
MEASURING PRODUCTIVITY IN HEALTHCARE: AN ANALYSIS OF THE LITERATURE

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INTRODUCTION

Measured productivity growth in the health care industry has generally been well below that of the economy as a whole. Many analysts attribute this low productivity growth to measurement problems. They argue that most of the productivity growth in health care has come in the form of improved quality rather than lower cost. Furthermore, they argue that many of the innovations that have reduced costs and increased productivity—such as moving from inpatient to outpatient care—are not captured in the standard measures. Others, however, believe that even when properly measured, productivity growth in the health sector is low because it is a service sector that has limited scope for efficiency improvements (Baumol’s “cost disease” argument).

The Affordable Care Act (ACA) has renewed attention on health care productivity because of changes it made to Medicare. In particular, under the ACA, the legislated payment updates for hospitals and other non-physician providers are determined by the difference between the growth in input costs (wages, rents, etc.) and the ten-year average increase in economy-wide multifactor productivity (MFP). If MFP in health care equals that of the economy as a whole, then this formula will update payments so as to cover the increased cost necessary to provide the same services over time. If, however, MFP in the health care sector is below that of the economy as a whole, then the payment updates will be insufficient to cover costs and providers will suffer increasing financial losses over time when treating Medicare patients, possibly limiting Medicare patients’ access to quality health care.

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I. TRADITIONAL MEASURES OF PRODUCTIVITY IN HEALTHCARE

There are several distinct productivity concepts. Labor productivity growth measures the increase in output per worker over time. Labor productivity can improve because of more educated workers, technological improvements or increased investment in other inputs—like capital (for example, a new computer). Multifactor productivity growth measures the increase in output over time that is achievable with the same set of inputs—same amount of labor, capital, energy, etc. Increases in MFP represent improvements in technology—with the same set of inputs, the economy figures out how to produce more. MFP is defined as a residual: it is the increase in output that cannot be explained by changes in inputs.

$$\text{MFP} = \text{Growth rate of real output} - \text{growth rate of inputs} * \text{input shares}$$

The traditional approach to measuring health care productivity typically defines output as spending on health goods and services—e.g., drugs, hospital services, physicians' services—deflated by an appropriate price index to get a measure of real output over time. Table 1 summarizes the results from studies of health care productivity using this traditional approach. On average, MFP growth in health care has been found to be smaller than economy-wide MFP or even negative. Using expenditure data and deflators from the Bureau of Economic Analysis, Triplett and Bosworth (2004) found negative productivity growth in U.S. medical care in 1987-2001, at a rate of about 1 percent per year, about the same rate of MFP growth found by Harper et al (2010) for 1987-2006. Cylus and Dickensheets (2007) measured productivity growth for hospitals; they used net revenue for hospitals deflated by the producer price index for hospitals as their measure of output. They found that the 10-year moving average of growth in hospital MFP for the 10-year period ending in 2005 was 0.3 to 0.6 percent, depending on the method used to measure hospital inputs. Over each of the 10-year periods ending in 1990-2005, the estimated average hospital MFP was less than one-half of average economy-wide MFP. Spitalnic et al. (2016) updated Cylus and Dickensheets' study by extending the period of study to 2013. Their results were quite similar. They calculated that, over the period 1990-2013, the average growth rate of hospital MFP was between 0.1 percent and 0.6 percent, compared to the average growth of private non-farm business MFP of 1 percent.

Fisher (2007) estimated MFP of physicians' offices and found wide variation over time: MFP rose at an average rate of 1.5 percent per year from 1982 to 1992, fell -0.6 percent per year on average from 1993 to 2000, and increased 1.7 percent per year from 2001 to 2004. Over the period as a whole, physician MFP was about the same as economy-wide MFP. Other measures of MFP have focused on measuring labor productivity instead of MFP. Chansky et al (2015), for example, find that labor productivity growth in hospitals averaged just ½ percent per year between 1993 and 2012, well below the 2¼ percent overall labor productivity in the United States over this time period. Studies of health care productivity in Canada, for example by Sharpe et al (2007), have also found very weak productivity growth.

| Table 1: Service-based Productivity Measures without Quality Adjustment | | | | | |
|--|--|--------------------|-------------------------------------|--|--|
| | Service | Measure | Time period | Annual Productivity/Price Growth | |
| United States | | | | | |
| Triplett and Bosworth (2004) | All | MFP | 1987-1995 1995-2001 | -1.5% -0.4% | |
| Cylus and Dickensheets (2007) | Hospitals | MFP | 2001-2005 | 0.1 to 1.0%. | |
| Spitalnic, Heffler, Dickensheets, and Knight (2016) | Hospitals | MFP | 1990-2013 | 0.1% to 0.6%. | |
| Harper, Khandrika, Kinoshita, and Rosenthal (2010) | All | MFP | 1987-2006 | -.7% : Ambulatory Care -.9% : Hospitals and Nursing Homes | |
| Chansky, Garner, and Raichoudhary (2015) | Hospitals | Labor Productivity | 1993-2012 | 0.5% | |
| Fisher (2007) | Physician Offices | MFP | 1983-1992 1993-2000 2001-2004 | 1.5%. -0.6%. 1.7%. | |
| International | | | | | |
| Sharpe, Bradley, and Messinger (2007) | All - Canada | Labor Productivity | 1987-2006 | -0.69% | |
| Gu and Li (2015) | All excluding Hospitals - Canada Nursing Homes - Canada | MFP | 1994-2003 | -2.9% to -3.8% | |
| Nghiem, Coelli, and Barber (2011) | Hospitals - Australia | MFP | 1997-2004 | 1.60% | |

In sum, multiple studies that measure productivity growth at the service level using standard price deflators have found weak or negative productivity growth in health care, with the Fisher's study on physicians being a notable exception.

II. PROBLEMS WITH TRADITIONAL MEASURES OF PRODUCTIVITY GROWTH

Traditional measures of productivity growth define health care output as the nominal expenditures on health care by service providers (hospitals, physicians, etc.) deflated by a price index for health care. In theory, this should yield a measure of units of output over time. However, if the price of health care is mismeasured, then so too will be the output and productivity measures. Thus, any problems with measuring prices of health care mean problems for measuring productivity.

Two main problems have been identified in the measurement of the price of health care, both discussed in detail below. One is in identifying the appropriate good. In the traditional approach, the good is the health care service or good actually purchased: a doctor's appointment, a hospital stay, a prescription. But, as noted by Triplett (2011), these purchases are better viewed as intermediate inputs into the production of what the consumer truly wants – better health. By viewing services in different categories as different goods, rather than as inputs in the production of one good, cost savings arising from substitution of one input for another are not taken into account.

