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, work, and invest. 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, 68⅘ 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.[1]

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.

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[1] 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.

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-living" index[2] was regularly published; by one account, more than half the settlements in wage disputes in 1923 were based on that index. The cost-of-living 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*

[2] The index was not a true measure of the cost of living, however. While it did measure the prices of goods and services, it did not include other outlays such as taxes and interest. In addition, there was no consideration of goods and services provided by government, nor of fringe benefits provided by employers.

averages. For example, since most people spend more 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 formulae 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 1988 the value of the CPI was 118.3, which means that the market basket cost 18.3 percent more in 1988 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 roughly three 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, and also 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: a quarterly Interview Survey, which is designed to obtain data on expensive items that are purchased relatively infrequently, and a Diary Survey to gather information on more frequently purchased items. The latest 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 1988, for example, the 1980 index would be based on the 1972-73 Consumer Expenditure Survey and the 1988 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. 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 major events, such as 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[3] and the official index afterward, 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 1988, with the CPI increasing sixfold, 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 late 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.
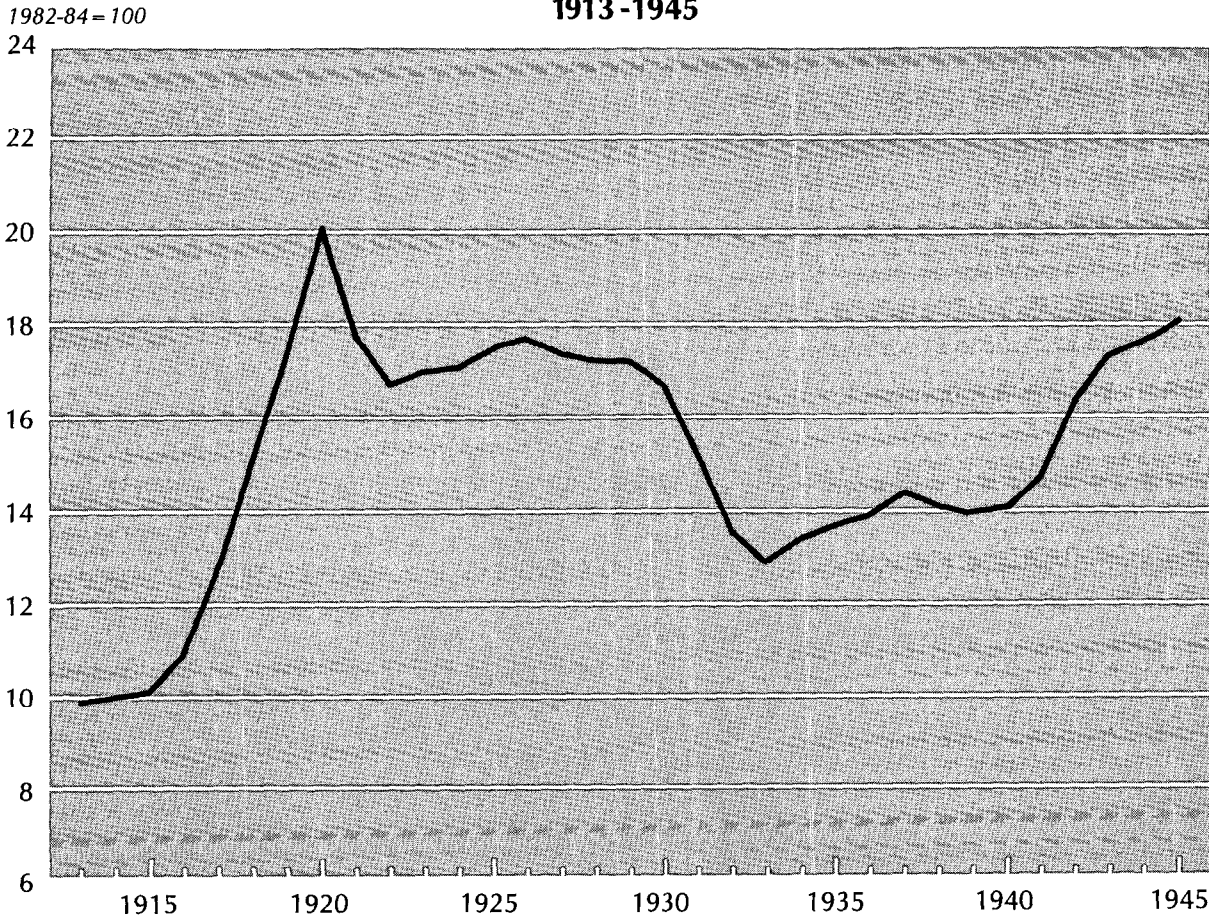
The Producer Price Indexes

