

Notes on Price Indexes and Inflation

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Introduction

The prices of goods and services are not constant over time. A general increase in prices, also known as inflation, leads to a decrease in the volume of goods and services that can be purchased with a given amount of money. Price indexes, such as the well-known consumer price index, or CPI, are a tool for measuring the relative purchasing power of money, that is, the volume of goods and services that can be purchased in one time period relative to another.

Calculating a Price Index

To calculate a price index, one must begin with a market basket of goods and services consumed by a typical household. This market basket consists of quantities purchased by a typical household during a year. Thus, the market basket consists of pounds of chicken, bottles of beer, pairs of pants, and so on. The market basket could reflect actual consumption in a particular year or could be some multi-year average. The issues to be considered in selecting the market basket are discussed in the last section of these notes.

In any given year, each item in the market basket sells for a particular price per unit. Now let Q_i be the quantity of good (or service) i in the market basket in and let P_{it} be the price of good i in year t . Then if there are N goods and services in the market basket, we can write the spending required to purchase the market basket in year t , S_t , as follows:

$$S_t = P_{1t}Q_1 + P_{2t}Q_2 + \dots + P_{Nt}Q_N$$

A price index is simply the spending required to purchase the market basket in year t relative to some base year. The role of the base year must be recognized. A price index does not indicate the purchasing power of money in any absolute sense but only relative to some base year. For example, a price index can indicate how much purchasing power has changed since last year or over the last decade. Thus, the selection of the base year depends on the question one is asking and, as we will see, one can easily switch from one base year to another.

Now suppose the base year is 2000 (a base year used in some federal statistics). Then the price index in year t , I_t , is defined to be

$$I_t = 100 \left(\frac{S_t}{S_{2000}} \right)$$

Note that the 100 in this definition is purely for convenience. It is easier to talk about a price index of 106 than a price index of 1.06. Because a price index cannot be calculated without selecting a base year, let us rewrite this equation with the base year identified:

$$I\{2000\}_t = 100 \left(\frac{S_t}{S_{2000}} \right)$$

Thus, a price index indicates the cost of a market basket of goods in a given year relative to some base year. If a price index has a value of 105, it indicates that the prices have risen 5 percent since the base year. A price index of 200 indicates that the prices have doubled, and a price index of 50 indicates that prices have been cut in half.

Real Versus Nominal Dollars

The principal use of price indexes is to translate data from nominal to real terms or visa versa. Data in nominal terms are expressed in actual or current dollars, which are defined to be dollars as they actually appear. If your actual income is \$50,000 for example, then your income in current dollars (or, equivalently, in nominal terms) also is \$50,000. Data in real terms are expressed in constant dollars, which are defined to be dollars of equal purchasing power to that in some base year. Thus constant dollars, like price indexes themselves, cannot be defined without a base year.

The distinction between current and constant dollars (or, equivalently, between nominal and real dollars) is important because we often want to determine what has happened to someone's ability to purchase goods and services. If we want to know whether people are as well off today as they were in 1980, for example, it makes no sense to compare their actual incomes in those two years because \$1 of income received in 1980 could purchase more goods and services than \$1 of income received today. To compare consumers' purchasing power in two different years, therefore, we must express their incomes in real terms (or, equivalently, in constant dollars). That's where price indexes come in.

The links between real (constant) and nominal (current) dollars are given by the following equations:

$$\text{Real} = \frac{\text{Nominal}}{\text{Price Index}/100}$$

or, equivalently,

$$\text{Constant} = \frac{\text{Current}}{\text{Price Index}/100}$$

Don't be confused by the 100 in these equations. Remember that price index is multiplied by 100 just to make it look pretty. These equations need precision, not looks, so we have to remove the 100.

Now suppose you observe that the income in a particular occupation is \$50,000 today and that prices have doubled since 1980. A doubling of prices means that \$1 today can purchase only half as much as it could in 1980. It also means that the today's price index (with 1980 as a base) is 200. In this case, the income in this occupation in constant 1980 dollars is only $\$50,000/(200/100) = \$50,000/2 = \$25,000$.

