Hospital Multifactor Productivity: A Presentation and Analysis of Two Methodologies

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In response to recent discussions regarding the ability of hospitals to achieve gains in productivity, we present two methodologies that attempt to measure multifactor productivity (MFP) in the hospital sector. We analyze each method and conclude that the inconsistencies in their outcomes make it difficult to estimate a precise level of MFP that hospitals have historically achieved. Our goal in developing two methodologies is to inform the debate surrounding the ability of hospitals to achieve gains in MFP, as well as to highlight some of the challenges that exist in measuring hospital MFP.

INTRODUCTION

MFP is defined by the U.S. Bureau of Labor Statistics (2007) (BLS) as the change in a level of outputs relative to the change in a level of two or more inputs. Recently, there has been debate as to whether hospitals are able to achieve gains in MFP. The Medicare Payment Advisory Commission (MedPAC) has suggested that Medicare providers, including hospitals, have the ability to reduce the quantity of inputs required to produce a unit of service, while maintaining a consistent level of quality of care. To encourage efficiency in the payment system, MedPAC has recommended that Medicare payment updates to hospitals be explicitly adjusted to account for expected improvements in productivity. The FY 2008 President's Budget has also proposed to adjust Medicare "…provider updates to account for gains in providers' productivity and efficiency" (Office of Management and Budget, 2007). According to MedPAC (2007), Medicare should expect some improvements in productivity "…[u]nless evidence suggests that this goal is unattainable systematically across a sector for reasons outside the industry's control." Previous attempts at measuring hospital MFP have had varying results (Ashby, Guterman, and Greene, 2000; Fisher, 1992a,b). To add to this discussion, this article presents two methodologies for measuring hospital MFP.

Method 1 derives outputs and inputs from hospital revenues and expenses, respectively. These dollar amounts are deflated by appropriate output and input price indexes to obtain implied quantities of outputs and inputs, which are required to calculate MFP. The second method generally follows the approach that BLS has used to calculate MFP in other industries. Due to limited data and the conceptual issue of measuring output quantities, BLS currently does not publish MFP data for hospitals or other health service sectors. Method 2 uses the same output measurement as Method 1; however, instead of deflating expenses to obtain implied quantities of inputs, Method 2 uses labor and capital quantities obtained directly from published data sources.

This analysis will show that despite the similarities between the data sources and approaches used in Methods 1 and 2, the results differ considerably. For example,

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Table 1

Average Estimates of Hospital Multifactor Productivity (MFP)

	Method 1	Method 2	Sensitivity 1	Sensitivity 2	Economywide
Average Annual MFP from 2001-2005	0.1	1.0	(0.3)	0.3	1.8
10-Year Moving Average MFP in 2005	0.3	0.6	0.1	0.1	1.5

NOTES: Method 1 derives outputs and inputs from select hospital revenues and expenses, respectively. Method 2 generally follows the approach that the U.S. Bureau of Labor Statistics (BLS) has used to calculate MFP in other industries. Labor quantities are estimated by merging Current Employment Statistics (CES) data for total hospital employees with Current Population Survey data for average work weeks and average weekly hours. Sensitivity 1 is based on Method 1 and derives outputs and inputs from total hospital revenues and expenses, respectively. Sensitivity 2 is based on Method 2 and estimates labor quantities using only CES data. Economywide represents total private, non-farm business sector MFP as calculated by BLS.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

from 2001 to 2005, average annual growth in hospital MFP was 0.1 percent using Method 1, and 1.0 percent using Method 2 (Table 1). Additionally, the annual changes in hospital MFP from the two methods often do not move in the same direction or to the same degree; the correlation coefficient based on the years 1981-2005 is positive, but not highly so, at 0.46 (Figure 1). The inconsistencies in the outcomes reveal some of the challenges in determining a precise level of MFP that hospitals have historically achieved.

METHOD 1

In Method 1, we assume that output and input quantities are embedded in nominal payments and expenditures. Trends in hospital output and input quantities are determined by deflating each nominal amount by appropriate output and input price indexes.

Outputs

Outputs are based on total net revenue data for community hospitals obtained from the American Hospital Association (AHA) Annual Survey.[1] Our goal is to select only those revenues that relate to the production of a specific health good or service that is provided to either patients or non-patients. For this analysis, we divide revenue into four categories:

- Paid Patient Care Net Revenues—Net patient care revenues (gross revenues less discounts) related to the sale of patient care goods and services.
- Unpaid Patient Care Revenues—Gross charges that are not collected by the hospital from the provision of patient care goods and services, such as bad debt and charity care.
- Non-Patient Care Operating Net Revenues—Net revenues derived from the sale of non-patient goods and services, such as items in the hospital gift shop.
- Non-Patient Care Non-Operating Net Revenues—Net revenues derived from other sources, such as tax appropriations, returns on investments, and donations.

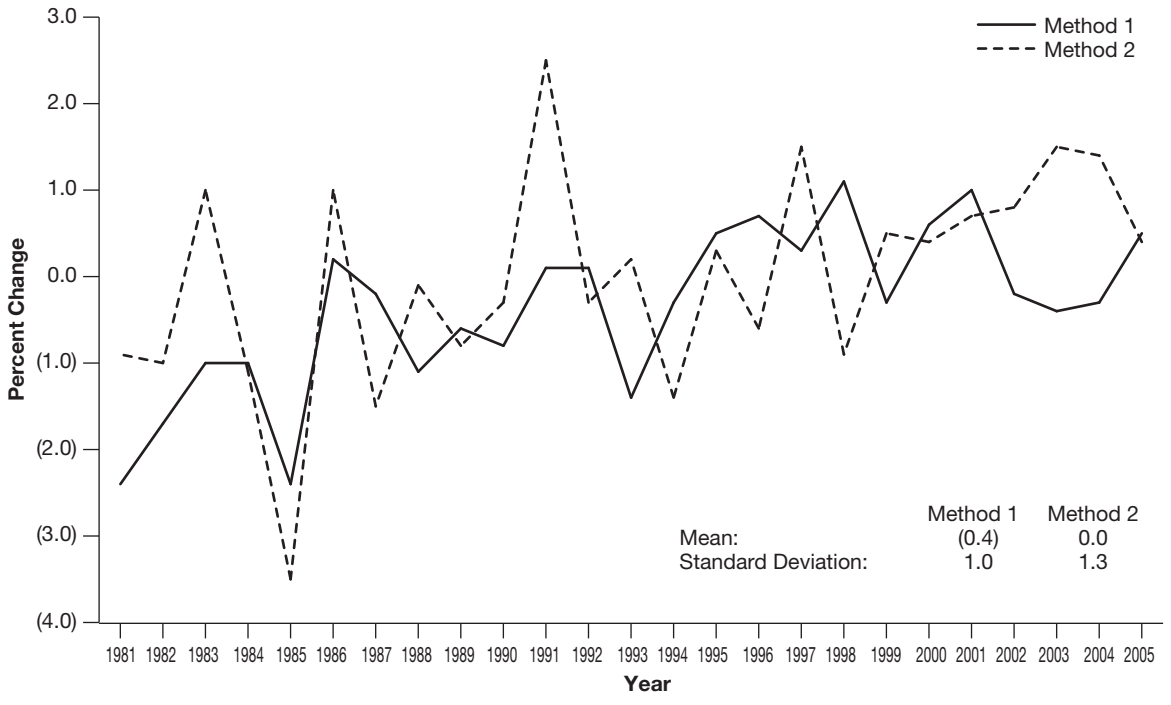
Because non-patient care non-operating net revenues represent financial gains that are unrelated to providing a specific health good or service, and therefore do not have associated output quantities, we exclude these revenues from our output calculation.

