CHAPTER 17

Index Numbers

CONTENTS

STATISTICS *in* PRACTICE

U.S. DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS

WASHINGTON, D.C.

The U.S. Department of Labor, through its Bureau of Labor Statistics, compiles and distributes indexes and statistics that are indicators of business and economic activity in the United States. For instance, the Bureau compiles and publishes the Consumer Price Index, the Producer Price Index, and statistics on average hours and earnings of various groups of workers. Perhaps the most widely quoted index produced by the Bureau of Labor Statistics is the Consumer Price Index. It is often used as a measure of inflation.

In March 2009, the Bureau of Labor Statistics reported that the Consumer Price Index (CPI) increased by .5% in February. The February level of 212.2 was .3% higher than in February 2008. On a seasonally adjusted basis, the CPI increased .4% in February after rising .3% in January. The 8.3% increase in the gasoline price index seemed to cause most of the increase. The food index actually declined .1%. Some economists considered the CPI increase good news because it reduced the likelihood of a deflationary period.

The Bureau of Labor Statistics, one day earlier, had reported that the Producer Price Index (PPI) increased by .1% in February, seasonally adjusted. The increase followed a .8% increase in January and a 1.9% decline in December. The PPI measures price changes in wholesale markets and is often seen as a leading indicator of changes in the Consumer Price Index. The slower rate of increase in February was heavily influenced by the declining rate of increase in energy goods. The energy goods index rose by 1.3% in February after rising by 3.7% in Janurary.

Gasoline prices are a component of the Consumer Price Index. © Jeff Chiu/ AP Photo.

In this chapter we will see how various indexes, such as the Consumer and Producer Price Indexes, are computed and how they should be interpreted.

Each month the U.S. government publishes a variety of indexes designed to help individuals understand current business and economic conditions. Perhaps the most widely known and cited of these indexes is the Consumer Price Index (CPI). As its name implies, the CPI is an indicator of what is happening to prices consumers pay for items purchased. Specifically, the CPI measures changes in price over a period of time. With a given starting point or *base period* and its associated index of 100, the CPI can be used to compare current period consumer prices with those in the base period. For example, a CPI of 125 reflects the condition that consumer prices as a whole are running approximately 25% above the base period prices for the same items. Although relatively few individuals know exactly what this number means, they do know enough about the CPI to understand that an increase means higher prices.

Even though the CPI is perhaps the best-known index, many other governmental and private-sector indexes are available to help us measure and understand how economic conditions in one period compare with economic conditions in other periods. The purpose of this chapter is to describe the most widely used types of indexes. We will begin by constructing some simple index numbers to gain a better understanding of how indexes are computed.

17.1 Price Relatives

TABLE 17.1
REGULAR GASOLINE (ALL FORMULATIONS) COST

Year	Price per Gallon ($)
1990	1.30
1991	1.10
1992	1.09
1993	1.07
1994	1.08
1995	1.11
1996	1.22
1997	1.20
1998	1.03
1999	1.14
2000	1.48
2001	1.42
2002	1.34
2003	1.56
2004	1.85
2005	2.27
2006	2.57
2007	2.80
2008	3.25

Source: U.S. Energy Information Administration.

The simplest form of a price index shows how the current price per unit for a given item compares to a base period price per unit for the same item. For example, Table 17.1 reports the cost of one gallon of regular gasoline for the years 1990 through 2008. To facilitate comparisons with other years, the actual cost-per-gallon figure can be converted to a **price relative**, which expresses the unit price in each period as a percentage of the unit price in a base period.

$$\text{Price relative in period } t = \frac{\text{Price in period } t}{\text{Base period price}}(100) \tag{17.1}$$

For the gasoline prices in Table 17.1 and with 1990 as the base year, the price relatives for one gallon of regular gasoline in the years 1990 through 2008 can be calculated. These price relatives are listed in Table 17.2. Note how easily the price in any one year can be compared with the price in the base year by knowing the price relative. For example, the price relative of 85.4 in 1995 shows that the price of gasoline in 1995 was 14.6% below the 1990 base-year price. Similarly, the 2002 price relative of 103.1 shows a 3.1% increase in the gasoline price in 2002 from the 1990 base-year price. And the 2008 price relative of 250.0 shows a 150% increase in the price of regular gesoline from the 1990 base-year price. Price relatives, such as the ones for regular gasoline, are extremely helpful in terms of understanding and interpreting changing economic and business conditions over time.

17.2 Aggregate Price Indexes

TABLE 17.2
PRICE RELATIVES FOR ONE GALLON OF REGULAR GASOLINE

Year	Price Relative (Base 1990)
1990	(1.30/1.30)100 = 100.0
1991	(1.10/1.30)100 = 84.6
1992	(1.09/1.30)100 = 83.8
1993	(1.07/1.30)100 = 82.3
1994	(1.08/1.30)100 = 83.1
1995	(1.11/1.30)100 = 85.4
1996	(1.22/1.30)100 = 93.8
1997	(1.20/1.30)100 = 92.3
1998	(1.03/1.30)100 = 79.2
1999	(1.14/1.30)100 = 87.7
2000	(1.48/1.30)100 = 113.8
2001	(1.42/1.30)100 = 109.2
2002	(1.34/1.30)100 = 103.1
2003	(1.56/1.30)100 = 120.0
2004	(1.85/1.30)100 = 142.3
2005	(2.27/1.30)100 = 174.6
2006	(2.57/1.30)100 = 197.7
2007	(2.80/1.30)100 = 215.4
2008	(3.25/1.30)100 = 250.0

Although price relatives can be used to identify price changes over time for individual items, we are often more interested in the general price change for a group of items taken as a whole. For example, if we want an index that measures the change in the overall cost of living over time, we will want the index to be based on the price changes for a variety of items, including food, housing, clothing, transportation, medical care, and so on. An **aggregate price index** is developed for the specific purpose of measuring the combined change of a group of items.

Consider the development of an aggregate price index for a group of items categorized as normal automotive operating expenses. For illustration, we limit the items included in the group to gasoline, oil, tire, and insurance expenses.

