, revenues.

To provide a measure of hospital output, revenues must be deflated by a price index of hospital output. (The need for a deflator was discussed earlier.) We used the "hospital and related services" component of the Consumer Price Index for this purpose. It incorporates hospital, nursing home, and convalescent room rates plus charges for 12 general hospital service categories, such as anesthesia, operating room, radiology, and pharmacy. The price index rose 78 percent from 1980 to 1986, which is equivalent to 9.6-percent annual inflation on a compounded basis.

Ideally, the price index should be of quality-adjusted or constant output. If the rising quality or intensity of hospital output is reflected in the index through higher prices, then deflated revenues will understate the growth in the content of hospital output. Unfortunately, although it appears to be the best price deflator available, hospital room prices almost certainly reflect the increased content of hospital output in addition to pure inflation because hospitals raise their room rates to pay for additional services they provide. For this reason, our deflated revenues measure probably understates the rate of growth of hospital output, but the downward bias should be less than for admissions or days. To the extent that output growth is understated, productivity growth estimates will be too low or even negative.

Trends

Hospital output

Trends in short-term general hospital output for 1980-86, using admissions, patient days, and deflated revenues output measures, are shown in Table 1. For each variable, trends in inpatient output and inpatient

plus outpatient (outpatient-adjusted) output are presented. Admissions fell gradually from their 1981 level of 36.5 million for 2 years; after 1983, they declined sharply, at an average annual rate of 3.6 percent, to 32.4 million in 1986. ProPAC's estimates of real case-mix severity increase are 0.5 percent per year for the period 1981-83, 0.7 percent in 1984, 0.8 percent in 1985, and 2 percent in 1986 (Prospective Payment Assessment Commission, 1988). Based on these figures, the percent changes in admissions shown in Table 1 understate the growth in output by 0.5 percent annually for 1981-83 and by 0.7 and 0.8 percent in 1984 and 1985, respectively. The 2-percent case-mix severity increase in 1986 would give a decline in admissions of −1.3 percent instead of −3.3 percent.

The drop in outpatient-adjusted admissions after 1983 (an average annual rate of −1.7 percent) was less than one-half as great as the drop in unadjusted admissions because of the shift in care to the outpatient department. Patient days declined at a more rapid rate than admissions after 1983 (−5.6 percent per annum on average) as lengths of stay became shorter. By 1986, they were only 82 percent of their value in 1982, the last year hospitals were not under either the Tax Equity and Fiscal Responsibility Act or PPS. Of the 4-year 18-percent decline in volume, 14 points occurred in just 2 years, 1984 and 1985. The rates of decline in admissions and days were nearly identical in 1986, implying a stabilization in lengths of stay after 1985. As was true of admissions, patient days fell more slowly when outpatient-adjusted than when only inpatient days were used.

Trends in deflated gross revenues are given in columns 9-12 of Table 1. All revenue figures are in 1980 dollars. Deflated inpatient revenues grew strongly during the period 1981-83, at an average annual rate of 3.6 percent, and then fell 6.0 percent from 1983 to 1985 before recovering by 1.1 percent in 1986. Deflated inpatient plus outpatient revenues fell more slowly in 1984 and 1985 than inpatient revenues did. They then increased by a large amount, 3.1 percent, in 1986, indicating a substitution of outpatient for inpatient care. In 1986, although deflated inpatient revenues were 5 percent lower than they were at their peak in 1983, deflated inpatient plus outpatient revenues were slightly higher than in 1983.

Deflated revenues grew substantially faster than admissions and patient days in the period 1981-83 and declined more slowly from 1983 to 1985. In 1986, although adjusted admissions fell 1.1 percent, deflated adjusted gross revenues increased 3.1 percent. As a result, 1986 deflated revenues are 6 percent (inpatient only) or 12 percent (inpatient plus outpatient) greater than their 1980 figures, but the admissions and days output variables range from 5 to 16 percent below their 1980 values. The higher growth of real revenues indicates that hospital output per admission and per day has risen markedly over this period. The increased output could result from greater case-mix severity of patients and/or rising intensity of treatment over