To convert each of the three remaining revenue segments into implied output quantities, we remove the price component of each revenue type using an appropriate output price deflator. Goods and services that are accounted for under paid patient care net revenues are valued at transaction

[1] AHA conducts an annual survey that solicits a broad range of utilization and financial data from hospitals. The community hospital portion of this survey represents our primary data source.

Figure 1

Average Annual Percent Change in Hospital Multifactor Productivity (MFP): 1981-2005



NOTES: Method 1 derives outputs and inputs from select hospital revenues and expenses, respectively. Method 2 generally follows the approach that the U.S. Bureau of Labor Statistics has used to calculate MFP in other industries. Labor quantities are estimated by merging Current Employment Statistics data for total hospital employees with Current Population Survey data for average work weeks and average weekly hours.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

prices (net of discounts). Therefore, we deflate these revenues using an adjusted version of the Producer Price Index (PPI), a transaction price index published by BLS for hospitals (North American Industry Classification System 622).[2] Conversely, unpaid patient care revenues reflect goods and services valued at non-discounted list prices and we deflate these amounts using the Consumer Price Index (CPI) for hospitals.[3] To obtain implied output quantities from non-patient care operating net revenues, we create a non-patient output price index based on a subset of goods and services from the U.S. Bureau of Economic Analysis' (BEA) National Income and Product Accounts. This index contains prices paid for products, such as purchased food, sundries, and parking fees, that are similar to those goods included in non-patient care operating net revenues. We add these three constant-dollar revenue series together for each year to construct a time series of total output quantities. The annual changes in total output quantities are used in both Methods 1 and 2.[4]

Inputs

To derive implied inputs, we begin with total expenses for community hospitals from the AHA Annual Survey. Again, the approach is to select only those expense

[2] OACT previously adjusted the hospital PPI to attempt to correct for measurement issues in certain years.

[3] BLS has recently moved toward defining the CPI as a measure of transaction prices.

[4] Our calculation of output quantities does not reflect improvements in health status.

amounts that directly pertain to the production of a specific health good or service. Investment losses, interest expenses, and business taxes are financial expenses that are not associated with any specific input quantity in this analysis, and therefore they must be subtracted from total expenses.

Because limited data are available, we estimate investment losses, interest expenses, and business tax data. Investment losses are based on their average annual share of total expenses from AHA for 1988 to 1993. Data for interest expenses are available from AHA for 1980 to 1993, and we estimate the remaining years based on interest expenses' average annual share of net revenues in the given years. Business taxes before 1987 are estimated based on their annual share of net revenues for private hospitals and nursing/residential facilities from BEA gross domestic product (GDP) by industry data.[5] We subtract these three categories of expenses from total expenses to obtain a value for total operating expenses.

The objective in Method 1 is to deflate total operating expenses by an input price index that reflects the input price pressures that are associated with these types of expenses. Currently, OACT produces two separate hospital input price indexes (IPIs): an operating IPI and a capital IPI. These IPIs are fixed-weight, Laspeyres-type price indexes, comprised of multiple cost weights and their associated price proxies.[6] They are designed to measure input price inflation faced by hospitals and are used to update Medicare hospital payments. We will use a weighted combination of the price proxies that comprise these IPIs to deflate total operating expenses. This new price index will be referred to as the MFP IPI.

For the MFP IPI, we separate total operating expenses into three categories—labor, capital, and intermediate input expenses—to determine their respective weights. Labor expenses include payroll expenses and fringe benefits, which are obtained from AHA. Capital expenses include depreciation and rent. Data for depreciation expenses are available from AHA only for 1980 to 1997; other years are estimated.[7] Also estimated are data for rent expenses.[8] Since we control the three input expense components to the total operating expenses estimate, intermediate input expenses are calculated as the residual of total operating expenses less labor and capital expenses. The percent contribution of each of these three components to total operating expenses is later used in the weighting of the MFP IPI.

We associate a specific price proxy with each category of total operating expenses. Within labor, payroll expenses correspond with the Employment Cost Index (ECI) for civilian hospital workers' wages, and fringe benefits correspond with the ECI for civilian hospital workers' benefits. Both of these indexes are published by BLS and are also used in OACT's operating IPI. For capital, depreciation expenses are aligned with a weighted average of price proxies for fixed and moveable equipment derived from OACT's capital IPI. Rent expenses correspond to the CPI for residential rent published by BLS, which is also used in OACT's operating IPI. We derive the price proxy related to intermediate input

[5] Data for the years 1980-1986 are not available from BEA. These years were estimated based on the relationship between taxes and revenues for 1987-1993.

[6] More detailed information can be found on the CMS Web site: http://www.cms.hhs.gov/MedicareProgramRatesStats/downloads/info.pdf.

[7] The remaining years are based on depreciation's share of net revenues for hospitals from the U.S. Census Bureau's Census Annual Service Surveys (2004-2005) and the Economic Census (2002).

[8] Rent expenses are based on rent's share of operating expenses for hospitals from the U.S. Census Bureau's Census Annual Service Surveys (2003-2005) and the Economic Census (1992, 1997, 2002).

expenses from a weighted average of price proxies and cost weights used in OACT's operating IPI for cost categories other than wages and benefits.[9]

The respective weights of labor, capital, and intermediate inputs determine the contribution of each corresponding price index to the MFP IPI (Table 2). We deflate total operating expenses by the MFP IPI to determine annual changes in the quantity of inputs. These data are then used to calculate MFP in Method 1.

MFP

Deflating net revenues and expenses removes the effect of price changes and generates implied quantities that represent the amount of real outputs and real inputs in the hospital industry. The ratio of the change in the real quantity of outputs to the change in the real quantity of inputs provides an estimate of hospital MFP in a given year. The annual percent change of this ratio over time reveals an estimated trend in hospital MFP. We will discuss the results obtained from Method 1 after we describe Method 2.

METHOD 2

The second method to calculate hospital MFP is also based on a change in outputs relative to a change in inputs. However, Method 2 differs from Method 1 primarily in that its labor and capital measures are obtained directly from public data sources as explicit quantities of inputs. Outputs and intermediate inputs in Method 2 are the same as those previously calculated in Method 1, as there are no straightforward quantity measurements available. In approximate terms, Method 1 views operating expenses as the product of explicit prices and implied quantities, whereas Method 2 views operating expenses as the product of implied prices and explicit quantities.