Table 17.3 gives the data for the four components of our automotive operating expense index for the years 1990 and 2008. With 1990 as the base period, an aggregate price index for the four components will give us a measure of the change in normal automotive operating expenses over the 1990–2008 period.

An unweighted aggregate index can be developed by simply summing the unit prices in the year of interest (e.g., 2008) and dividing that sum by the sum of the unit prices in the base year (1990). Let

$$P_{it} = \text{unit price for item } i \text{ in period } t$$
$$P_{i0} = \text{unit price for item } i \text{ in the base period}$$

An unweighted aggregate price index in period t, denoted by I_t, is given by

$$I_t = \frac{\Sigma P_{it}}{\Sigma P_{i0}}(100) \tag{17.2}$$

where the sums are for all items in the group.

TABLE 17.3 DATA FOR AUTOMOTIVE OPERATING EXPENSE INDEX

Item	Unit Price ($) 1990	2008
Gallon of gasoline	1.30	3.25
Quart of oil	2.10	8.00
Tire	130.00	140.00
Insurance policy	820.00	1030.00

An unweighted aggregate index for normal automotive operating expenses in 2008 ($t = 2008$) is given by

$$I_{2008} = \frac{3.25 + 8.00 + 140.00 + 1030.00}{1.30 + 2.10 + 130.00 + 820.00}(100)$$
$$= \frac{1181.25}{953.4}(100) = 124$$

From the unweighted aggregate price index, we might conclude that the price of normal automotive operating expenses has only increased 24% over the period from 1990 to 2008. But note that the unweighted aggregate approach to establishing a composite price index for automotive expenses is heavily influenced by the items with large per-unit prices. Consequently, items with relatively low unit prices such as gasoline and oil are dominated by the high unit-price items such as tires and insurance. The unweighted aggregate index for automotive operating expenses is too heavily influenced by price changes in tires and insurance.

If quantity of usage is the same for each item, an unweighted index gives the same value as a weighted index. In practice, however, quantities of usage are rarely the same.

Because of the sensitivity of an unweighted index to one or more high-priced items, this form of aggregate index is not widely used. A weighted aggregate price index provides a better comparison when usage quantities differ.

The philosophy behind the **weighted aggregate price index** is that each item in the group should be weighted according to its importance. In most cases, the quantity of usage is the best measure of importance. Hence, one must obtain a measure of the quantity of usage for the various items in the group. Table 17.4 gives annual usage information for each item of automotive operating expense based on the typical operation of a midsize automobile for approximately 15,000 miles per year. The quantity weights listed show the expected annual usage for this type of driving situation.

TABLE 17.4
ANNUAL USAGE INFORMATION FOR AUTOMOTIVE OPERATING EXPENSE INDEX

Item	Quantity Weights*
Gallons of gasoline	1000
Quarts of oil	15
Tires	2
Insurance policy	1

*Based on 15,000 miles per year. Tire usage is based on a 30,000-mile tire life.

Let Q_i = quantity of usage for item i. The weighted aggregate price index in period t is given by

$$I_t = \frac{\Sigma P_{it} Q_i}{\Sigma P_{i0} Q_i}(100) \qquad \textbf{(17.3)}$$

where the sums are for all items in the group. Applied to our automotive operating expenses, the weighted aggregate price index is based on dividing total operating costs in 2008 by total operating costs in 1990.

Let $t = 2008$, and use the quantity weights in Table 17.4. We obtain the following weighted aggregate price index for automotive operating expenses in 2008.

$$I_{2008} = \frac{3.25(1000) + 8.00(15) + 140.00(2) + 1030.00(1)}{1.30(1000) + 2.10(15) + 130.00(2) + 820.00(1)}(100)$$
$$= \frac{4680}{2411.5}(100) = 194$$

From this weighted aggregate price index, we would conclude that the price of automotive operating expenses has increased 94% over the period from 1990 through 2008.

Clearly, compared with the unweighted aggregate index, the weighted index provides a more accurate indication of the price change for automotive operating expenses over the 1990–2008 period. Taking the quantity of usage of gasoline into account helps to offset the smaller percentage increase in insurance costs. The weighted index shows a larger increase in automotive operating expenses than the unweighted index. In general, the weighted aggregate index with quantities of usage as weights is the preferred method for establishing a price index for a group of items.

In the weighted aggregate price index formula (17.3), note that the quantity term Q_i does not have a second subscript to indicate the time period. The reason is that the quantities Q_i are considered fixed and do not vary with time as the prices do. The fixed weights or quantities are specified by the designer of the index at levels believed to be representative of typical usage. Once established, they are held constant or fixed for all periods of time the index is in use. Indexes for years other than 2008 require the gathering of new price data P_{it}, but the weighting quantities Q_i remain the same.

In a special case of the fixed-weight aggregate index, the quantities are determined from base-year usages. In this case we write $Q_i = Q_{i0}$, with the zero subscript indicating base-year quantity weights; formula (17.3) becomes

$$I_t = \frac{\Sigma P_{it} Q_{i0}}{\Sigma P_{i0} Q_{i0}} (100) \qquad \textbf{(17.4)}$$

Whenever the fixed quantity weights are determined from base-year usage, the weighted aggregate index is given the name **Laspeyres index**.

Another option for determining quantity weights is to revise the quantities each period. A quantity Q_{it} is determined for each year that the index is computed. The weighted aggregate index in period t with these quantity weights is given by

$$I_t = \frac{\Sigma P_{it} Q_{it}}{\Sigma P_{i0} Q_{it}} (100) \qquad \textbf{(17.5)}$$

Note that the same quantity weights are used for the base period (period 0) and for period t. However, the weights are based on usage in period t, not the base period. This weighted aggregate index is known as the **Paasche index**. It has the advantage of being based on current usage patterns. However, this method of computing a weighted aggregate index presents two disadvantages: The normal usage quantities Q_{it} must be redetermined each year, thus adding to the time and cost of data collection, and each year the index numbers for previous years must be recomputed to reflect the effect of the new quantity weights. Because of these disadvantages, the Laspeyres index is more widely used. The automotive operating expense index was computed with base-period quantities; hence, it is a Laspeyres index. Had usage figures for 2008 been used, it would be a Paasche index. Indeed, because of more fuel efficient cars, gasoline usage decreased and a Paasche index differs from a Laspeyres index.