The PPIs are used to estimate prices received by domestic producers of goods at various levels of processing. The PPI is largely composed of manufactured products, as shown in Table I. A notable omission from the PPI is the service sector, which

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[3] 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, Bicentennial Edition, Part 1*, Washington, D.C., 1975, pp. 200-201.

Chart 1

CONSUMER PRICE INDEX
1913-1945

1982-84 = 100

has grown rapidly in the United States during the twentieth century.[4]

Producer Price Indexes are presented in a number of ways based on different classifications of goods. The classification by *Stage of Processing* 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

[4] The BLS is studying price indexes for services. It is possible that experimental indexes could be introduced for those services for which the quantity produced can be most accurately measured, such as transportation and communication. It would be much more difficult to produce meaningful indexes for services such as medical care, banking, and insurance where the quantity and quality produced is difficult to measure accurately.

Table I

COMPOSITION OF
PRODUCER PRICE INDEX
DECEMBER 1986

Manufacturing	83.6 percent
Mining	7.2 percent
Agriculture	5.1 percent
Electric Power	3.4 percent
Other	0.7 percent

Source: *Monthly Labor Review,* August 1987, page 14.

Chart 2

CONSUMER PRICE INDEX CHANGES
1945-1988

Percent
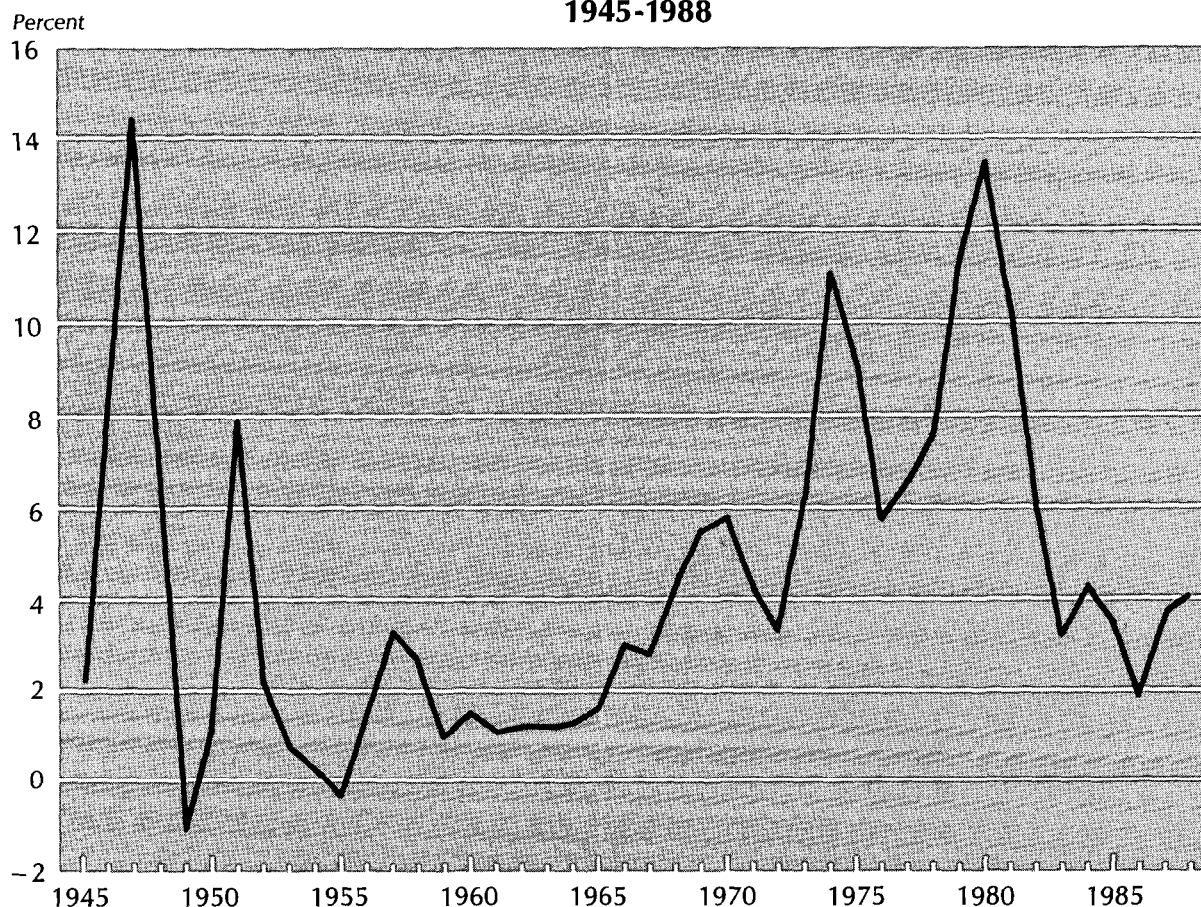
material composition. Examples include the PPIs for industrial commodities and for farm products. Also, there are producer price indexes for the net output of different industries and their products.