Inputs

In order to compute changes in inputs using the BLS methodology for calculating industry MFP, BLS requires a set of weights, as well as a set of real ratio changes, for the three major categories of inputs, which are labor, capital, and intermediate inputs. Method 2 generally follows the BLS (1997) method. Weights are calculated for each input based on that input's average share of total net revenues over 2 years. These Tornqvist input weights are then merged with direct measurements of ratio changes in labor, capital, and intermediate inputs in order to measure changes in total real inputs. The formula for calculating MFP in Method 2 is as follows:

In the formula,

$$\ln\left(\frac{A_t}{A_{t-1}}\right) = \ln\left(\frac{Q_t}{Q_{t-1}}\right) - \left[w_l\left(\ln\frac{L_t}{L_{t-1}}\right) + w_i\left(\ln\frac{I_t}{I_{t-1}}\right) + w_k\left(\ln\frac{K_t}{K_{t-1}}\right)\right]$$

A = multifactor productivity;
Q = output quantity;
L = labor input;
I = intermediate input;
K = capital input; and
w_l, w_i, w_k = Tornqvist input weights.

Tornqvist Input Weights

Weights for each of the input components are calculated based on that component's average share of total net revenues over 2 years. The percentage of total net revenues is used rather than total expenses, because

[9] Cost categories include professional fees, utilities, malpractice, and all other products and services (e.g., drugs, food-direct purchase, food-away from home, and medical instruments).

Table 2

Construction of the Multifactor Productivity (MFP) Input Price Index (IPI) for Method 1: 1981-2005

	Share of Total Operating Expenses							Input Price Index Ratio Changes					
Year	Payroll	Fringe Benefits	Total Labor	Depreciation	Rent	Total Capital	Intermediate Inputs	Payroll	Fringe Benefits	Depreciation	Rent	Intermediate Inputs	MFP IPI
1981	51.7	8.3	60.0	4.2	1.2	5.4	34.6	1.108	1.124	1.084	1.087	1.101	1.106
1982	51.2	8.7	59.9	4.2	1.2	5.4	34.6	1.109	1.153	1.083	1.076	1.062	1.095
1983	50.8	9.1	59.9	4.5	1.2	5.7	34.4	1.066	1.066	1.078	1.058	1.041	1.058
1984	50.4	9.3	59.7	4.9	1.2	6.1	34.1	1.051	1.064	1.073	1.052	1.048	1.052
1985	49.5	9.3	58.8	5.4	1.2	6.6	34.6	1.052	1.050	1.064	1.061	1.038	1.048
1986	48.6	8.9	57.5	5.6	1.2	6.8	35.7	1.034	1.040	1.056	1.058	1.032	1.035
1987	47.9	8.7	56.6	5.7	1.2	6.9	36.4	1.047	1.034	1.051	1.041	1.039	1.043
1988	47.7	8.7	56.4	5.8	1.2	7.0	36.6	1.054	1.064	1.047	1.038	1.059	1.056
1989	47.5	9.1	56.6	5.8	1.2	7.0	36.4	1.063	1.079	1.045	1.039	1.050	1.058
1990	47.5	9.3	56.8	5.8	1.2	7.0	36.2	1.061	1.088	1.042	1.042	1.038	1.054
1991	47.2	9.7	56.9	5.7	1.2	6.9	36.2	1.048	1.069	1.037	1.035	1.037	1.045
1992	46.6	9.9	56.5	5.6	1.2	6.8	36.6	1.036	1.067	1.032	1.025	1.027	1.035
1993	46.0	10.2	56.2	5.7	1.2	6.9	36.9	1.032	1.048	1.029	1.023	1.024	1.031
1994	46.2	10.3	56.5	6.0	1.2	7.2	36.3	1.028	1.034	1.028	1.024	1.020	1.026
1995	45.9	10.2	56.1	6.3	1.2	7.5	36.4	1.024	1.024	1.026	1.025	1.036	1.029
1996	45.7	9.8	55.6	6.5	1.2	7.7	36.8	1.024	1.023	1.024	1.026	1.017	1.021
1997	45.3	9.6	54.9	6.6	1.2	7.8	37.3	1.020	1.007	1.023	1.029	1.012	1.016
1998	45.1	9.5	54.6	6.3	1.2	7.5	37.9	1.027	1.022	1.020	1.032	1.032	1.028
1999	44.5	9.3	53.8	6.1	1.2	7.3	38.9	1.029	1.034	1.018	1.031	1.017	1.024
2000	44.5	9.3	53.8	5.9	1.3	7.2	39.0	1.037	1.042	1.016	1.036	1.030	1.034
2001	44.2	9.5	53.6	5.7	1.3	7.0	39.4	1.051	1.058	1.014	1.045	1.028	1.040
2002	44.2	10.1	54.3	5.4	1.3	6.7	39.0	1.049	1.060	1.014	1.039	1.017	1.035
2003	43.7	10.6	54.2	5.4	1.3	6.6	39.1	1.037	1.063	1.012	1.029	1.038	1.039
2004	43.1	10.9	54.1	5.5	1.4	7.0	39.0	1.034	1.061	1.014	1.027	1.043	1.039
2005	42.9	10.9	53.9	5.4	1.4	6.9	39.3	1.034	1.056	1.016	1.030	1.049	1.041

NOTE: Method 1 derives outputs and inputs from select hospital revenues and expenses, respectively.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

it is assumed that any profits in excess of expenses are returned to capital accounts. Thus, every dollar of total net revenues is assumed to be attributed to labor, capital, or intermediate inputs.

The labor component weight w_l is determined by the share of total net revenues that is comprised of labor compensation. Labor compensation includes payroll expenses and fringe benefits, similar to Method 1. The intermediate input component weight w_i is determined by the share of total net revenues that is comprised of intermediate input expenses. Since data on intermediate input expenses are not otherwise available, we assume that intermediate input expenses are the same as those calculated in Method 1 (the residual of operating expenses less payroll expenses, fringe benefits, depreciation, and rent). Finally, we assume that capital expenses in Method 2 represent total net revenues less labor compensation and intermediate inputs. As a result, the capital component weight w_k consists of depreciation, rent, and the remaining portion of total net revenues. Any profits are categorized as a return to capital accounts.

Input Components

Although Method 1 attributes changes in inputs to changes in the deflated dollars spent on those inputs, Method 2 does not. Instead, in Method 2, real measurements are utilized where available to reflect the changes in the quantities of those inputs.

