How price indexes affect BLS productivity measures

Price indexes play a significant role in measuring real output and productivity; thus, potential bias in price indexes, as well as a lack of price indexes, can impact the accuracy of productivity measures

Lucy P. Eldridge

Productivity growth for the U.S. business sector has been slow since 1973, compared with that of earlier periods. From 1959 to 1973, for example, estimates prepared by the Bureau of Labor Statistics showed that labor productivity (output per hour) in the business sector increased by about 3 percent per year. Since 1973, by contrast, the growth rate has been just slightly more than 1 percent per year. Interestingly, however, during this recent period of relatively slow productivity growth, industrial technology advanced considerably, and the financial markets were healthy as well, phenomena often associated with *increases* in the rate of productivity growth.

As a result of this apparent contradiction, many economists and government officials have begun to question whether the slower growth was real or the result of measurement problems in the official government productivity statistics. In particular, recent discussions have focused on the issue of possible upward bias in the Consumer Price Index (CPI), leading some economists to assert that productivity growth has been understated as a result. This article attempts to add to these discussions by examining the relationship between price indexes and productivity statistics, gauging the relative importance of each of the various indexes used.

The Office of Productivity and Technology publishes productivity statistics for major sectors and subsectors of the U.S. economy, as well as for many domestic industries and foreign countries.[1] In this article, the focus is on labor productivity statistics for the business sector of the U.S. economy. These statistics relate the real output of an aggregate sector of the U.S. economy to the labor resources used to produce that output. Hence, data series on labor productivity, or output per hour, capture changes in output that cannot be attributed to changes in labor inputs. Growth in labor productivity can be a result of many influences, including changes in technology, capital investment, purchased inputs from outside the sector, capacity utilization, returns to scale, and workforce skill and effort.

To calculate labor productivity for the U.S. business sector, BLS combines indexes of real output from the national income and product accounts (national accounts), produced by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce, with hours measures constructed primarily using data from the BLS Current Employment Statistics program, Current Population Survey (CPS), and the Hours-at-Work Survey.[2] Thus, the article begins with a discussion of three methods used by BEA to construct time series for real components of gross domestic product (GDP) and for the business sector output used to construct BLS productivity measures: deflation, extrapolation and direct-valuation techniques. (The deflation and extrapolation techniques make use of various price indexes, including the CPI.)

Lucy P. Eldridge is an economist in the Office of Productivity and Technology.

Next, using BEA data from 1997, the relative importance of various price indexes in measuring business sector output is examined. These calculations indicate that components of the CPI are used to construct approximately 57 percent of the business sector output measure used for BLS productivity statistics. Due to its relative importance in measuring real output, the CPI receives more attention here than do the other indexes. In addition, some aspects of the recent controversy surrounding the CPI and its methodology are reviewed, including a discussion of the Advisory Commission to Study the Consumer Price Index (Boskin Commission) December 1996 report to the Senate Finance Committee and the official BLS response to the Boskin Commission's findings.

Finally, the article discusses an area that has not been highlighted in the recent evaluation of productivity measures: the use of input-based methods to construct components of real output. Input-based methods include the use of input data to construct deflators and to construct output trends using extrapolation techniques. Although the major portion of real business sector output is constructed using the CPI, input-based methods have important implications for measuring productivity as well. Because productivity statistics relate the growth in output to the growth in inputs, an output measure that grows at a rate dominated by the growth in inputs may result in a measure of productivity that is biased toward zero. Thus, the role that these techniques play in measuring output and the implications for measuring productivity are examined.

Business sector output

The most widely known measure of aggregate output for the U.S. economy is GDP. GDP is the sum of (1) personal consumption expenditures, (2) gross private domestic investment, (3) net exports of goods and services, and (4) government consumption expenditures and gross investment. BEA constructs nominal output for detailed components of GDP from various data sources. These components of nominal GDP are converted to real measures and then aggregated to the four expenditure categories, which are further aggregated to calculate GDP.

As a fundamental part of the national accounts, BEA also distinguishes homogeneous aggregate groups, or sectors, of GDP, the members of which are engaged in similar types of transactions.[3] The national accounts identify three primary sectors: business, household, and government. The household sector includes the services rendered by paid household workers and the services rendered by nonprofit institutions serving households. The government sector includes the services rendered by government employees and by government fixed capital. The household and government sectors are relatively small, compared with the business sector. The business sector accounts for the bulk of national output. BEA calculates the measure of business sector output by removing from GDP the gross product of general government, private households and nonprofit institutions.[4]

Although it would be preferable to measure productivity for the U.S. economy at the most aggregate level of domestic output, GDP, it is not possible to construct reliable estimates at such an aggregate level. Productivity measurement requires independently produced, well-defined, data on inputs and outputs. As a result, BLS excludes several activities from aggregate output in order to remove potential sources of bias specific to productivity measurement. The real gross products of general government, private households, and nonprofit institutions are estimated primarily using data on hours worked. The trends in such output measures will, by definition, move with measures of input data and will tend to imply little or no labor productivity growth. Although these measures are the best available estimates of nonmarket components of GDP, including them in measures of aggregate productivity for the economy would bias labor productivity trends toward zero. Therefore, the business sector is the most comprehensive sector for which BLS publishes an output-per-hour measure.

The BLS measure of business sector output is slightly narrower than the BEA measure, excluding the gross product of owner-occupied housing and the rental value of buildings and equipment owned and used by nonprofit institutions serving individuals.[5] (See table 1.) These components are excluded because no adequate corresponding labor input measures can be developed. In 1997, the BLS measure of business sector output accounted for approximately 77 percent of the value of GDP, while the corresponding BEA measure accounted for 84 percent of GDP. For the remainder of this article, the term, "business sector," will refer to the BLS measure, not the BEA measure.

Calculating real output. BEA effectively separates changes in current-dollar GDP into price-change elements and quantity-change elements. The quantity-change elements are often referred to as real components of GDP.[6] BEA constructs quantity-change measures, or real output, at fine levels of detail and then aggregates these components to arrive at real GDP. In early 1996, BEA began featuring national accounts data using

Table 1. GDP and business sector output, 1997
[Billions of current 1997 dollars]

Gross domestic product	$8,110.9
Less:	
Private households	12.0
General government	912.9
Nonprofit institutions	349.4
BEA business sector	6,836.6
Less:	
Gross housing product, owner-occupied	518.7
Rental value of buildings and equipment owned and operated by nonprofit institutions serving individuals	48.6
BLS business sector	6,269.3

chain-type annually-weighted indexes to avoid a systematic bias that was embodied in the earlier constant-dollar indexes of real output.[7] The chain Fisher index is used to combine aggregate growth rates between pairs of adjacent years to create an aggregate index-number time series.

