

# MACROECONOMIC PRICE INDEXES

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Price indexes allow one to compare the average levels of prices at different times. By summarizing information on price trends, the indexes help people adjust for inflation when they choose how much to save, spend, and work. Government officials, as well as voters, use price indexes to evaluate economic policies. In addition, both private contracts and government programs often use a particular price index to adjust payments for inflation.

## EXAMPLES OF EARLY USES

One of the first uses of a price index in the United States arose from the substantial inflation of the Revolutionary War period. In order to maintain the real, or inflation-adjusted, pay of soldiers, officials in Massachusetts tracked the price of acquiring a market basket of the following goods: 5 bushels of corn, 68 4/7 pounds of beef, 10 pounds of wool, and 16 pounds of leather. The basic idea was simple: the percentage increase in the price of the market basket would have to be matched by the same percentage increase in soldiers' wages to compensate for inflation.<sup>1</sup>

The federal government began collecting national price statistics in the late nineteenth century to evaluate the effects of tariffs. A particularly notable achievement was the production of a 50-year historical series of wholesale prices by the federal Bureau of Labor. In 1902 the Bureau began to regularly publish a Wholesale Price Index that could be used to track recent data. That price index was the forerunner of the current Producer Price Index (PPI); the agency is now known as the Bureau of Labor Statistics (BLS) and remains the primary source for aggregate price data in the United States.

During World War I the BLS collected data on the pattern of consumer expenditures and retail prices. The data were used in adjusting wages of workers for wartime inflation. After the war, the "cost-of-

<sup>1</sup> This and many other early uses are described in W. Erwin Diewert, "The Early History of Price Index Research," National Bureau of Economic Research Working Paper No. 2713, 1988.

living" index was regularly published;<sup>2</sup> by one account, more than half the settlements in wage disputes in 1923 were based on that index. That index was the predecessor of the Consumer Price Index (CPI).

In short, the subject of price indexes was of great interest even before the sustained inflation of the last half century. That prolonged period of inflation has in turn stimulated more interest in the subject of price indexes. And that additional interest has in turn led to the use of economic and statistical theory to make the indexes more accurate and more relevant.

## THE MAJOR INDEXES

### Consumer Price Index

The CPI is the most widely used barometer of the average price level. The index is watched closely by workers, retirees, participants in financial markets, and government officials. The CPI's prominence as an inflation measure is reflected in its widespread use as an escalator for wages and benefit payments. Many collective bargaining agreements, other private contracts, social security benefits, and federal and state assistance programs allow for increases in wages and transfer payments tied to increases in the CPI. Elements of the federal income tax structure, including tax brackets and personal exemptions, are also adjusted to reflect movements in the CPI. In addition, the CPI is used to adjust other economic statistics, including hourly and weekly earnings and median family income, for price changes.

The CPI is expressed as the ratio of average prices currently paid by consumers to the average prices paid in a reference, or base, period. Since items vary in importance in personal budgets, both the numerator and denominator of the ratio are *weighted averages*. For example, since most people spend more

<sup>2</sup> It was not a valid cost-of-living index, however, as economists define the term. A cost-of-living index should measure the least expenditure necessary for an individual to achieve a certain level of satisfaction from consumption, with other important factors such as real after-tax income and wealth held constant.

on housing than on socks, the price of housing has a larger weight in the index than the price of socks. More precisely, the CPI is an estimate of the ratio of the current price of a fixed market basket of consumer goods and services of constant quality to the price of that market basket in a specific base period. (See the appendix for algebraic formulas for the CPI and other price indexes discussed in this article; in addition, numerical examples are also presented.) This market basket is designed to represent the average expenditures of a certain segment of the population at a certain time. The CPI is expressed as an index number. In 1993 the value of the CPI was 144.5, which means that the market basket cost 44.5 percent more in 1993 than it did in 1982-84, the base period.

Two versions of the CPI are published monthly by the BLS. They are published with a lag of about two weeks following the end of the month covered by the index. One is the *CPI for Urban Wage Earners and Clerical Workers (CPI-W)*, which is based on expenditures by consumers who represent about 32 percent of the U.S. population. The other is the *CPI for All Urban Consumers (CPI-U)*, which represents the spending habits of 80 percent of the U.S. population. The CPI-U, introduced in 1978, extended coverage to self-employed, professional, managerial and technical workers as well as to the unemployed, retirees, and others not in the labor force. People who live in rural areas are the largest population group whose expenditures are not explicitly represented in the CPI-U. In practice, the CPI-U and CPI-W data are similar. For example, the compounded annual inflation rate over the period 1972 through 1986 was measured by the CPI-U to be 7.12 percent, whereas the CPI-W rose 7.01 percent.

The quality of the CPI as a measure of price change can be affected by the representativeness of the market basket that is priced each month. A *Consumer Expenditure Survey* is used to identify and specify quantities of the goods and services that will make up the market basket of the CPI. It consists of two separate surveys of about 6,000 households, an Interview Survey and a Diary Survey, that have been conducted continuously since 1979. The survey conducted by the Census Bureau from 1982 through 1984 was used to modify expenditure weights in the CPI beginning in 1987.

The weights in the CPI remain unchanged for relatively long periods; the CPI is therefore often referred to as a *fixed-weight* price index. Strictly speaking, however, the entire record is a set of several

time series of fixed-weight indexes that are spliced together. Since one set of expenditure weights is not used to calculate the CPI for every date, it is possible that a user viewing different dates will use index numbers based on different market baskets. Calculating inflation from 1980 to 1990, for example, the 1980 index would be based on the 1972-73 Consumer Expenditure Survey and the 1990 index would be based on the 1982-84 survey.