Labor quantities are obtained by measuring total annual hospital industry labor hours. Data from the Current Population Survey (CPS), which is published by BLS, are used to calculate, for private, and State and local hospital workers (1) the average number of work weeks per year and (2) the average number of work hours per week.[10] The average number of work weeks is tabulated by the University of Minnesota Integrated Public Use Microdata Series using CPS data. Data from the Current Employment Statistics (CES) Survey, also published by BLS, are then used to calculate the total number of private and State and local hospital employees. The product of these three amounts represents the total quantity of labor hours for hospital workers in a given year. We follow BLS's methodology for calculating industry MFP and do not adjust labor inputs for changes in the skill level of the work force.[11]

Capital quantities are obtained using BEA's Fixed Asset Series, which, like the capital quantities in Method 1, are based on deflated capital expenditures. Our goal is to determine the ratio change in total fixed asset quantities for private and State and local hospitals.[12] BEA's Fixed Asset Series provides quantity index levels for total fixed assets, structures, and equipment for private hospitals. For State and local hospitals, BEA's Fixed Asset Series reports only quantity index levels for structures. We assume that the ratio change of the State and local quantity index levels for equipment is equal to that for private equipment.[13] We calculate quantity index levels for State and local total fixed assets by weighting the index levels for State and local structures and State and local equipment by the percent contribution of each category's expenditures to total State and local fixed asset

[10] The CPS is a joint survey conducted by BLS and the U.S. Census Bureau.

[11] For its calculation of MFP for the major sectors (private and private non-farm business), BLS adjusts its measure of labor inputs to account for changes in labor composition.

[12] Changes in quantities of hospital capital stock are available from BEA for all hospitals, not community hospitals. We assume that the data for all hospitals approximate those for community hospitals.

[13] We note that the ratio change of the quantity index levels for State and local structures is different from that of the quantity index levels for private structures.

Table 3

Hospital Multifactor Productivity (MFP) Variables for Method 2: 1981-2005

	Tornqvist Input Weights			Quantity Ratios			
Year	Labor	Intermediate Inputs	Capital	Labor	Intermediate Inputs	Capital	Output
1981	55.7	32.3	11.9	1.045	1.061	1.029	1.039
1982	55.6	32.1	12.3	1.029	1.091	1.028	1.038
1983	55.3	31.9	12.8	1.007	1.058	1.036	1.037
1984	54.8	31.4	13.8	0.999	0.998	1.037	0.993
1985	53.6	31.1	15.3	1.007	1.030	1.035	0.983
1986	52.4	31.7	15.9	1.006	1.077	1.029	1.042
1987	51.9	32.8	15.3	1.054	1.065	1.027	1.038
1988	51.9	33.5	14.5	1.030	1.050	1.030	1.036
1989	52.1	33.6	14.3	1.036	1.034	1.034	1.027
1990	52.2	33.4	14.4	1.038	1.063	1.035	1.043
1991	52.4	33.3	14.3	1.015	1.067	1.037	1.061
1992	52.0	33.4	14.6	1.065	1.085	1.036	1.064
1993	51.6	33.6	14.8	0.995	1.051	1.045	1.023
1994	51.4	33.4	15.2	1.030	1.000	1.039	1.007
1995	51.0	32.9	16.1	1.005	1.001	1.032	1.011
1996	50.0	32.8	17.2	1.017	1.020	1.027	1.014
1997	49.2	33.0	17.8	0.987	1.042	1.027	1.027
1998	49.0	33.6	17.3	1.036	1.026	1.048	1.026
1999	49.1	34.7	16.2	0.982	1.062	1.041	1.024
2000	49.0	35.5	15.5	1.025	1.037	1.038	1.036
2001	49.1	35.8	15.1	1.025	1.056	1.038	1.046
2002	49.3	35.8	14.8	1.026	1.058	1.034	1.047
2003	49.5	35.6	14.9	0.998	1.043	1.043	1.036
2004	49.2	35.4	15.4	0.995	1.021	1.044	1.026
2005	48.9	35.4	15.7	1.029	1.030	1.041	1.035

NOTES: Method 2 generally follows the approach that the U.S. Bureau of Labor Statistics has used to calculate MFP in other industries. Labor quantities are estimated by merging Current Employment Statistics data for total hospital employees with Current Population Survey data for average work weeks and average weekly hours. Tornqvist weights are calculated for each input based on that input's average share of total net revenues over 2 years.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

expenditures.[14] This calculation generates quantity index levels for both private total fixed assets and State and local total fixed assets. A weighted average of these index levels is then calculated based on the total fixed asset expenditures for private hospitals and the total fixed asset expenditures for State and local hospitals. Because we assume that capital goods do not immediately impact hospital output, hospital capital quantities are lagged 1 year in the equation.[15]

To calculate MFP, the year-to-year ratio changes of the output quantity and each input quantity, as well as the Tornqvist input weights, are substituted into the formula previously described (Table 3). This formula replicates the output to input ratio of Method 1 by subtracting weighted logarithms of the change in each input from the logarithm of the change in output.

[14] State and local equipment expenditures are not available from BEA. State and local equipment expenditures are calculated from the ratio of private equipment expenditures to private structures expenditures multiplied by State and local structures expenditures.

[15] We note that not lagging capital does not materially affect the final MFP calculation.

COMPARISON OF RESULTS

As stated previously, these two methods use the same measures of changes in outputs and intermediate inputs. In theory, if valid labor and capital price measures are used in Method 1, and if accurate measures for labor and capital quantities are used in Method 2, both methods should yield similar measures for changes in inputs; the primary difference in MFP should be due to deviations in the input weights. However, the annual MFP calculations resulting from these two methods vary.

Annual percent changes in hospital MFP are more volatile in Method 2 than in Method 1. The annual values of hospital MFP obtained from the two methods often do not move in the same direction or to the same degree; their correlation coefficient of 0.46 is positive, but not highly so. On a year-by-year basis, it is important to note that Methods 1 and 2 are frequently inconsistent on whether hospitals were experiencing positive or negative MFP. In 6 of the 25 years, Method 1 reported negative MFP while Method 2 reported positive MFP. Conversely, in 3 of the 25 years, Method 1 reported positive MFP while Method 2 reported negative MFP. The annual results obtained from the two methods varied from being relatively close (0.1 percentage point difference in 1984 and 2005) to very dissimilar (a discrepancy of 2.4 percentage points in 1991) (Figure 1).

Given the historical changes in the hospital industry—namely, the implementation of Medicare's inpatient prospective payment system in 1983 and cost containment measures introduced during the era of managed care—it may be useful to focus on hospital MFP results during a more recent period. From 2001-2005, which is the most recent 5-year period for which data are available, average annual growth in hospital MFP was estimated at 0.1 percent using Method 1, and 1.0 percent using Method 2 (Table 1). In addition, there was a wide divergence in the trends in MFP during these years (Figure 1).

Due to the volatility of the annual estimates of hospital MFP, we also analyze the results using 10-year moving averages. Method 1 produces 10-year average growth in hospital MFP of 0.3 percent for the 10-year period ending in 2005. For Method 2, that average is 0.6 percent (Table 1). The 10-year moving average over the entire period, 1981 to 2005, is equal to -0.2 percent in Method 1, and 0.0 percent in Method 2. Both methodologies show increasing MFP over time. The 10-year moving average MFP in Method 2 is greater than in Method 1 for all but 3 years of the study period. Additionally, Method 2 shows that hospitals first achieved average positive gains in MFP over the preceding 10-year period in 1997. Method 1 indicates that hospitals had just barely begun to show average positive gains in MFP over the preceding 10-year period by 1999 (Figure 2).