Table 1
Trends in short-term general hospital output: United States, 1980-86

Year	Admissions Inpatient Number in millions (1)	Admissions Inpatient Annual percent change (2)	Admissions Outpatient-adjusted Number in millions (3)	Admissions Outpatient-adjusted Annual percent change (4)	Patient days Inpatient Number in millions (5)	Patient days Inpatient Annual percent change (6)	Patient days Outpatient-adjusted Number in millions (7)	Patient days Outpatient-adjusted Annual percent change (8)	Deflated revenues[1] Inpatient Amount in billions[2] (9)	Deflated revenues[1] Inpatient Annual percent change (10)	Deflated revenues[1] Outpatient-adjusted Amount in billions[2] (11)	Deflated revenues[1] Outpatient-adjusted Annual percent change (12)
1980	36.2	—	41.7	—	273.9	—	315.1	—	$77.8	—	$89.5	—
1981	36.5	0.8	41.9	0.3	279.1	1.9	319.8	1.5	80.9	4.0	93.1	4.1
1982	36.4	-0.2	42.2	0.7	278.6	-0.2	321.9	0.7	83.8	3.5	96.6	3.7
1983	36.2	-0.6	42.0	-0.3	273.8	-1.7	317.1	-1.5	86.7	3.4	99.9	3.5
1984	35.2	-2.8	41.4	-1.5	257.1	-6.1	301.6	-4.9	84.7	-2.4	98.8	-1.2
1985	33.5	-4.8	40.4	-2.5	237.1	-7.8	284.5	-5.7	81.6	-3.6	97.3	-1.5
1986	32.4	-3.3	39.9	-1.1	230.1	-3.0	282.3	-0.8	82.5	1.1	100.3	3.1
1981-83	—	0.0	—	0.2	—	0.0	—	0.2	—	3.6	—	3.8
1984-86	—	-3.6	—	-1.7	—	-5.6	—	-3.8	—	-1.6	—	0.1

[1]For community hospitals as defined by the American Hospital Association.
[2]1980 dollars.

NOTE: Outpatient-adjusted: inpatient plus outpatient output.

SOURCES: Admissions and days—American Hospital Association: Annual Survey of Hospitals data tapes, 1980-86. Gross revenues—American Hospital Association: *Hospital Statistics*, 1981-87. Revenue deflator (the "hospital and related services" component of the Consumer Price Index)—U.S. Bureau of the Census: *Statistical Abstract of the United States*. Washington. U.S. Government Printing Office, various years.

time. Clearly, the content-adjusted revenue-based output measures are more likely to show positive productivity trends than raw admissions or days are.

Hospital inputs

To calculate productivity indexes, growth rates in output must be compared with growth rates in inputs. We first consider changes in labor inputs. In the first row of Table 2, we show the annual levels and growth in FTE total hospital personnel for 1980-86. Total hospital personnel grew 2.5 percent per year during the period 1981-83; then the trend turned negative, averaging −0.8 percent for 1984-86. Once again, there actually is a slight increase for 1986 (0.9 percent). During the entire 6-year period, FTE employment grew 4.9 percent.

Unadjusted employment figures do not reflect changes in the occupational composition of the hospital labor force. In the remaining rows of Table 2, labor inputs for 29 separate categories of hospital workers are displayed. In the few years preceding PPS, the high-growth occupations included administrators (15.2 percent annually), dental residents (8.3 percent), registered nurses (3.9 percent) and ancillary nursing personnel (4.3 percent), pharmacists (6.1 percent) and pharmacy technicians (8.0 percent), radiographers (4.6 percent), occupational therapists (8.5 percent), physical therapists (4.5 percent), respiratory therapists (8.3 percent), and other nonprofessionals (6.6 percent). Growth rates by occupational category were generally lower and often negative after 1983. The few groups that grew relatively fast included administrators, physicians, radiation therapy technologists, occupational therapists, respiratory therapists, and other health professionals. Those occupations most affected negatively by the declining hospital volumes included licensed practical nurses and ancillary nursing personnel (down 8 percent annually since 1983), pharmacy staff, physical therapy assistants and respiratory therapy technicians, and other nonprofessionals.

The trends suggest an enrichment in skill mix following implementation of PPS as hospitals laid off less skilled workers within departments. This is especially pronounced in the large area of nursing. In 1983, there were 1,225,400 nursing personnel in short-term general hospitals, 57 percent of whom were registered nurses (RN's). Just 3 years later, the total number had fallen to 1,134,400, and the RN share had risen to 65 percent. It is interesting to note that the ratio of total nurses to patient days rose 10 percent after PPS implementation, even with all of the layoffs, and the ratio of RN's to patient days rose 25 percent in just 3 years.