The PPI is calculated from approximately 70,000 individual prices. Like the CPI, it is constructed using fixed weights for relatively long times. 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 surveys, conducted in 1982, have been incorporated in the PPI as of 1987. Previous value weights, which were used from 1976 through 1986, were based on Census results of 1972.

The PPI for all commodities in 1986 was 100.17. That is a concise way of saying that prices producers received in primary markets for a group of items had increased 0.17 percent since 1982, with the prices of those items weighted by the relative values of 1982 shipments.

Price Measures from the National Income and Product Accounts

In the process of estimating GNP 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 GNP 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 GNP, 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 other factors than changes in prices. In fact, when two periods are compared (neither being the base period), the calculated change in the deflator depends both on the price change and also 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 GNP and many of its components. The weights are the amounts produced in a particular base period, which at present is 1982.

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. The BEA therefore provides another alternative, a *chain price index*. It uses past prices for weights, but with the previous quarter as the base period. The change between two adjacent quarters is therefore determined solely by price changes. In that respect it is like the fixed-weight indexes. Unlike a fixed-weight index, however, shifting expenditure patterns will be incorporated in the chain index with only a one-quarter lag.

Although the differing measures of price levels may seem confusing, they usually tell similar stories over time. For example, between 1959 and 1988 the implicit price deflator for GNP and the GNP chain price index each grew at a 4.9 percent annual rate; the GNP fixed-weight price index grew at a 4.2 percent 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.[5]

Chart 3 shows the GNP fixed-weight price index and the implicit price deflator for the last ten years. Note that they both reveal the decline in inflation in the early 1980s and the gradual rise since 1986. The implicit deflator is more volatile, however, as exemplified in 1986.

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.