BEA uses three different methods to calculate real output for detailed product-side components of GDP: deflation, quantity extrapolation, and direct base-year valuation.[8] To calculate real output for the business sector, the real gross products of general government, private households, nonprofit institutions, and owner-occupied housing are removed using the annual-weighting technique.[9] Using information published by BEA in 1998,[10] and with the help of the BEA staff, the relative importance of each of these methods in computing GDP and business sector output were estimated. The estimates use 1997 current-dollar data, as revised in July 1998. Table 2 shows the distribution of methods used to measure real GDP and real output for the business sector.

Deflation. The deflation method is applied to the majority of both GDP and business sector output. Using the deflation method, the quantity index is obtained by dividing current dollars by an appropriate index. BEA makes use of several different indexes, including BLS consumer price indexes, producer price indexes, export and import price indexes, as well as BEA price indexes, Census price indexes, composite indexes of input prices and costs, and other indexes.[11] BEA's composite indexes of input prices and costs are based primarily on input data, and will be referred to as input-based indexes. BEA uses composite indexes based on input data as deflators for those categories of expenditures for which specific price indexes do not exist, such as for nonresidential buildings. In GDP, real trends for nonmarket outputs are also constructed using cost data; there are no nonmarket outputs in the business sector for which real trends are calculated by deflation.

Based on the estimates of this study, using 1997 current-dollar data, the following tabulation shows the relative importance of the various indexes used to construct real output with the deflation method.

	GDP	*Business sector*
Total	83.6	93.3
BLS consumer price index	49.7	55.9
BLS producer price index	11.8	15.3
BEA input-based indexes	13.2	10.6
BLS export price indexes	8.5	11.0
BLS import price indexes	–9.9	–12.8
Other price indexes	10.3	13.3

As can be seen, BLS consumer price indexes are used as deflators to construct real values for the majority of both GDP and business sector output. BEA primarily uses consumer price indexes as deflators for components of personal consumption expenditures.[12] Input-based indexes also play a significant role in the construction of real GDP and output for the business sector. Roughly 11 percent of business sector output is constructed using BEA input-based indexes as deflators. This is a reduction from the 13 percent of GDP that uses these indexes, resulting mainly from the exclusion of the gross product of nonprofit institutions from the business sector. BLS producer price indexes are primarily used by BEA to construct real components of gross private domestic investment, while BLS export and import price indexes are primarily used as deflators for net exports of goods and services.

Table 2. Methods used to calculate real output

[Percentages based on annual 1997 current dollars]

Output measure	Deflation	Extrapolation	Direct valuation
Gross domestic product	83.6	14.3	2.1
Business sector	93.3	6.1	.7

A relatively small portion of both GDP and business sector output use other price indexes as deflators. This category is dominated by the use of the Bureau of the Census price index for single family homes and the BEA price index for multifamily homes. These two indexes account for about 22 percent of the "other price indexes" used to construct real business sector output and real GDP. Other price indexes also include the BEA price index for computers, Department of Defense prices, the BEA price index for airline transportation, implicit price deflators, and other composite indexes.[13]

Extrapolation and direct valuation. BEA uses extrapolation methods to calculate real trends for approximately 6 percent of output for the business sector, and for about 14 percent of GDP. The remaining components are constructed using direct base-year valuation methods. The quantity-extrapolation and direct-valuation techniques are similar in that they both use explicit quantity data. For quantity extrapolation, real output is calculated using various quantity indicators to extrapolate the base-year nominal value in both directions. For example, real output for services furnished without payment by financial intermediaries is calculated by using paid employee hours as the quantity indicator. Quantity indicators that are made up of input data, such as employee hours, will be referred to here as input-based quantity indicators.

For some expenditure categories, a deflated value measure is used as the quantity indicator to extrapolate real output. For example, the quantity indicator for auto insurance expenditures is the deflated value of premiums; the quantity indicator for health insurance expenditures is the deflated value of benefits; and the quantity indicator for parimutuel net receipts is the deflated value of gross winnings. For the insurance measures, a component index of the CPI is used to create the deflated value quantity indicator; for gross winnings, the all-item CPI is used to create the deflated value quantity indicator. For the remaining components of output that are extrapolated, physical quantity data are used as the quantity indicators. For example, the quantity indicator for brokerage charges is based primarily on BEA estimates of orders derived from volume data from the Security and Exchange Commission and trade sources.

Based on an analysis of 1997 current-dollar data, the following tabulation shows the relative importance of the various quantity indicators used to extrapolate real output.

	GDP	*Business sector*
Total	14.3	6.1
Input-based indicators	12.3	3.5
Deflated value indicators (CPI)	1.2	1.5
Other indicators	.8	1.1

The use of input-based data to extrapolate series of real output is more significant for GDP than for business sector output. This is due to the fact that most of the activities of general government, which are removed from business sector output, are extrapolated using hours-worked data.[14] The single category of services furnished without payment by financial intermediaries accounts for almost the entire portion of business sector output for which BEA uses input-based indicators to extrapolate real output.

Finally, the direct-valuation method is used to calculate quantity indexes by multiplying the base-year price by the actual quantity data for the index period; the resulting series is then expressed as an index with the base year equal to 100. This method is used only for a small portion of output, including used automobiles; inventories of utilities; purchases of stocks of coal, petroleum, and natural gas, and some government expenditures.[15]

The Consumer Price Index

BEA constructs approximately 50 percent of GDP and 56 percent of business sector output using component indexes of the CPI as deflators. In addition, BEA uses components of the CPI to construct deflated-value quantity indicators to extrapolate output for about 1 percent of GDP and 2 percent of business sector output. When the quantity indicator that is used for extrapolation is itself a deflated value based on a component index of the CPI, the CPI will directly influence the real output series. Thus, based on the estimates of this study, component indexes of the CPI influence approximately 51 percent of GDP and *57 percent* of business sector output. For this reason, the recent attention focusing on possible upward bias in the CPI is of interest to those who analyze trends in productivity. In general, if there is a bias in price measures used to construct real output trends, then there will be some resulting bias in output and productivity growth.

Background. The CPI, produced and published by the BLS Office of Prices and Living Conditions, measures the change in the prices paid by consumers for a fixed market basket of goods and services. The components of the fixed market basket are established using information collected from the BLS Consumer Expenditure Survey, and the Point-of-Purchase Survey conducted by the Bureau of the Census.

The CPI, a Laspeyres-type index, is constructed in two stages, or levels, of aggregation. In the first stage, price data are collected for specific items and aggregated to form subindexes for categories of items, a process referred to as lower-level aggregation. The CPI classifies all expenditure items into 206 categories, or strata, of items and 44 geographical strata, creating 9,064 item-area strata indexes. To construct the individual strata indexes, BLS uses price data collected from a sample of outlets and items. The Point-of-Purchase Survey identifies the places where households purchase various types of goods and services and is used to select the sample of outlets. From each outlet, a BLS field economist selects one or more varieties of items for which prices will be collected, with probability of selection proportional to sales.

New samples for most item categories are routinely introduced to keep the CPI sample representative of consumer spending patterns. Historically, the samples for approximately 20 percent of the indexes were rotated each year, with full rotation completed every 5 years.[16] Strata indexes are constructed using base-period weights generated from either the Consumer Expenditure Survey or the Point-of-Purchase Survey.