The second problem in constructing price indexes for medical care is that the nature of the good is changing. In particular, medical care outcomes have tended to improve over time. Measures of prices that don't capture these increases in quality will overstate price growth in health care and understate productivity growth.¹

III. DISEASED-BASED APPROACHES TO MEASURING HEALTH CARE QUANTITIES AND PRICES

There has been a large push toward redefining the health sector's output as disease treatments, rather than as medical goods and services. This was the approach advocated by the National Academies Committee on National Statistics (Schultze and Mackie (2002)). As a result, the Bureau of Economic Analysis has introduced Health Satellite Accounts that account for health spending on a disease basis and the BLS has introduced experimental disease-based price indexes (Dunn et al(2015b); Bradley et al (2015); OECD (2001); Schreyer and Mas (2013); Schreyer (2010)).²

1 One interesting question is which industry's productivity growth is being understated. For example, if a new cancer drug is invented that improves outcomes, then the productivity growth is in the pharmaceutical industry, not the hospital that administers the drug. For hospital productivity, both outputs (health) and inputs (quality-adjusted drugs) would be underestimated, though hospital MFP would not be. But, as discussed below, for the purposes of the sustainability of the ACA cuts, this distinction is unimportant.

2 BEA provides annual price indexes for 15 broad disease categories for 2000-2010/2012, whereas BLS provides monthly price indexes for 19 disease categories for 1999-2015.

Box 1 summarizes the various methods that have been used to implement disease-based approaches.

Moving to a disease-based index (often referred to as Medical Care Expenditure index, or MCE index) does not affect nominal expenditures on health care, but it can affect how prices are measured. Under the disease-based approach, the medical service being purchased is a treatment for a particular disease. Thus, spending increases over time either because disease prevalence increases—that is, the quantity of treatment increases (for example, rates of diabetes are increasing)—or because the average cost to treat someone with diabetes is increasing. The latter measure is viewed as the “price” of a diabetes treatment.

Disease-based price indexes can evolve quite differently from traditional service-based price indexes (SPIs) that measure the price of a fixed basket of medical services.

One advantage of the disease-based approach is that it captures shifts between providers. For example, improvements in technology mean that numerous treatments that used to require a hospital stay can now be provided at a lower cost in an outpatient setting. The traditional approach to measuring health care prices, which uses the change in prices for a fixed bundle of medical services—such as an hour of physician’s time or a hospital stay—would miss the effects of this shift in treatment methods on the price of health care. But, in theory, a treatment-based approach aggregates all spending for a particular disease—regardless of where or by whom it is provided—and hence would count the substitution of lower-cost outpatient care of higher-cost inpatient care as a price reduction.³

On the other hand, increases in the intensity of services used to treat diseases—for example, more doctor visits per episode—would increase the average cost of treating a disease and would show up as a price increase in the treatment-based approach. But it would show up as an increase in the quantity of health care services—not the price—in a service-based approach.

Table 2 summarizes the studies that have been done using the disease-based approach. The last column of Table 2 compares the disease-based price indexes with more traditional service price indexes (SPIs). Dunn et al (2015b) compare disease-based price indexes with the official price indexes for medical care used in the National Income and Product Accounts (NIPA), which are themselves based on the Bureau of Labor Statistics Producer Price Indexes. They find that price increases using the disease-based approach are, on average, higher than the official price indexes for medical care over the 2000-2010 period. Similarly, Aizcorbe and Highfill (2015) found that, from

³ One problem with using a disease-based approach is that not all spending can be allocated to diseases. One cannot attribute spending on preventative health services, for example, to a disease. In addition, the information required to attribute spending to a disease is often not available. For example, prescription drug data don’t include any codes for diagnoses. Dunn et al (2015b) were able to allocate about 80 percent of health spending into disease categories, and an additional 6 percent into a category called preventative medicine.

| Table 2: Disease-based expenditure index studies | | | |
|---|---------------------------------|--|--|
| Source | Time period | Data source | Excess of service price index over disease-based price (average annual growth rate) |
| Dunn, Rittmueller, and Whitmire (2015) | 2001-2010 | Medical Expenditures Panel Survey and Commercial Claims data | -0.9% - 1.3% (Excess of PCE Health Deflator over disease-based price) |
| Bradley, Hunjan, and Rozentel (2015) | 1999-2014 | Medical Expenditures Panel Survey | 0.5% |
| Dunn, Liebman, and Shapiro (2015) | 2003-2007 | Commercial claims data from MarketScan Research Database (Truven Health) | 0.4% |
| Aizcorbe and Highfill (2015) | 1980-87 1987-96 1996-2006 | National Medical Care Utilization and Expenditure Survey, National Medical Expenditure Survey, Medical Expenditure Panel Surveys | -0.3% 3.5% -2.6% |
| Dunn, Liebman, Rittmueller, and Shapiro (2014) | 2003-2007 | Commercial claims data from MarketScan Research Database (Truven Health) | Not reported |
| Hall (2014) | 2001-2009 | Medicare Current Beneficiary Survey | Not reported |
| Hall and Highfill (2013a) | 2001-2005 | Medicare Current Beneficiary Survey | 0.1% to -0.4% |
| Hall and Highfill (2013b) | 2001-2009 | Medicare Current Beneficiary Survey and the Medical Expenditure Panel Survey | Not reported |
| Bradley (2013) | 2004-2010 | Medical Expenditures Panel Survey and BLS CPI production data | 1.1% to 1.2% |
| Dunn, Liebman, Pack and Shapiro (2013) | 2003-2007 | MarketScan Commercial Claims and Encounters Database | 0.7% |
| Aizcorbe and Nestoriak (2011) | 2003-2005 | Claims from the Pharmetrics, Inc. | 2.4% |
| Song, Marder, Houchens, Conklin, and Bradley (2009) | 1999-2002 | MarketScan Commercial Claims and Encounters Database and the Medicare Supplemental and Coordination of Benefits Database | 5.8% to 12.7% |
| Aizcorbe and Nestoriak (2008) | 2003-2005 | Claims from the Pharmetrics, Inc. | 1.7% |
| Shapiro, Shapiro, and Wilcox (2001) | 1969-1994 | Consumer Price Index for Cataract Surgery | 5.1% |

1996-2006, using the Medical Expenditure Panel Survey and other sources, the disease-based price indexes rose 5.3 percent per year, much faster than the 2.7 percent rise in the official NIPA price index.

On the other hand, Bradley (2013) finds that, for the period 2004 to 2010, health care inflation using a disease-based approach averaged about 1 percent below the official measures of health care inflation published by the Bureau of Labor Statistics. A number of earlier studies had also concluded that disease-based price indexes generally show lower medical inflation than service-based prices, including Song et al (2009), Aizcorbe and Nestoriak (2011), and Dunn et al (2013). Dunn et al (2015a) attribute this discrepancy to differences in the way the traditional service-price indexes are defined: The official price indexes tend to price a fixed basket of procedures (e.g., an X-ray or an MRI) whereas the service-based price indexes used in much of the literature price encounters (a physician visit, a hospital stay). Increases in the intensity of medical services that raise the cost of encounters are called price increases in the encounter-based approach used by researchers but not in the procedure-based approach used in the official price statistics.

Whether an increase in intensity of service used should be viewed as part of the price or not depends on whether that increased use was valuable. If the increase in intensity represents better medical care, then it should clearly be viewed as an increase in quality, not price. Advocates of disease-based prices recognize that calling all such increases in spending as price inflation isn't accurate. They note, however, that because the quality of health care can only be measured on a treatment-by-treatment basis, a treatment-based approach is a necessary first step in deriving quality-adjusted health care price index.