The annual rates of growth of unadjusted and skill-mix adjusted FTE's are compared in columns 1 and 2 of Table 3. The adjustment for skill mix was made using the methodology described previously. When hospitals have been upgrading their skill mix, the adjusted percent changes will exceed the unadjusted percentages (or the rates of decline will not be as great). From 1980 to 1983, hospital skill mix actually declined, resulting in a slower growth rate for skill-mix-adjusted than for unadjusted labor. Comparing the 1984-86 period (since PPS) with 1983, unadjusted labor fell 2.5 percent while adjusted labor inputs fell only 1.4 percent, implying a 1.1-percent enhancement in hospital skill mix in 3 years. Most of this enhancement has resulted from the substitution of RN's for other nurses and the reversal in trends for other health professionals versus nonprofessionals.

Our estimates of changes in real capital input are given in columns 3 and 4 of Table 3. Real annual growth, as measured by the change in deflated net plant and equipment assets (column 3), averaged 7.9 percent in 1981-83, then fell to 6.3 percent in 1984-86. In total, we estimate that hospital capital stocks increased 51 percent during the 6-year period. Hospital occupancy rates were nearly constant from 1980 to 1982, at 75-76 percent, but then declined steeply to 64.8 percent in 1985 as patient days decreased much more rapidly than beds did. Occupancy stabilized in 1986, falling only slightly, to 64.3 percent. In column 4 of Table 3, we give an occupancy-adjusted capital input index. From 1983 to 1984, real stocks grew 6.8 percent, but the occupancy rate fell 6.2 percent, so the net increase in the flow of capital services was only 0.6 percent. The sharp declines in capacity utilization in 1984 and 1985 almost eliminated any net capital growth in those 2 years, even turning growth slightly negative in 1985. Overall, adjusting for occupancy reduces the growth of capital input for the period 1981-86 from 51 to 30 percent. Productivity trends have been calculated using both capital series to show the impact of fluctuations in demand. (In applying occupancy rates to the entire capital stock, we assume that equipment utilization follows the same trend as occupancy, which is probably not strictly true.)

Even when capacity adjusted, our estimate of capital input growth from 1981 to 1986 is much higher than our estimate of the growth in labor inputs alone or the growth in output as measured by admissions, days, or deflated revenues. These high capital growth rates will tend to turn the total factor productivity estimates negative, although adjusting for lower occupancy will have a significant effect in the PPS period.

In columns 5 and 6 of Table 3, we show annual percent changes in total factor input. Column 5 contains growth rates in the basic index. In column 6, we show the percent changes that are obtained from adjusting the capital series for declining occupancy and from adjusting for the improved quality of the labor input. From the unadjusted index, we derive an estimate of 18.4 percent for the 6-year (1981-86) growth in total factor inputs. This is about 33 points lower than the growth for capital and 13 points higher than that for labor. Average annual growth was 4.3 percent for 1981-83 but only 1.5 percent for 1984-86.

Adjusting for occupancy rates and labor skill mix (column 6), total factor input growth is lower in every

Table 2
Number of full-time equivalent employees in short-term general hospitals and percent change, by occupational group: United States, 1980-86