In the second stage of aggregation, known as upper-level aggregation, the item-area strata indexes are aggregated using base-period weights from the Consumer Expenditure Survey to derive the all-item CPI. The base-period weights determine the importance of each item in the index structure, reflecting consumer spending for the base period. The current weights are based on expenditures during 1993–95 and were introduced in January 1998. These weights historically have been updated at roughly 10-year intervals.[17]

The CPI and business sector productivity. Because BEA uses component indexes of the CPI to develop about 57 percent of the components of real output for the business sector, a bias in the CPI—of any size, in either direction—potentially also will bias the growth rates of real output and productivity measures. To evaluate the impact of any possible bias in component indexes of the CPI on business sector output and productivity, it is necessary to focus on only those components that are constructed using the CPI.

It is important to be aware that goods and services enter business sector output in different proportions than they enter the all-item CPI market basket. Table 3 shows the shares of all components of business sector output that are constructed using component indexes of the CPI, using 1997 data and presented according to 1997 CPI major-item groups. The table also shows the importance of the same CPI major-item groups

Table 3. Relative importance of CPI component indexes

[Percentages based on 1997 data]

CPI major item groups	Share of business sector output	Share of all-item CPI
Total	57.4	100.0
1. Food and beverage	12.1	17.5
2. Housing	17.3	41.5
3. Apparel and upkeep	5.6	5.3
4. Transportation	9.4	16.6
5. Medical care	3.4	7.4
6. Entertainment	5.1	4.3
7. Other goods and services	4.4	7.4

in the all-item CPI.[18]

The portion of business sector output that is constructed using components of the CPI consists predominantly of components of personal consumer expenditures. However, there are a few components of government, private investment, and net exports that are also constructed using consumer price indexes.

For several of the CPI major-item groups, the groups constitute a much smaller share of business sector output than of the all-item CPI. Note that the housing group's share in the all-item CPI is more than double its share in business sector output. The primary components of housing in the business sector are renters' costs and household furnishings. In the all-item CPI, the largest component of housing is shelter, which includes renters' costs, homeowners' costs, and owners' equivalent rents. Recall that in the construction of the business sector data, the gross product of owner-occupied housing is removed from GDP. Also note that transportation CPI indexes play a smaller role in business sector output than in the all-item CPI. The primary components of the transportation major-item group in the CPI include new vehicles, motor fuels, and auto insurance. These components have smaller weights in the national accounts. In addition, real expenditures for several transportation components are constructed without using the CPI—for example, net purchases of used vehicles and air transportation.

Also of interest is the relatively small role that the consumer price indexes for medical care play in measuring business sector output. A significant portion of medical care services, such as physicians' services, medical laboratories, home health care, and for-profit and government hospitals and nursing homes, are constructed by deflation with producer price indexes. Thus, only about 13 percent of personal consumption expenditures on medical care are constructed using the CPI.

In December 1996, the Boskin Commission's report to the Senate Finance Committee was released. This report questioned the methodology used to construct the CPI, claiming that the index is biased. The report stated that the CPI, when judged as a cost-of-living index, is biased upward and that the best estimate of the bias, looking forward, is 1.1 percentage points per year (a range of 0.8 to 1.6 percent per year).[19] Because the distribution of the components of the all-item CPI is different from the distribution in business sector output, adjustments must be made when considering the influence of possible bias in the CPI on business sector output and productivity. That is, *if* bias estimates are presented for component indexes of the CPI to generate an estimate of bias for the all-item CPI, these component biases must be re-weighted to reflect their impact on the business sector.

It should be noted that BLS disagreed with the findings of the Boskin Commission, especially concerning the *level* of bias in the CPI. Conducting their own research on the issue, BLS price economists found fault with many aspects of the Boskin Commission's report.[20] The following sections present some of the specific BLS criticisms of the report.

Sources of CPI bias

The price measurement literature separates potential sources of bias in the CPI into four categories: upper-level substitution bias, lower-level substitution bias, new-outlet substitution bias, and quality-change and new-product bias. In this section, each of these categories are discussed, presenting both the Boskin Commission's conclusions and the BLS response. The existence of upper- and lower-level substitution bias in the CPI has been studied extensively by BLS. Research on the other sources of bias, by contrast, has been much more limited. And while outlet-substitution, quality-change, and new-product bias are often discussed when estimating sources of bias in the CPI, very little empirical evidence to support such claims can be found in the literature on price indexes.

Substitution bias in the CPI. Substitution bias refers to the inability of a fixed-weight index number to account for consumers' tendencies to substitute among items or categories of items as relative prices change over time. The CPI has the potential for substitution bias when judged from the perspective of a cost-of-living index. A true cost-of-living index provides a means for assessing changes in consumer welfare. Hence, such an index would capture substitutions made by consumers responding to price changes, as they attempt to maintain a fixed level of satisfaction. The CPI is constructed using fixed base-period weights that preclude such substitutions. Substitution bias can cause an overstatement of growth in an index for periods after the base year. The CPI is a 2-tiered index that uses some fixed weights for both lower and upper levels of aggregation. Thus, there is the potential for substitution bias at both stages of index construction.

The Boskin Commission's findings claimed that substitution bias exists both at upper and lower levels of aggregation.[21] BLS acknowledges that the formulas currently used to construct the CPI do not fully account for substitution by consumers but disagrees with the Boskin Commission on the estimated degree of bias.[22] By implementing the 1998 CPI revision, and by adopting geometric mean indexes for a portion of the CPI in January 1999, BLS has taken steps to reduce substitution bias in the CPI.[23]

Upper-level substitution. BEA primarily uses component indexes of the CPI, not the all-item CPI, to construct real output for detailed components of GDP. Thus, upper-level aggregation in the CPI should have no influence on GDP. To compute indexes of aggregate output, BEA recently moved away from a fixed-weight measure of constant-dollar GDP to a changing-weight Fisher index. The Fisher index, a superlative index number formula, changes weights annually to reflect shifts in the relative importance of the various expenditure categories that occur over time. In particular, these changing weights will reflect consumers' substitution resulting from relative price changes. Therefore, any potential bias associated with upper-level substitution does not significantly affect BEA's GDP data or the BLS major-sector productivity statistics.

Lower-level substitution. As noted earlier, BEA uses component indexes of the CPI to construct trends in real output for a significant portion of the business sector. Therefore, the possibility of lower-level substitution bias is a concern in constructing business sector output and productivity measures. Over the past several years, BLS has been investigating alternative ways to aggregate price quotes to address lower-level substitution bias. The geometric mean formula, a superlative index formula, has been suggested as a possible alternative index formula.[24]

Several studies conducted by BLS have shown that Laspeyres price indexes grow faster than superlative price indexes.[25] A 1995 BLS study by Brent Moulton and Karin Smedley conducted a detailed comparison of a weighted geometric mean index formula and the current CPI formula for basic component indexes over the period from June 1992 to December 1994.[26] This study showed that the Laspeyres-type formula tends to grow at a faster rate than the geometric mean index for most items. Also, the study showed that the magnitude of the variation between the two formulas differed significantly between classes of items. The largest difference between the two indexes was for fresh fruits and vegetables. Other items, such as housekeeping services and motor fuels, had a much smaller difference between the two formulas. This finding was consistent with the fact that the different item-strata of goods and services have varying price elasticities of substitution, and different degrees of heterogeneity in price trends.