To adjust for significant quality changes, statisticians sometimes 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 features or additional items that were once optional before becoming standard equipment. Thus if a new audio system added one percent to a car's cost of production and the new car price rose three percent, the quality-adjusted price increase would be two 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:
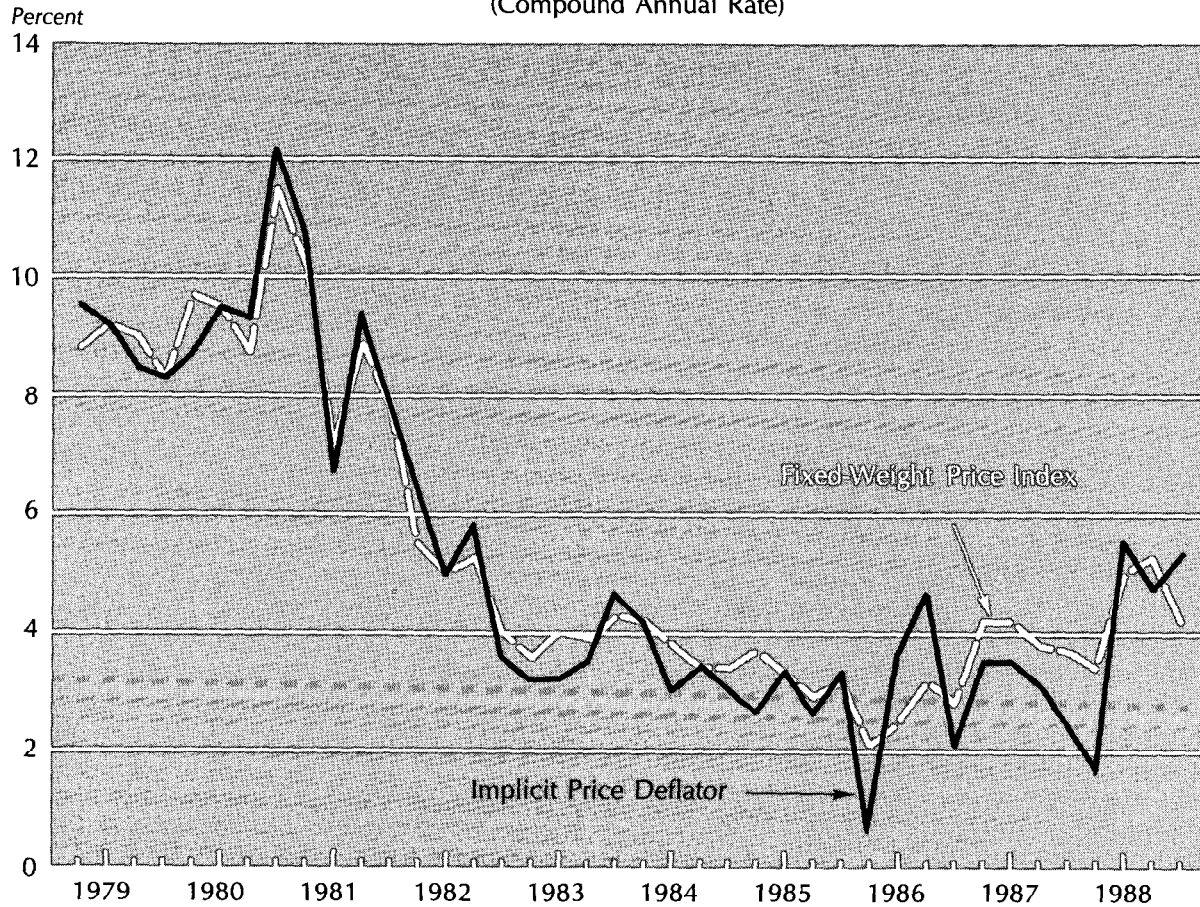
> The typical product, whether automobiles in the 1920s, TV sets in the 1950s or electronic calculators in the 1970s, experiences after its invention an initial period of declining price, as its manufacturers spread the fixed cost of development over more and more units sold. Then, as the product becomes mature, there is less opportunity for

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[5] Although not regularly published, another type of index appeals to many economists. It is simply the geometric average—that is, the square root of the product—of an index based on historical fixed weights and an index based on current weights. For the case of GNP, one could use the average of the GNP fixed-weight price index and the implicit price deflator. This type of index was labeled an Ideal index by Irving Fisher, who was one of the first to note many of its advantages.

