Measuring Inflation In a High-Tech Age

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When Americans ask themselves former New York Mayor Edward Koch's favorite question "How'm I doing?" many of them may answer, "Not so hot." For when they look at their "real wages" corrected for inflation using the Consumer Price Index (CPI), it appears that many Americans are earning less than they were two decades ago (Figure 1). Is this really the case? Or is the CPI misleading as a standard for purchasing power?

I will argue that the answer to the second question is yes, which is disturbing for several reasons. What we normally mean by inflation is the loss of purchasing power of dollars. If the CPI is giving an upwardly biased view of inflation, then our inflation-adjusted measures of consumers' purchasing power and well-being will be too low. As we shall see, there is

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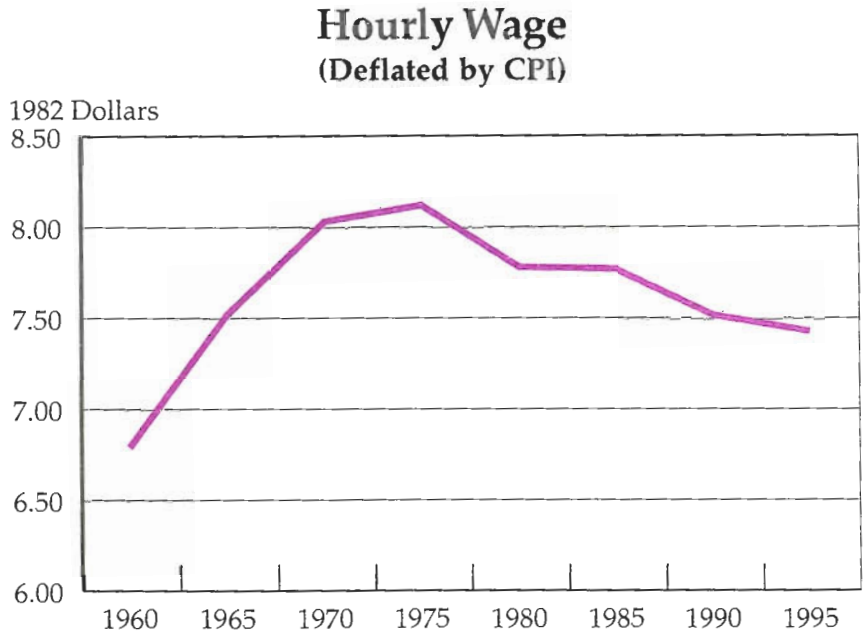
FIGURE 1



The real wage rate of $7.43 for 1995 equals the July 1995 actual measurement.

some evidence that the CPI has been upwardly biased more than 1 percent annually over the past 20 years. If the CPI is revised down 1 percent annually, the post-1975 decline in real wages disappears (Figure 2). Second, many economic payments—including major ones such as Social Security benefits and federal income taxes—are tied to the CPI to insulate them from inflation, but the CPI may be systematically distorting them. Some Social Security benefits may be too high by 20 percent, again using the 1 percent estimate.[1] Personal income tax brackets are also indexed to the CPI. If we extrapolate estimates from the Congressional Budget Office, between these and other corrections, it is quite possible that the budget deficit would be substantially smaller if the CPI had been correctly measured.[2]

Moreover, it is quite possible that the overstatement of inflation is worsening. If mismeasurement is accelerating, new dangers arise. Policymakers may have greater difficulty recognizing progress toward price stability. And the inflation-adjusted rate of interest—adjusted by the CPI—may be increasingly misleading to borrowers, lenders, and policymakers.

Why might the overstatement of inflation be worsening? Two complementary trends are at work. First, high-tech investment goods (such as computers and telecommunications equipment) are playing an increasing role in the economy and are rapidly increasing their ability to store, process, and transmit data, text,