The preference for the Laspeyres formula versus the geometric mean formula hinges on the within-strata price elasticity of substitution. Research results show that if items have an elasticity of substitution equal to one, the geometric mean formula is an exact cost-of-living formula.[27] Alternatively, if the elasticity of substitution is equal to zero, the fixed market basket formula is the correct formula. It is probable that the actual elasticities of substitution for many subindexes of the CPI are somewhere along the continuum between zero and one. Thus, the geometric mean index will approximate the preferred formula for some components of the CPI where it is anticipated that consumers will make substitutions to offset relative price changes; possible examples are apples, men's footwear, and major appliances. However, the Laspeyres index will approximate the preferred formula for other item stratas where customers are less likely to make substitutions; possible examples are electricity, physicians' services, and rent of primary residence.[28]

The Boskin Commission's estimate of a 0.25-percent per year lower-level substitution bias in the CPI was based primarily on the assumption that the geometric mean is the preferred formula for *all* components of the CPI. The Boskin Commission calculated this estimate by combining components of various BLS research efforts. The 1995 study by Moulton and Smedley showed that the difference between the Laspeyres-type index used for lower-level aggregation by BLS and a weighted geometric mean formula for all nonshelter items is approximately 0.49 percentage points per year.

Since that study was released, BLS has introduced several new procedures into the CPI. These procedures effectively reduced several sources of bias in the components of food-at-home, shelter, and prescription drugs.[29] BLS estimated that the implementation of these changes would reduce bias by 0.14 percent per year.[30] Additional changes for nonshelter items made in 1996 would further reduce the bias by 0.1 percent per year.[31] The Boskin Commission removed these BLS estimates from the Moulton-Smedley estimate to arrive at the 0.25-percent per year lower-level substitution bias estimate.

BLS did not agree with the 0.25-percent per year bias estimate because it was based exclusively on using the geometric mean index formula to calculate all component indexes of the CPI. The geometric mean index formula assumes that the price elasticity of substitution is equal to one, and thus consumers make substitutions as relative prices change in order to maintain constant expenditure shares for each item. This assumption probably does not hold for all items in the CPI, and thus BLS viewed the 0.25-percent per year upward bias in the CPI as an upper bound for estimating lower-level substitution bias. Since the Boskin Commission's report was released, BLS economists have worked to determine which CPI basic indexes are best calculated using the geometric mean formula.

Early in 1997, BLS introduced experimental consumer price indexes, or CPI-U-XG indexes, that use geometric means to combine price quotations at the lower level of aggregation. Because BLS has adopted methodological changes for the CPI since 1990, experimental test-Laspeyres indexes, or CPI-U-XL indexes, were released for historical comparisons with the CPI-U-XG. The CPI-U-XL differs from the CPI-U-XG only in the use of the Laspeyres formula rather than the geometric mean formula for aggregation of price quotations.[32] Both the CPI-U-XG and the CPI-U-XL incorporate the methodological improvements adopted by the CPI in 1995 and 1996.

Using the experimental geometric mean series, BLS conducted research to identify, for each basic index category, the extent to which consumers can be expected to alter their spending when relative prices change. This research examined the following evidence: (1) highly detailed supermarket scanner data on prices charged for, and quantities sold of, a limited number of individual item categories; (2) measures of the extent of substitution at index calculation levels above the basic level, which can be viewed as providing evidence concerning the likelihood of substitution behavior within item categories; and (3) estimates of the magnitude and prevalence of the substitution effect derived from a survey of the relevant empirical literature. From the results of this research effort, BLS concluded that "this evidence did not provide definitive support concerning the existence and magnitude of the substitution effect in each of the basic index categories. . . . Taken in its entirety, however, the evidence unambiguously supported the proposition that consumers can, and do, alter their purchasing behavior in response to changes in the array of prices confronted in the market place."[33] In early 1998, BLS announced that, beginning in January 1999, it would adopt the geometric mean formula to construct index categories for approximately 61 percent of total consumer spending represented by the CPI-U.[34]

Using the experimental geometric mean indexes for the period from May 1996 to December 1997, this study estimates the influence on business sector output of replacing components of the current consumer price indexes with geometric mean indexes. Table 4 shows the impact on business sector output of adopting the CPI-U-XG formula, by CPI major-item groups.[35]

Comparing the CPI-U-XL and the CPI-U-XG for the period from May 1996 to December 1997 reveals that the all-item CPI containing only geometric mean basic indexes grows at a rate that is approximately 0.26 percent slower than the existing all-item CPI. This estimate corresponds to the Boskin Commission's bias estimates. Table 4 shows that replacing all of the CPI item indexes with the geometric mean formula will increase the measure of business sector output by approximately 0.19 percent per year. The two major-item groups that contribute most significantly to the total increase in business sector output are housing and apparel. Within the housing group, household furniture and audio equipment contribute the major portion of the increase in output. Within the apparel major-item group, women's and girls' clothing accounts for approximately 40 percent of the estimated bias.

Recent BLS research results suggesting that the geometric mean formula is preferred for 61 percent of the CPI, lead to a slightly smaller estimate of bias in business sector output. A consumer price index containing geometric mean indexes for only 61 percent of its components grows at an annual rate that is approximately 0.21 percent slower than the existing all-item CPI.[36] Table 4 shows that replacing these CPI item indexes with the geometric mean formula also would increase measured business sector output growth by approximately 0.19 percent per year. This increase in business sector output has the potential to increase business sector productivity measures. In July 1998, BEA revised the 1995–97 GDP data using the CPI geometric mean indexes, thus eliminating this source of lower-level substitution bias in GDP and the BLS business sector output and productivity data.

Table 4. Impact on business sector output of adopting the geometric mean index formula

[Weights based on 1997 current dollars]

CPI major item groups	Adopting the geometric mean formula for 61 percent of CPI component indexes	Adopting the geometric mean formula for all CPI component indexes
Total	.192	.188
1. Food and beverage	.030	.030
2. Housing	.037	.036
3. Apparel	.055	.055
4. Transportation	.013	.013
5. Medical care	.017	.014
6. Entertainment	.031	.031
7. Other goods and services	.008	.008

Outlet substitution. Just as consumers respond to changes in prices by substitution in favor of relatively lower-priced items, consumers also respond to price changes by shopping at different retail outlets. When consumers switch to new this move is detected in the Point-of-Purchase Survey that is conducted for 20 percent of the CPI sample on an annual basis. The new outlets are linked into the survey, and prices at the old and new outlets are not compared directly. Therefore, any savings that consumers potentially receive from shopping at the new outlets are not reflected by the CPI, understating consumer gains. However, if the outlets were compared directly, and the new outlet provides a lower level of services, a direct comparison could lead to an overstatement of consumer gains.[37] Because it is difficult to measure the quality of services provided by outlets, it is difficult to provide a precise measure of outlet-substitution bias.