Once the expenditure weights are determined, the computation of the CPI for each month requires data on the current prices of items in the market basket. To obtain the price data, the BLS sends agents to many retail establishments in different parts of the country to obtain prices for about 100,000 items each month. The BLS then uses the individual prices to calculate CPI statistics at the local, regional, and national levels. (CPIs for each state are not produced, however.) In addition to the index for all items, the BLS calculates price indexes for selected components of the market basket such as food or entertainment.

Chart 1 graphs the CPI over its first 32 years. One can see the impact of three major events, the wartime inflation in the two world wars and the beginning of the Great Depression. Otherwise there is no clear trend; only the level is affected by various events. That is also the case when looking farther back. Using one estimate of the producer price index before 1890<sup>3</sup> and the official index thereafter, the level of that index only increased by about 10 percent from 1785 to 1913.

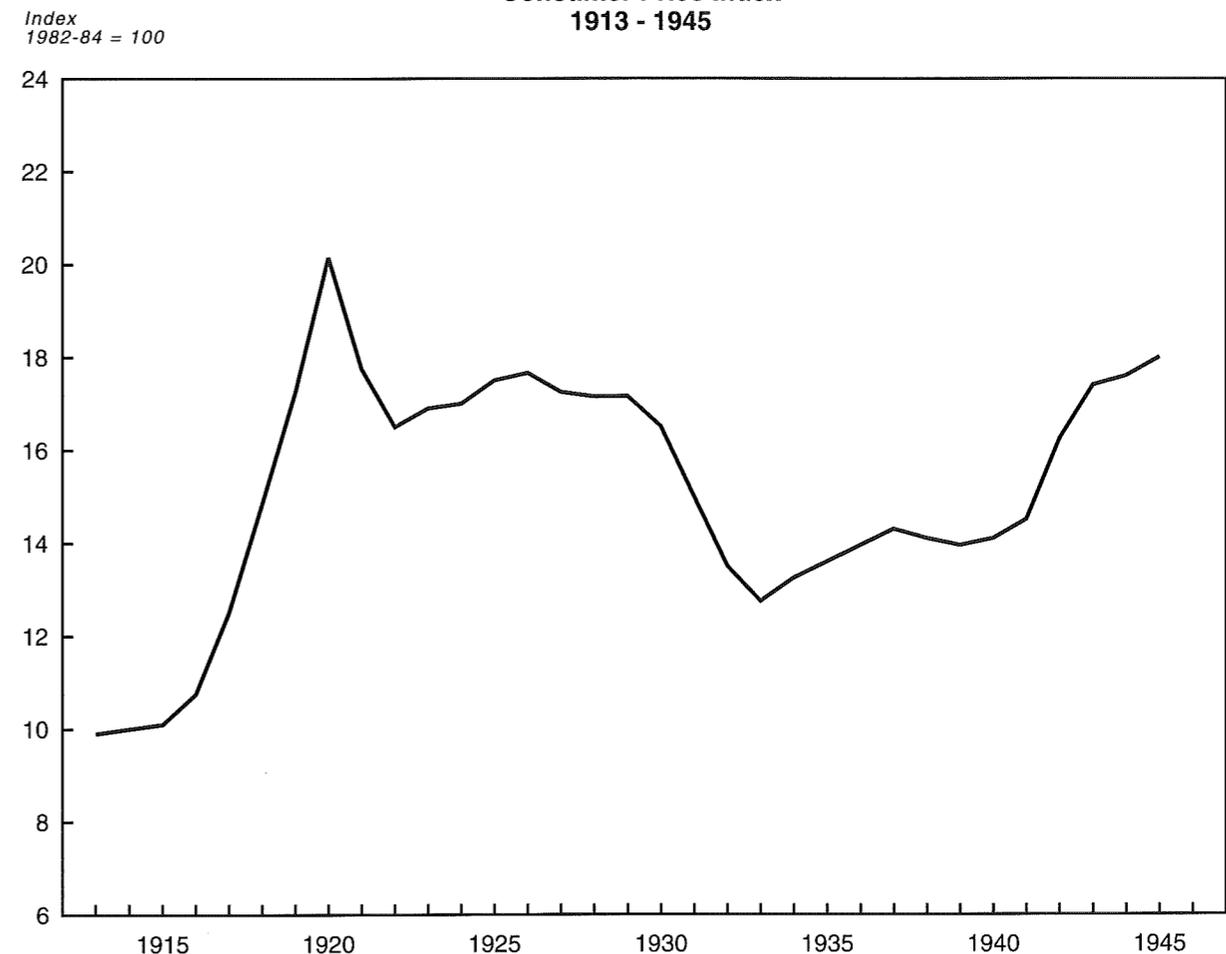
The picture shown in Chart 2 is somewhat different. Due to substantial inflation from 1945 to 1993, with the CPI increasing eightfold, this chart contains *percentage changes* in the CPI rather than the levels shown in Chart 1. At first, high rates of inflation were associated with wars; during the 1970s, however, sustained high rates of inflation occurred during peacetime. Unlike the prewar period, there was no tendency for inflationary periods to be offset by deflation at other times.

### The Producer Price Indexes

The PPIs are used to estimate prices received by domestic producers of goods at various levels of processing. The classification by stage of processing

<sup>3</sup> The series was estimated by G. F. Warren and F. A. Pearson and is reprinted in U.S. Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970, Part 1*, Washington, D.C., 1975, 200-201.