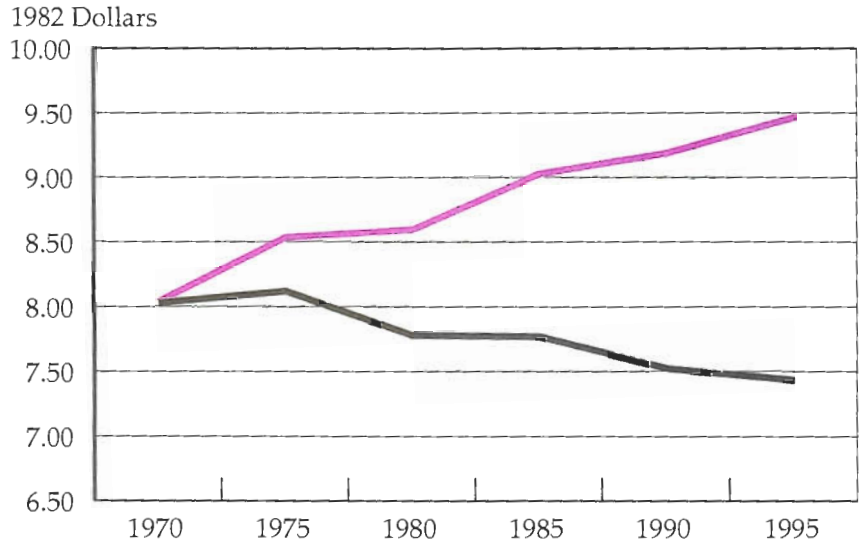
[1]It has been argued that the adjustment for the cost of living in Social Security benefits is inadequate because rapidly inflating medical costs are a larger part of expenses for the retired. However, as I argue below, rapid inflation in medical expenses appears to be, at least in part, an artifact of inadequate adjustment for the increased quality of medical care.

[2]See Peterson, Congressional Budget Office, October 1994. Peterson's paper estimates that an increase of 0.1 percent in the CPI adds $ 0.5 billion to the deficit, so a CPI that is 20 percent lower would mean roughly a $100 billion lower annual deficit. To this must be added the cumulative effect of past overly large deficits on the total net interest paid, which would also lower the current deficit. However, the effect is actually somewhat less, since Congress has not always allowed the inflation adjustment to tax brackets to come into effect.

images, and sound. This progress has both direct and indirect impacts on high-tech consumption goods, such as home PCs and cars, and services, such as telecommunications, cable TV, and medical care. The CPI undermeasures these new products and services and their contributions to welfare. Second, improvements in consumption in the United States now increasingly take the form of greater variety and quality, rather than increases in quantity.[3] New products and services (both high tech and low tech) are proliferating at an increasing rate. For example, half of all prescription drugs and one-third of breakfast cereals have been introduced in the last decade. Unfortunately, the CPI is not designed to capture changes in consumer welfare due to new goods and services.

FIGURE 2

Hourly Wage Adjusted for Lower Inflation (1%)
(Deflated by CPI)



This graph is intended to show a reasonable minimum on the bias in the CPI, based on documentation to date. It is not intended to show the most likely amount of bias or the right amount of acceleration in bias. The top line represents the effects of lowering the inflation rate 1 percent. The last data entries, for 1995, reflect July 1995 data.

The CPI measures the changing price of a fixed basket of goods. Currently, that basket is based on surveys of consumer purchases taken in the years 1982 to 1984, more than a decade ago. New goods and services are conceptually irrelevant, since the basket of goods whose prices are measured is held fixed. (In practice, the BLS cannot stick to the pure standard of a fixed basket of goods, because many of the goods and services available in 1982-84 have become obsolete and are no longer sold.[4]) If most of our economic progress is due to changes in the types of goods and services consumed, the CPI is not a good guide to how the cost of maintaining a certain standard of living is evolving. This is not the fault of the Bureau of Labor Statistics (BLS), which is responsible for

[3] The *Economic Report of the President, February 1995*, puts it this way: "The output of the economy increasingly is shifting away from standardized commodities with easily definable characteristics that change little over time, towards goods and services for which issues of quality and even definition are of primary importance." See Leonard I. Nakamura, "Is U.S. Economic Performance Really That Bad?" Federal Reserve Bank of Philadelphia Working Paper No. 95-21 for evidence on the deceleration of physical output and consumption in the United States over the course of the 20th century.

[4] As we shall see below, in practice the CPI does incorporate some new products, although it does not fully capture their benefits.

collecting the basic data for and calculating the CPI, but a problem created by the increasing divergence between the conceptual basis of the CPI and a true cost-of-living index.

These problems are not insuperable, but solving them may involve a change in our approach to the collection of statistics and in our use of economic theory to guide us in setting up the indexes. Ironically, the improvements in information processing and communications that are helping to make our current data-collection system outmoded could facilitate sharp improvements in price measurement.

DOES THE CPI MEASURE THE COST OF LIVING?

A true cost-of-living index answers the question: How much must I spend to maintain my standard of living? For example, if I must spend 5 percent more this year to give me the same enjoyment as last year, a true cost-of-living index would rise 5 percent. Such an index ought to take into consideration changing prices of one good relative to another and new goods and services that become available and how people benefit from these changes. These considerations are important because to take advantage of these changes as they occur, I will likely buy a different bundle of goods this year, even if I can still afford to buy what I bought last year.