Exercises

Methods

SELF test

1. The following table reports prices and usage quantities for two items in 2007 and 2009.

	Quantity		Unit Price ($)	
Item	2007	2009	2007	2009
A	1500	1800	7.50	7.75
B	2	1	630.00	1500.00

a. Compute price relatives for each item in 2009 using 2007 as the base period.
b. Compute an unweighted aggregate price index for the two items in 2009 using 2007 as the base period.
c. Compute a weighted aggregate price index for the two items using the Laspeyres method.
d. Compute a weighted aggregate price index for the two items using the Paasche method.

2. An item with a price relative of 132 cost $10.75 in 2009. Its base year was 1992.
   a. What was the percentage increase or decrease in cost of the item over the 17-year period?
   b. What did the item cost in 1992?

Applications

SELF test

3. A large manufacturer purchases an identical component from three independent suppliers that differ in unit price and quantity supplied. The relevant data for 2007 and 2009 are given here.

		Unit Price ($)	
Supplier	Quantity (2007)	2007	2009
A	150	5.45	6.00
B	200	5.60	5.95
C	120	5.50	6.20

   a. Compute the price relatives for each of the component suppliers separately. Compare the price increases by the suppliers over the two-year period.
   b. Compute an unweighted aggregate price index for the component part in 2009.
   c. Compute a 2009 weighted aggregate price index for the component part. What is the interpretation of this index for the manufacturing firm?

4. R&B Beverages, Inc., provides a complete line of beer, wine, and soft drink products for distribution through retail outlets in central Iowa. Unit price data for 2006 and 2009 and quantities sold in cases for 2006 follow.

		Unit Price ($)	
Item	2006 Quantity (cases)	2006	2009
Beer	35,000	17.50	20.15
Wine	5,000	100.00	118.00
Soft drink	60,000	8.00	8.80

   Compute a weighted aggregate index for the R&B Beverage sales in 2009, with 2006 as the base period.

5. Under the last-in first-out (LIFO) inventory valuation method, a price index for inventory must be established for tax purposes. The quantity weights are based on year-ending inventory levels. Use the beginning-of-the-year price per unit as the base-period price and develop a weighted aggregate index for the total inventory value at the end of the year. What type of weighted aggregate price index must be developed for the LIFO inventory valuation?

		Unit Price ($)	
Product	Ending Inventory	Beginning	Ending
A	500	.15	.19
B	50	1.60	1.80
C	100	4.50	4.20
D	40	12.00	13.20

17.3 Computing an Aggregate Price Index from Price Relatives

In Section 17.1 we defined the concept of a price relative and showed how a price relative can be computed with knowledge of the current-period unit price and the base-period unit price. We now want to show how aggregate price indexes like the ones developed in Section 17.2 can be computed directly from information about the price relative of each item in the group. Because of the limited use of unweighted indexes, we restrict our attention to weighted aggregate price indexes. Let us return to the automotive operating expense index of the preceding section. The necessary information for the four items is given in Table 17.5.

One must be sure prices and quantities are in the same units. For example, if prices are per case, quantity must be the number of cases and not, for instance, the number of individual units.

Let w_i be the weight applied to the price relative for item i. The general expression for a weighted average of price relatives is given by

$$I_t = \frac{\sum \frac{P_{it}}{P_{i0}}(100)w_i}{\Sigma w_i} \tag{17.6}$$

The proper choice of weights in equation (17.6) will enable us to compute a weighted aggregate price index from the price relatives. The proper choice of weights is given by multiplying the base-period price by the quantity of usage.

$$w_i = P_{i0}Q_i \tag{17.7}$$

Substituting $w_i = P_{i0}Q_i$ into equation (17.6) provides the following expression for a weighted price relatives index.

$$I_t = \frac{\sum \frac{P_{it}}{P_{i0}}(100)(P_{i0}Q_i)}{\Sigma P_{i0}Q_i} \tag{17.8}$$

With the canceling of the P_{i0} terms in the numerator, an equivalent expression for the weighted price relatives index is

$$I_t = \frac{\Sigma P_{it}Q_i}{\Sigma P_{i0}Q_i}(100)$$

Thus, we see that the weighted price relatives index with $w_i = P_{i0}Q_i$ provides a price index identical to the weighted aggregate index presented in Section 17.2 by equation (17.3). Use

TABLE 17.5 PRICE RELATIVES FOR AUTOMOTIVE OPERATING EXPENSE INDEX

	Unit Price ($)			
Item	1990 (P_0)	2008 (P_t)	Price Relative $(P_t/P_0)100$	Annual Usage
Gallon of gasoline	1.30	3.25	250.0	1000
Quart of oil	2.10	8.00	381.0	15
Tire	130.00	140.00	107.7	2
Insurance policy	820.00	1030.00	125.6	1

TABLE 17.6 AUTOMOTIVE OPERATING EXPENSE INDEX (1990–2008) BASED ON WEIGHTED PRICE RELATIVES

Item	Price Relatives $(P_{it}/P_{i0})(100)$	Base Price ($) P_{i0}	Quantity Q_i	Weight $w_i = P_{i0}Q_i$	Weighted Price Relatives $(P_{it}/P_{i0})(100)w_i$
Gasoline	250.0	1.30	1000	1300.00	325,000.00
Oil	381.0	2.10	15	31.50	12,001.50
Tire	107.7	130.00	2	260.00	28,002.00
Insurance	125.6	820.00	1	820.00	102,992.00
			Totals	2411.50	467,995.50

$$I_{2008} = \frac{467{,}995.50}{2411.50} = 194$$

of base-period quantities (i.e., $Q_i = Q_{i0}$) in equation (17.7) leads to a Laspeyres index. Use of current-period quantities (i.e., $Q_i = Q_{it}$) in equation (17.7) leads to a Paasche index.