IV. ADJUSTING HEALTH CARE FOR CHANGES IN QUALITY

The second major problem with measuring the price of health care is that health care is a rapidly evolving industry with changes in treatments and quality over time. Increases in spending over time that are associated with improved outcomes should not be viewed as increases in prices, but as changes in the nature of the good. There are two elements involved in adjusting for quality. First, one needs to be able to define quality and measure it. Second, one needs to decide how to incorporate that measurement into the price index or, equivalently, into the measure of real output.⁴

IV.A. Measuring Health Care Quality

Hall (2015) reviews the various methods currently used to measure the quality of health care. One approach is to track outcomes. Researchers who have measured quality through outcomes

⁴ Because real output is defined as nominal output over the price, an adjustment to real output, given nominal output, also implies an adjustment to the price, and vice versa.

have defined quality improvements by changes in life expectancy (Cutler et al (1998, 2001, 2006), Howard et al (2010), Rosen, et al (2007), Romley et al (2015)); and in disability-adjusted life years (Highfill and Bernstein (2014)).

Others have used less direct measures to measure quality. For example, Lakdawalla et al (2015) rely on the medical literature to assess changes in expected life expectancy arising from new therapies for colorectal cancer and multiple myeloma. Berndt et al (2002) use expert opinions on the likelihood of remission as the measure of quality when assessing treatments for depression. Eggleston et al (2011) use the change in modifiable cardiovascular risk for diabetes as the quality metric, a measure that examines modifiable patient conditions, like glycated hemoglobin levels, that are associated with risks of cardiac events.

Another approach is to focus on inputs, without any direct measure of actual or even expected outcomes. This is the approach currently used by the BLS in their quality adjustment for hospital producer price indexes for treatment of heart attack, heart failure, pneumonia, and surgery (Hospital Quality Valuation Team (2008)). Their quality adjustment defines quality by hospital performance on metrics included in the Centers for Medicare and Medicaid Services (CMS) Hospital Compare database. These metrics are, in general, based on hospital inputs, not outcomes.⁵ For example, the metrics for heart failure include whether patients were given ACE inhibitors when indicated and whether they were given discharge instructions and smoking cessation advice. Similarly, the BLS adjusts prices of nursing home services by the level of nurse staffing (BLS, Quality Adjustment (2014)).

As Hall (2015) notes, improved measurement of outcomes will be necessary if health expenditures are ever to be fully quality adjusted; many health care issues are not life-threatening and therefore focusing on mortality reductions will leave most quality improvements unmeasured. Similarly, focusing on adherence to guidelines or best practices, such as whether patients are given discharge instructions, might capture some aspects of quality but may end up disregarding the most valuable improvements. Even if adhering to guidelines would improve important outcomes like mortality and disability, it is likely that much of the improvement in treatment would have been disseminated before becoming part of official guidelines, as these tend to lag best practices (Porter and Teisberg, (2004)).

IV.B. Incorporating Quality Changes Into Price Indexes and Measures of Productivity

The second issue is how changes in quality, once they have been agreed upon and measured, should be incorporated into price indexes. Table 3 provides a summary of the literature that has attempted to quality-adjust measures of health care prices and output. Three major approaches have been used. As we discuss below, these three measures can yield very different results, even

⁵ However, recently CMS has added a number of outcomes based measures, including complication rates for hip and knee replacements, and 30-day death and readmission rates following surgery.

though, under certain conditions, they are identical.

- **The Cost-of-Living Approach:** Cutler et al (1998, 2001) calculate a “cost of living index” (COLI) for heart attack treatment that adjusts the overall price level for the *value* of the improved life expectancy arising out of improved treatments. This method has also been used by Eggleston et al (2011) and Eggleston et al (2009) for diabetes treatment, Ladhakwalla et al (2015) for multiple myeloma and colorectal cancer, and by Constant et al (2006) for cancer treatment in Canada.
- **The “Redefine the Good” Approach:** Romley et al (2015) adjust for quality by redefining the health care good. Rather than using the number of interventions as a measure of the quantity of health care, they measure the number of successful interventions. As health quality improves, more interventions are successful (by saving more lives or diminishing symptoms, for example) and so real quantities increase more rapidly than nominal spending using standard price deflators.
- **The Cost of Quality Improvement Approach:** BLS adjusts the hospital producer price index for changes in quality by subtracting an estimate of the cost of the quality improvement from its price (Hospital Valuation Team (2008)). This approach is often used in comparing goods that change over time—for example, if a table top changes from pine to oak, the price is adjusted down to reflect the higher cost of oak (BLS, Quality Adjustment (2014))—but it is the only case that we know of where it has been used for health care.

The Cost-of-Living Approach

As noted by Bradley et al (2015), the ideal Cost of Living Index measures the relative cost of obtaining the same level of utility at different points in time. Under this definition of a COLI, improvements in health care that increase life expectancy or reduce disability should be valued at their monetary worth. Typically, this is measured by the changes in income required to buy the same good as in the previous period (for a Laspeyres price index) at the new prices. But when the quality of the good changes this is no longer appropriate.

Instead, Cutler et al (1998, 2001) calculate a price index by using a direct measure of the amount of income one could take away in period t to have the same utility as in period $t-1$. Define NB_t as the net benefit that one receives from the increase in health spending between time $t-1$ and t . It is equal to the value of the additional health received less the cost. Then, assuming that all other prices stay fixed, the percentage change in the COLI between time $t-1$ and t , $\Delta COLI$, is simply:

$$\Delta COLI = \frac{-NB_t}{Y_t}$$

As a simple example, assume that in period 1 income is \$100 and health spending is \$10. Then in period 2, health spending increases to \$15 but the value to the person of that additional \$5 in health