Chart 3

PRICE MEASURES OF GROSS NATIONAL PRODUCT
QUARTERLY CHANGES: 1Q 1979 - 4Q 1988
(Compound Annual Rate)

Percent

14

12

10

8

6

Fixed-Weight Price Index

4

2

Implicit Price Deflator

0

1979   1980   1981   1982   1983   1984   1985   1986   1987   1988

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 overstate 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.[6]

For example, consider the difficulty in measuring the price of computers. For many years computer price changes were not included in the PPI, nor in the CPI's market basket, nor in the national income and product accounts; the price change was simply

assumed to be zero. Over the last few decades, however, the price of computing has fallen substantially; the price indexes therefore overstated the average inflation rate. Recently, the BEA has 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;[7] it will therefore never be revised to account for the price declines found by the BEA for personal computers.

Other durable goods may also 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

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[6] Robert J. Gordon, "The Consumer Price Index: Measuring Inflation and Causing It." *The Public Interest* (Spring 1981), pp. 129-30.

[7] Since the CPI is so frequently used to adjust contractual payments and government benefits, revising historical values could lead to complex revisions of liabilities and payments.

deflator for that category grew by 383 percent.[8] 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.[9]

Problems in measuring quality change are especially severe for services, which are of growing importance in the economy. Traditional methods to correct for quality improvement are difficult to apply since by their very nature services leave little tangible product to examine once they have been rendered. For example, suppose that as a result of advances in medical knowledge a physician's effectiveness doubled, while the hourly fee increased by 50 percent. While only the fee could be accurately measured, it would dramatically overstate the price change for constant-quality physician's services.

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.[10] That belief, however, is extremely difficult 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.

Homeownership

The CPI increased sharply in the late 1970s and early 1980s, with its annual rate of increase peaking at 15 percent in 1980. Some analysts have argued

that flaws in the measurement of the cost of homeownership in the CPI contributed to its sharp increase.[11] 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 rental prices.[12]

The rental equivalence approach was already used in another index of consumer prices, the 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 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.

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[8] Robert J. Gordon, *The Measurement of Durable Goods Prices*, Chicago: University of Chicago Press for the National Bureau of Economic Research, forthcoming. Part of the work is summarized in Martin N. Bailey and Robert J. Gordon, "The Productivity Slowdown, Measurement Issues, and the Explosion of Computer Power," *Brookings Papers on Economic Activity* 2 (1988): 347-431. The figures in the text are from the BPEA article, page 382.

[9] Gordon's estimates are probably not universally accepted, however. As Jack Triplett put it (not referring to these particular estimates), "Just because an economist produces an index that differs from an official index, this does not necessarily imply that it is the official index that must be the incorrect one." ["Quality Bias in Price Indexes and New Methods of Quality Measurement," in Zvi Griliches, ed., *Price Indexes and Quality Change* (Cambridge: Harvard University Press, 1971), p. 212.]

[10] On the other hand, it is of course possible to find products where quality has deteriorated. One example could be the growing use of graduate students for undergraduate instruction in many universities.

[11] For example, see Alan S. Blinder, "The Consumer Price Index and the Measurement of Recent Inflation," *Brookings Papers on Economic Activity* 2 (1980).

[12] The same type of problem applies to other durable goods as well. The theoretically appropriate price to include is usually the price of obtaining the services of that good, not the purchase price of the durable itself. The normal approach in constructing the indexes, however, considers only the purchase price. Autos, therefore, are priced by the cost of buying a car, not the cost of driving a mile.