SENSITIVITY ANALYSES

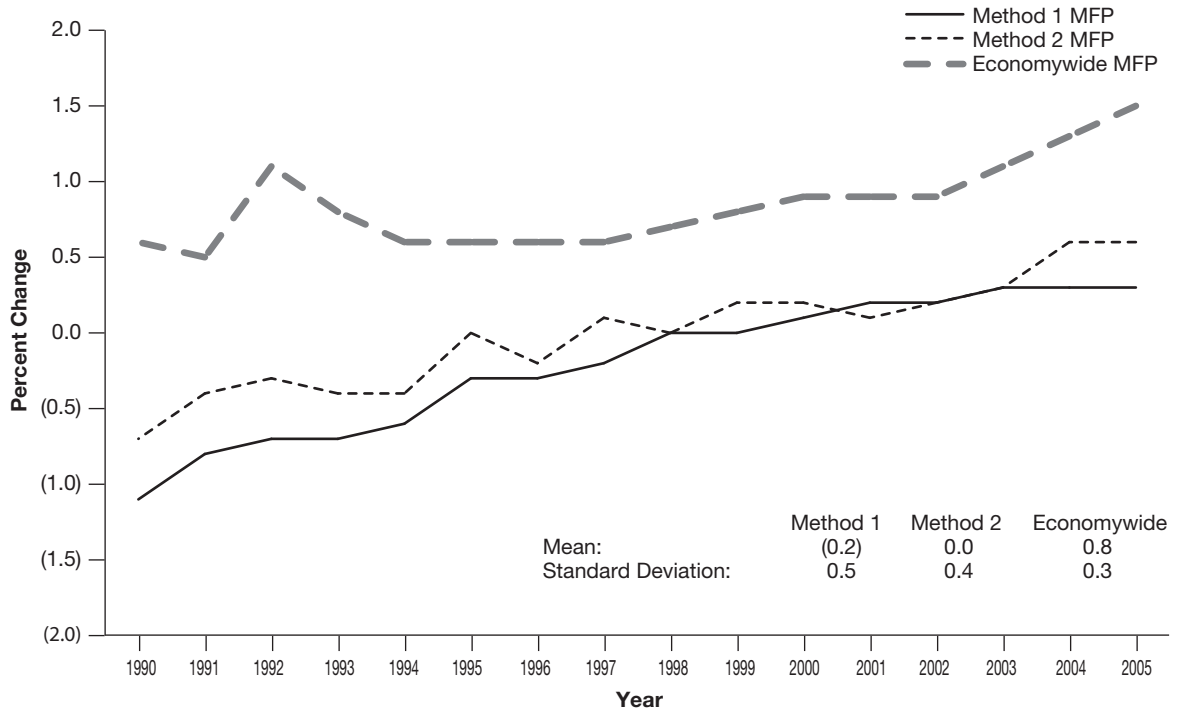
Although we have evaluated the data sources available and made assumptions when data are incomplete, we recognize that there are alternative ways to define hospital outputs and inputs. This next section analyzes the effects of changing some of our assumptions in order to test whether they have a material impact on the results.

Method 1—Sensitivity 1

Many of our assumptions in Method 1 involve hospital revenue and expenditure categories that do not make up a significant share of outputs or inputs. For example, non-patient care net revenues comprised only 7 percent of total net revenues in 2005.

Figure 2

10-Year Moving Average Percent Change in Hospital Multifactor Productivity (MFP) and Private Non-Farm Business Economywide MFP:1990-2005



NOTES: Method 1 derives outputs and inputs from select hospital revenues and expenses, respectively. Method 2 generally follows the approach that the U.S. Bureau of Labor Statistics (BLS) has used to calculate MFP in other industries. Labor quantities are estimated by merging Current Employment Statistics data for total hospital employees with Current Population Survey data for average work weeks and average weekly hours. Economywide represents total private, non-farm business sector MFP as calculated by BLS.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

Similarly, non-operating expenses (which are not included in the MFP calculation) made up approximately 4 percent of total expenses in 2005. These non-operating expenses include expenditures such as investment losses, interest expenses, and business taxes, for which several assumptions are made to derive their values. It is unlikely that these categories materially affect the resulting hospital MFP.

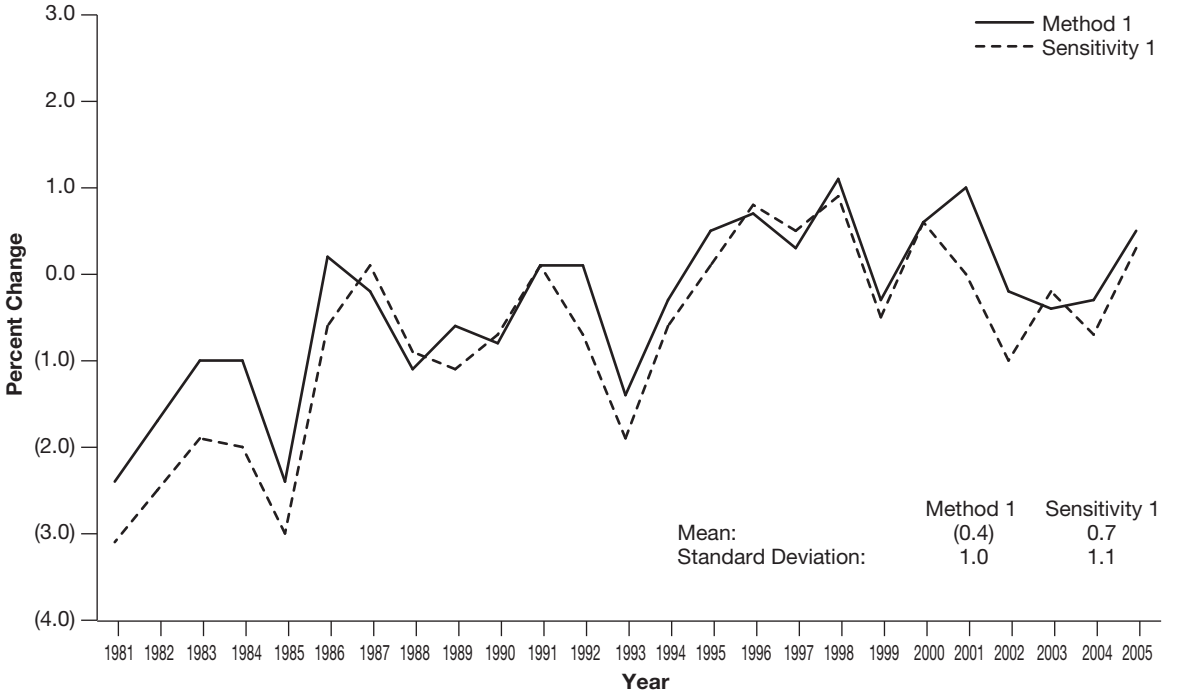
Therefore, to test the robustness of our calculation, we include all previously excluded revenues and expenses. To compute an alternative measure of hospital MFP, outputs are represented by total net revenues deflated by the adjusted hospital PPI, and inputs are represented by total expenses deflated by a weighted average of OACT's operating and capital IPIs for hospitals.[16]