In a 1993 study, Marshall B. Reinsdorf evaluated the treatment of new discount outlets in BLS sampling and estimation procedures for food and motor fuel items. The study compared prices of items during periods of sample rotation. Assuming that prices are not offset by a decline in quality, Reinsdorf found that a possible new-outlet-substitution bias of 0.25 percent per year may exist for certain food and motor fuel items.[38]

At this point there is little empirical evidence on the impact of discount outlets on the components of the all-item CPI. In a 1994 study, David E. Lebow and others identified 11 categories of the CPI in which they assume outlet substitution bias is present.[39] These categories account for 40 percent of the all-item CPI, and include food and beverages, household maintenance and repair commodities, household fuels, household furnishings, housekeeping supplies, apparel commodities, motor fuel, medical care commodities, entertainment commodities, tobacco and smoking products, and personal care. The authors apply the Reinsdorf estimate to these categories and estimate a 0.1-percent per year outlet-substitution bias in the all-item CPI (0.25 times 40 percent). The Boskin Commission refers to both of these studies to suggest that the current methodology used to construct the CPI does not account sufficiently for shifts of consumers to discount outlets, adopting the estimate of 0.1 percent per year upward bias in the CPI due to outlet substitution.

The categories identified by Lebow and his co-authors account for approximately 32 percent of business sector output. If the 0.25-percent Reinsdorf estimate of upward bias is applied to these components, the suggested 0.1-percent per year upward bias in the CPI could lead to a 0.08-percent per year downward bias in business sector output. However, there are serious concerns associated with using the Reinsdorf estimate to project bias for all items in the CPI. As Brent R. Moulton noted in 1996, the results of the Reinsdorf study are barely statistically significant.[40] In addition, Reinsdorf looked at only two item categories—food and motor fuels—over a 2-year period. There is no reason to believe that these items are representative of other CPI item categories, and it is unlikely that the 2 years are representative of long-term trends. Therefore, Reinsdorf's bias estimates should be viewed with some skepticism. In the absence of research on additional item categories and additional years, it is not possible to determine if the estimates of outlet-substitution bias are too high or too low.[41]

Quality-change and new-product bias in the CPI. The quality of goods and services changes over time, reflecting changes in technology and consumer demand. Such quality changes often are reflected in changes in market prices and quantities demanded. Therefore, the accuracy of output measures is contingent upon price measures that control for quality variations over time.

BLS makes a conscious effort to account for quality change as it collects price data. Using checklists of detailed commodity descriptions, price-data collectors are able to detect when commodity characteristics change between collection periods. To assist in adjusting for quality changes, commodities in the market basket are replaced using a procedure called *item substitution*. BLS has various methods to make adjustments for quality when item substitutions occur, including direct comparisons between old and new products, overlap pricing of old and new products, linking of old and new products, class-mean price imputation, and direct quality adjustments, such as hedonic regression techniques.[42]

Adjustments made by BLS for quality changes in goods and services amounted to approximately 1.76 percentage points during 1995.[43] BLS also has procedures in place to introduce new products into the market basket. New expenditure shares are introduced every 10 years, and, to keep pace with the constantly shifting market, 20 percent of the component indexes of the CPI are re-sampled each year. This periodic rotation of the sample of items and outlets allows new goods and services to enter the market basket. In 1999, BLS will redesign the sample rotation procedures in order to accelerate the introduction of new items and outlets.

Although significant steps are taken, BLS acknowledges that the CPI does not capture all quality changes, especially in the difficult-to-measure services industries. The inability to account precisely for rapid introduction of new products and quality changes will lead to some level of bias in price measures, which will inevitably affect the real output and productivity measures for the business sector. In preparing real trends in output components of the national accounts, BEA uses alternative price indexes for output components where it anticipates that quality measurement problems exist in the CPI.[44]

The Boskin Commission report evaluates the CPI, examining each of the 27 major-item categories, in an attempt to quantify bias that may be a result of mismeasured quality change. In this exercise, the Boskin Commission treats new-product introduction as a component of quality-change bias and evaluates them jointly. Because of a lack of hard evidence regarding the magnitude of biases, the Boskin Commission uses research on bias in one category to estimate bias for other categories that seem related. In areas where no research exists, the Boskin Commission estimates the level of bias by employing its best judgment based on how various developments in the marketplace may have influenced consumer value. In this exercise, the Boskin Commission concludes that the CPI is biased upward by 0.6 percentage points per year.[45]

A 1977 study by Brent R. Moulton and Karin E. Moses also evaluates the 27 major-item categories and questions the Boskin Commission's estimates of upward bias in the CPI due to quality change and new-product introduction.[46] The study concludes that the Boskin Commission's bias estimates are too high for many item categories, including rent, fresh fruits and vegetables, apparel, new vehicles, and motor fuels.[47] The authors state that

> there are two major components, medical care and appliances, where we agree with the Advisory [Boskin] Commission that the evidence of upward bias due to quality and new goods is convincing. We also agree that new products contribute an upward bias across many components of the index, though we think the Commission and others have overstated the magnitude of this bias. There are many important components of the in-

dex, though, including shelter, apparel, and new vehicles, where we have not seen convincing evidence of upward bias, and indeed think there is the possibility that the methods used by the BLS may in some circumstances over-adjust for quality change. [48]

The task of adjusting price fluctuations to reflect changes in quality requires an evaluation of product characteristics, as well as consumers' perceptions of value. Because consumers are heterogeneous and preferences change over time, such adjustments are difficult. Due to the difficulties involved in collecting data to analyze quality issues, research in this area tends to be focused on specific products or narrow data sets for tractability. It is unclear that results of this sort can be considered representative for broad categories of the CPI. Therefore, specific conclusions based on the limited body of research in the area of quality change should be viewed skeptically.

Having said that, the following "what if" exercise is conducted in response to public inquiry. Assuming the Boskin Commission's estimates of bias in components of the CPI are correct, when the category weights in table 3 are combined with the Boskin Commission's bias figures, the impact of the suggested quality-related bias on the measure of business sector output can be estimated. Thus, *if* the Boskin Commission's estimates are accurate, the upward bias of 0.6 percent per year in the CPI generates a downward bias in real output growth for the business sector of approximately 0.32 percent per year.

The Boskin Commission study suggests that, in 1996, consumer electronics and medical services were the largest sources of quality-change bias in the CPI. Note that within the business sector components of the national accounts, BEA uses alternative price indexes for portions of consumer electronics and medical services. In medical services, BEA uses producer price indexes to construct real trends for the output of physicians' services, medical laboratories, home health care, and for-profit and government hospitals and nursing homes. In consumer electronics, BEA uses a quality-adjusted index to construct real trends for computers.