Let us return to the automotive operating expense data. We can use the price relatives in Table 17.5 and equation (17.6) to compute a weighted average of price relatives. The results obtained by using the weights specified by equation (17.7) are reported in Table 17.6. The index number 194 represents a 94% increase in automotive operating expenses, which is the same as the increase identified by the weighted aggregate index computation in Section 17.2.

Exercises

Methods

SELF test

6. Price relatives for three items, along with base-period prices and usage are shown in the following table. Compute a weighted aggregate price index for the current period.

		Base Period	
Item	Price Relative	Price	Usage
A	150	22.00	20
B	90	5.00	50
C	120	14.00	40

Applications

SELF test

7. The Mitchell Chemical Company produces a special industrial chemical that is a blend of three chemical ingredients. The beginning-year cost per pound, the ending-year cost per pound, and the blend proportions follow.

	Cost per Pound ($)		Quantity (pounds)
Ingredient	Beginning	Ending	per 100 Pounds of Product
A	2.50	3.95	25
B	8.75	9.90	15
C	.99	.95	60

a. Compute the price relatives for the three ingredients.
b. Compute a weighted average of the price relatives to develop a one-year cost index for raw materials used in the product. What is your interpretation of this index value?

8. An investment portfolio consists of four stocks. The purchase price, current price, and number of shares are reported in the following table.

Stock	Purchase Price/Share ($)	Current Price/Share ($)	Number of Shares
Holiday Trans	15.50	17.00	500
NY Electric	18.50	20.25	200
KY Gas	26.75	26.00	500
PQ Soaps	42.25	45.50	300

Construct a weighted average of price relatives as an index of the performance of the portfolio to date. Interpret this price index.

9. Compute the price relatives for the R&B Beverages products in exercise 4. Use a weighted average of price relatives to show that this method provides the same index as the weighted aggregate method.

17.4 Some Important Price Indexes

We identified the procedures used to compute price indexes for single items or groups of items. Now let us consider some price indexes that are important measures of business and economic conditions. Specifically, we consider the Consumer Price Index, the Producer Price Index, and the Dow Jones averages.

Consumer Price Index

The CPI includes charges for services (e.g., doctor and dentist bills) and all taxes directly associated with the purchase and use of an item.

The **Consumer Price Index (CPI)**, published monthly by the U.S. Bureau of Labor Statistics, is the primary measure of the cost of living in the United States. The group of items used to develop the index consists of a *market basket* of 400 items including food, housing, clothing, transportation, and medical items. The CPI is a weighted aggregate price index with fixed weights.[1] The weight applied to each item in the market basket derives from a usage survey of urban families throughout the United States.

The February 2009 CPI, computed with a 1982–1984 base index of 100, was 212.2. This figure means that the cost of purchasing the market basket of goods and services increased 112.2% since the base period 1982–1984. The 45-year time series of the CPI from 1960–2005 is shown in Figure 17.1. Note how the CPI measure reflects the sharp inflationary behavior of the economy in the late 1970s and early 1980s.

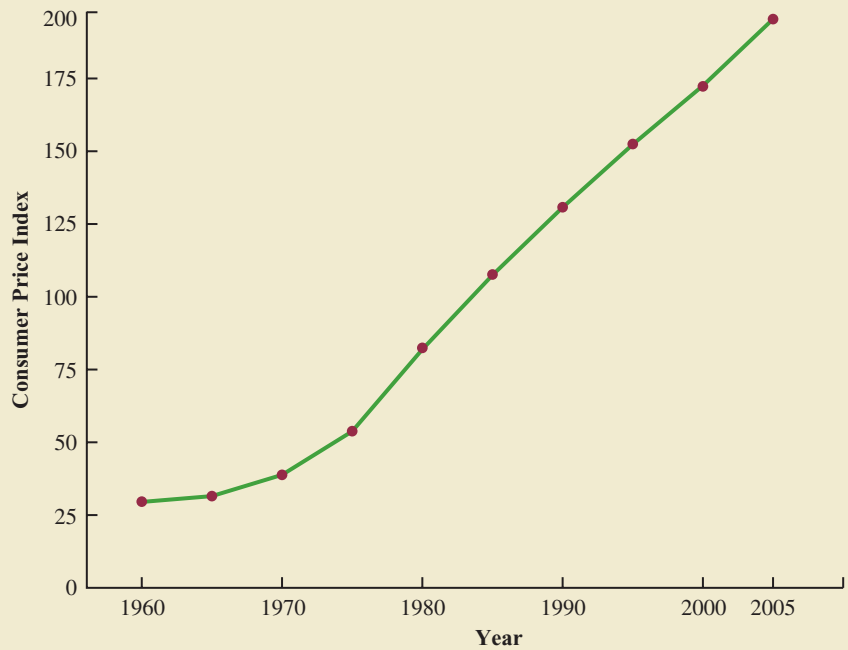
Producer Price Index

The PPI is designed as a measure of price changes for domestic goods; imports are not included.

The **Producer Price Index (PPI)**, also published monthly by the U.S. Bureau of Labor Statistics, measures the monthly changes in prices in primary markets in the United States. The PPI is based on prices for the first transaction of each product in nonretail markets. All

[1]The Bureau of Labor Statistics actually publishes two Consumer Price Indexes: one for all urban consumers (CPI-U) and a revised Consumer Price Index for urban wage earners and clerical workers (CPI-W). The CPI-U is the one most widely quoted, and it is published regularly in *The Wall Street Journal*.

FIGURE 17.1 CONSUMER PRICE INDEX, 1960–2005 (BASE 1982–1984 = 100)



commodities sold in commercial transactions in these markets are represented. The survey covers raw, manufactured, and processed goods at each level of processing and includes the output of industries classified as manufacturing, agriculture, forestry, fishing, mining, gas and electricity, and public utilities. One of the common uses of this index is as a leading indicator of the future trend of consumer prices and the cost of living. An increase in the PPI reflects producer price increases that will eventually be passed on to the consumer through higher retail prices.

Weights for the various items in the PPI are based on the value of shipments. The weighted average of price relatives is calculated by the Laspeyres method. The preliminary February 2009 PPI, computed with a 1982 base index of 100, was 171.3.