| Table 3: Relevant studies that implemented a quality adjustment | | | | | | |
|---|--------------|---------------|--|--|-----------------------------|---|
| Authors | Service type | Time period | Disease / condition | Quality measure | Quality adjustment approach | Findings |
| United States | | | | | | |
| Howard, Bach, Berndt, and Conti (2015) | drugs | 1995-2013 | Cancer | Increased life expectancy | Redefine the Good | Launch prices per year of life expectancy increased by 10% per year. |
| Romley, Goldman, and Sood (2015) | hospitals | 2002-2011 | Heart attack, heart failure, and pneumonia | Successful interventions | Redefining the Good | The rates of annual productivity growth were 0.78 percent for heart attack, 0.62 percent for heart failure, and 1.90 percent for pneumonia |
| Lakdawalla, Shafirin, Lucarelli, Nicholson, et al. (2015) | drugs | 1998-2009 | Colorectal cancer and multiple myeloma | Life expectancy | COLI | For Colorectal cancer, costs increased by \$34,493 (2014 prices), but quality adjusted costs increased only by \$1,377. For multiple myeloma, costs of care increased by \$72,937, but quality adjusted costs fell by \$67,863. |
| Highfill and Bernstein (2014) | mixed | 1987-2010 | Thirty chronic conditions | DALYs gained | COLI | The net value was positive for twelve of the 30 diseases. |
| Dunn (2012) | drugs | 1996-2005 | Conditions for which anti-cholesterol drugs are used | Changes in the compensating variation derived from the estimated demand model | COLI | The average price does not change but the constant-quality price index drops by 27 percent. |
| Eggleston, Shah, Smith, Berndt, and Newhouse (2011) | mixed | 1999-2009 | Diabetes | Life expectancy | COLI | Quality adjusted prices unchanged. |
| Eggleston, Shah, Smith, et al. (2009) | mixed | 1997-2005 | Diabetes | Life expectancy | COLI | The net value was \$10,911 per patient. |
| Lucarelli and Nicholson (2009) | drugs | 1993-2005 | Colorectal cancer | Life expectancy and QALYs | COLI | Price index flat. |
| Hospital Quality Valuation Team (2008) | hospitals | | Heart attack, heart failure, pneumonia, surgery | Composite quality utilization scores for hospitals at the DRG level | Cost of Quality Improvement | Little effect on prices. |
| Frank, Berndt, Busch, and Lehman (2004) | mixed | 1994-2000 | Schizophrenia | Indicators for various treatment regimens | Cost of Quality Improvement | Costs increased 0.5% per year but quality-adjusted costs fell 5.5% per year. |
| Berndt, Bir, Busch, Frank, and Normande (2002) | mixed | 1991-1996 | Depression | Probability of remission | Redefine the Good | Price index fell 1.66% to 2.13% per year. |
| Cutler, McClellan, Newhouse, and Remler (2001) | hospitals | 1983/4 - 1994 | Heart attack | Life expectancy | COLI | Quality-adjusted prices declined 1.5%-1.7% per year. ^b |
| Busch, Berndt, and Frank (2001) | mixed | 1991-1996 | Mental health conditions | Treatment regimens ranked for their effectiveness | Redefine the Good | The quality-adjusted index declined 2.7 percent per year unadjusted prices rose 2.6 percent per year. |
| UK | | | | | | |
| UK Office for National Statistics (2015) | mixed | 2002-2012 | All | Increased survival rate | Redefine the Good | The quality adjustment factor adds 0.5 percent per year on average to output growth. |
| Castelli, Dawson, Gravelle, et al. (2007) | hospitals | 1997-2004 | All | Life expectancy and change in waiting times | Redefine the Good | MFP growth was -87% per year with quality adjustment and -1.11% per year without. |
| Canada | | | | | | |
| Constant, Benda, Ariste, and Mallory (2006) | hospitals | 1995- 2002 | Lung, breast, prostate and colorectal cancer | Life expectancy | COLI | The SPI rose at 1.9% annually but the COLI fell by 2.6% annually. |
| Multiple countries | | | | | | |
| O'Mahony, Huttli, Mas, et al. (2014) | mixed | 2003-2009 | | Increased survival rates, health gain from hospital stay, change in waiting times, and a measure of patient experience of services | * | Output growth is highest in the UK followed by Germany. |

spending is \$10. Then, the person is better off by \$5. This is equivalent to a 5 percent ($\$5/\100) reduction in overall prices, which would increase the person's buying power by the same \$5.

Using this method to investigate the COLI for heart attack treatment, Cutler et al (2001) found that, between 1984 and 1994, life expectancy for heart attack victims increased by about 1 year, at an increased cost of about \$7,000. They calculate that, if the value of an additional life year is \$25,000 (a reasonable mid-point from the literature for elderly people), then, properly measured, the price of heart attacks actually declined.⁶

Although the literature has generally missed this point, it is important to note that these COLIs should not be viewed as quality-adjusted health spending deflators. Rather, they are akin to the changes to the aggregate deflator (say, the GDP deflator) that arise because of improvements in health technology. To convert these to health deflators, one would divide the measured change in prices by the income share of health. For example, in the simple example above, the share of health spending in year $t-1$ is 10 percent of income. To get a 5 percent reduction in the GDP deflator, health prices would have to be viewed as having decreased 50 percent. Assuming that no other prices increased, then a 50 percent reduction in health prices with a 10 percent weight on health prices in income would produce an overall inflation rate of -5 percent, or a real income gain of \$5.

As shown in Box 2, the COLI approach is equivalent to one in which the quality-adjusted price is equal to the actual price less the *utility value* (in monetary terms) of the quality improvement. Applying this method to the data in Cutler et al (2001), we find that the quality-adjusted price of heart attack treatment fell by about 14 percent per year between 1984 and 1994. These calculations are shown in Table 4.

The “Redefine the Good” Approach

A second way to adjust for quality is to redefine the good. People do not want health treatments because they enjoy them, but because they achieve results. Thus, one can define the good that is purchased as a “successful treatment” and think about the costs of unsuccessful treatment as simply raising the price of successful treatments. (This approach would be most reasonable if people simply repeated treatments until they worked.) Similarly, one could think of the good being purchased as additional years of life or additional years of disability-free life, and calculate the cost of that good over time.

Romley et al (2015) use this methodology to study productivity growth in the hospital treatment of

6 Cutler et al (2001) compute an overall decline in the cost of living arising out of improved heart attack treatment of 1.5 percent per year. However, as shown in Box 2, this shouldn't be viewed as the decline in the price of heart attack treatment. Furthermore, this calculation is done only for heart attack victims and uses the present value of 5 years of income, so it is hard to compare it to overall price deflators or price deflators for heart attacks.

**Table 4: Calculating the Health Price Deflator
using data from Cutler, McClellan, Newhouse, and Remler, 2001.**

| Year | Life expectancy following Treatment (Months) | Treatment Cost | No Quality Adjustment | | COLI Method | | | Redefine the Good | |
|-----------|--|----------------|----------------------------------|-----------------------------------|--|---|---------------------------|-------------------|------|
| | | | Treatment Health Price Inflation | Unadjusted Health Price Inflation | Valuation of Additional Life (@\$25,000 per Life Year) | Quality Adjusted Health Price Inflation | Cost/Year Life Expectancy | Price Index | |
| 1984 | 60 | \$11,483 | | | | | | \$2,297 | |
| 1985 | 60 | \$12,066 | 5% | 5% | \$0 | 5% | | \$2,413 | 5% |
| 1986 | 61 | \$12,395 | 3% | 3% | \$2,083 | -15% | | \$2,438 | 1% |
| 1987 | 62 | \$12,673 | 2% | 2% | \$4,167 | -15% | | \$2,453 | 1% |
| 1988 | 64 | \$13,123 | 4% | 4% | \$8,333 | -29% | | \$2,461 | 0% |
| 1989 | 66 | \$13,588 | 4% | 4% | \$12,500 | -28% | | \$2,471 | 0% |
| 1990 | 68 | \$14,186 | 4% | 4% | \$16,667 | -26% | | \$2,503 | 1% |
| 1991 | 69 | \$15,293 | 8% | 8% | \$18,750 | -7% | | \$2,660 | 6% |
| 1992 | 70 | \$16,867 | 10% | 10% | \$20,833 | -3% | | \$2,891 | 9% |
| 1993 | 72 | \$17,581 | 4% | 4% | \$25,000 | -20% | | \$2,930 | 1% |
| 1994 | 72 | \$18,165 | 3% | 3% | \$25,000 | 3% | | \$3,028 | 3% |
| 1984-1994 | | | 4.7% | | | -14.4% | | | 2.8% |

three diagnoses: heart attack, heart failure, and pneumonia. For each condition, they define quality-adjusted output as the number of patients who survived at least thirty days beyond their admission and did not have an unplanned readmission within thirty days of discharge.⁷ They find that, without any adjustments for quality or patient severity, productivity growth for these three diagnoses between 2002 and 2011 was negative; however, when using the number of successful treatments as the measure of output, rather than the number of treatments overall, and adjusting for patient severity, hospital productivity growth was positive for all three diagnoses, averaging 0.8 percent for heart attack, 0.6 percent for heart failure, and 1.9 percent for pneumonia.