Chart 1  
Consumer Price Index  
1913 - 1945



divides goods into three main categories: *crude, intermediate, and finished goods*. Crude goods are items that are entering the market for the first time, that have not been manufactured or fabricated, and that are not sold directly to consumers. They include items like grains, livestock, cotton, and crude oil. Items like lumber, fertilizer, machine belts, and yarn are intermediate goods. They have been processed but may require further processing, or may be complete but will be used by businesses as material inputs. Finished goods will not undergo further processing; that category includes consumer goods as well as capital equipment.

Indexes are also calculated for special commodity groupings, organized by similarity of end-use or material composition. Examples include the PPIs for industrial commodities and for farm products. Also, there are producer price indexes for the net output

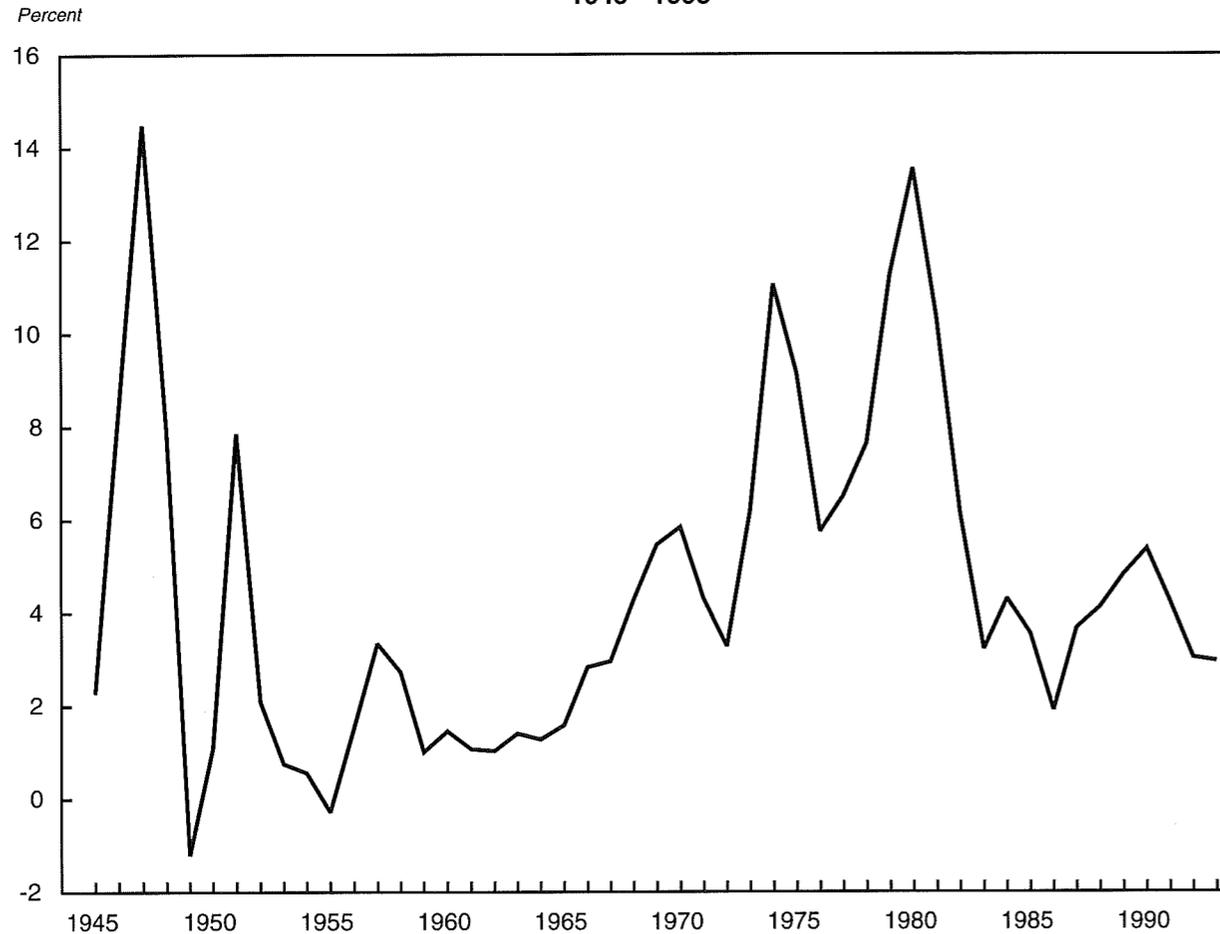
of different industries and their products. The entire system of PPIs consists of over 10,000 indexes.

The widely followed PPIs cover prices of physical commodities in manufacturing, mining, agriculture, and to a small extent electric power production. Coverage of physical products is comprehensive and detailed. Coverage of services, which now account for the bulk of total economic activity, is at best partial. Recently, PPIs for some service industries have been constructed, but are not included in the indexes of final, intermediate, and crude goods. Certain transportation, utility, and medical prices are reported at the industry level, while prices in other service industries such as banking and insurance are not yet covered.

The PPIs are calculated from a large number of individual prices. Like the CPI, they are constructed

Chart 2

### Consumer Price Index Changes 1945 - 1993



using fixed weights for a number of years. The weight for each individual component is the relative value of shipments of that item. Periodically, the Bureau of the Census conducts industry surveys that the BLS uses to update the value weights. Among the most important surveys are the Census of Manufactures, the Census of Agriculture, and the Census of Minerals, which includes oil and gas production. The latest update of the PPIs uses surveys that were conducted in 1987 and have been incorporated in the PPI as of 1992.

The PPI for finished goods in 1993 was 124.7. That is a concise way of saying that prices producers received in primary markets for finished goods had increased 24.7 percent since 1982, with the prices of those items weighted by the relative values of 1987 shipments.