Here is a slightly more complicated example. Suppose one wants to compare an actual income of \$25,000 in 1980 with a \$50,000 income in 2000. Suppose further that one has obtained a published price index, with a 1983 base, equal to 82.4 in 1980 and 172.2 in 2000. Then real income with a 1983 base is $\$25,000/(82.4/100) = \$30,340$ in 1980 and $\$50,000/(172.2/100) = \$29,036$ in 1990. Even though nominal income is twice as high in 2000, in other words, real income is slightly higher in 1980.

A word of caution: In focusing on price indexes, people often forget that prices are not the only economic variable that changes over time. Even if prices double over some time period, people will not be any worse off if their incomes also double. In fact, the general phenomenon of inflation tends to affect incomes as well as prices so that inflationary periods are not necessarily, or even usually, periods of falling real incomes. This is not to say that inflation is neutral. Many analysts argue that inflation, particularly unanticipated inflation, disrupts investment plans and undercuts economic growth. But it is to say that inflation, particularly steady, anticipated inflation, is not necessarily harmful to an economy. Instead of assuming that price increases make people worse off, one should use price indexes to determine whether process have increased faster than incomes, that is, whether real incomes have fallen.

Another common misconception is that inflation hurts the poor. In fact, many poor people are insulated against inflation by either transfer payments that increase automatically or wages that tend to increase with inflation. The major losers during an inflationary period are rich people who hold interest-bearing assets, which lose value when unanticipated inflation occurs. In most cases, inflation does not harm the lowest

income classes but significantly reduces the average real incomes of the highest income classes.¹

Sometimes one may want to change a price index from one base to another. To compare two different price indexes, for example, one must express them both in terms of the same base year. Translation from one base year to another is straightforward. Consider the change from base year b to base year c . From the definition of a price index, we find that

$$I\{c\}_t = 100 \left(\frac{S_t}{S_c} \right)$$

and

$$I\{b\}_t = 100 \left(\frac{S_t}{S_b} \right)$$

So

$$I\{c\}_t = 100 \left(\frac{S_t}{S_c} \right) = 100 \left(\frac{S_t}{S_b} \right) \left(\frac{S_b}{S_c} \right) = I\{b\}_t \left(\frac{S_b}{S_c} \right) = \frac{I\{b\}_t}{I\{b\}_c / 100}$$

In words, one can change an index with base year b into an index for base year c simply by dividing the original index by its own value in year c (with the 100 removed). Suppose, for example, that you want to change a price index from a 1983 base to a 2000 base. Then if, as in an earlier example, the price index for 2000 using the 1983 base is 172.2, one can translate the price index with a 1983 base into a price index with a 2000 base simply by dividing the former by 1.722. Thus, if the price index for 2004 using a 1983 base is 188.9, then the price index for 2004 using a 2000 base is $188.9/1.722 = 109.7$.

Note that changing the base year does not change one's conclusions about the extent to which prices have increased or decreased. In the above example, the price index with a 1983 base went from 172.2 in 2000 to 188.9 in 2004. Thus prices increased by $(188.9-172.2)/172.2 = 9.7$ percent over this period. The price index with a 2000 base went from 100 in 2000 to 109.7 in 2004, which also corresponds to a 9.7 percent increase.

¹ See, for example, Joseph J. Minarki, "The Size Distribution of Income During Inflation," *The Review of Income and Wealth*, December 1979.

Selecting a Price Index

Many different price indexes are published: the CPI, the wholesale price index, and a whole series of “implicit” price deflators that are used in national income accounting. These implicit price deflators include one for personal consumption expenditures and one for state and local government purchases.

Different price indexes are appropriate in different contexts. To measure price changes facing consumers, one should use the CPI or the implicit price deflator for personal consumption expenditures. Although the CPI is well known, it has some technical problems, especially in its treatment of housing. As a result, many analysts believe that the CPI exaggerates inflation and prefer the personal consumption deflator.² To measure price changes facing state and local governments, one obviously should use the implicit price deflator for state and local government purchases.