Using the Boskin Commission's bias estimates for detailed components, the major-item groups of housing and apparel contribute the largest shares to the bias estimates for total quality change in the business sector. Apparel and upkeep accounts for approximately 17 percent of the bias associated with unmeasured quality change, while housing accounts for 35 percent. The major group, housing, includes expenditures on audio and video products and the subcomponent, personal computers. Note that the Boskin Commission's bias estimate for audio and video products is 4 percent per year. By contrast, the Boskin Commission's bias estimate for personal computers is 15 percent per year. Because the CPI is not used to deflate the output measure for personal computers, the audio and video category only accounts for about 14 percent of the business sector bias estimate. The major-item group, medical care, contributes 15 percent of the estimated bias in business sector output, with the majority of the bias accounted for by dental services.[50] (Note that the Boskin Commission's bias estimate for professional medical services is primarily based on research concerning services of physicians.)

The study by Moulton and Moses agreed that evidence of upward bias due to quality and new goods is convincing in medical care and consumer electronics. The magnitude of the bias estimates, however, remains controversial. For other item categories, such as apparel and new vehicles, BLS flatly disagrees with the Boskin Commission on the presence of any upward bias in the CPI indexes due to quality change. It should be emphasized that, due to the lack of strong data-based analysis of quality-related bias, it is uncertain whether the bias estimate of 0.6 percent per year is accurate. Thus, its impact on business sector output and productivity also is uncertain.

Because about 57 percent of business sector output is constructed using components of the CPI, any measurement bias in the CPI will play a significant role in trends in business sector output and productivity. This article has discussed some of the aspects of the recent controversy concerning the construction of the CPI and its impact on business sector output and productivity measures. If the Boskin Commission's estimate of upward bias of 1.1 percent per year is accepted, a downward bias in business sector output of approximately 0.6 percent per year could result. But the recent adoption of the geometric mean index formula for components of business sector output based on personal consumption expenditures however, reduces this bias to 0.4 percent per year.

Due to weaknesses in the Boskin Commission's analysis and a lack of strong evidence to support many of its claims, the report's findings should be viewed skeptically. Although evidence exists to suggest that, through 1998, a 0.2-percent lower-level substitution bias was present in the CPI, there is insufficient evidence to determine whether the estimates of outlet-substitution and quality-related bias are, in fact, too high or too low.[51]

BLS price economists often have been in the forefront of research to discover sources of bias in the CPI and have developed innovative techniques for reducing known bias. In addition, changes resulting from the 1998 revision of the CPI have further reduced sources of bias.[52] Specifically, the market basket expenditure weights were updated, item categories were redefined, and a new geographic sample was introduced. Further, in January 1999, experimental geometric mean indexes were adopted for 61 percent of component indexes of the CPI.

In constructing real trends in output for the national accounts, BEA makes an effort to reduce measurement problems identified in the CPI. In some instances, this requires that they use alternative price indexes. However, in areas where the CPI is used, as improvements are made in the CPI and its subindexes, and as BEA adopts these improvements, the BLS productivity measures for major sectors of the economy also will improve.

Input-based methods

Several recent studies have asserted that the CPI is a possible source of bias in BLS productivity measures.[53] A potential source of bias that has received much less attention, however, is the use of input data to construct trends in output. As discussed earlier, for productivity measurement, it is important to have well-defined measures of inputs and outputs that are measured independently. For several nonmarket components of GDP, BEA calculates output using cost data and thus uses input-based indicators to generate real values. Although these techniques provide a means to measure components of output that are difficult to measure, they also inherently bias productivity measures. For some market outputs in GDP and the business sector, BEA uses input-based methods primarily because accurate price indexes do not exist.

BEA calculates approximately 11 percent of business sector output using composite indexes of data on input prices and costs as deflators. In addition, BEA constructs real output using input-based quantity indicators to extrapolate real output for about 3 percent of business sector output. Thus, based on the 1997 estimates in this study, input-based methods are used in computing approximately 14 percent of business sector output. Composite indexes of input data are used to deflate life insurance, the bulk of investment in nonresidential structures, and some components of government expenditures. Input-based extrapolation techniques are used to construct the real output of services furnished without payment by financial intermediaries, using employee hours as the quantity indicator. Services furnished without payment by financial intermediaries are the largest component of final demand expenditures on banking.

The use of input-based methods to construct real output has been a concern for BLS. The development of real output using input data implicitly assumes that the rate of growth in output will be correlated with the rate of growth in inputs. Because productivity statistics relate the growth in output to the growth in inputs, an output measure that grows at a rate dominated by the growth in inputs may result in a measure of productivity that is biased toward zero. Specifically, if output actually rises more rapidly than inputs due to gains in productivity, then the use of an input measure to create real output will understate output and productivity growth. If productivity growth occurs, input prices (or costs) can rise more rapidly than the prices of the output precisely because productivity has grown. Hence, deflation with input prices will lead to an underestimation of productivity.

BEA is well aware of the shortcomings of input-based techniques for generating real output for productivity measurement. However, there are no price indexes currently available for these components of the national accounts. It should be noted that the majority of the components that are constructed using input-based methods are expenditures on services.[54] The output of services is characterized by measurement problems that make accurate price measurement difficult.[55] BLS has been working to expand price index coverage in service industries, which has led to a decline in BEA's use of input-based deflators. In addition, BLS and BEA are working jointly to develop price indexes for construction, a category that is currently dominated by input-based methods. As more price indexes become available to replace input-based methods, and as they are integrated into the national accounts, productivity measures will improve.[56]

METHODS USED BY BEA TO CALCULATE REAL OUTPUT directly affect BLS measures of productivity for the business sector and other major sectors of the U.S. economy. Price indexes play a significant role in measuring real output and productivity; thus potential bias in price indexes, as well as a lack of price indexes, can impact the accuracy of productivity measures.Whenever posible, BEA takes steps to reduce the impact of bias in the CPI on the real trends in GDP and business sector output.

The adoption by BLS of the geometric mean formula in January 1999 eliminated a downward substitution bias of approximately 0.2 percent in the BLS business sector output and productivity data. Because the CPI is used in calculating about 57 percent of measured output, however, potential bias in the CPI—whether due to outlet substitution effects or mismeasured quality changes—will affect the accuracy of measured growth in output and productivity.

In addition to possible bias in the CPI, the use of input-based methods to calculate real output series has important implications for measuring productivity as well. Real output trends that are developed using input-based indexes will tend to grow, by construction, with input data. Because productivity statistics relate the growth in output to the growth in inputs, an output measure that grows at a rate dominated by the growth in inputs may result in a measure of productivity that is biased toward zero. The use of input-based methods to construct output measures could lead to measurement error in about 14 percent of business sector output and productivity.

Footnotes

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1 The major-sector and industry-level measures are developed indepen-

dently. Measures of productivity for industries are based on the production of an industry and thus rely heavily on industry producer price indexes. Relatively few industry measures, approximately 14 percent of industries published by BLS, make use of consumer price indexes. In addition, BLS industry productivity statistics do not use input data to measure output and they do not use input data to construct output deflators. For more information, see *BLS Handbook of Methods*, Bulletin 2490 (Bureau of Labor Statistics, 1997), pp. 89–121.