Dow Jones Averages

The **Dow Jones averages** are indexes designed to show price trends and movements associated with common stocks. The best known of the Dow Jones indexes is the Dow Jones Industrial Average (DJIA), which is based on common stock prices of 30 large companies. It is the sum of these stock prices divided by a number, which is revised from time to time to adjust for stock splits and switching of companies in the index. Unlike the other price indexes that we studied, it is not expressed as a percentage of base-year prices. The specific firms used in July 2009 to compute the DJIA are listed in Table 17.7.

Charles Henry Dow published his first stock average on July 3, 1884, in the Customer's Afternoon Letter. *Eleven stocks, nine of which were railroad issues, were included in the first index. An average comparable to the DJIA was first published on October 1, 1928.*

Other Dow Jones averages are computed for 20 transportation stocks and for 15 utility stocks. The Dow Jones averages are computed and published daily in *The Wall Street Journal* and other financial publications.

TABLE 17.7 THE 30 COMPANIES USED IN THE DOW JONES INDUSTRIAL AVERAGE (JULY 2009)

3m	Disney	Kraft Foods
Alcoa	DuPont	McDonald's
American Express	ExxonMobil	Merck
AT&T	General Electric	Microsoft
Bank of America	Hewlett-Packard	Pfizer
Boeing	Home Depot	Procter & Gamble
Caterpillar	IBM	Travelers
Chevron Corp.	Intel	United Technologies
Coca-Cola	Johnson & Johnson	Verizon
Cisco Systems	J. P. Morgan Chase	Wal-Mart Stores

Source: Barron's, July 13, 2009.

17.5 Deflating a Series by Price Indexes

Time series are deflated to remove the effects of inflation.

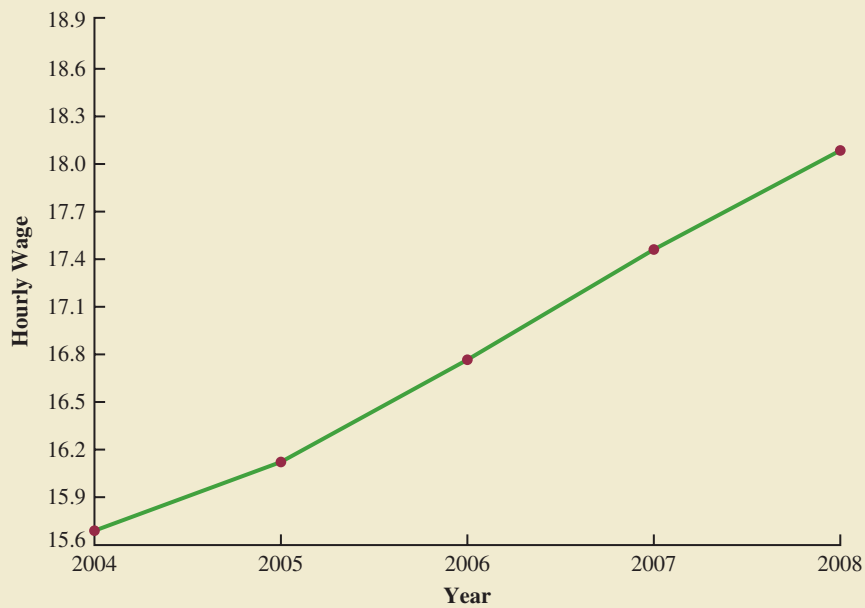
Many business and economic series reported over time, such as company sales, industry sales, and inventories, are measured in dollar amounts. These time series often show an increasing growth pattern over time, which is generally interpreted as indicating an increase in the physical volume associated with the activities. For example, a total dollar amount of inventory up by 10% might be interpreted to mean that the physical inventory is 10% larger. Such interpretations can be misleading if a time series is measured in terms of dollars, and the total dollar amount is a combination of both price and quantity changes. Hence, in periods when price changes are significant, the changes in the dollar amounts may not be indicative of quantity changes unless we are able to adjust the time series to eliminate the price change effect.

For example, from 1976 to 1980, the total amount of spending in the construction industry increased approximately 75%. That figure suggests excellent growth in construction activity. However, construction prices were increasing just as fast as—or sometimes even faster than—the 75% rate. In fact, while total construction spending was increasing, construction activity was staying relatively constant or, as in the case of new housing starts, decreasing. To interpret construction activity correctly for the 1976–1980 period, we must adjust the total spending series by a price index to remove the price increase effect. Whenever we remove the price increase effect from a time series, we say we are *deflating the series.*

In relation to personal income and wages, we often hear discussions about issues such as "real wages" or the "purchasing power" of wages. These concepts are based on the notion of deflating an hourly wage index. For example, Figure 17.2 shows the pattern of hourly wages of production workers for the period 2004–2008. We see a trend of wage increases from $15.69 per hour to $18.07 per hour. Should production workers be pleased with this growth in hourly wages? The answer depends on what happened to the purchasing power of their wages. If we can compare the purchasing power of the $15.69 hourly wage in 2004 with the purchasing power of the $18.07 hourly wage in 2008, we will be better able to judge the relative improvement in wages.

Table 17.8 reports both the hourly wage rate and the CPI (computed with a 1982–1984 base index of 100) for the period 2004–2008. With these data, we will show how the CPI can be used to deflate the index of hourly wages. The deflated series is found by dividing

FIGURE 17.2 ACTUAL HOURLY WAGES OF PRODUCTION WORKERS



Real wages are a better measure of purchasing power than actual wages. Indeed, many union contracts call for wages to be adjusted in accordance with changes in the cost of living.

the hourly wage rate in each year by the corresponding value of the CPI and multiplying by 100. The deflated hourly wage index for production workers is given in Table 17.9; Figure 17.3 is a graph showing the deflated, or real, wages.

What does the deflated series of wages tell us about the real wages or purchasing power of production workers during the 2004–2008 period? In terms of base period dollars (1982–1984 = 100), the hourly wage rate remained relatively flat over the period. After removing the inflationary effect we see that the purchasing power of the workers only increased by $.08 over the four-year period. This effect is seen in Figure 17.3. Thus, the advantage of using price indexes to deflate a series is that they give us a clearer picture of the real dollar changes that are occurring.