Chart 4

CHANGES IN CONSUMER PRICE MEASURES
1Q 1976 - 4Q 1983
(Compound Annual Rates)
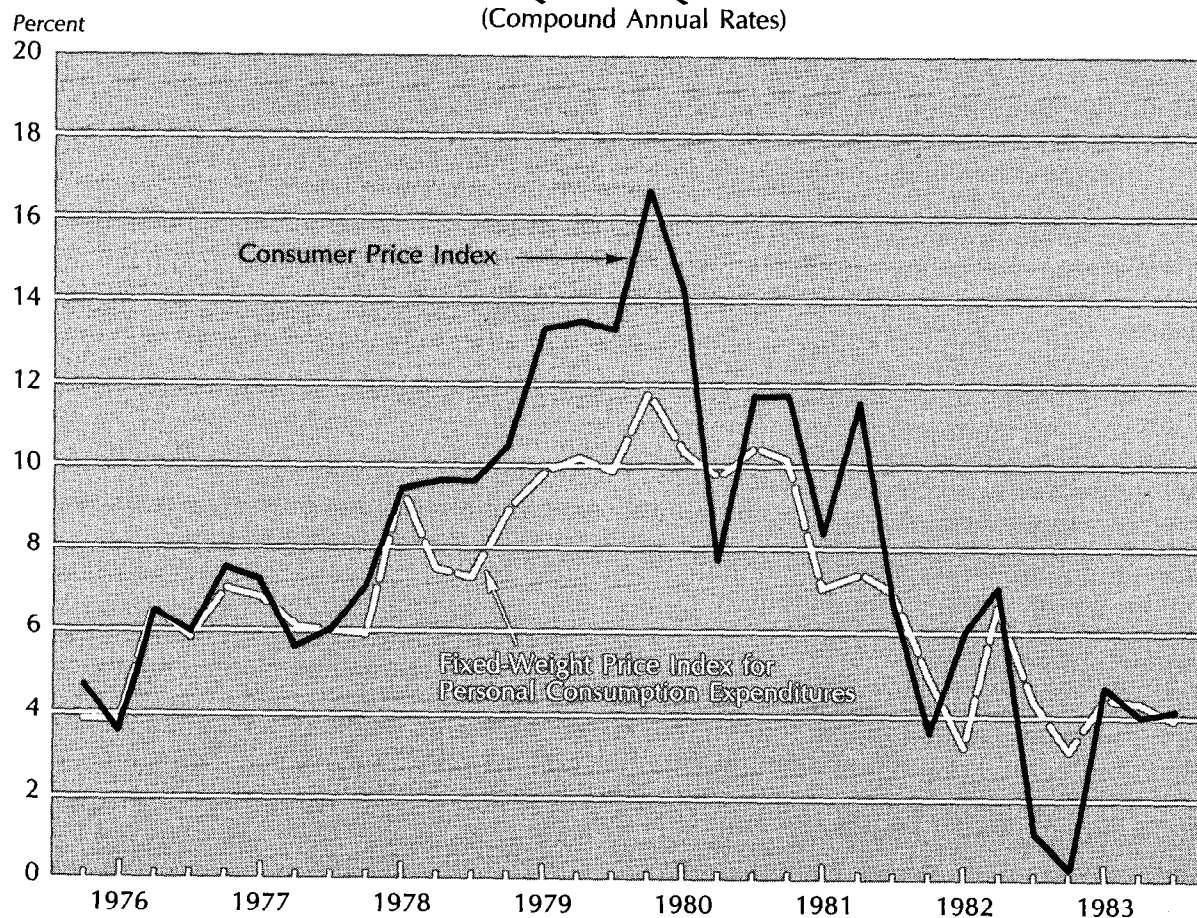
Changing Quantities

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 II provides a contrast between the 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

Table II

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: Relative- importance of items, -stated as percentages of annual expenditure.

Source: Monthly Labor Review, June 1986, page 17.

recent study found substitution bias for the CPI from 1959 to 1985 was only about 0.18 percent per year.[13]

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 financial services like banking 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 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. The CPI for Belgium, for example, does not include housing.

Miscellaneous Statistical Problems

The value weights now used to calculate the PPI are based on data from 1982, when the economy was in a severe recession. By contrast, during the previous survey year, 1972, the economy was rapidly expanding. The different phases of the business cycle in 1972 and 1982 would have led to substantial changes in the value weights in the PPI, whether or not there was any structural change in the economy. Thus the latest weights have fallen for industrial materials used in cyclically sensitive industries, such as construction and automobiles.