Relative Changes in Price. Suppose I buy only clothing and computer supplies. In 1994, I had $200 to spend on articles of clothing priced at $10 each or on computer supplies also $10 each, and I bought 10 clothing items and 10 computer items. In 1995, I am earning 5 percent more, or $210, and clothing increases in price to $12 while computer supplies decrease to $9. I could again buy 10 clothing items and 10 computer items, but I choose to buy seven clothing items and 14 computer items (Table 1).

My standard of living has improved: I could have bought exactly what I did last year, but I didn't. I prefer what I am buying this year, which I couldn't buy last year, so I am better off. A true cost-of-living index should help us measure, as precisely as possible, this improvement in the standard of living.

But the CPI, conceptually, doesn't do this. It takes the base-year bundle of goods (1994, in our example) and asks: How much does it cost to buy that same bundle this year? In our example, the base bundle costs $200 in 1994 and $210 in 1995, a 5 percent increase. So if we set the CPI equal to 100 in 1994, it would equal 105 in 1995 (Table 2). Since my income has risen 5 percent and the CPI has risen 5 percent, if I think of the CPI as a measure of the cost of living, my "real income" is unchanged. But as I've shown, I'm actually better off this year because I can buy a bundle of goods I prefer to the one I bought last year. If we compare the total purchases columns for 1995 in Tables 1

TABLE 1

Actual Purchases

	1994			1995		
Item	Price	Quantity	Total	Price	Quantity	Total
Clothes	$10	10	$100	$12	7	$84
Computer	$10	10	$100	$9	14	$126
Total			$200			$210

and 2, we see the source of the difference: the CPI puts greater weight on clothes, the good whose quantity has fallen, relative to my actual current purchases.

A price index like the CPI that uses base-year weights (in our example, 1994) has a somewhat out-of-date comparison basket; a natural alternative would be to use an end-year weighted index (in our example, 1995).[5] Using 1995 weights would result in giving greater weight to computer items whose price has fallen; buying 14 computer items and seven clothing items in 1994 would cost $210, the same as in 1995, so an end-year index would show no price increase. However, it is difficult to do this in a timely fashion, 1995 quantity weights generally not being available until 1996.

An alternative is to set up a quantity index and derive an implicit price deflator. The Bureau of Economic Analysis (BEA) begins by constructing a measure of real personal consumption expenditures (PCE) by valuing current consumption at base-year prices. In our example, that means measuring 1995 consumption (seven pieces of clothing and 14 computer items) at 1994 prices ($10 for each). By this measure, this year's consumption has risen 5 percent, to $210 (Table 3). This index of real purchases can be converted to an implicit price index by dividing the real purchases into nominal purchases: for 1994 this is $200/$200 = 1 and for 1995 this is $210/$210 = 1, so according to this implicit price deflator, the 1995 price level is unchanged from the 1994 level, just like the end-year index.[6]

In general, price indexes like the CPI (which compares today's cost of the *base year consumption bundle* to what it cost in the base year) will tend to understate improvements in welfare

[5]A base-year quantity weighted price index is called a Laspeyres index. An end-year quantity weighted price index is called a Paasche index.

[6]This is not a coincidence—an end-year quantity weighted price index is the same as the implicit price deflator for a base-year price weighted quantity index for the entire period between the base and end years, but not for intermediate years. For example, if the base year is 1994 and the end year is 1996, the 1996 end-year price index and the implicit price deflator whose base year is 1994 will agree on the overall inflation rate from 1994 to 1996, but not necessarily on the rates for each intermediate year 1994 to 1995 and 1995 to 1996. The implicit price index for the intermediate years does not have a clear interpretation, being a kind of odd residual, unlike the end-year price index.

TABLE 2

Consumer-Price-Index Method of Calculation

	1994			1995		
Item	Price	Quantity	Total	Price	1994 Quantity	Total
Clothes	$10	10	$100	$12	10	$120
Computer	$10	10	$100	$9	10	$90
Total			$200			$210
CPI	1994=100		100			105
Real Spending	deflated by CPI		$200			$200

TABLE 3

PCE and Implicit Price Deflator Method of Calculation

	1994			1995		
Item	Price	Quantity	Total Purchase	1994 Price	Quantity	Total Purchase
Clothes	$10	10	$100	$10	7	$70
Computer	$10	10	$100	$10	14	$140
Real Spending	in 1994 prices		$200			$210
Total Spending	in current year prices		$200			$210
Implicit price deflator			100			100

and overstate price increases, while price indexes like the implicit price deflator (which compares today's cost of *today's consumption bundle* to what it would have cost in the base year) will tend to exaggerate improvements in welfare and implicitly understate price increases.[7] These effects increase as prices diverge further from those in the base year. So when there are divergent price trends, these effects accumulate over time until the base year is updated.