#### Price Measures from the National Income and Product Accounts

In the process of estimating GDP and its components, the Bureau of Economic Analysis (BEA) also estimates corresponding price measures, including fixed-weight price indexes, *implicit price deflators*, and *chain price indexes*.

To calculate GDP and its components, the BEA estimates the dollar value of spending for current production. It then calculates what that spending would have been if current quantities had not been valued at current prices but rather at prices paid during a reference (base) period. The ratio of the two spending totals, current dollar spending divided by constant dollar spending, is an implicit price deflator. Implicit price deflators are computed for GDP, for broad expenditure categories such as

consumer spending, and for more narrow categories such as consumer spending for stationery and writing supplies.

In the appendix it is shown that an implicit deflator is unlike the indexes discussed above in two important respects. First, instead of using historic weights, a deflator uses current quantities as weights. Second, an implicit deflator is not a pure price index, since changes in the index may reflect factors other than changes in prices. In fact, when two periods are compared (neither being the base period), the calculated change in the deflator depends on both the price change and on any change in the relative quantities exchanged.

An implicit deflator can therefore behave differently from a fixed-weight index. For example, if people spend their money for different products, that by itself does not immediately affect the CPI or PPI, which are not affected unless individual prices change. The implicit deflators, however, can be very much affected when relative quantities change. To provide users with better data on price movements, the BEA also publishes fixed-weight price indexes for GDP and many of its components. The weights are the amounts produced in a particular base period, which at present is 1987.

Since the National Income and Product Accounts are used to study the economy over long periods of time, there is also a disadvantage to the fixed-weight price indexes; the farther from the base period, the less representative will be the base-period weights. In fact, the BEA has stopped publishing the fixed-weight price index for GDP and several of its components before 1982 because using the 1987 weight for computers can make the fixed-weight price index behave strangely.

The BEA therefore provides two additional alternatives.<sup>4</sup> A chain-type annual-weighted price index is calculated for a particular year as the geometric average (that is, the square root of the product) of two price indexes: one uses the previous year as the base period, and the other uses the particular year as the base period. The resulting values can then be "chained" to form a time series that in effect uses weights that change each year. A similar procedure is followed for the other alternative, a benchmark-years weighted price index. Instead of

<sup>4</sup> A more complete discussion of this topic is contained in Allan H. Young, "Alternative Measures of Change in Real Output and Prices," *Survey of Current Business*, April 1992, 35-48.

weights changing annually, however, they change every five years. (Detailed information from economic censuses is available at five-year intervals.)

Although the differing measures of price levels may seem confusing, they usually tell similar stories over time. For example, between 1982 and 1993 the GDP fixed-weight price index, the implicit price deflator for GDP, and the GDP annual-weighted chain-type price index each grew at a 3.6 percent annual rate. Quarterly changes in the statistics, however, can diverge substantially; when they do, it is best to discount extreme movements in the implicit price deflator, which can result from changes in relative quantities produced between two particular quarters.

Chart 3 shows the GDP annual-weighted chain-type price index and the implicit price deflator. Note that they both reveal rising inflation in the late 1960s and 1970s and lower inflation in the 1980s and 1990s. On a quarterly basis, however, the implicit deflator is more volatile.

#### CAUTIONS

Price indexes are invaluable tools; however, no single index gives unambiguous answers to all questions. Some important cautions should be kept in mind.

#### Quality Change

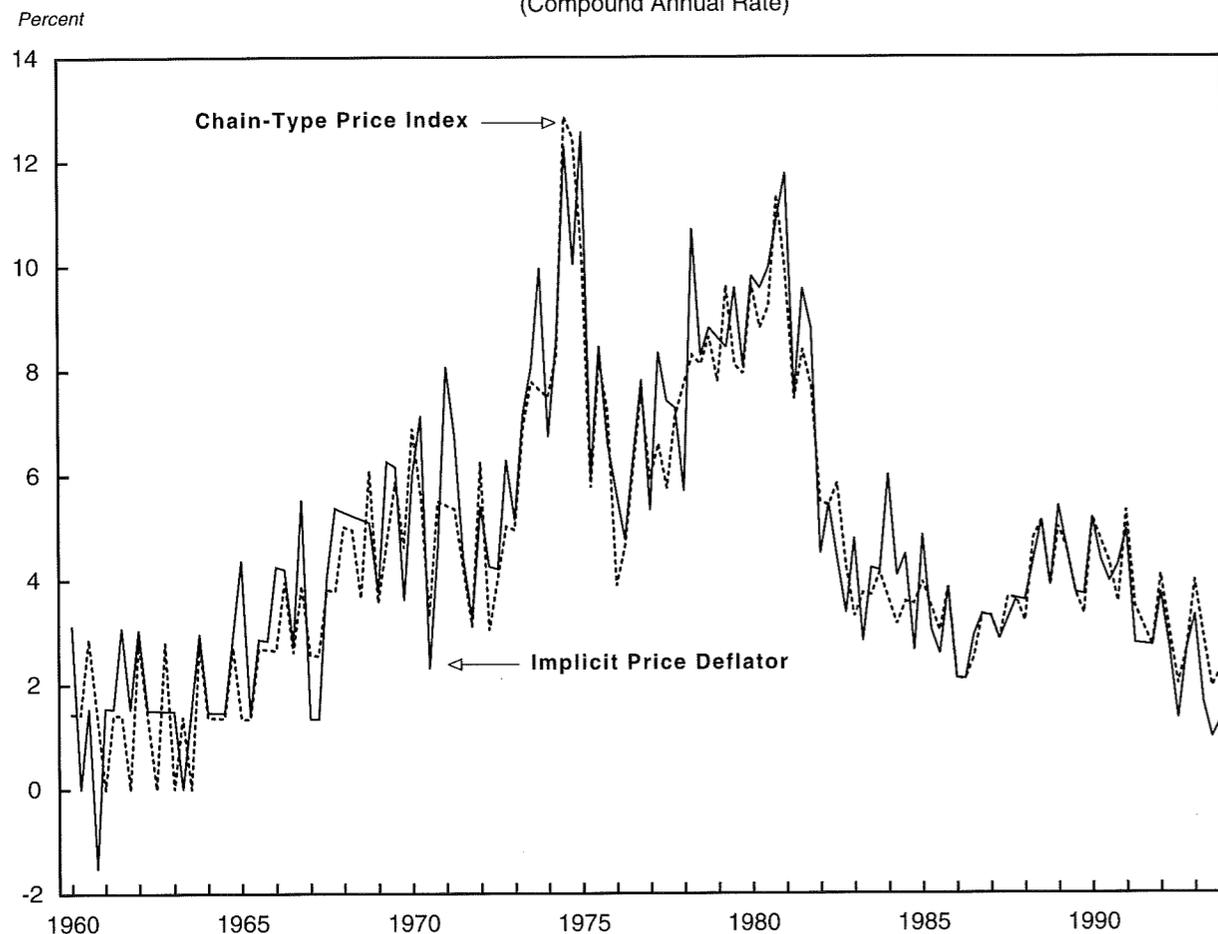
Ideally, one can use price indexes for different dates to measure the average price change of goods and services of constant quality. Therefore, if a price increase of an item is due solely to quality improvement, then that price increase should not affect the index.