This process of deflating a series measured over time has an important application in the computation of the gross domestic product (GDP). The GDP is the total value of all

TABLE 17.8 HOURLY WAGES OF PRODUCTION WORKERS AND CONSUMER PRICE INDEX, 2004–2008

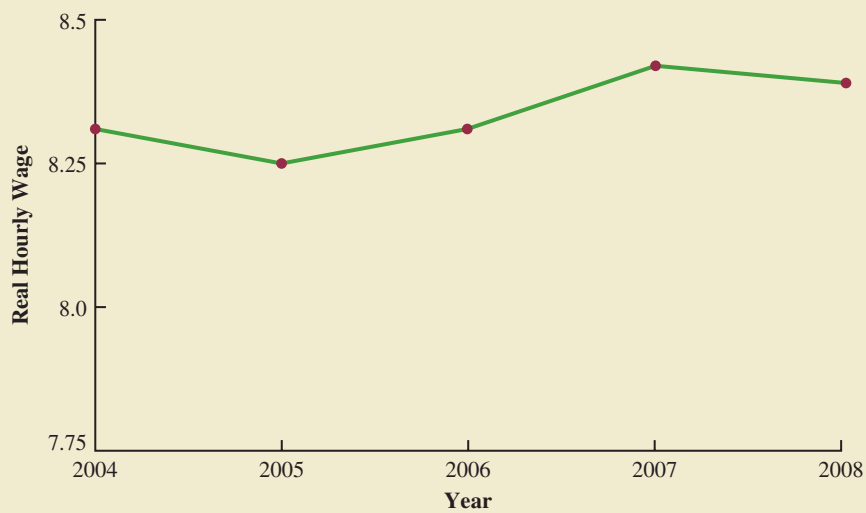
Year	Hourly Wage ($)	CPI
2004	15.69	188.9
2005	16.12	195.3
2006	16.76	201.6
2007	17.45	207.3
2008	18.07	215.3

Source: Bureau of Labor Statistics. CPI is computed with a 1982–1984 base index of 100.

TABLE 17.9 DEFLATED SERIES OF HOURLY WAGES FOR PRODUCTION WORKERS, 2004–2008

Year	Deflated Hourly Wage
2004	($15.69/188.9)(100) = $8.31
2005	($16.12/195.3)(100) = $8.25
2006	($16.76/201.6)(100) = $8.31
2007	($17.45/207.3)(100) = $8.42
2008	($18.07/215.3)(100) = $8.39

FIGURE 17.3 REAL HOURLY WAGES OF PRODUCTION WORKERS, 2004–2008



goods and services produced in a given country. Obviously, over time the GDP will show gains that are in part due to price increases if the GDP is not deflated by a price index. Therefore, to adjust the total value of goods and services to reflect actual changes in the volume of goods and services produced and sold, the GDP must be computed with a price index deflator. The process is similar to that discussed in the real wages computation.

Exercises

Applications

SELF test

10. Average hourly wages for production workers in February 1996 were $11.86; in February 2009, they were $18.55. The CPI in February 1996 was 154.9; in February 2009 it was 212.2.
    a. Deflate the hourly wage rates in 1996 and 2009 to find the real wage rates.
    b. What is the percentage change in actual hourly wages from 1996 to 2009?
    c. What is the percentage change in real wages from 1996 to 2009?

11. Average hourly wages for workers in service industries for the four years from 2002 through 2005 are reported here. Use the Consumer Price Index information provided to deflate the wages series. Calculate the percentage increase or decrease in real wages and salaries from 2003 to 2005.

Year	Hourly Wages	CPI (1982–1984 base)
2002	18.52	179.9
2003	18.95	184.0
2004	19.23	188.9
2005	19.46	195.3

Source: Bureau of Labor Statistics.

12. The U.S. Census Bureau reported the following total manufacturing shipments for the three years from 2005 through 2007.

Year	Manufacturing Shipments ($ billions)
2005	4742
2006	5020
2007	5081

a. The CPI for 2005–2007 is given in Table 17.8. Use this information to deflate the manufacturing shipments series and comment on the pattern of manufacturers' shipments in terms of constant dollars.
b. The following Producer Price Indexes (finished consumer goods) are for 2005 through 2007, with 1982 as the base year. Use the PPI to deflate the series.

Year	PPI (1982 = 100)
2005	155.8
2006	160.3
2007	166.6

c. Do you feel that the CPI or the PPI is more appropriate to use as a deflator for manufacturing shipments?

13. Dooley Retail Outlets' total retail sales volumes for selected years since 1982 are shown in the following table. Also shown is the CPI with the index base of 1982–1984. Deflate the sales volume figures on the basis of 1982–1984 constant dollars, and comment on the firm's sales volumes in terms of deflated dollars.

Year	Retail Sales ($)	CPI (1982–1984 base)
1982	380,000	96.5
1987	520,000	113.6
1992	700,000	140.3
1997	870,000	160.5
2002	940,000	179.9
2007	990,000	207.3

17.6 Price Indexes: Other Considerations

In the preceding sections we described several methods used to compute price indexes, discussed the use of some important indexes, and presented a procedure for using price indexes to deflate a time series. Several other issues must be considered to enhance our understanding of how price indexes are constructed and how they are used. Some are discussed in this section.

Selection of Items

The primary purpose of a price index is to measure the price change over time for a specified class of items, products, and so on. Whenever the class of items is very large, the index cannot be based on all items in the class. Rather, a sample of representative items must be used. By collecting price and quantity information for the sampled items, we hope to obtain a good idea of the price behavior of all items that the index is representing. For example, in the Consumer Price Index the total number of items that might be considered in the population of normal purchase items for a consumer could be 2000 or more. However, the index is based on the price-quantity characteristics of just 400 items. The selection of the specific items in the index is not a trivial task. Surveys of user purchase patterns as well as good judgment go into the selection process. A simple random sample is not used to select the 400 items.

After the initial selection process, the group of items in the index must be periodically reviewed and revised whenever purchase patterns change. Thus, the issue of which items to include in an index must be resolved before an index can be developed and again before it is revised.