One quick fix for the problem, proposed early in this century by economist Irving Fisher, is to update every year and average the quantity-based index and the price-based index. Fisher's so-called Ideal Index multiplies the two indexes and then takes the square root. In our example, this would result in an inflation rate of 2.4 percent, about midway between the zero inflation of the BEA's method and the 5 percent inflation of the BLS's. The BEA has begun emphasizing Fisher Ideal price and output indexes in its reporting of the U.S. Gross Domestic Product and its components (see *BEA's Chain-Weighted Price and Quantity Indexes*).[8]

How large is the impact of the relative price problem that we have described? It depends on the rate of divergence of relative prices of goods and the average interval between updating the market basket. Historical comparisons of a Fisher Ideal Index with the CPI provide a measure of the size of the upward bias in the CPI growth rate, and such studies broadly agree that the bias is about 0.2 percentage points annually.[9]

[7]This holds for inflation after the base year; the base year is periodically updated.

[8]For further discussion, see Robert 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*, August 1995; and Jack E. Triplett, "Economic Theory and BEA's Alternative Quantity and Price Indexes," *Survey of Current Business*, April 1992.

[9]Marilyn E. Manser and Richard J. McDonald, "An Analysis of Substitution Bias in Measuring Inflation, 1959-1985," *Econometrica*, 56, July 1988, pp. 908-30; and Ann M. Aizcorbe and Patrick C. Jackman, "The Commodity Sub-

The BEA's Chain-Weighted Price and Quantity Indexes

The Bureau of Economic Analysis, beginning at the end of 1995, will emphasize chain-weighted price and quantity indexes (Fisher Ideal indexes) in its monthly reports on the national income and product accounts, rather than the more familiar output measures based on 1987 prices. The result will be lower measured real output and higher prices compared with the 1987 price-weighted output and the implicit price deflator. The major reason for the reduction in estimated output is a reduced weight for computers, cut by more than half.

The BEA is entirely correct to make this change. The change makes more urgent, however, revisions to the fundamental price series to enable them to capture more of the consumer surplus lost using current measurement conventions. The BEA and the BLS (which has the primary responsibility for price measurement) are, of course, taking steps in this direction.* For example, the BLS is correcting the rotation bias in foods, where it appears to be most important, and it is improving its methodology for measuring prices of prescription drugs as well. But other steps will take longer to implement, particularly under the tightening budget constraints these agencies face. The net result is that, in the short run, measures of price and output may be further from, rather than closer to, reality.

*BEA, "Mid-Decade Strategic Review of BEA's Economic Accounts: An Update," Survey of Current Business, April 1995, pp. 48-56.

New Products in Old Price Indexes. The solution outlined above gets us only part of the way toward a true cost-of-living index because the price indexes typically ignore new goods, and when they do consider these goods, they do so too late. Suppose, continuing our earlier example, a new good, the CD ROM, appears in 1995 and costs $10.50. I decide to buy two CD ROMs and therefore reduce my purchases of both clothing and computer supplies by one item each (Table 4). Now I am even better off because I prefer the CD ROMs to the articles they replaced.

Note that the new good would not affect the CPI. Since the CPI uses base year (1994) quantities of each item, and for CD ROMs that quantity is zero, the price of the new good is irrelevant, conceptually. But the BLS in practice must confront the problem, because goods in the base market basket sometimes disappear from the marketplace as they succumb to competition from newer products. Moreover, in constructing the PCE deflator or a true cost-of-living index, the BEA needs to construct a 1994 price for CD ROMs.

There are four basic ways to deal with this problem.

Ignore it. One could assume no change in price for the good. For many years, the BEA had no statistics on actual prices of mainframe computers and kept the computer price index at 1.[10] Since the general price level was rising, this implied that mainframe computer prices were falling relative to the prices of other goods. However, there is no reason to believe that this method provides very accurate answers.

Alternatively, one could use changes in the prices of similar products to measure the price change for new goods, which may make some

stitution Effect in CPI Data, 1982-1991," *Monthly Labor Review.* These studies cover a longer period and extend over periods where the base year has been changed. They average out the effects of the different base years that have been applied to achieve the long-run index.