In many cases statisticians do not make any adjustment for quality changes. Banking, for example, has become much more convenient over time as extended hours, automated teller machines, and credit cards have eased banking transactions. None of the major price indexes adjusts for that quality change.

When they do adjust for quality change, statisticians often use a practice known as linking. That procedure estimates a price change for a new product by the price change of a similar product for which quality did not change. In other instances statisticians estimate the amount of quality change by the cost of producing it. For example, car manufacturers routinely provide the BLS with cost data for new

Chart 3

**Price Measures for Gross Domestic Product**  
**Quarterly Changes: 1Q 1960 - 4Q 1993**  
 (Compound Annual Rate)



features or additional items that were once optional before becoming standard equipment. Thus, if a new audio system added 1 percent to a car's cost of production and the new car price rose 3 percent, the quality-adjusted price increase would be 2 percent.

While those adjustments are clearly better than no adjustment for quality change, many observers believe they do not go far enough. As Robert J. Gordon has put it:

The typical product, whether automobiles in the 1920s, TV sets in the 1950s or electronic calculators in the 1970s, experiences after its invention an initial period of declining price, as its manufacturers spread the fixed cost of development over more and more units sold. Then, as the product becomes mature, there is less opportunity for efficiency gains to cancel out increased wages and other costs, so prices begin to rise. Three aspects of the CPI cause it to understate quality improvements and to over-

state price movements. First, the use of obsolete weights from decade-old expenditure surveys tends to place too little weight on modern products where price increases are relatively slow. Second, new models and products are typically introduced in the index much later than the date when their sales volume becomes important. And finally, the linking procedure, by far the most common quality-adjustment technique used by the BLS, tends both to treat new products as if they were mature products and to ignore performance improvements.<sup>5</sup>

For example, consider the difficulty in measuring the price of computers. For many years computer price changes were not included in the PPI or in the CPI's market basket or in the national income and product accounts; the price change was simply assumed to be zero. Over the last few decades,

<sup>5</sup> Robert J. Gordon, "The Consumer Price Index: Measuring Inflation and Causing It," *The Public Interest* (Spring 1981), 129-30.

however, the price of computing has fallen substantially; the price indexes therefore overstated the average inflation rate. Recently, the BEA revised the national income and product accounts back to 1970 to account for computer prices, which they now estimate have been falling by 15 percent per year. In contrast, the CPI is not revised once it is published;<sup>6</sup> it will therefore never be revised to account for the price declines found by the BEA for personal computers.

Other durable goods also may have higher quality levels that are not accurately reflected in price indexes. For example, Gordon has calculated that producers' durable equipment prices grew by 66 percent from 1947 to 1983; in contrast, the BEA's official deflator for that category grew by 383 percent.<sup>7</sup> The huge difference is accounted for by Gordon's detailed quality adjustments for many items using sources other than the BLS or BEA. In some cases his estimates were based on conventional methods such as linking; in other cases, however, he went beyond usual methods when new models performed much better than old ones.

Problems in measuring quality change are especially severe for services, which account for a large fraction of economic activity. (Employment in service-producing industries recently accounted for three-fourths of private nonfarm employment.) Traditional methods to correct for quality improvement are difficult to apply since the product of a service industry can have attributes such as convenience that are difficult to measure. The chapter on price indexes for medical care provides details that illustrate the difficulty of constructing a price index for a service with substantial quality change.

Due to technical progress and increasing knowledge, many observers believe that the average quality of goods and services has risen over time, and that unmeasured quality change has caused inflation in the United States to be overstated by most price indexes.<sup>8</sup> That belief, however, is extremely difficult

<sup>6</sup> Since the CPI is used frequently to adjust contractual payments and government benefits, revising historical values could lead to complex revisions of liabilities and payments. The non-seasonally adjusted version of the index is not revised after publication, while the seasonally adjusted version is only revised to the extent that seasonal factors are revised.

<sup>7</sup> Robert J. Gordon, *The Measurement of Durable Goods Prices*, University of Chicago Press for the National Bureau of Economic Research, 1990.