Occupational group	1980	1981	1982	1983	1984	1985	1986	Annual percent change 1981-83	1984-86
			Number in thousands					Percent	
Total hospital personnel	2,918.0	3,078.1	3,145.3	3,139.4	3,059.0	3,033.1	3,060.5	2.5	-0.8
Administrators and assistant administrators	20.0	27.0	28.1	29.1	30.7	30.5	33.1	15.2	4.6
Physicians and dentists	32.5	32.3	28.7	27.1	28.4	28.7	30.5	-5.5	4.2
Medical residents	54.8	57.1	57.7	59.1	61.1	58.5	62.3	2.6	1.8
Dental residents	0.8	0.8	0.8	1.0	0.9	0.8	0.9	8.3	-3.3
Registered nurses	624.8	631.8	671.6	697.5	697.1	707.9	732.6	3.9	1.7
Licensed practical nurses	230.1	236.0	239.8	231.7	206.4	188.5	174.5	0.2	-8.2
Ancillary nursing personnel	262.2	282.3	287.3	296.2	261.1	237.7	227.3	4.3	-7.8
Medical record administrators	6.2	6.4	6.4	6.5	6.6	6.6	7.0	1.6	2.6
Medical record technicians	31.6	32.8	33.0	33.7	34.9	35.6	37.3	2.2	3.6
Licensed pharmacists	24.6	26.5	27.8	29.1	29.3	29.9	29.7	6.1	0.7
Pharmacy technicians	19.9	22.1	23.6	24.7	24.4	24.7	25.1	8.0	0.5
Medical technologists	78.5	80.5	85.8	85.2	84.4	83.8	81.7	2.8	-1.4
Other laboratory personnel	67.5	69.0	69.2	67.1	64.4	63.2	64.2	-0.2	-1.4
Dieticians	12.3	12.7	12.3	12.4	11.9	11.7	11.1	0.3	-3.5
Dietetic technicians	32.2	28.7	27.1	25.4	24.0	22.8	23.2	-7.0	-2.9
Radiographers and radiologic technologists	48.1	51.1	53.1	54.7	53.3	54.0	54.6	4.6	-0.1
Radiation therapy technologists	4.2	3.8	4.2	3.8	3.8	3.7	4.5	-3.2	6.1
Nuclear medicine technologists	6.5	6.9	7.0	7.2	7.3	7.2	7.2	3.6	0.0
Other radiologic personnel	32.5	30.8	31.4	28.9	28.5	28.6	28.5	-3.7	-0.5
Occupational therapists	4.7	5.2	5.6	5.9	6.2	6.6	7.3	8.5	7.9
Occupational therapy assistants and aides	1.7	1.8	1.8	1.8	1.7	1.8	1.7	-2.0	2.1
Physical therapists	14.1	15.2	15.5	16.0	16.2	16.9	17.3	4.5	2.7
Physical therapy assistants and aides	13.3	13.6	14.0	14.0	13.5	13.4	13.0	1.8	-2.4
Recreational therapists	1.8	1.9	2.0	2.0	2.1	2.1	2.2	3.7	3.3
Respiratory therapists	21.7	23.2	25.3	27.1	27.8	29.2	30.9	8.3	4.7
Respiratory therapy technicians	24.6	25.3	25.6	25.7	24.6	23.2	21.9	1.5	-4.9
Medical social workers	13.8	14.4	14.7	15.0	15.5	15.7	16.1	2.9	2.4
All other health professionals and technicians	338.4	326.6	319.2	202.8	204.1	214.7	236.9	-13.4	5.6
All other nonprofessional personnel	939.0	1,027.1	1,043.0	1,125.0	1,104.6	1,101.0	1,078.1	6.6	-1.4

NOTE: Total does not equal sum of individual occupations because of nonreporting.

SOURCE: American Hospital Association: Annual Survey of Hospitals data tapes, 1980-86.

Table 3
Annual percent change in short-term general hospital labor, capital, and total factor inputs: United States, 1981-86

Year	Labor input (full-time equivalent personnel)		Capital input (net plant and equipment assets)		Total factor input	
	Unadjusted (1)	Skill-mix adjusted (2)	Unadjusted (3)	Occupancy adjusted (4)	Unadjusted[1] (5)	Adjusted[2] (6)
	Annual percent change					
1981	5.5	4.2	7.9	8.6	6.3	5.6
1982	2.2	2.2	7.4	6.5	3.9	3.5
1983	-0.2	-0.9	8.4	6.0	2.6	1.3
1984	-2.5	-2.0	6.8	0.6	0.5	-1.1
1985	-0.8	-0.5	5.8	-0.1	1.3	-0.4
1986	0.9	1.1	6.2	5.5	2.7	2.5
1981-83	2.5	1.8	7.9	7.0	4.3	3.5
1984-86	-0.8	-0.5	6.3	2.0	1.5	0.3

[1]Based on full-time equivalent hospital personnel and net plant and equipment assets.
[2]Based on skill-mix-adjusted hospital personnel and occupancy-adjusted capital input.
SOURCE: American Hospital Association: Annual Survey of Hospitals data tapes, 1980-86.

year, especially for the period 1983-85, when occupancy declined sharply. Input growth is actually negative in 1984 and 1985 when adjusted to reflect declining capacity utilization. Overall, adjusted inputs rose 12 percent, compared with the unadjusted increase of 18 percent. The unadjusted-adjusted input growth differences result almost entirely from the occupancy adjustment to the capital series; controlling for occupational mix has little effect on input growth, except for slightly attenuating the decline in input levels after 1983.

Total factor and labor productivity

Total factor productivity growth rates, using outpatient-adjusted admissions, patient days, and deflated revenues as output measures, are given in Table 4. They are determined by subtracting total factor input growth rates (columns 5 and 6, Table 3) from output growth rates presented in Table 1 (columns 4, 8, and 12). Admission-based trends are adjusted in column 3 by a Prospective Payment Assessment Commission (1988) estimate of real case-mix growth.