[10]This period was before personal computers were an important share of computer sales.

TABLE 4

Actual Purchases—With New Good Added

	1994			1995		
Item	Price	Quantity	Total Purchase	Price	Quantity	Total Purchase
Clothes	$10	10	$100	$12.00	6	$72
Computer	$10	10	$100	$9.00	13	$117
CD ROM	?	0	$0	$10.50	2	$21
Total Spending			$200			$210

sense if the products are moving similarly in price. However, this is probably not the case as the "similar" products are typically older products and may well be outmoded. Moreover, the very existence of the new products increases the standard of living by making possible a greater variety of purchases. So ignoring the problem is highly unsatisfactory.

Use sample rotation. A partial solution is to add new items to the price survey as they appear, for example, to begin collecting data on CD ROMs in 1995 and to lump them in with some pre-existing good. For example, CD ROMs could be considered computer supplies. To keep abreast of new products and stores, the BLS rotates the sample of goods and outlets whose prices it collects. It rotates 20 percent of the sample each year, but it takes two years after new items are identified before they are introduced into the surveys. As a result, the actual goods priced are, on average, about five years out of date.

Unfortunately, the BLS's sample rotation procedure itself biases the CPI upward. If an item is selling at a temporarily reduced price when the BLS rotates it into the sample, the quantity sold will be temporarily high, so the item will appear in the CPI basket of goods with a higher quantity weight than justified by its average sales. And items that are at a sale price when rotated into the sample show a high rate of price increase as they return to a more normal price. So sample rotation gives a bigger weight to goods whose prices are likely to rise. This effect alone is estimated to have erroneously raised inflation between 0.2 and 0.3 percent annually over the 15 years since the BLS introduced sample rotation.[11] The BLS has recently taken steps to remove this bias from the foods category, where the effect has been quite pronounced.

Use product characteristics. When a variant replaces an existing product, if the value of the changes in the product can be given a price, then the new and old products can be compared. In the auto industry, for example, the *resource costs* to the manufacturer of optional equipment that has been made standard are used to compare new models with old ones. For example, if a new model has a driver's-side air bag as standard equipment and the old model did not, BLS deducts the wholesale cost of the bag, electronics, and installation, plus a standard markup, before it calculates how much the price of the new model differs from the old.

The hedonic method is a somewhat more

[11]Brent R. Moulton, "Basic Components of the CPI: Estimation of Price Changes," *Monthly Labor Review*, December 1993, pp. 13-24.

theoretically satisfying statistical technique that values changes in goods by the implicit *retail price* of the changed characteristic. This method uses statistical regressions to estimate how much consumers pay for each of a product's specific characteristics or parts (like an air bag), controlling for other characteristics.[12] In the computer industry, at least in the 1980s when the BEA introduced this technique, the most important characteristics of computers were processing speed and memory size. So a computer with twice as much processing speed and twice as much memory was considered to be twice as much computer. Since the processing speed of different computers and their memory sizes could be calculated, at least for some given benchmark set of tasks, then even though whole new generations of computers appeared, their prices could be compared.[13]

Hedonic methods help to capture the resource cost, including the cost of the sales effort, of new characteristics of products. But they do not fully capture the benefits that accrue to consumers from the introduction of new goods.

Estimate consumer surplus. When a new product is introduced, consumers receive a welfare gain (called "consumer surplus"), which is the difference between what they would be willing to pay for the product and what they actually have to pay. In our example, suppose that I would have been willing to pay $35 to buy the two CD ROMs, but I only had to pay $21.00. To be explicit, suppose I would be willing to pay $20 for one CD ROM, $15 for a second one, and $10 for a third. At a price of $10.50 each, I will buy two, and the welfare gain I will receive is the same one I would have got if the price had fallen from $17.50 to $10.50.

Note that a product need not be wholly new to provide surplus. Consider the opening of a discount clothing store near my home. Again using the example, suppose the price of clothing has gone up from $10 to $12 at the store I patronized in 1994, but the discounter sells the same items for $10, so I decide to purchase the clothes from the discounter. If I am just as happy to shop at the discounter as to go to the old store, my price of clothes has not risen. The arrival of the discounter gives me "surplus" compared with shopping at the old store—I would be willing to pay up to $12 for clothes and would still switch to the discounter, but I pay only $10.