The resulting annual MFP calculation from Sensitivity 1 trends very closely to the original Method 1 MFP. The correlation coefficient between the original Method 1 and the sensitivity analysis is highly positive at 0.94 (Figure 3). From 2001-2005, the most recent 5-year period for which data are available, the average annual hospital MFP in Sensitivity 1 was -0.3 percent compared to 0.1 percent in the original Method 1. The 10-year moving average MFP in

[16] We assigned a weight of 9 percent to the capital IPI and the remaining 91 percent to the operating IPI based on average annual expense data from Method 1.

Figure 3

Average Annual Percent Change in Hospital Multifactor Productivity (MFP) for Method 1 and Sensitivity 1: 1981-2005



NOTES: Method 1 derives outputs and inputs from select hospital revenues and expenses, respectively. Sensitivity 1 is based on Method 1 and derives outputs and inputs from total hospital revenues and expenses, respectively.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

Sensitivity 1 was 0.1 percent in 2005 and 0.3 percent in the original Method 1 (Table 1). The 10-year moving average over the entire period was equal to -0.5 percent, which is less than the -0.2 percent calculated using the original method (Figure 4). These results are similar and indicate that the assumptions made in Method 1 do not have a material effect on hospital MFP.

Method 2—Sensitivity 2

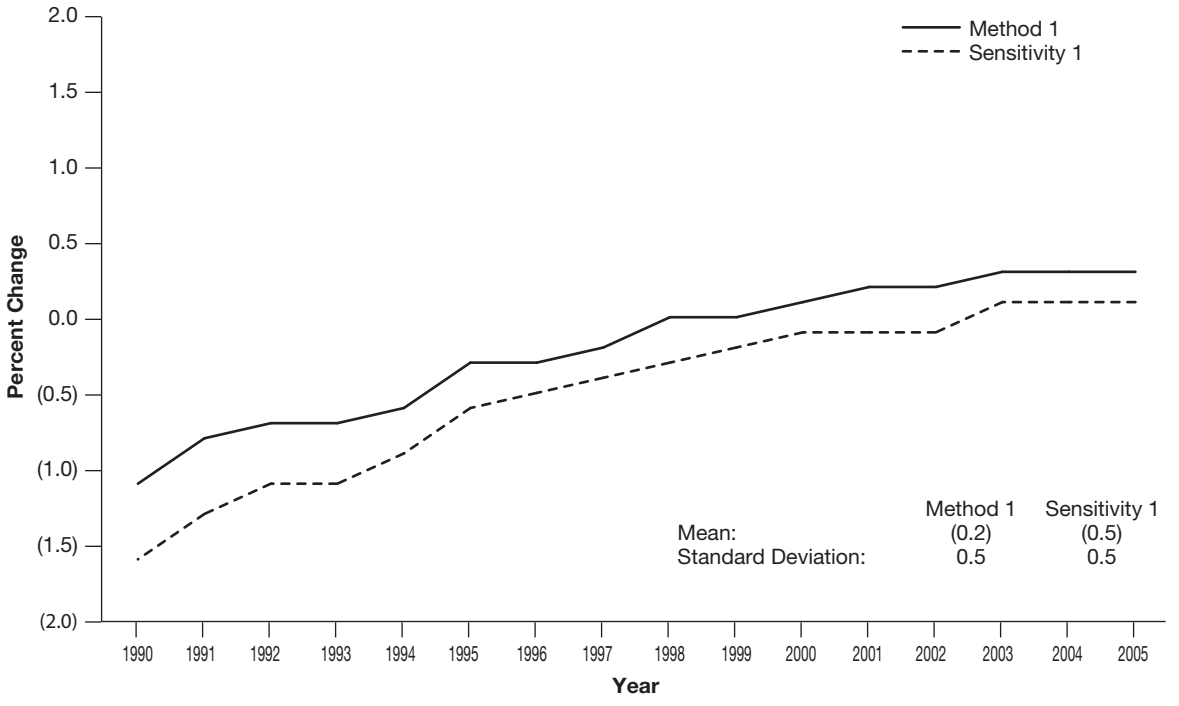
In Method 2, as previously noted, we obtain labor quantities by merging CES data for total hospital employees with CPS data for average work weeks and average weekly hours. The CPS is a sample survey of approximately 60,000 households while the CES survey represents a sample of 160,000 business and government agencies. BLS notes that the data by occupation and industry provided by households in the CPS "…are more subject to nonsampling error than are establishment-based surveys" such as the CES survey (Bowler and Morisi, 2006).

In Sensitivity 2, we calculate an alternative measure of labor quantities using only CES data. The total number of hospital employees is multiplied by average weekly hours for hospital production workers, and this number is multiplied by 52 weeks per year.[17] These new labor quantities are substituted into Method 2 to derive an alternative calculation of hospital MFP. The correlation coefficient between Method 2 and Sensitivity 2 is positive at 0.66 (Figure 5).

[17] BLS does not collect data on non-supervisory hospital employees. We assume that non-supervisory workers' weekly hours were the same as production workers' weekly hours.

Figure 4

10-Year Moving Average Percent Change in Hospital Multifactor Productivity (MFP) for Method 1 and Sensitivity 1: 1990-2005



NOTES: Method 1 derives outputs and inputs from select hospital revenues and expenses, respectively. Sensitivity 1 is based on Method 1 and derives outputs and inputs from total hospital revenues and expenses, respectively.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