Of course, exactly how one redefines the good can have large effects on measured prices and productivity. For example, in their baseline case, Romley et al (2015) define quality-adjusted output as the number of treatments in which the patient survived 30 days without a readmission; they also show estimates when the good is defined by 14-day survival and one-year survival. Measured productivity growth doesn't vary much across these three different definitions of the good for pneumonia, but it does for both heart attack and heart failure. For example, when using a 14-day survival period as the good in heart attack treatment, measured productivity growth is less than ½ percent per year; when using one-year survival as the definition of a successful treatment, measured productivity growth is 1¾ percent per year.

The Cost of Quality Improvement Approach

A third approach to quality-adjusting health care when constructing a price deflator is to subtract from the price in period t the costs of any quality improvements that were made to the product since the previous period. For example, if the price of a hospital stay increased by 10 percent in a particular year, but half of that increase represented the cost incurred by the hospital for improving quality, then the quality-adjusted price increase under this approach would be just 5 percent. The idea behind this approach is that it measures changes in the cost of producing the “old” good, rather than the new higher-quality one. This is the method that BLS has adopted to incorporate quality adjustments into the quality-adjusted hospital and nursing home PPIs discussed above (BLS, Hospital Quality Valuation Team (2008); BLS, Quality Adjustment (2014)).

One significant drawback to this approach is the general lack of data on the costs of improving quality.⁸ Thus, any attempt to use this approach necessarily relies on strong assumptions relating inputs to outcomes—that is, strong assumptions about the health production function. As noted above, the BLS uses performance on Hospital Compare to measure quality. Because they have

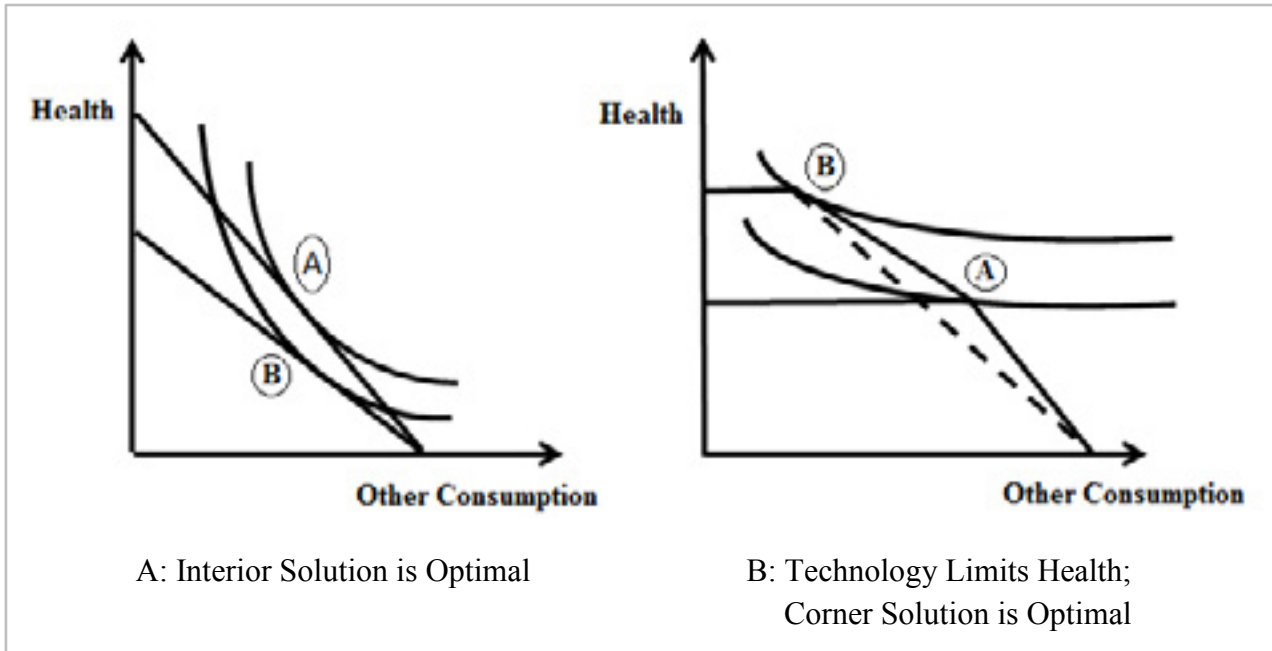
⁷ Rather than adjusting the price of hospital output to compute the quantity, they measure the quantity of output directly. The quality-adjusted price can be backed out by computing the ratio of nominal to real hospital expenditures.

⁸ But see Frank et al (2004) for a study of treatment of mental health where the costs of treatment improvements are known.

no data on the costs of improving quality, they assume that an x percent change in quality (where quality is the average of each of their Hospital Compare measures) represents an x percentage increase in costs. For example, if quality increases by 1 percent, they assume that costs likewise increased by 1 percent, and subtract this increment from the price change.⁹ As shown in Box 3, under this linearity assumption (and only under this linearity assumption), the Redefine the Good approach and the Cost of Quality Improvement approach are essentially the same.

A Comparison of Methods

Figure 1: Budget Constraints and Optimal Health Consumption



Although each of these three methods seems reasonable, they can produce very different results. This can be demonstrated using the heart attack data from Cutler et al (2001). As discussed above, using the COLI approach with these data, the price of heart attack treatment fell by about 14 percent a year from 1984 to 1994. What if we instead used the Redefine the Good approach with life expectancy post heart-attack as the good? In 1984, heart attack treatment cost \$11,483 (1991 dollars), and life expectancy following it was 5 years. Thus, in 1984, the cost per year of life expectancy following a heart attack was \$2,297. By 1994, the cost of a heart attack treatment had increased to \$18,165 (1991 dollars), but life expectancy was 6 years, for an average cost per year of \$3,027. Using this Redefine the Good method, the real price of health care increased 2.8 percent per year—much less than the 4.7 percent annual rise in the unadjusted treatment price, but still a much faster rate of growth than found using the COLI method of quality adjustment. Table 4 calculates the deflators for the COLI and Redefine the Good methods year by year.

⁹ The BLS does not include the mark-up of prices over costs in making this quality adjustment. One could argue that this approach inadequately compensates for quality changes because it allows the markup on the quality improvement to be viewed as an increase in the price.