The assumption implicitly made in the CPI and in the PCE deflator in this example and others is that there is no consumer surplus from the introduction of the new product. Under this assumption, there is no measurement problem. The arrival of a new product, such as a CD ROM, makes no difference to my welfare. In the discounter example, the discounter's clothes are considered new clothes

[12]See Jack E. Triplett, "The Economic Interpretation of Hedonic Methods," *Survey of Current Business*, January 1986, pp. 36-40.

[13]Product characteristic adjustments are used for housing and new autos, two areas in which quality improvements are sometimes thought to be overstated rather than understated. But this doesn't mean that the CPI is overstating quality as a whole, since the upward biases produced by sample rotation and relative price changes are much larger than the downward biases in the measurement of housing and auto prices. Between 1983 and 1988, the BLS failed to adequately correct for the aging of housing units. This resulted in a downward bias of roughly 0.1 percent annually and was eliminated in 1988. See William C. Randolph, "Housing Depreciation and Aging Bias in the Consumer Price Index," *Journal of Business and Economic Statistics*, July 1988. The other widely cited indication of downward bias is the correction for environmental controls in new cars. However, this effect has been estimated to be less than 0.05 percent per year. See John F. Peterson, "Is the Growth of the CPI a Biased Measure of Changes in Cost of Living?" Congressional Budget Office paper, 1994. Thus, over the past 10 or 15 years, the average effect of these overstatements of quality must be less than 0.1 percent annually. The well-documented errors of underestimation of quality due to sample rotation bias and relative price bias are roughly five times as large.

items, different from the old store's. There is no consumer surplus from the arrival of the discounter—it is assumed that any consumer surplus I would have gained is eaten up in the switch (the old retailer's friendliness and service that have been lost are equal to the full difference in price).

An alternative assumption is that shifts in consumer demand in response to changes in price are informative about the amount of consumer surplus consumers receive. If, when the CD ROM is introduced, consumers purchase them in large amounts and their purchases thereafter are relatively insensitive to price increases, that is an indication that had the CD ROMs been available earlier, consumers would have been willing to pay more than required. In other words, consumers are receiving a substantial consumer surplus. If consumers switch to discount outlets in large numbers and are relatively insensitive to price swings at the new outlets, they are receiving a substantial consumer surplus. To measure the price sensitivity of consumers requires statistical analysis and extensive data. This is the textbook problem of estimating the consumer's demand curve.

One such study has been conducted for pharmaceuticals. After Eli Lilly's drug Keflex lost patent protection in 1987, generic versions became available at roughly half the price of the brand-name product. Eli Lilly did not cut the price of Keflex but, indeed, raised it 24 percent over the next three years. Meanwhile, the price for the generic drug fell 30 percent, and generics garnered 83 percent of the market measured in doses. Until recently, in such instances, the BLS treated the generic drug as a separate product that was worth only half as much as the brand-name product (the relative price of the generic at introduction) and would have likely recorded a rising price index for this drug. But many purchasers are probably indifferent to the brand name and would have experienced a pure price decline when the generic became available. A study by Franklin Fisher and Zvi Griliches argues that the most reasonable measure of the consumer surplus realized by purchasers who switched would lead to a price index that declines 48 percent, compared with the BLS approach, which would show a price increase of 14 percent. This is a 19 percent annual rate difference over the 45 months covered in the study.[14] In January 1995, the BLS changed its procedure to reflect a price decline when a therapeutically equivalent generic version of a drug replaces a brand-name patent drug. This change should substantially reduce this problem of pricing drugs.

Although there is some arbitrariness to estimates of the value of consumer surplus from the introduction of new goods and services, they are surely an improvement over assuming that new product introductions result in no consumer surplus.[15] Moreover, private data companies, as well as many retailers, regularly

[14]Franklin M. Fisher and Zvi Griliches, "Aggregate Price Indices, New Goods, and Generics," *Quarterly Journal of Economics* 110, February 1995, pp. 229-44. They make the assumption that consumers vary in their relative valuations of the generic product, but that those who switch are evenly spread over the spectrum of possible types—from those for whom the entire difference in price is surplus, to those who receive no surplus. This and other studies on prescription drugs have been done at the wholesale level where the data are relatively easy to come by. In summarizing them, F.M. Scherer has estimated conservatively that the BLS's treatment of the introduction of generics implies an upward bias of 1.2 percent a year in the Producer Price Index for prescription drugs. F.M. Scherer, *Journal of Economic Perspectives* 7, Summer 1993, pp. 97-115.