<sup>8</sup> There are, of course, counterexamples that would illustrate quality declining, such as decreasing legroom in coach seats on airplanes.

to quantify. The examples above certainly indicate that the problem of measuring quality change is important and should be studied. Unfortunately, they do not provide the final word on the magnitude of unmeasured quality changes in the major indexes.

### Homeownership

The CPI increased sharply in the late 1970s and early 1980s, with its annual rate of increase peaking at 15 percent in 1980. Flaws in the measurement of the cost of homeownership in the CPI contributed to its sharp increase.<sup>9</sup> At that time the CPI's cost of homeownership contained two main components, the house purchase price and the mortgage interest cost, as well as other expenses such as taxes, maintenance, and insurance. That method overweighted the cost of homeownership for two reasons. First, it treated the investment in a house much like the purchase of a nondurable good. Second, it confused the purchase price with the method of financing. That method therefore tended to overstate the CPI in the late 1970s as house prices and mortgage rates increased sharply.

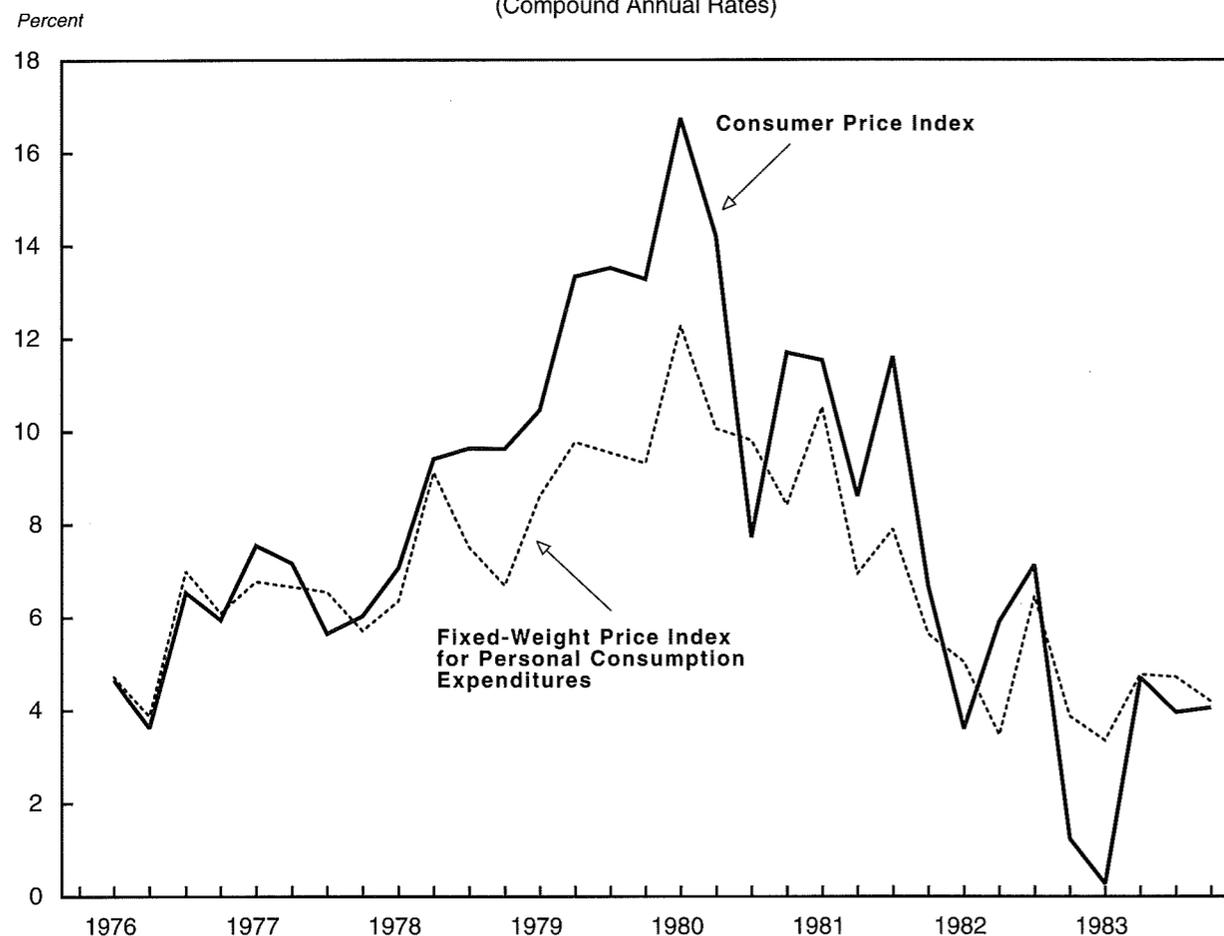
Economists usually consider the purchase of a house to be an investment and the use of a house to be consumption. The CPI, as a measure of the cost of consuming a bundle of goods and services, should therefore incorporate only the change in the current cost of housing services. One estimate of the current cost of using owner-occupied housing is the amount it would cost to rent a similar property. Starting in 1983 with the CPI-U and in 1985 with the CPI-W, the BLS adopted a *rental equivalence* approach to measure the cost of housing services. Rental equivalence approximates the change in the cost of services of homeownership with an index of the rental value of owner-occupied housing.

The rental equivalence approach was already used in the National Income and Product Accounts and its personal consumption expenditure fixed-weight price index. Chart 4 shows the period in which the different measures diverged substantially; from 1978 to 1982, the CPI rose 10.7 percent whereas the fixed-weight price index for consumer spending rose 8.9 percent. The most important difference in the two statistics is their different methods of estimating prices for housing. Since the BLS does not revise CPI data once they are published, users

<sup>9</sup> For a more detailed account, see Alan S. Blinder, "The Consumer Price Index and the Measurement of Recent Inflation," *Brookings Papers on Economic Activity* 2:1980, 539-73.