There is an inevitable lag between population movements, changes in regional weights of the indexes, and changes in expenditure patterns. For example, consider net population migration from cold to warm areas. If that migration did not promptly

affect the weights in the CPI's market basket, the index could overweight items such as snow blowers and underweight other items such as swimwear.

There has long been concern that the indexes may include list prices for some items rather than actual transaction prices. Since departures from list prices usually reflect sale items or negotiated discounts, any failure to use actual transaction prices would tend to overstate the price level.[14] Moreover, if the number of sales or discounts increases when the economy is relatively weak, indexes calculated from list prices would overstate cyclical price rigidity.

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 satisify 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.[15]

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, Part I and II*, describe 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 following were particularly valuable for this article: Jack E. Triplett, "Reconciling the CPI and the PCE Deflator," *Monthly Labor Review*, September 1981; and Andrew G. Clem and William D. Thomas, "New Weight Struc-

[13] Marilyn E. Manser, and Richard J. McDonald, "An Analysis of Substitution Bias in Measuring Inflation, 1959-85," *Econometrica* 56 (July 1988): 909-30.

[14] In countries with price controls, however, the actual transaction price is often higher than the list price. In that case the price index would understate the price level.

[15] *The Purchasing Power of Money* (1911; reprint, New York: Augustus M. Kelley, 1963), p. 212.

ture Being Used in the PPI," *Monthly Labor Review*, August 1987.

The implicit PCE and GNP deflators are explained in most macroeconomic textbook discussions of the National Income and Product Accounts, such as in *Macroeconomics* by R. Dornbusch and S. Fischer (1984). 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.

Problems of quality adjustment in the price indexes are discussed in Robert J. Gordon's articles cited in footnotes 6 and 8 above. Other useful critiques of

official indexes include: 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.

On the relation of economic theory and index numbers, an accessible account is Peter Hill's "Recent Developments in Index Number Theory and Practice," *OECD Economic Studies #10*, Spring 1988. A classic comparison of many different price indexes is Irving Fisher, *The Making of Index Numbers*, Riverside Press, Cambridge, 1922.

APPENDIX

PRICE INDEXES AND IMPLICIT DEFLATORS

The CPI, PPI, and GNP 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):

$$P_t = \frac{\Sigma p_t q_b}{\Sigma p_b q_b} \tag{1a}$$

$$= \Sigma \left(\frac{p_t}{p_b}\right)\left(\frac{p_b q_b}{\Sigma p_b q_b}\right) \tag{1b}$$

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 GNP 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):

$$P_t = \frac{\Sigma p_t q_t}{\Sigma p_b q_t} \tag{2}$$

where P_t is the price index in period t, the summation signs represent summation over all commodities coverd 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 quantites 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.

The chain price indexes reported in the accounts are base-weighted, with the base period for any quarter being the previous quarter; a chain index can be constructed using equation (1a) or (1b) above. Since the base shifts over time the weights can more accurately represent current production than would a fixed-weight index based in a distant period. Moreover, it avoids much of the difficulty of interpretation of an implicit deflator for quarterly changes. On the down side, however, changes in the chain index over long periods of time may themselves be difficult to interpret, since the items produced can vary substantially.

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 III shows the prices of apples and oranges in April, May, June, and July and the amounts consumed. A fixed-weight Fruit Price Index (FPI)

Table III

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
CFI: Level	100	148	100	70
Percentage change		48	−32	−30
Avg.: Level	100	140	133	96
Percentage change		40	−5	−28

is calculated, using quantities consumed 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 Fruit Index (CFI). Finally, as suggested in footnote 4, the geometric average of the FPI and IFD is presented (Avg.).

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 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, since it results 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.

Fourth, 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.

Finally, note that the geometric average occupies the middle ground between the extremes. In this case it shows relatively little average price change over the summer; in contrast, the fixed-weight index shows substantial inflation and the implicit deflator and chain index both show substantial deflation.