What accounts for this dramatic difference in the results using the two approaches? The basic difference is that the Redefine the Good method doesn't account for the fact that the marginal value of a year of life is much greater than its marginal cost. For most products that we purchase, we can purchase as much as we want of them at market price. Thus, marginal value and marginal cost are equated. But, in health care, technology limits how much we can buy. Doubling spending on heart attack treatments in 1984 would not have doubled life expectancy.

Figure 1 uses simple budget constraints and indifference curves to explain.¹⁰ Assume there are two goods, years of life and all other consumption. The budget constraint shows all the potential combinations of years of life and other consumption a person can afford. Assume that, as in the heart attack treatment, the price per year of life increases over time while the price of other consumption is unchanged. This is shown as an inward shift of the budget constraint.

Figure 1, Panel A shows a budget constraint when consumers are at interior solutions: They are just indifferent between an extra year of life and the extra consumption of other goods they could have if they were to forego that extra year. In this case, an increase in the cost per year of life would make them worse off, and the Redefine the Good method would yield virtually the same result as the COLI method. Note that, for this figure to apply, consumers would have to be indifferent between an extra year of life and the extra consumption that could be financed with it. But that is not the case: most measures of the value of an additional year of life far exceed the cost. That is, if patients could have doubled spending and doubled years of life following heart attack treatment, they would have been much better off. Thus, consumers are often at corner solutions when it comes to health: they would like to buy more health at current prices, but medical technology isn't capable of delivering it.

This situation is shown in Figure 1, Panel B. Note that the years of life expectancy possible are capped. The optimal consumption mix in the first period, given the constraint, is shown by point A. In period 2, technology has improved so that more years of life are possible, although the incremental cost for that additional year is higher than previously: the price per year of life has increased. Nonetheless, people are better off and move to a higher indifference curve. In period 2, one would have to take away income for people to have the same utility that they had in period 1. The COLI measure captures this improvement in welfare. A quality adjustment that simply measures the price of an additional year of life expectancy does not.

V. HEALTHCARE PRODUCTIVITY AND THE ACA PROVIDER CUTS

The Affordable Care Act changed the way hospitals and most non-physicians' payments are calculated. Under the legislation prevailing before the ACA, annual updates to payments were set equal to the increase in input costs. For example, if wages and other costs increased 4 percent,

¹⁰ Think of these as societal budget constraints. More resources spent on health care necessitate fewer resources spent on other consumption goods.

so too would the amount that Medicare paid.¹¹ The ACA changed this formula, so that payment updates are now equal to input price growth less the ten-year average of economy-wide MFP. If wages and other input costs in the health sector increase at the same pace as in the overall economy, then the ACA payment updates will be about equal to economy-wide inflation. If health sector productivity growth is the same as overall productivity growth, then providers will be able to continue to provide a constant quality of care even under this new payment formula.

V.A. The ACA and Historical Healthcare Productivity

Some worry that, because measured health care productivity in the health sector has been so low, this indicates that the ACA provider cuts will not be sustainable. For example, the Office of the Actuary at CMS assumes that “based on the historical evidence of health sector productivity gains, the labor-intensive nature of health care services, and presumed limits on the extent of current excess costs and waste that could be removed from the system, actual health provider productivity is very unlikely to achieve improvements equal to the economy as a whole over sustained periods” (Shatto and Clemens (2015)). However, the papers summarized in Table 3 clearly suggest that health care productivity has been underestimated. In virtually all areas that have been examined, the quality of health care has been improving. After adjusting for changes in quality, the price of health care services may not have increased relative to the price of non-health services.

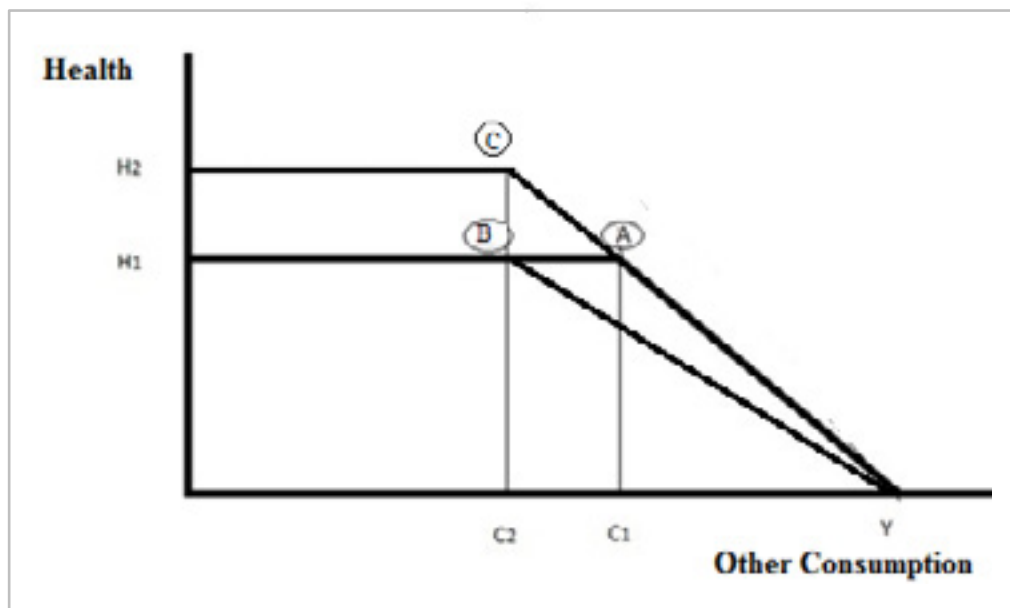
From the perspective of the sustainability of the ACA cuts, a key question is: Can health care providers provide a constant quality of health care under the ACA payment system?¹² Methods of quality adjustment like the COLI that rely on the utility value of incremental health spending are not well suited to answer this question, because they don’t shed any light on how much health care could be produced if health expenditures had not increased. In other words, they tell us whether past increases in spending have been “worth it”, but they don’t tell us if this year the providers could provide the same quality of care as last year using fewer resources.

The Redefine the Good approach can shed light on this question. Figure 2 again uses the simple budget constraint. In period 1, with income of Y , consumption is C_1 and the quantity of health is H_1 . The relative price of health care is measured by the slope of the line between Y and point A: it measures how much consumption of non-health must be given up to purchase a unit of health. (So, a steeper slope means less consumption must be given up, meaning the price of health is lower.) In period 2, consumption falls to C_2 —health spending has increased, crowding out non-health consumption.

11 In practice, Congress often adjusted these updates downward, so that the actual payment updates were often much lower than input price growth. See Technical Review Panel (2012).

12 A related but separate question is: How will the rise in Medicare payments compare to the increase in provider payments made by private insurers? If Medicare payments under the ACA are just sufficient to keep quality constant over time—because economic-wide productivity is equal to health-care productivity, for example—but are rising less quickly than private insurance payments, then the ACA cuts could still make Medicare patients relatively unattractive. For some thoughts on this issue, see Sheiner (2015).

Figure 2: Health Price Comparisons with and without Redefine the Good Quality Adjustment



Assume that, without an adjustment for quality, the quantity of health hasn't increased—people are still getting the same number of doctor's appointments, the same number of surgeries, etc. The traditional measure of health prices would find that we are at point B—same health care and less non-health care consumption. The relative price of health care would appear to have increased. Under this scenario, the only way to afford the same quantity of health services in the second period as in the first—H1—is to increase health spending and lower non-health consumption.