[2] BLS publishes labor productivity measures for six major sectors. Business sector, nonfarm business sector and nonfinancial corporations make use of BEA data; manufacturing, durable goods manufacturing, and nondurable goods manufacturing do not.

[3] Allan H. Young and Helen Stone Tice, "An Introduction to National Economic Accounting," *Survey of Current Business*, March 1985, pp. 59–76.

[4] The gross product of general government is the sum of government expenditures on compensation of general government employees and the general government consumption of fixed capital, which measures the services of general government fixed assets. Government expenditures on goods and services purchased from the private sector are not excluded from business sector output. The gross product of private households is the compensation of paid employees of private households. The gross product of nonprofit institutions serving individuals is the compensation paid to employees of these institutions.

[5] The rental value of buildings and equipment owned and used by nonprofit institutions serving individuals is measured as the sum of consumption of fixed capital, indirect business taxes, and interest paid.

[6] It should be noted that this article discusses components of total GDP and business sector GDP, which are derived by aggregating final expenditures on goods and services. The output of individual industries, such as BEA's data on gross product originating (GPO) by industry or the gross output of industries is not discussed. For the latest BEA estimates of gross product by industry and a discussion of the relationship between the estimates of GDP by expenditures and by industry, see BEA's *Survey of Current Business*, pp. 20–40.

[7] For a detailed discussion of BEA's new measures of output, see Steven J. Landefeld and Robert P. Parker, "Preview of the Comprehensive Revision of the National Income and Product Accounts: BEA's New Featured Measures of Output and Prices," *Survey of Current Business*, July 1995, pp. 31–38.

[8] A listing of the product-side components of the national accounts, the methods used to calculate real output, and the source data is published annually by BEA in the *Survey of Current Business*. The most recent listing appears in the September 1998 issue, pp. 14–35.

[9] The real gross product of general government, private households, and owner-occupied housing are included in total GDP as components of expenditures, and removed by BEA to construct business sector output measures for BLS. However, the output of nonprofit institutions enters GDP through a variety of product-side expenditure categories and then is removed by BEA as two income-side components. The first component is an independent aggregate based on compensation of employees of nonprofit institutions, referred to as gross product of nonprofit institutions. This series is constructed as the nonprofits' share of industry employee compensation, as defined by legal form of organization. The compensation of employees of nonprofit institutions is deflated by BEA using a BEA index of compensation per hour for those industries in which nonprofits are concentrated. This deflator is constructed using primarily BLS wages and hours data. The second component is the annual series of rental value of buildings and equipment owned and operated by nonprofit institutions. This component is deflated using an implicit price deflator constructed from the BEA nonresidential building series, which is calculated using a BEA composite cost index. Hence, both of these real components for nonprofits are constructed using input-based deflators. In order to prepare data on the methods used to calculate the various components of real output, this article subtracts the value of these components from the total amount of GDP that is constructed using input-based deflators. This technique is reasonable because the product-side components that reflect nonprofit activities (for example, nonprofit hospitals, clubs and fraternal organizations, religious and welfare activities, and education and research) are also constructed using input-based deflators.

[10] "Updated Summary Methodologies," *Survey of Current Business*, September 1998, pp. 14–35.

[11] "Updated Summary Methodologies."

[12] Based on 1997 current-dollar data, personal consumption expenditures account for about 68 percent of GDP and 73 percent of business sector output.

[13] Other composite indexes refer to BEA deflators that are composites of input data and price indexes. In instances when output data is not available at a lower level of detail, this study groups these components in the category of deflation by other indexes. Approximately 11 percent of all of the "other price indexes" used to construct both GDP and business sector output are composites of input data and price indexes.

[14] For military compensation, hours worked are adjusted for changes in employment by rank and length of service. For civilian defense employee compensation, hours worked are adjusted for changes in employment by grades. For State and local government education compensation, hours worked are adjusted for changes in education and experience. For additional details, see "Government Transactions," *Methodology Article Series* MP-5, November 1998.

[15] "Updated Summary Methodologies."

[16] As part of the 1998 revision, the sample was updated and item categories were redesigned to allow for the introduction of new items. In 1999, the sample rotation is being redesigned to accelerate the introduction of new items and outlets. For an overview of the 1998 revision, see John S. Greenlees and Charles C. Mason, "Overview of the 1998 revision of the Consumer Price Index, *Monthly Labor Review*, December 1996, pp. 3–9; see also, Brent R. Moulton, "Bias in the Consumer Price Index, What is the evidence?" *The Journal of Economic Perspectives*, Fall 1996, pp. 159–77.

[17] Moulton, "Bias in the Consumer Price Index."

[18] The components are presented in the seven major-item groups of the CPI. The expenditure components of the business sector have been regrouped into these CPI groups. In January 1998, the CPI redesigned its major groups to include an eighth major group, education and communications. This new group contains components previously in housing and other goods and services.

[19] *Toward a More Accurate Measure of the Cost of Living*, final report to the Senate Finance Committee from the Advisory Commission to Study the Consumer Price Index, S.Prt. 104–72 (U.S. Senate, Committee on Finance, December 1996.)

[20] "Measurement Issues in the Consumer Price Index" (Bureau of Labor Statistics, June 1997). Prepared in response to a letter from Congressman Jim Saxton to Katharine G. Abraham, Commissioner of Labor Statistics.

[21] Upper-level substitution bias refers to a measurement error that occurs as the strata indexes are aggregated to form the all-item CPI, using fixed (Computer Expenditure Survey) base-period weights; this can occur if consumers substitute *across* categories, or strata, of goods and services as relative prices change. Lower-level substitution bias refers to a measurement error that occurs as price data are aggregated to calculate the component, or strata, indexes, using fixed (Point-of-Purchase Survey and Computer Expenditure Survey) base-period weights; this can occur as consumers substitute among items *within* a specific category, or item strata, as relative prices change.

[22] "Measurement Issues in the Consumer Price Index."

[23] As part of the 1998 CPI revision, BLS introduced new expenditure weights used for upper-level aggregation. Beginning with January 1998 data, expenditure weights are based on 1993–95 spending patterns in order to reflect more accurately what consumers are buying.

[24] The geometric mean index formula requires expenditure and price data for each period and makes use of these data to allow for substitution. This index assumes that customers will substitute to offset relative price changes in order to maintain constant expenditure shares for each item.

[25] For a review of studies on upper-level substitution bias, see Ana M. Aizcorbe and Patrick C. Jackman, "The commodity substitution effect in CPI data, 1982–91," *Monthly Labor Review*, December 1993, pp. 24–33.

For a review of studies on lower-level substitution bias, see Brent R. Moulton, "Basic components of the CPI: estimation of price changes," *Monthly Labor Review*, December 1993, pp. 13–24; and Brent R. Moulton and Karin E. Smedley, "A Comparison of Estimators for Elementary Aggregates of the CPI," paper presented at the Western Economic Association International Conference, San Diego, CA, July 7, 1995.