[15]When goods and services and outlets disappear from the marketplace, consumer surplus is lost. But, in general, this consumer surplus is likely to be small compared with the consumer surplus of new product introductions because consumers will not choose to switch from high consumer-surplus goods to low ones, and because suppliers of high consumer-surplus goods can raise their prices and still retain demand, and so are unlikely to go out of business.

collect the data necessary for these estimates. A study by Jerry Hausman examines ready-to-eat breakfast cereals, specifically Apple-Cinnamon Cheerios, using supermarket data.[16] Hausman found that accounting for new cereal introductions, as measured in a true cost-of-living index, might have reduced the CPI for ready-to-eat breakfast cereals by 20 percent over the 10-year period 1980 to 1990, or about 2 percent a year.[17]

IMPROVEMENTS IN QUALITY PLAY IMPORTANT ROLE IN ECONOMY

What is driving these rapid product and service innovations? Dramatic improvements in high-tech investment goods are an important force in the availability of new goods and services. Investment in high-tech goods accounts for more than 4 percent of the economic output of the United States. For many of these goods, substantial price *deflation* is normal. For example, between 1951, when the first computer was designed, and 1984 the cost of computers—adjusting for changes in quality—fell an estimated 1000-fold.[18] Since 1984 computer prices have continued to fall dramatically. Large price declines appear in other recent high-tech investment goods, such as telecommunications equipment and medical equipment. While there have always been some goods whose prices are declining, the declines haven't been as large. In the early part of this century and over roughly the same period as that for computers, the price of automobiles declined substantially, but only about tenfold.[19]

High-tech investment goods are primarily purchased by businesses rather than consumers; their effect on consumer prices is indirect and often is not captured statistically. For example, buying automatic teller machines may improve banking services, but the impact is difficult to measure and, in practice, is not captured. Similarly, as new medical equipment is introduced, its effect on the quality of diagnosis and treatment is typically not included in the pricing of medical services.

High-Tech Entertainment Goods and Personal Computers. As measured in the CPI, PC prices fell about 10 percent in 1994, about the same rate of decline for the whole period 1987 to 1994. This appears to underestimate the rate of decline: computer magazine advertisements show a much sharper rate of decline: approximately 24 percent over the course of 1994.[20] A recent study by Ernst Berndt and Zvi Griliches shows a decline of 30 percent annually for 1982-88.[21] The likely reason for this discrepancy is that the CPI tends to underestimate the price decline for personal computers because the sample being surveyed is too old.[22]

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[16]Jerry A. Hausman, "Valuation of New Goods Under Perfect and Imperfect Competition," NBER Working Paper 4970, December 1994.

[17]This measure depends on an assumption of a "representative consumer," i.e., that all consumers are alike.

[18]Robert J. Gordon, "The Postwar Evolution of Computer Prices," in Dale G. Jorgenson and Ralph Laundau, eds., *Technology and Capital Formation* (MIT, 1990).

[19]Daniel M. G. Raff and Manuel Trajtenberg, "Quality-Adjusted Prices for the American Automobile Industry: 1906-1940," NBER Working Paper 5035, February 1995.

[20]I collected data from advertisements of Dell and Gateway, the two largest mail-order PC firms. Price level data indicate a decline of $570 on an average price of $2380, or almost 24 percent. Complete data for the study can be found on the Federal Reserve Bank of Philadelphia Internet site at http://libertynet.org/~fedresrv/fedpage.html.

[21]Ernst Berndt and Zvi Griliches, "Price Indexes for Microcomputers: An Exploratory Study," in Murray F. Foss, Marilyn E. Manser, and Allan H. Young, eds., *Price Measurements and Their Uses*, NBER Studies in Income and Wealth No. 57 (University of Chicago, 1993).

[22]The introduction of the P6 Intel processor in 1995 marks the sixth generation of PC microprocessors since the

Similar measurement problems exist for a broad spectrum of products that have electronic components embedded in them. A readily identifiable segment in personal consumption expenditures includes video and audio products, computing equipment, and musical instruments; this segment accounted for 1.6 percent of consumer purchases in 1994. Electronic parts play a large role in a wide variety of other consumer products. For example, the value of the electronic components of new cars is approximately the same as that of the steel in them—and improvements in the quality of these components are not well captured in the CPI for new cars.

Medical Goods and Services. The development of new drugs and diagnostic and treatment methods make medical care an area where quality change has been important. Studies of prescription drugs suggest that annual inflation in this product group may be overstated 6 or 7 percent because the BLS does not account for quality improvements. Although such drugs account for only about 1 percent of consumer expenditures, the net effect may be close to 0.1 percent on the overall index.[23] And these drugs are less than one-fifth of the portion of consumer expenditures accounted for by medical costs.