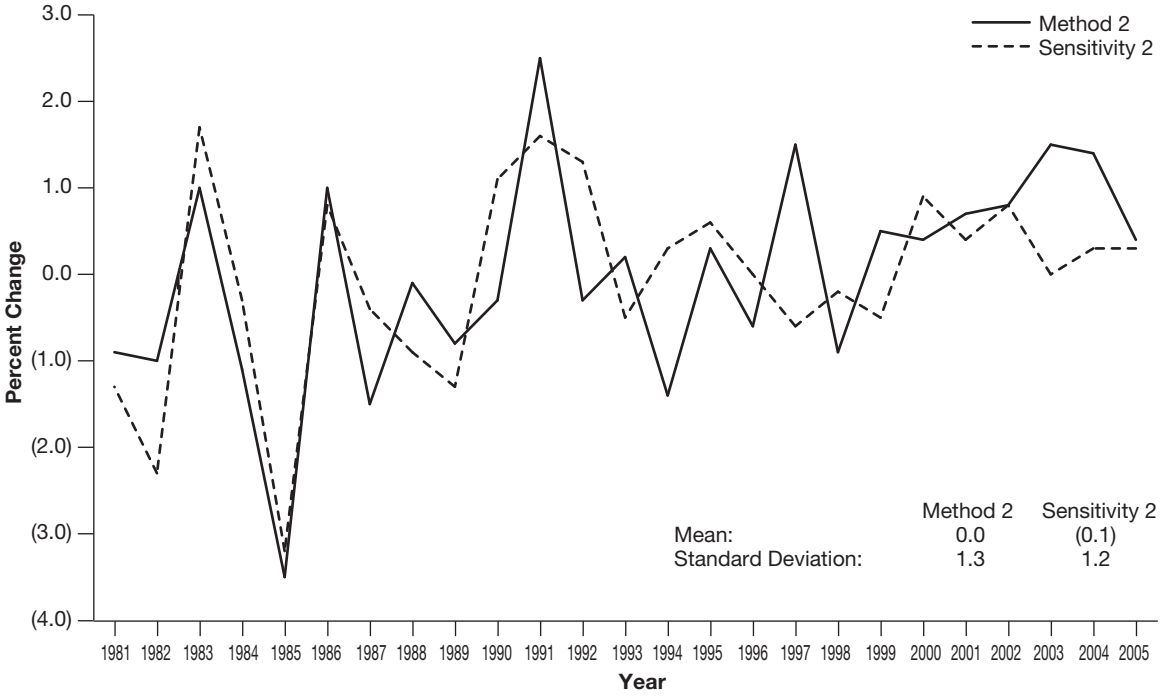
From 2001-2005, the average annual hospital MFP in Sensitivity 2 was 0.3 percent compared to 1.0 percent in the original Method 2. The 10-year average hospital MFP in Sensitivity 2 was 0.1 percent for the 10-year period ending in 2005, compared to 0.6 percent in Method 2 (Table 1). The 10-year moving average over the entire period was equal to 0.1 percent compared to 0.0 percent originally. Although the data do not trend exactly on a year-by-year basis, the overall long-term results appear consistent (Figure 6).

BENEFITS AND LIMITATIONS OF BOTH METHODOLOGIES

Both of these methodologies have notable benefits and limitations. Method 1 has a parallel construction in that real outputs and real inputs are similarly calculated using nominal amounts and associated price index deflators. Method 2 incorporates both data and a methodology that are consistent with the way BLS presently constructs its measures of industry MFP. However, the output quantities used in both methodologies are not quality-adjusted, and their reliability is dependent on whether the payment amounts and associated price deflators are appropriately measured. In addition, the accuracy of input quantities is dependent on whether the underlying nominal amounts used in Method 1, and the explicit quantity amounts used in Method 2, are reliable.

Figure 5

Average Annual Percent Change in Hospital Multifactor Productivity (MFP) for Method 2 and Sensitivity 2: 1981-2005



NOTES: Method 2 generally follows the approach that the U.S. Bureau of Labor Statistics has used to calculate MFP in other industries. Labor quantities are estimated by merging Current Employment Statistics (CES) data for total hospital employees with Current Population Survey data for average work weeks and average weekly hours. Sensitivity 2 is based on Method 2 and labor quantities are estimated using only CES data.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

Outputs

We stated previously that hospital outputs are defined as nominal revenues deflated by a price index. This output measurement accounts for changes in the volume and mix of cases treated by hospitals, but does not adjust for changes in quality, such as health outcomes. Although health care quality has changed over time, there is currently no widely accepted method that includes quality measures as a component of hospital output.

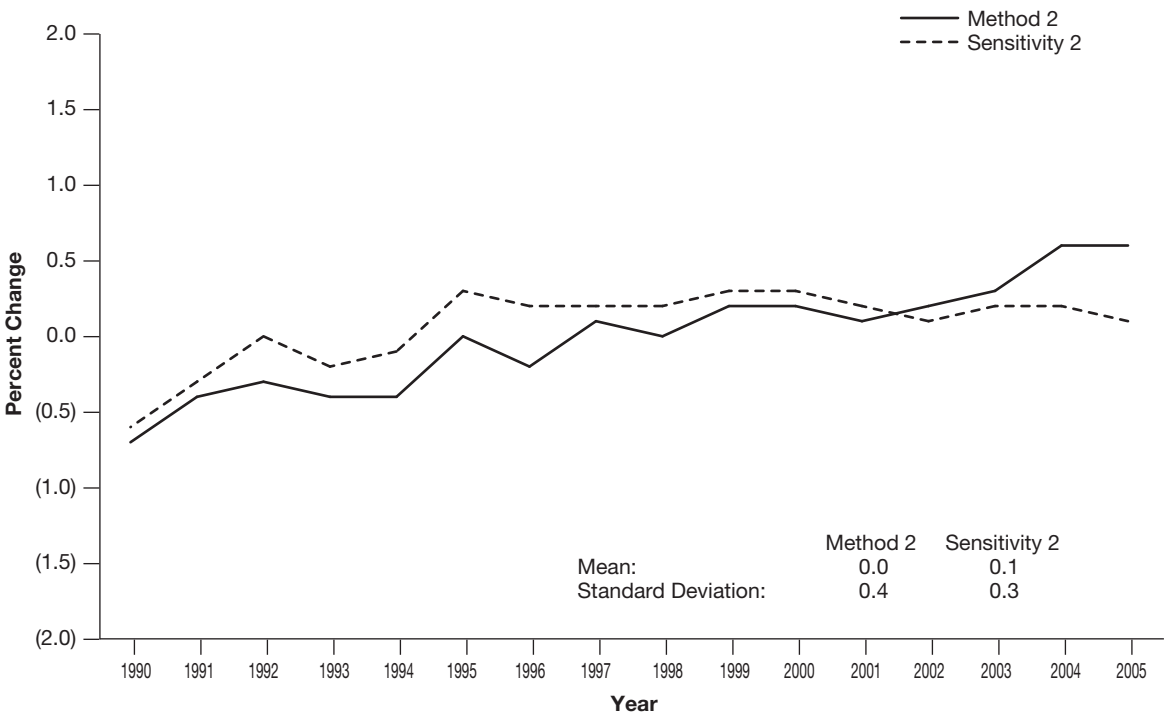
Our attempt is to estimate real revenues as output; however, the hospital PPI is not an ideal measure of transaction prices for our purposes. The Medicare portion of this index reflects a fixed annual rate of payment for hospitals. In the case of the hospital sector (as well as with many other health care sectors), prices are administered rather than reached through open competition. Thus, it can be argued that deriving outputs using nominal payments and the hospital PPI results in a distorted measure. Nevertheless, in the absence of better data, this method of calculating outputs remains one of our only options.