Using admissions or days output measures (columns 1, 2, and 4), productivity growth is consistently negative over the period 1981-86, with annual declines averaging 3-4 percent. Overall, according to these calculations, hospital productivity, unadjusted for case mix, fell 15-25 percent over the 6-year period. For 1983-85, the capacity utilization and skill-mix adjustments significantly attenuate the negative productivity trend, although never by enough to turn it positive. (Compare columns 1 and 2.) This result is the sum of opposing effects. Declining occupancy explains several percentage points of the decline in productivity for 1983-85. The occupational-mix adjustment has a relatively minor effect on the productivity trends but makes the decline slightly

more pronounced for the period 1984-86, during which skill mix was increasing. By 1986, the PPS-induced reductions in capacity utilization had ended and adjusted admissions productivity, using both unadjusted and adjusted inputs, had returned to its previous rate of decline.

Adjusting admissions for real case-mix trends (column 3) lowers the rate of total factor productivity decline for the pre-PPS period from -3.2 to -2.7 percent. The effect is much greater in the PPS period—more than a percentage point improvement in the annual rate. A major reason for such strong negative trends in measured productivity growth is that admissions or days variables do not capture all changes in hospital output, even with a real case-mix adjustment (as discussed in the section on hospital product). In addition to measuring changes in case mix, deflated revenues should be a better measure of changes in the intensity or quality of hospital care. Using deflated gross patient revenues as the output measure, the overall change in productivity for 1981-86 is still negative with unadjusted inputs (column 5), but much less so than with admissions or days output measures. Productivity falls by 5.5 percent from 1981 to 1986 instead of, for example, the 20-percent drop registered using adjusted admissions (column 1). Even more strikingly, after adjusting inputs for occupancy and skill mix, deflated revenue total factor productivity (column 6) appears nearly unchanged over 6 years. The 0.3-percent growth in 1981-86 is in contrast to a 15-percent decline measured using adjusted admissions (column 2). Moreover, positive total factor productivity for the industry is shown for several years now, especially 1983 and 1986.

The rapid growth in capital inputs over this period (Table 3) also tends to turn total factor productivity growth rates negative. In columns 7-9 of Table 4, we present productivity growth rates based on hospital

Table 4

Annual rate of change in total factor and labor productivity for short-term general hospitals: United States, 1981-86

| | Total factor productivity | | | | | | Labor productivity | | |
| | Adjusted admissions | | | Adjusted patient days (with I_2) (4) | Adjusted deflated revenues | | Adjusted admissions | | Adjusted deflated revenues (with I_4) (9) |
Year	With I_1 (1)	With I_2 (2)	With I_3 (3)		With I_1 (5)	With I_2 (6)	With I_4 (7)	With I_5 (8)	
				Annual percent change					
1981	−6.0	−5.3	−4.8	−4.0	−2.2	−1.5	−3.9	−3.4	−0.1
1982	−3.2	−2.8	−2.3	−2.9	−0.2	0.2	−1.5	−1.0	1.5
1983	−2.9	−1.6	−1.1	−2.9	0.8	2.2	0.6	1.1	4.4
1984	−2.0	−0.4	0.3	−3.6	−1.7	−0.1	0.5	1.2	0.8
1985	−3.9	−2.1	−1.3	−5.2	−2.8	−1.1	−2.1	−1.3	−1.0
1986	−3.7	−3.6	−1.6	−3.6	0.4	0.6	−2.1	−0.1	2.0
1981-83	−4.0	−3.2	−2.7	−3.3	−0.5	0.3	−1.6	−1.1	1.9
1984-86	−3.2	−2.0	−0.9	−4.1	−1.4	−0.2	−1.2	−0.1	0.6

NOTES: I_1—Total factor inputs with no adjustments. I_2—I_1 adjusted for capacity utilization and occupational mix. I_3—I_2 adjusted for real case-mix change (Prospective Payment Assessment Commission, 1988): 1981, 0.5 percent; 1982, 0.5 percent; 1983, 0.5 percent; 1984, 0.7 percent; 1985, 0.8 percent; 1986, 2.0 percent. I_4—Skill-mix-adjusted labor inputs. I_5—I_4 adjusted for real case-mix change.