Selection of a Base Period

Most indexes are established with a base-period value of 100 at some specific time. All future values of the index are then related to the base-period value. What base period is appropriate for an index is not an easy question to answer. It must be based on the judgment of the developer of the index.

Many of the indexes established by the U.S. government as of 2009 use a 1982 base period. As a general guideline, the base period should not be too far from the current period. For example, a Consumer Price Index with a 1945 base period would be difficult for most individuals to understand because of unfamiliarity with conditions in 1945. The base period for most indexes therefore is adjusted periodically to a more recent period of time. The CPI base period was changed from 1967 to the 1982–1984 average in 1988. The PPI currently uses 1982 as its base period (i.e., 1982 = 100).

Quality Changes

The purpose of a price index is to measure changes in prices over time. Ideally, price data are collected for the same set of items at several times, and then the index is computed. A basic assumption is that the prices are identified for the same items each period. A problem is encountered when a product changes in quality from one period to the next. For example, a manufacturer may alter the quality of a product by using less expensive materials, fewer features, and so on, from year to year. The price may go up in following years, but the price is for a lower-quality product. Consequently, the price may actually go up more than is represented by the list price for the item. It is difficult, if not impossible, to adjust an index for decreases in the quality of an item.

A substantial quality improvement also may cause an increase in the price of a product. A portion of the price related to the quality improvement should be excluded from the index computation. However, adjusting an index for a price increase that is related to higher quality of an item is extremely difficult, if not impossible.

Although common practice is to ignore minor quality changes in developing a price index, major quality changes must be addressed because they can alter the product description from period to period. If a product description is changed, the index must be modified to account for it; in some cases, the product might be deleted from the index.

In some situations, however, a substantial improvement in quality is followed by a decrease in the price. This less typical situation has been the case with personal computers during the 1990s and early 2000s.

17.7 Quantity Indexes

In addition to the price indexes described in the preceding sections, other types of indexes are useful. In particular, one other application of index numbers is to measure changes in quantity levels over time. This type of index is called a **quantity index**.

Recall that in the development of the weighted aggregate price index in Section 17.2, to compute an index number for period t we needed data on unit prices at a base period (P_0) and period t (P_t). Equation (17.3) provided the weighted aggregate price index as

$$I_t = \frac{\Sigma P_{it} Q_i}{\Sigma P_{i0} Q_i} (100)$$

The numerator, $\Sigma P_{it} Q_i$, represents the total value of fixed quantities of the index items in period t. The denominator, $\Sigma P_{i0} Q_i$, represents the total value of the same fixed quantities of the index items in year 0.

Computation of a weighted aggregate quantity index is similar to that of a weighted aggregate price index. Quantities for each item are measured in the base period and period t, with Q_{i0} and Q_{it}, respectively, representing those quantities for item i. The quantities are then weighted by a fixed price, the value added, or some other factor. The "value added" to a product is the sales value minus the cost of purchased inputs. The formula for computing a weighted aggregate quantity index for period t is

$$I_t = \frac{\Sigma Q_{it} w_i}{\Sigma Q_{i0} w_i} (100) \qquad \textbf{(17.9)}$$

In some quantity indexes the weight for item i is taken to be the base-period price (P_{i0}), in which case the weighted aggregate quantity index is

$$I_t = \frac{\Sigma Q_{it} P_{i0}}{\Sigma Q_{i0} P_{i0}} (100) \qquad \textbf{(17.10)}$$

Quantity indexes can also be computed on the basis of weighted quantity relatives. One formula for this version of a quantity index follows.

$$I_t = \frac{\sum \frac{Q_{it}}{Q_{i0}} (Q_{i0} P_i)}{\Sigma Q_{i0} P_i} (100) \qquad \textbf{(17.11)}$$

This formula is the quantity version of the weighted price relatives formula developed in Section 17.3 as in equation (17.8).

The **Index of Industrial Production**, developed by the Federal Reserve Board, is probably the best-known quantity index. It is reported monthly and the base period is 2002. The index is designed to measure changes in volume of production levels for a variety of manufacturing classifications in addition to mining and utilities. In February 2009 the index was 99.7.

Exercises

Methods

SELF test

14. Data on quantities of three items sold in 1995 and 2009 are given here along with the sales prices of the items in 1995. Compute a weighted aggregate quantity index for 2009.

	Quantity Sold		
Item	1995	2009	Price/Unit 1995 ($)
A	350	300	18.00
B	220	400	4.90
C	730	850	15.00

Applications

SELF test

15. A trucking firm handles four commodities for a particular distributor. Total shipments for the commodities in 1994 and 2009, as well as the 1994 prices, are reported in the following table.

	Shipments		Price/Shipment
Commodity	1994	2009	1994
A	120	95	$1200
B	86	75	$1800
C	35	50	$2000
D	60	70	$1500

Develop a weighted aggregate quantity index with a 1994 base. Comment on the growth or decline in quantities over the 1994–2009 period.

16. An automobile dealer reports the 1992 and 2009 sales for three models in the following table. Compute quantity relatives and use them to develop a weighted aggregate quantity index for 2009 using the two years of data.

	Sales		Mean Price per Sale
Model	1992	2009	(1992)
Sedan	200	170	$15,200
Sport	100	80	$17,000
Wagon	75	60	$16,800

Summary

Price and quantity indexes are important measures of changes in price and quantity levels within the business and economic environment. Price relatives are simply the ratio of the current unit price of an item to a base-period unit price multiplied by 100, with a value of 100 indicating no difference in the current and base-period prices. Aggregate price indexes are created as a composite measure of the overall change in prices for a given group of items or products. Usually the items in an aggregate price index are weighted by their quantity of usage. A weighted aggregate price index can also be computed by weighting the price relatives by the usage quantities for the items in the index.

The Consumer Price Index and the Producer Price Index are both widely quoted indexes with 1982–1984 and 1982, respectively, as base years. The Dow Jones Industrial Average is another widely quoted price index. It is a weighted sum of the prices of 30 common stocks of large companies. Unlike many other indexes, it is not stated as a percentage of some base-period value.