But this may be misleading. Assume that the quality of health care has increased so that, on a quality-adjusted basis, the quantity of health care services actually has increased to H2. Then, the relative price of health care has not increased. In this case, it would be possible to have the same level of health spending in period 2 as in period 1 while still maintaining consumption at C1. (And, if the real quantity of health services was even higher than H2, then the relative price of health services would have declined, implying that with updates just equal to inflation, the quality of health services could increase over time.)

Budget Constraints and MFP

How does this relate to the question of MFP? If the price of achieving a reduction in health care has fallen, that can be either because (1) health-sector MFP has increased, that is, the health system has figured out how to use a given set of inputs more efficiently, or (2) the real price of inputs has decreased, that is, MFP has increased in medical devices, pharmaceuticals, or other inputs.¹³

¹³ If the increased quality of health care output is solely attributable to an increase in the quality of the inputs, then the understatement of MFP is in the inputs, not in the hospital sector, because hospital MFP is equal to the percent increase in real outputs less percent increase in real inputs.

In either case, the available evidence on the mismeasurement of health care quality suggests the ACA cuts would be more sustainable than is suggested by looking at unadjusted hospital output. If hospital MFP is at least as high as economy-wide MFP, then hospitals will be able to provide a constant quality output even given the ACA cuts. If the underestimate of MFP is in the mismeasurement of inputs, then that means that the growth in input costs is overstated, and, by using these overstated input costs as the basis for the Medicare payment update, Medicare is paying more than enough to maintain a constant level of quality. In either case, spending is increasing because quality is increasing, and slower growth in spending would be sufficient to maintain constant quality.

V.B. Potential for the ACA to Lead to Increased Productivity growth in Healthcare

In addition to the question of the mismeasurement of past productivity, there is a question about future productivity in health care. Many analysts believe that there is much that can be done to improve the efficiency of health care; they believe that our health system does not produce the maximum benefit given its level of inputs (Chandra and Skinner (2012)). Thus, the potential may exist to improve health care productivity beyond what we have observed in the past, at least for a time. An oft-cited statistic is that about one-third of health spending in the United States is wasteful. (Blumenthal et al (2013)). Health care reforms that lead to a reduction in waste would improve productivity—if properly measured.

The ACA contains a multitude of provisions that are aimed at closing the gap between actual health care productivity and potential health care productivity. These include the Hospital Readmissions Reduction and the Hospital-Acquired Condition Reduction programs, which penalize hospitals for excess rates of readmissions and hospital-acquired conditions, respectively; the Hospital Value-Based Purchasing program, under which Medicare pays hospitals according to their performance on a set of quality measures, encompassing both inputs (clinical processes), outputs (outcomes and patient experience of care) and efficiency (costs); the Shared Savings Program for Accountable Care Organizations, which allows groups of providers who meet quality standards and reduce costs to share in the cost savings; the Bundled Payments for Care Improvement Initiative, which provides a single payment for an episode of care to be shared among multiple service providers (including hospital, physician, post-acute, etc.); and the Medicare Advantage Quality Bonus program, which pays Medicare Advantage Plans more if they meet quality standards. In addition, the recently enacted Medicare Access and CHIP Reauthorization Act of 2015 (MACRA)—the legislation that repealed the Sustainable Growth Rate formula for physician payments—will establish a merit-based incentive payment system that will tie payments more closely to measures of performance (Anderson et al (2015)).

The ACA also created the Center for Medicare and Medicaid Innovation to develop and test value-based alternative payment methods, and granted the HHS secretary the authority to adopt innovations found to save money and improve quality for use throughout the Medicare program. Thus, looking forward, new payment models are likely to be implemented. By 2019, HHS expects

90 percent of traditional Medicare provider payments to be tied to quality or value (U.S. Department of Health and Human Services (2015)).

It remains to be seen how effective these innovations will be. Research to date has shown some limited increases in productivity arising from these new payment models (Anderson et al (2015), GAO (2015)). But the programs are still quite new, and it is likely too early to tell what effects they might have over the longer run.

What are the implications of these potential productivity improvements for the sustainability of the ACA cuts? From the perspective of traditional Medicare payment methods, it is not clear. A reduction in readmissions, for example, while improving the overall quality of health care and reducing Medicare expenditures, may not lower the resources required for any given hospital stay. However, an Accountable Care Organization that is paid a fixed payment per beneficiary—rather than on a fee-for-service basis—would be able to provide higher quality care for less money if these reforms are successful, thus making the ACA cuts consistent with continued improvements in health care quality and thus, more likely to be economically and politically sustainable. More generally, to the extent the ACA payment reforms lead to higher quality at lower cost, they will free up resources that could be used to boost provider payments in traditional fee-for-service Medicare if necessary.

VI. SUMMARY

Traditional measures of productivity growth in the health sector most likely understate it, because they don't adjust prices for substitution from higher to lower cost inputs and because they don't take account of changes in quality over time. There are a number of different methods to take quality into account. From a welfare perspective, one that measures the changes in the value of health care seems most appropriate. But from the perspective of the sustainability of the ACA provider cuts, measures that calculate cost per unit of quality-adjusted health care seem preferable. The evidence to date suggests that adjusting health care expenditures for changes in quality leads to a significant reduction in the rise in health prices over time, and, indeed, these prices may even have declined relative to other prices.

In addition, there are reasons to suspect that the Affordable Care Act will lead to improvements in the efficiency of the health care sector beyond what occurred in the past. In particular, payments are moving steadily away from paying on the basis of the quantity of services delivered toward paying for the quality and cost-effectiveness of delivered services. To the extent these innovations are successful, they will help boost health care productivity and allow the quality of the health care provided to Medicare beneficiaries to continue to increase over time.

BOX 1: METHODS OF IMPLEMENTING DISEASE-BASED PRICES

There are two main tasks in implementing the disease-based approach – aggregation and attribution (National Research Council (2010)). At the aggregation step, a classification scheme establishing disease categories is selected. At the attribution step, total health care spending is allocated among the disease categories.

Most studies use the International Classification of Diseases at the aggregation step. The ICD-9 includes 17 broad disease categories, including one which is “symptoms, signs, and ill-defined conditions.” As Triplett (2011) points out, preventive care and some nursing home care generally cannot be attributed to a chapter of the ICD, but most other care fits well into this system. There are three conceptually different approaches to attributing spending (Rosen and Cutler (2009)).

In the encounter-based approach, a person’s health care spending associated with a particular encounter (or visit) is assigned to the diagnosis listed on a medical claim. If there are multiple diagnoses, the primary diagnosis is usually selected. Thus, co-morbidities are ignored. Also, some portion of health care spending will remain unallocated if it has no associated claims or diagnosis codes. This attribution is done for all medical claims for all people until all claims with diagnosis codes are assigned to disease categories. Aggregation of encounters across people makes it difficult to link health care spending to health outcomes that are at the person level.