Chart 4

**Changes in Consumer Price Measures**  
1Q 1976 - 4Q 1983  
(Compound Annual Rates)



of old CPI data should realize that the CPI-U data before 1983 (and the CPI-W before 1985) still use the old measurement of housing cost and thus overstate the actual price increases. Similarly, other statistics that are adjusted for inflation by using the CPI are biased downward for that period, including real hourly earnings and real family incomes.

#### Outlet Substitution Bias

When preparing the CPI, the BLS considers an item purchased at a discount store and the same item purchased at a traditional retailer to be different goods, presumably reflecting a lower quality of service by the discount store. Thus, the post-World War II shift in purchases toward discounters is not reflected in the indexes, and the CPI overstates the change in the average price paid for many items. In the 1980s, for example, the CPI for an average of

many food items grew at a 2.1 percent higher rate than the corresponding average prices consumers actually paid.<sup>10</sup> To the extent that price differences among stores do not represent quality differences, the failure of the CPI to incorporate the effect of discounters would bias it upward.

#### Changing Quantities

People shift their buying habits over time due to changes in relative prices, real incomes, demographic characteristics, and tastes. The CPI, however, is based on a market basket that is fixed for long intervals. Table 1 provides a contrast between the

<sup>10</sup> Marshall Reinsdorf, "The Effect of Outlet Price Differentials on the CPI," in Murray Foss, Marilyn Manser, and Allan Young, *Price Measurements and Their Uses*, University of Chicago Press, 1993.

Table 1

#### Composition of Consumer Spending

Expenditure Group	Consumer Expenditure Survey	
	1972-73	1982-84
Food and Beverages	18.7	18.1
Food away from home	3.8	4.9
Housing	28.0	30.7
Apparel and Services	7.8	5.4
Transportation	18.7	19.7
Gasoline and motor oil	4.3	5.6
Medical Care	4.6	4.4
Other	22.2	21.7

Note: Figures represent the relative importance of items, stated as percentages of annual expenditure.

Source: *Monthly Labor Review*, June 1986, p. 17.

major expenditure shares based on the 1972-73 and the 1982-84 Consumer Expenditure Surveys.

The CPI's fixed expenditure weights become less representative over time as consumption patterns change. For example, consumers normally reduce consumption of items for which price increases are relatively large. This problem is often referred to as substitution bias. It is inherent in any price index whose weights are fixed, and it becomes more serious when price movements are widely dispersed. In practice, substitution bias may not be very large. One recent study found substitution bias for the CPI from 1959 to 1985 was only about 0.18 percent per year.<sup>11</sup>

#### Lack of Good Data on Individual Prices

The BEA uses prices of individual items that were first collected for the CPI and PPI to estimate over 90 percent of the private sector prices in the National Income and Product Accounts. Since the accounts attempt to cover all current production, whereas the CPI and PPI cover limited areas, prices of some items remain to be estimated by the BEA. They may not have usable data for some of those remaining items, such as commercial construction or financial services, where both price and quantity may be difficult to define. In those cases the BEA may use the cost of production to estimate a product's price; the quantity produced is then estimated as total

<sup>11</sup> Marilyn E. Manser and Richard J. McDonald, "An Analysis of Substitution Bias in Measuring Inflation, 1959-85," *Econometrica* (July 1988), 909-30.

spending divided by that estimated price. If there are substantial productivity gains in those industries, however, then that procedure will overstate price change and correspondingly underestimate real output growth.

#### International Comparisons

As should now be apparent, compiling a price index involves many choices among imperfect alternatives. Not surprisingly, statistical agencies of different nations have made different choices. Thus, one cannot assume that the price indexes of different nations are exactly comparable even if they have the same title.

#### CONCLUSION

These caveats indicate that price indexes do not answer all questions as well as we might wish. Despite their imperfections, however, the existing price indexes are invaluable. As Irving Fisher put it:

But, although in the science of optics we learn that a perfect lens is theoretically impossible, nevertheless, for all practical purposes lenses may be constructed so nearly perfect that it is well worth while to study and construct them. So, also, while it seems theoretically impossible to devise an index number, P, which shall satisfy all of the tests we should like to impose, it is, nevertheless, possible to construct index numbers which satisfy these tests so well for practical purposes that we may profitably devote serious attention to the study and construction of index numbers.<sup>12</sup>

#### SUGGESTIONS FOR FURTHER READING

The Bureau of Labor Statistics is the primary source for the CPI and the PPI and publications explaining their construction. The monthly publications *CPI Detailed Report* and *The Producer Price Indexes* present the actual data and contain brief introductions to the construction of the CPI and the PPI; they also announce and explain periodic revisions in the series. The *BLS Handbook of Methods* describes in more detail the construction of the CPI and the PPI. The *Monthly Labor Review* contains recent data as well as articles on topics related to the CPI and PPI.

The implicit PCE and GDP deflators are explained in most macroeconomic textbook discussions of the National Income and Product Accounts. The *Survey of Current Business*, published monthly by the Commerce Department, presents the data and regularly provides brief explanations of the deflators and price indexes.

<sup>12</sup> *The Purchasing Power of Money* (1911; reprint, New York: Augustus M. Kelley, 1963), p. 212.