One interesting study of CT scanners shows that the average price rose about 160 percent between 1973 and 1982. However, correcting for quality, using characteristics like resolution and speed, produces a price *decline* of 72 percent. Finally, a third method that includes consumer surplus shows a 1000-fold price decrease![24]

Technological advance in medical care has been profound. Yet the benefits to the consumer of such advances are not included in our price statistics. Medical care is a large proportion of the consumer budget, accounting for roughly 7 percent of the CPI.[25] If we extrapolate the 6 percent quality improvement in drugs to all of medicine, this one source can reduce the inflation rate, as measured by the CPI, 0.4 percentage points annually.

HOW BAD ARE THESE PRICING PROBLEMS?

The best estimates for the impact of the first problem we discussed, relative price movements, show the CPI about 0.2 percent too high annually. The upward bias from sample rotation has been reliably estimated at 0.2 to 0.3 percentage points annually. For quality gains whose costs go unmeasured there is considerable uncertainty, but they are likely to account for more than half a percentage point.[26] Thus the CPI may well be overstated 1 percent annually even if we take no account of the consumer surplus associated with the introduction of new goods and services. Studies of CT scanners and of generic pharmaceuticals show that consumer surplus in high-tech goods may be very large. And Hausman's study of breakfast cereals suggests that non-high-tech goods may also have very substantial consumer surpluses.

first IBM PC in 1979, or a new generation every three years. It is obviously extremely difficult to keep up with this rate of product introduction using conventional methods of price data collection.

[23]Zvi Griliches and Iain Cockburn, "Generic and New Goods in Pharmaceutical Price Indexes," Harvard Discussion Paper 1664, Cambridge, MA 1993.

[24]Manuel Trajtenberg, *Economic Analysis of Product Innovation: The Case of CT Scanners* (Harvard, 1990).

[25]It has been argued that its proportion of the consumer budget is actually twice as large because the 7 percent figure does not take into consideration government and corporate subsidies of these payments.

[26]The extrapolations discussed in the text for medicine and high-tech consumer goods alone would amount to 0.6 percentage points annually on the CPI, and these goods account for less than one-twelfth of consumer expenditures.

HOW CAN WE DO BETTER?

Right now, most price data are obtained by sending BLS price collectors on their rounds of retail establishments to fill out pricing forms. This seems unnecessary. Improvements in computer and telecommunication facilities mean that many retailers, wholesalers, and manufacturers routinely capture detailed item-by-item transactions data as part of their billing systems. If the BLS could tap this information, collecting price data might be less expensive and more accurate than current methods. A pilot project to use scanner codes (universal product codes) as a basis for price-data collection is under way at the BLS.[27] Moreover, broad collection of data of this type would facilitate further studies on demand curves that could help measure the impact of increases in variety and quality on welfare.

Another question arises in regard to data collection: Should a private firm collect the data for and publish the Consumer Price Index? Having private firms collect price data might enhance efficiency, but there are a number of problems. One is that a private data collector might not be able to protect the privacy of voluntary data providers, and this might discourage such providers. Another problem is that the private data collector might be tempted to use the data for private gain. If the private data collector were to pick up indications that the price index was going to be surprisingly high, it might be tempted to use this information to make speculative gains in interest rate markets. Thus, it would appear unlikely that purely private data collection would enhance price measurement.

Public-private cooperation would probably be essential to an improved effort to collect statistics. In the past, private corporations have been very useful to the BLS and the BEA in assisting them in improving statistics. For example, special arrangements with automobile manufacturers help provide more accurate statistics on new car and truck sales. And a team of economists from IBM was very helpful in setting up the hedonic price regressions for computers. Large firms may have the resources to assist in such an effort, and the incentive to do so, since sound government policy-making and improved public perceptions of economic reality are likely to be in their best interest.

CONCLUSION

U.S. economic performance is most probably better than has been reported in our official statistics. Documented biases and extrapolations from other studies suggest that the CPI may distort our picture of recent U.S. economic history. A true cost-of-living index would show prices rising more slowly than reported in the CPI; most likely, inflation would be at least one percentage point per year lower. Improving data collection and providing firmer economic foundations for the price measures themselves are important elements in improving economic decision-making and contracting in the United States.

[27] Marshall Reinsdorf, "Constructing Basic Component Indexes for the U.S. CPI from Scanner Data: A Test Using Data on Coffee," U.S. Bureau of Labor Statistics, mimeo.

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