Inputs

Within inputs, we focus on the labor measure because the measure for intermediate inputs is identical for both methods

Figure 6

10-Year Moving Average Percent Change in Hospital Multifactor Productivity (MFP) for Method 2 and Sensitivity 2: 1990-2005



NOTES: Method 2 generally follows the approach that the U.S. Bureau of Labor Statistics has used to calculate MFP in other industries. Labor quantities are estimated by merging Current Employment Statistics (CES) data for total hospital employees with Current Population Survey data for average work weeks and average weekly hours. Sensitivity 2 is based on Method 2 and calculates labor quantities using only CES data.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

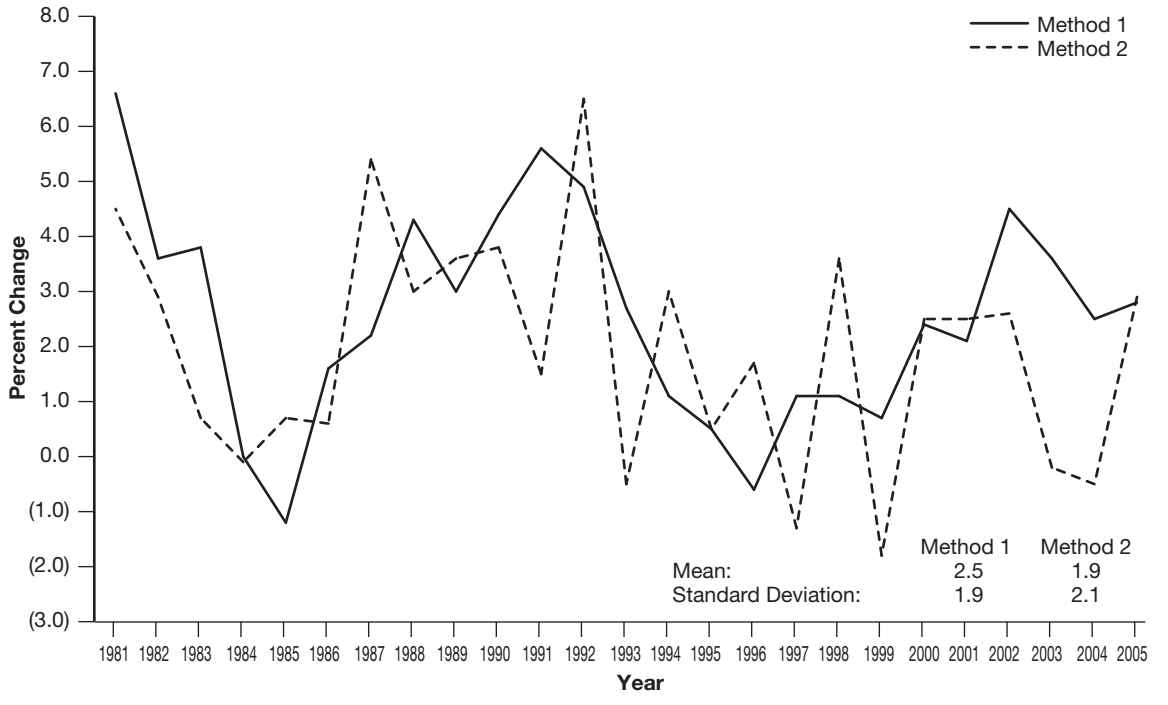
and the capital weight is small. In Method 1, nominal labor expenses are deflated by ECIs for hospital workers. In Method 2, real labor quantities are estimated using annual hours of work per employee, number of work weeks, and total number of employees for hospitals. Method 1 yields a relatively smooth curve for changes in labor quantities; Method 2 yields a more volatile curve, likely because it incorporates multiple surveys with different sampling frames (Figure 7). The inconsistencies in these data suggest that further research is required in order to determine an accurate measure of labor quantities.

COMPARISON WITH ECONOMYWIDE PRODUCTIVITY

MedPAC has recommended that Medicare payments to hospitals be offset by gains in MFP. In March 2006, MedPAC stated that the Medicare payment update to hospitals in 2007 should be decreased by one-half of MedPAC's expectation regarding the 10-year moving average of MFP gains in the total private, non-farm business sector as calculated by BLS (Medicare Payment Advisory Commission, 2006). Subsequently, in March 2007 MedPAC recommended that its target in 2008 for improving efficiency in hospitals

Figure 7

Comparison of Labor Quantities



NOTES: Method 1 labor quantities are estimated by deflating nominal labor expenses by hospital worker Employment Cost Indexes. Method 2 labor quantities are estimated by merging Current Employment Statistics data for total hospital employees with Current Population Survey data for average work weeks and average weekly hours.

SOURCE: Centers for Medicare & Medicaid Services, Office of the Actuary, 2007.

be equal to the 10-year moving average of MFP for the total private, non-farm business sector (Medicare Payment Advisory Commission, 2007).

We compared the 10-year moving averages of our estimates of hospital MFP using Methods 1 and 2 with total private, non-farm business MFP for the overall economy.[18] Over each of the 10-year periods ending in 1990-2005, estimates of average hospital MFP from Methods 1 and 2 were less than one-half of average economywide MFP (Figure 2).

[18] Data for private non-farm business sector MFP represent the historical MFP measures published by BLS (Standard Industrial Code for years 1981-1987 linked to North American Industry Classification System for 1987-2005).

LABOR-INTENSIVE NATURE OF HOSPITAL SECTOR

We also compared the shares of total expenses that labor and capital represent over time. In Method 1, total labor compensation fell from 60 percent of total operating expenses in 1981 to 54 percent in 2005, while capital expenses increased from 5 percent of total expenses to 7 percent over this same time period (Table 2). Similarly, in Method 2, total labor compensation fell from 56 percent of total revenues in 1981 to 49 percent in 2005; capital's share increased from 12 to 16 percent (Table 3).[19] These results suggest that, as would be expected, hospitals have moved toward

[19] Capital's share of expenses is greater in Method 2 because it assumes that profits are returns to capital accounts.

more technology-intensive inputs by substituting capital for labor over time.

Despite a declining share as a percent of total operating expenses, labor still consistently comprises the largest input weight of the three components. Compared to manufacturing industries, it appears that hospitals are less able to substitute technology-intensive inputs for labor-intensive inputs. As a result, positive gains in MFP may be more difficult to achieve in hospitals relative to manufacturing industries due to their labor-intensive nature. This is commonly referred to as the Baumol Effect (Baumol and Bowen, 1966).

CONCLUSION

Recently, there has been discussion among policymakers and researchers as to whether hospitals are able to achieve gains in MFP. MedPAC's recommendation that Medicare payments to hospitals be offset by gains in MFP has further stimulated this debate. This article presents two methodologies to calculate historical measurements of hospital MFP. Though they use some of the same measurements, these methods produce conflicting results, largely due to variations in the data. It is our view that it is necessary to present each method individually in order to highlight the benefits of each—namely, that Method 1 uses a consistent approach as a price-derived measure and that Method 2 follows the general BLS approach for calculating industry MFP. In spite of the limitations of these methods, we hope that this work will facilitate more research into this topic.

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