SOURCE: American Hospital Association: Annual Survey of Hospitals data tapes, 1980-86.

labor input alone. These are the growth rates most relevant to the PPS update factor, which is applied only to operating (mostly labor) costs. (Capital costs are passed through.) Changes in labor productivity were derived by subtracting the growth rate in adjusted FTE's (column 2, Table 3) from the growth in adjusted admissions (column 4, Table 1) or in deflated revenues (column 12, Table 1). In column 8, we present labor productivity trends, making an additional adjustment to admissions for real case-mix increase.

Because the growth in capital input exceeded that in labor input during this period, the labor productivity growth rates are consistently less negative or more positive than their total factor productivity counterparts. (Compare column 7 with column 2, column 8 with column 3, or column 9 with column 6.) With the adjusted admissions output variable (column 7), labor productivity fell by only 8.3 percent for the period 1981-86, as opposed to a 14.9-percent decline in total factor productivity (column 2). Medicare's prospective payment system appears to have had a marked positive impact on adjusted admissions hospital labor productivity in 1983 and 1984, although previous trends reasserted themselves in 1985-86. Further, adjusting for real case-mix increase (column 8) actually produces positive labor productivity growth that exceeds 1 percent annually for the period 1982-84. Moreover, the large productivity decline in 1986 is almost completely offset by the 2-percent case-mix growth in that year.

Unlike any other index in Table 4, the real revenue measure of labor productivity (column 9) rises substantially during the 1981-86 period. Skill-adjusted labor productivity is estimated to be 7.8 percent higher in 1986 than in 1980, compared with an 8.3-percent fall on an adjusted admissions basis (column 7). Labor productivity gains are particularly large in

two years, 1983 and 1986. According to evidence presented elsewhere, such as HCFA's 1985 Annual Report to Congress on PPS (Health Care Financing Administration, 1987), hospitals underwent changes in anticipation of PPS implementation; therefore, 1983 should also be considered a "PPS year." From this viewpoint, the average annual gain in labor productivity resulting from PPS, on an adjusted gross revenue basis, would be 1.6 percent for the period 1983-86. In contrast, productivity decreased 0.8 percent annually on an adjusted admissions basis.

Implications

By constructing hospital labor and total factor productivity indexes for the 1981-86 period, we have shown that total factor productivity growth on an admissions basis has been negative since at least 1981, even after adding an allowance for outpatient department expansion and case-mix change. On the other hand, the rate of productivity decline slowed in 1983, when PPS was implemented, in spite of a major downturn in admissions. Furthermore, total factor productivity growth on a deflated revenue basis was a positive 1.6 percent for 1983 to 1986, which can be considered the PPS period if it is assumed that 1983 changes reflect anticipatory response.

A total factor productivity measure using admissions as an output measure clearly understates real productivity growth in two important ways. First, scientific advances may improve outcomes, adding to inputs but not to admissions per se. Second, if case mix has become more complicated, input requirements will increase even though admissions actually decrease if easier cases are not being treated on an acute basis.

Deflated gross revenue growth, we believe, is a truer measure of total output growth than changes in admissions or patient days in that it reflects both

changing volume (inpatient and outpatient) and growing intensity per case. For this reason, revenue-based productivity indexes are a preferred measure of hospitals' efficiency in producing intermediate hospital services. If hospitals are becoming more efficient in supplying these intermediate services, they can provide their current intensity of care for a lower cost. Prospective rates can therefore be reduced by the increase in productivity without denying hospitals the resources needed to maintain current services. (Increases in intensity resulting from real case-mix change and efficacious scientific advances are funded through separate components of the discretionary update factor.) Based on this information, an argument can be made for using a revenue-based total factor productivity measure in calculating the discretionary update factor, with no further adjustment for case mix.

Finally, if capital were being paid prospectively under PPS, as are operating costs, a total factor productivity index would be the appropriate productivity index. However, capital continues to be reimbursed on a passthrough basis, so the PPS update factor does not need to reflect all inputs, only labor. This argues for using in the discretionary update factor a labor productivity growth index on an adjusted revenue basis to approximate hospital productivity. Using this index, we observe that labor productivity grew an average of 1.6 percent annually for the period 1983-86.

These increases could be justification for a debit to the market basket for growing productivity. In fact, they could be taken as a lower bound for the productivity adjustment. They do not reflect potential cost reductions through the elimination of unnecessary services (i.e., those with a low or zero contribution to health outcomes). The Prospective Payment Assessment Commission (1988) has taken the position that the productivity offset to the discretionary update factor can include both increased efficiency in providing intermediate services and reductions in service intensity.

Acknowledgments

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