Problems of quality adjustment in the price indexes are discussed in Robert J. Gordon's works cited in footnotes above. Other useful critiques of official indexes include the following: Phillip Cagan and Geoffrey H. Moore, *The Consumer Price Index: Issues and Alternatives*, American Enterprise Institute, Washington, 1981; and Council on Wage and Price Stability, *The Wholesale Price Index: Review and Evaluation*, Washington, 1977.

## APPENDIX

The CPI, PPI, and GDP fixed-weight price indexes all reflect weighted averages of prices relative to average prices in a base period. Since the weights on specific prices remain fixed for long periods of time, the indexes are often referred to as fixed-weight indexes. In symbols, a fixed-weight index can be represented as in equation (1a) or its possibly more intuitive form, (1b):

$$P_t = \frac{\sum p_t q_b}{\sum p_b q_b} \quad (1a)$$

$$= \sum \left( \frac{p_t}{p_b} \right) \left( \frac{p_b q_b}{\sum p_b q_b} \right) \quad (1b)$$

where  $P_t$  is the price index in period  $t$ , the summation signs represent summation over all commodities covered by the index,  $p_t$  is the price of a specific item in period  $t$ ,  $q_b$  represents either the quantity of a specific item included in the market basket (CPI) or the quantity produced in the base period (PPI or GDP indexes), and  $p_b$  is the price of a specific item in the base period. In words, equation (1b) states that the price index is a weighted average of the relative price changes for specific items (the first term in parentheses), with the weights being the relative importance of the items in the base period (the second term in parentheses).

The deflators used in the National Income and Product Accounts are somewhat different since the weights of individual prices can vary over time. A deflator can be represented as in equation (2):

$$P_t = \frac{\sum p_t q_t}{\sum p_b q_t} \quad (2)$$

where  $P_t$  is the price index in period  $t$ , the summation signs represent summation over all commodities covered by the index,  $p_t$  is the price of a specific item in period  $t$ ,  $q_t$  is the current quantity consumed of that specific item, and  $p_b$  is the price of a specific

item in the base period. In words, equation (2) states that the price index is the ratio of current expenditure to current quantities times base period prices. When compared to the base period, an implicit deflator is a current-weight price index. That is, it is a weighted average of prices, with the weights being current quantities. When two periods other than the base period are compared, however, the change in the deflator is a muddle of price and quantity changes that can be difficult to interpret.

A final type of index considered is the chain-type price index of the national income accounts. In symbols it is

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$$P_t = \sqrt{\frac{\sum p_t q_{t-1}}{\sum p_{t-1} q_{t-1}} \times \frac{\sum p_t q_t}{\sum p_{t-1} q_t}} \quad (3)$$

where  $P_t$  is the price index in period  $t$ , the summation signs represent summation over all commodities covered by the index,  $p_t$  is the price of a specific item in period  $t$ , and  $q_t$  is the current quantity consumed of that specific item. In words, equation (2) states that the price index is the geometric average of two fixed-weight price indexes; one uses last period's quantities as weights, and the other uses the current period's quantities as weights.

A simple example may help clarify the types of indexes. Suppose that one wishes to construct a price index for fruit. There are two types of fruit, apples and oranges. Table 2 shows the prices of apples and oranges in April, May, June, and July and the amounts bought. A fixed-weight Fruit Price Index (FPI) is calculated, using quantities bought in April as the base; as is conventional, the index value in the base period is 100. An Implicit Fruit Deflator (IFD) is also calculated, as is a Chain-Type Price Index (CTPI).

Table 2  
Numerical Examples of Price Statistics

	APRIL	MAY	JUNE	JULY
Price per apple	12	20	20	20
Number of apples bought	6	3	2	2
Price per orange	4	4	4	2
Number of oranges bought	7	10	15	30
FPI: Level	100	148	148	134
Percentage change		48	0	-9
IFD: Level	100	132	119	69
Percentage change		32	-10	-42
CTPI: Level	100	140	100	66
Percentage change		40	-29	-34

For example, using equation (1a) to construct the FPI for May,

$$FPI = \frac{(20 \times 6) + (4 \times 7)}{(12 \times 6) + (4 \times 7)} = \frac{120 + 28}{72 + 28} = 148.$$

Similarly, using equation (2) to construct the IFD for June,

$$IFD = \frac{(20 \times 2) + (4 \times 15)}{(12 \times 2) + (4 \times 15)} = \frac{40 + 60}{24 + 60} = 119.$$

A few points are worth emphasizing. First, the monthly estimates of price change can differ substantially, depending only on how the index is constructed. The differences in this example are extreme since the relative price changes and quantity changes are also extreme.

Second, the implicit deflator is less than the fixed-weight index. That is often the case in the real world as well, resulting from the tendency to switch consumption toward relatively less expensive goods when relative prices change.

Third, although neither price changed in June, both the implicit deflator and the chain index changed substantially.

Finally, in July there was a substantial decline in the price of oranges. The fixed-weight index put little weight on that decline due to the small relative importance of oranges in the base period, April.

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Thank you for your recent order for *Macroeconomic Data: A User's Guide*. Unfortunately, it contains errors on pages 68 and 69 that are corrected below. Please insert this sheet in your book for future reference, and please accept our apologies for the inconvenience.

- Equation 3 on page 68 should read:

$$\frac{P_t}{P_{t-1}} = \sqrt{\frac{\sum p_t q_{t-1}}{\sum p_{t-1} q_{t-1}} \times \frac{\sum p_t q_t}{\sum p_{t-1} q_t}} \quad (3)$$

- Using that formula, the bottom of Table 2 on page 69 should be:

CTPI: Level	100	140	140	93
Percentage change		40	0	-34

- In addition, the next to last paragraph on page 69 should read:

Third, although neither price changed in June, the implicit deflator changed substantially.