For purposes of comparison, Table 1 lists three different price indexes over the 1960-2004 period. Disposable (that is, after-tax) personal income per capita also is presented. The first price index, the CPI, has a base year set at the average of 1982 to 1984. The other two indexes have a base year of 2000. According to the CPI, prices are more than six times as high today as they were in 1960 ($188.8/29.6 = 6.38$). The personal consumption deflator shows a smaller increase in prices ($107.8/20.8 = 5.28$), whereas the implicit deflator for state and local government purchases shows a larger increase ($112.2/14.7 = 7.63$). Using the CPI, we can also determine that real income (in 1982-84 dollars) has increased from $(\$2,022/0.296) = \$6,831$ in 1960 to $(\$29.334/1.078) = \$15,529$ in 2004. This is an increase of $(\$15,529 - \$6,831)/\$6,831 = 1.27 = 127$ percent.

As an exercise, restate the CPI with a 2000 base and compare it with the implicit deflator for personal consumption expenditures. Which index indicates a greater price increase between 2000 and 2004? As another exercise, use the personal consumption deflator to translate disposable income into constant dollars. How much did real disposable income increase between 1960 and 2004 using this price index?

The Index Number Problem

Finally, a technical problem, called the index number problem, arises with all price indexes (as well as with many other kinds of indexes). The problem is that the composition of the market basket, that is, the set of purchases by a typical household, changes over time. This change has several causes. Increases in income lead people to shift out some goods into others. The number of children in the typical family (or some other demographic characteristic) may change and thereby alter the consumption of

² For a discussion of the problems with the CPI, see Charles L. Schultze, “The Consumer Price Index: Conceptual Issues and Practical Suggestions,” *Journal of Economic Perspectives*, Winter 2003, pp. 3-22. Available through www.jstor.org.

goods designed for children. Relative prices may change, and people will substitute away from goods with relative price increases to goods for which relative prices decrease.

Because the market basket changes over time, the definition of the market basket itself, namely the Q_i s defined earlier, becomes ambiguous. Should one use the consumption pattern in the base year, in the current year, or in some intermediate year? The answer to this question matters because it can alter the story told by a price index. Suppose that between two years people stop purchasing a good the price of which increases more rapidly than the prices of all other goods. Then using the consumption pattern in the first year will yield a price index that increases more rapidly than an index using the consumption pattern in the second year.³ In fact, it is possible to design extreme examples in which prices increase using one year's consumption bundle and decrease using the other.

Although elaborate technical methods allow one to minimize it, this problem is inescapable. Whenever consumption patterns change, one must make an arbitrary decision about the composition of the market basket, and this decision, unlike the choice of a base year, may affect one's conclusions about the extent to which prices have changed. The importance of this problem should not be exaggerated, however. Consumption patterns tend to change slowly, and standard price indexes are not unduly affected by the choice of a consumption bundle. Moreover, the people who calculate these indexes have developed reasonable procedures to account for gradual changes in consumption patterns and even for the introduction of new products.⁴

³ A point of terminology: An index calculated with first-year quantities is called a Laspeyres index, and one calculated with second-year quantities is called a Paasche index.

⁴ For a discussion of these issues in the case of the CPI, see Charles L. Schultze, *op. cit.*

Table 1. Price Indexes, 1960-2009

Year	CPI (1982- 1984=100)	Personal Consumption Deflator (2000=100)	State and Local Gov't Deflator (2000=100)	Disposable Income Per Capita (current \$)
1960	29.6	20.8	14.7	2,022
1965	31.5	22.1	16.7	2,562
1970	38.8	26.4	22.5	3,586
1975	53.8	36.0	33.5	5,497
1980	82.4	52.1	48.9	8,794
1985	107.6	66.9	64.7	12,911
1990	130.7	80.5	77.4	17,004
1995	152.4	91.6	87.8	20,470
2000	172.2	100.0	100.0	25,994
2001	177.1	102.1	102.9	26,805
2002	179.9	103.5	105.4	27,799
2003	184.0	105.6	109.7	28,805
2004	188.9	108.4	114.4	30,287
2005	195.3	111.6	121.9	31,318
2006	201.6	114.7	128.1	33,157
2007	207.3	117.7	134.7	34,512
2008	215.3	122.0	143.6	35,931
2009	214.5			35,888
2010	218.1			36,691

Source: Annual Report of the Council of Economic Advisers, Washington, DC, Government Printing Office, 2010. Available at <http://www.gpoaccess.gov/eop/>.