[26] Moulton and Smedley, "A Comparison of Estimators," July 1995.

[27] The seasoning method used to estimate the CPI component indexes is also unbiased if the following assumptions hold: stationarity, small correlation of relative prices over time, and utility functions characterized by constant elasticity of substitution. See Matthew D. Shapiro and David W. Wilcox, "Mismeasurement in the Consumer Price Index: An Evaluation," in Ben S. Bernanke and Julio J. Rotemberg, eds. *NBER Macroeconomic Annual 1996* (Cambridge, MA, MIT Press, 1996).

[28] Katharine G. Abraham, Commissioner of Labor Statistics, "Research issues related to the geometric mean formula for elementary indexes," attachment C of materials presented by the author in testimony given to the Senate Budget Committee, January 30, 1997.

[29] In the January 1996 comprehensive revision of the national income and product accounts, BEA incorporated the adjustments made to the CPI's for food and housing. BEA incorporated these changes in revised estimates of output beginning with 1978 data.

[30] Improvements in CPI methodologies after 1993 are discussed in Paul A. Armknecht, Brent R. Moulton, and Kenneth J. Stewart, "Improvements to the Food at Home, Shelter, and Prescription Drug Indexes in the U.S. Consumer Price Index," BLS Working Paper 263, February 1995.

[31] See "Extending the improvements in the CPI sample rotation procedures and improving the procedures for substitute items," *CPI Detailed Report: Data for March 1996*, April 1996, pp. 4–5.

[32] See "The experimental CPI using geometric means," *CPI Detailed Report: Data for March 1997*, May 1997, pp. 5–18.

[33] See "Planned change in the Consumer Price Index formula," *CPI Detailed Report: Data for April 1998*, June 1998, pp. 6–8.

[34] There are 15 categories that will continue to be calculated as they are currently. These categories are: rent of primary residence; owners' equivalent rent of primary residence; housing at school, excluding board; electricity; utility natural gas service; residential water and sewerage maintenance; State and local registration, license, and motor vehicle property tax; telephone services, local charges; cable television; physicians' services; dental services; eyeglasses and eye care; services by other medical professionals; hospital services; and nursing homes and adult daycare.

[35] The business sector estimates presented in table 4 are based on the difference between the CPI-U-XG and the CPI-U-XL at a finer level of detail than the seven categories presented. The detailed differences are weighted using business sector shares and aggregated to the seven major-item groups. The seven major-item groups reflect the categories used by BLS prior to January of 1998. Beginning in January 1998, BLS introduced a new structure of eight major-item groups. Paul Liegey, of the BLS Division of Consumer Prices and Price Indexes, provided CPI-U-XG and CPI-U-XL measures for sub-indexes of the CPI for May 1996 and December 1997.

[36] This value corresponds with the 0.2 bias estimate discussed in Kenneth Stewart, "The experimental CPI using geometric means," BLS working article, April 1997. The 0.2 level of bias is based on data from the middle of 1996 through December of 1997.

[37] Moulton, "Bias in the Consumer Price Index."

[38] Marshall B. Reinsdorf, "The Effect of Output Price Differentials on the U.S. Consumer Price Index," in Murray F. Foss, Marilyn Manser, and Allan H. Young, eds., *Price Measurements and Their Uses*, Studies in Income and Wealth, vol. 57 (Chicago, University of Chicago Press for NBER, 1993).

[39] David E. Lebow, John M. Roberts, and David J. Stockton, "Monetary Policy and 'The Price Level'" (Board of Governors of the Federal Reserve System, August 1994).

[40] Moulton, "Bias in the Consumer Price Index."

[41] In a more recent study, "Price dispersion, seller substitution and the U.S. CPI," BLS Working Paper 252 (Bureau of Labor Statistics, 1994), Reinsdorf shows that, for CPI food indexes, over the period from 1948 to 1963 and from 1967 to 1976, price decline due to new outlets was about 0.1 percent per year. Although this estimate is smaller than the 0.25 percent estimate of his earlier study, there is insufficient evidence to generate estimates of bias for other CPI component indexes.

[42] For a detailed discussion of quality change in the CPI, see Brent R. Moulton and Karin E. Moses, "Addressing the Quality Change Issue in the Consumer Price Index," *Brookings Papers on Economic Activity*, no. 1, 1997.

[43] This quality effect is based on an arithmetic method of aggregation. If outliers—which may be a result of sample turnover—are eliminated, the estimate drops to 1.1 percent. Alternatively, a logarithmic method of aggregation indicates a range of quality change of 0.28 to 0.44 percent. *Ibid.*

[44] For all periods through 1997, BEA uses a quality-adjusted index for computers, and beginning in 1995, uses an alternative index for cellular phone service. Beginning with 1998 data, BEA will begin using the new CPI for computers, which uses a hedonic model to adjust prices for changes in quality. BEA uses PPI's for for-profit and government hospitals, medical laboratories, physicians' services and home health care, beginning with 1993, 1994, 1995, and 1997, respectively.

[45] *Toward a More Accurate Measure of the Cost of Living*.

[46] Moulton and Moses, "Addressing the Quality Change Issue."

[47] Due to the lack of available data, Moulton and Moses do not attempt to make specific quantity estimates of the potential bias that might result from quality change and new product introduction.

[48] Moulton and Moses, "Addressing the Quality Change Issue."

[49] *Toward a More Accurate Measure of the Cost of Living*.

[50] In the national accounts, there is a category of other medical professionals for which real trends are calculated using the PPI and the CPI. Detailed data is not available to disaggregate this component and therefore it is not counted as using the CPI. Thus the estimate above should be viewed as a lower bound.

[51] See Kenneth Stewart, "The experimental CPI."

[52] For an overview of the 1998 CPI revision, see Greenlees and Mason, "Overview of the 1998 revision of the Consumer Price Index."

[53] L. Slifman and C. Corrado ("Decomposition of Productivity and Costs," Occasional Staff Studies, OSS no. 1, Federal Reserve Board, November 1996) present service industry measures of productivity, displaying negative productivity trends that seem inconsistent with anecdotal evidence of technological advances in service industries. Note that the study primarily discusses data for gross product originating for industries, which are not used to construct business sector GDP.

[54] Expenditures on services constitute about 41 percent of final demand in the business sector, and approximately 54 percent of GDP, based on 1997 current dollars. Of the 14 percent of GDP that is constructed using input-based methods, 78 percent is expenditures on services; of the 11 percent of business sector output constructed with input-based methods, 50 percent is expenditures on services.

[55] For a detailed discussion of the difficulties in measuring service output, see Mark K. Sherwood, "Difficulties in the Measurement of Service Output," *Monthly Labor Review*, March 1994, pp. 11–19.

[56] For a brief discussion of BLS and BEA efforts to improve the national accounts data, see the article in this issue of the *Review* by Edwin R. Dean, pp. 24–34.