In the episode-based approach, an episode of care associated with treatment of a disease is defined and all care during the episode is attributed to the disease. For chronic conditions an episode of care is usually set at one year. This approach is often implemented with commercial grouper software which groups all of a patient’s claims associated with a given diagnosis over a set time period. Commercial groupers differ in their input data, the number of disease categories they produce, the way they identify severity, and the way they define “clean” periods marking a transition between episodes. The major issues are co-morbidities, linking data across providers, defining episodes for chronic conditions, and allocating all spending into disease categories.

In the person-based approach, an individual’s total health care spending over a pre-defined time period is attributed to a set of diseases that the person has, not just the primary diagnosis on a claim. The individuals are categorized based on similar demographic and clinical characteristics (there is grouper software for this purpose as well). An individual’s total health care spending over a period is regressed on indicators for the presence of all medical conditions. The assumption is that co-morbidities have independent effects on spending. This person-based approach can be linked to health outcomes, and although spending that is not tied to a listed diagnosis can still be allocated, it may be difficult to allocate disease spending back across different services.

BOX 2: CONVERTING COLIs INTO HEALTH PRICE DEFLATORS

- Start with a disease-based approach that calls the average cost of treatment the price.
- Then the change in price, ΔP , is just equal to the change in the cost of heart attack treatments between period 1 and period 2, ΔC .
- Let ΔV be the increase in value to heart attack victims from health care improvements between periods 1 and 2.
- Denote average income by Y .
- Let s be the share of the population that experiences a heart attack each year.
- Let α be the income share of heart attack treatment in the economy in period 1, which is equal to the share of the population with a heart attack, s , times the cost of a heart attack treatment, divided by income.

$$\alpha = \frac{sC_1}{Y} = \frac{sP_1}{Y}$$

- Denote $\Delta COLI$ as the change in the overall price deflator and \hat{P}_2 as the quality-adjusted price of heart attacks in period 2.

Then,

- The per capita net benefit that society receives from the improvement in health, NB , is just the change in value less the change in cost, multiplied by the share of the population affected:

$$NB = s(\Delta V - \Delta C) = s(\Delta V - \Delta P)$$

- The change in the COLI is the loss of income in period 2 that would leave people as well off as in period 1. This is the change in the overall price deflator and is equal to:

$$\Delta COLI = \frac{-NB}{Y} = \frac{-s(\Delta V - \Delta P)}{Y}$$

- To convert this into a price deflator for heart attack treatment, assume that all other prices remain constant. Then, using period 1 shares, we need the change in heart attack treatment prices multiplied by the share of heart attacks in the economy to equal the overall change in the COLI. Define \hat{P}_2 as quality adjusted price of heart attack treatment in period 2.

$$\alpha \left(\frac{\hat{P}_2 - P_1}{P_1} \right) = \frac{-s(\Delta V - \Delta P)}{Y}$$

- The price deflator for health, then, is just the change in the COLI divided by the share of health expenditures in income.

Calculations continue on next page →

BOX 2: CONVERTING COLIs INTO HEALTH PRICE DEFLATORS (CONT'D)

- Using some algebra, this yields:

$$\alpha \left(\frac{\hat{P}_2 - P_1}{P_1} \right) = \frac{sP_1}{Y} \left(\frac{\hat{P}_2 - P_1}{P_1} \right) = \frac{-s(\Delta V - (P_2 - P_1))}{Y} \rightarrow$$

$$(\hat{P}_2 - P_1) = P_2 - P_1 - \Delta V \rightarrow$$

$$\hat{P}_2 = P_2 - \Delta V$$

- The quality adjusted price in period 2 is just the actual price in period 2 less the value of the quality improvement to those who have had a heart attack.¹
- Then, the deflator for heart attack treatment, π^{COLI} is defined as:

$$\pi^{COLI} = \frac{\hat{P}_2}{P_1} - 1 = \frac{P_2 - \Delta V}{P_1} - 1 = \% \Delta P - \frac{\Delta V}{P_1}$$

- The inflation rate for quality-adjusted health is just the inflation rate for unadjusted health, less the value of the improvement as a share of period 1 prices.¹⁴

¹⁴ Note that this is the exact approach taken by Lakdawalla et al (2015) to quality adjust treatment prices for colorectal cancer and multiple myeloma.

BOX 3: COMPARING THE REDEFINE THE GOOD APPROACH WITH THE COST OF QUALITY IMPROVEMENT APPROACH

- Assume that the quality measure is probability of survival after treatment, λ .
- Let P_2 be the unadjusted and \hat{P}_2 be the quality-adjusted price of treatment in period 2.
- Let Q be the quantity of treatments (successful or not).
- Define the quality-adjusted inflation rate, π^{adj} , as the percentage change in quality adjusted prices.

The Redefine the Good approach to quality adjustment is as follows:

- Define the quality adjusted price as nominal spending per successful treatment:

$$\hat{P}_2 = \frac{P_2 Q_2}{\lambda_2 Q_2} = \frac{P_2}{\lambda_2} \quad \hat{P}_1 = \frac{P_1 Q_1}{\lambda_1 Q_1} = \frac{P_1}{\lambda_1}$$

- Quality-adjusted price inflation is then equal to the percent change in unadjusted prices less the percent change in the success rate.

$$\pi^{adj} = \frac{\hat{P}_2}{\hat{P}_1} - 1 \cong \% \Delta P - \% \Delta \lambda$$

The Cost of Quality Improvement approach used by BLA adjusts prices as follows:

- Let $C(\Delta\lambda)$ be the cost of producing the increase in survival between periods 1 and 2.
- Then, the quality adjusted price in period 2 is defined as:

$$\hat{P}_2 = P_2 - C(\Delta\lambda)$$

- Quality-adjusted price inflation is then just unadjusted price inflation less the ratio of the cost of the improvement to the price in period 1.

$$\pi^{adj} = \frac{\hat{P}_2}{\hat{P}_1} - 1 = \% \Delta P - \frac{C(\Delta\lambda)}{P_1}$$

- The Cost of Quality Improvement approach is equivalent to the Redefine the Good Approach if the percentage increase in price due to the cost of any improvements is equal to the percentage change in treatments.

$$\frac{C(\Delta\lambda)}{P_1} = \% \Delta \lambda$$

Calculations continue on next page →

BOX 3: COMPARING THE REDEFINE THE GOOD APPROACH WITH THE COST OF QUALITY IMPROVEMENT APPROACH (CONT'D)

- Under the assumption used to estimate the cost of improvement by BLS, this is almost but not quite true. The main difference is that BLS only adjusts for the change in cost associated with the improvements, and not the change in price. Because they assume that there is markup of prices over costs, m , this leads to the following result:

$$C(\Delta\lambda) = \% \Delta\lambda * C_1 = \% \Delta\lambda * mP_1$$

- The BLS Cost method is equivalent to the Redefine the Good method, except for the effect of the markup.

$$\pi^{adj} = \% \Delta P - \frac{C(\Delta\lambda)}{P_1} = \% \Delta P - m \% \Delta\lambda$$

- An alternative specification (where one adjusts prices for both the cost of the improvements and the markup on that cost) would make these two methods identical.

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