Often price indexes are used to deflate some other economic series reported over time. We saw how the CPI could be used to deflate hourly wages to obtain an index of real wages. Selection of the items to be included in the index, selection of a base period for the index, and adjustment for changes in quality are important additional considerations in the development of an index number. Quantity indexes were briefly discussed, and the Index of Industrial Production was mentioned as an important quantity index.

Glossary

Price relative A price index for a given item that is computed by dividing a current unit price by a base-period unit price and multiplying the result by 100.
Aggregate price index A composite price index based on the prices of a group of items.
Weighted aggregate price index A composite price index in which the prices of the items in the composite are weighted by their relative importance.
Laspeyres index A weighted aggregate price index in which the weight for each item is its base-period quantity.
Paasche index A weighted aggregate price index in which the weight for each item is its current-period quantity.
Consumer Price Index (CPI) A monthly price index that uses the price changes in a market basket of consumer goods and services to measure the changes in consumer prices over time.
Producer Price Index (PPI) A monthly price index designed to measure changes in prices of goods sold in primary markets (i.e., first purchase of a commodity in nonretail markets).
Dow Jones averages Aggregate price indexes designed to show price trends and movements associated with common stocks.
Quantity index An index designed to measure changes in quantities over time.
Index of Industrial Production A quantity index designed to measure changes in the physical volume or production levels of industrial goods over time.

Key Formulas

Price Relative in Period *t*

$$\frac{\text{Price in period } t}{\text{Base period price}}(100) \qquad \textbf{(17.1)}$$

Unweighted Aggregate Price Index in Period *t*

$$I_t = \frac{\Sigma P_{it}}{\Sigma P_{i0}}(100) \tag{17.2}$$

Weighted Aggregate Price Index in Period *t*

$$I_t = \frac{\Sigma P_{it} Q_i}{\Sigma P_{i0} Q_i}(100) \tag{17.3}$$

Weighted Average of Price Relatives

$$I_t = \frac{\sum \frac{P_{it}}{P_{i0}}(100) w_i}{\Sigma w_i} \tag{17.6}$$

Weighting Factor for Equation (17.6)

$$w_i = P_{i0} Q_i \tag{17.7}$$

Weighted Aggregate Quantity Index

$$I_t = \frac{\Sigma Q_{it} w_i}{\Sigma Q_{i0} w_i}(100) \tag{17.9}$$

Supplementary Exercises

17. The median sales prices for new single-family houses for the years 2004–2007 are as follows (Census Bureau website, March 19, 2009).

Year	Price ($1000s)
2004	221.0
2005	240.9
2006	246.5
2007	247.9

a. Use 2004 as the base year and develop a price index for new single-family homes over this four-year period.
b. Use 2005 as the base year and develop a price index for new single-family homes over this four-year period.

18. Nickerson Manufacturing Company has the following data on quantities shipped and unit costs for each of its four products:

Products	Base-Period Quantities (2003)	Mean Shipping Cost per Unit ($)	
		2003	2009
A	2000	10.50	15.90
B	5000	16.25	32.00
C	6500	12.20	17.40
D	2500	20.00	35.50

a. Compute the price relative for each product.
b. Compute a weighted aggregate price index that reflects the shipping cost change over the four-year period.

19. Use the price data in exercise 18 to compute a Paasche index for the shipping cost if 2009 quantities are 4000, 3000, 7500, and 3000 for each of the four products.

20. Boran Stockbrokers, Inc., selects four stocks for the purpose of developing its own index of stock market behavior. Prices per share for a 2007 base period, January 2009, and March 2009 follow. Base-year quantities are set on the basis of historical volumes for the four stocks.

			Price per Share ($)		
Stock	Industry	2007 Quantity	2007 Base	January 2009	March 2009
A	Oil	100	31.50	22.75	22.50
B	Computer	150	65.00	49.00	47.50
C	Steel	75	40.00	32.00	29.50
D	Real Estate	50	18.00	6.50	3.75

Use the 2007 base period to compute the Boran index for January 2009 and March 2009. Comment on what the index tells you about what is happening in the stock market.

21. Compute the price relatives for the four stocks making up the Boran index in exercise 20. Use the weighted aggregates of price relatives to compute the January 2009 and March 2009 Boran indexes.

22. Consider the following price relatives and quantity information for grain production in Iowa (Census Bureau website, March 19, 2009).

Product	1991 Quantities (millions of bushels)	Base Price per Bushel ($)	1991–2007 Price Relatives
Corn	1427	2.30	173.9
Soybeans	350	5.51	197.8

What is the 2007 weighted aggregate price index for the Iowa grains?

23. Fresh fruit price and quantity data for the years 1988 and 2007 follow (Census Bureau website, March 19, 2009). Quantity data reflect per capita consumption in pounds and prices are per pound.

Fruit	1988 per Capita Consumption (pounds)	1988 Price ($/pound)	2007 Price ($/pound)
Bananas	24.3	.41	.53
Apples	19.9	.71	1.12
Oranges	13.9	.56	.91
Pears	3.2	.64	1.27

a. Compute a price relative for each product.
b. Compute a weighted aggregate price index for fruit products. Comment on the change in fruit prices over the 19-year period.

24. Starting faculty salaries (nine-month basis) for assistant professors of business administration at a major Midwestern university follow. Use the CPI to deflate the salary data to constant dollars. Comment on the trend in salaries in higher education as indicated by these data.

Year	Starting Salary ($)	CPI (1982–1984 Base)
1970	14,000	38.8
1975	17,500	53.8
1980	23,000	82.4
1985	37,000	107.6
1990	53,000	130.7
1995	65,000	152.4
2000	80,000	172.2
2005	110,000	195.3

25. The five-year historical prices per share for a particular stock and the Consumer Price Index with a 1982–1984 base period follow.

Year	Price per Share ($)	CPI (1982–1984 Base)
2004	51.00	188.9
2005	54.00	195.3
2006	58.00	201.6
2007	59.50	207.3
2008	59.00	215.3

Deflate the stock price series and comment on the investment aspects of this stock.

26. A major manufacturing company reports the quantity and product value information for 2005 and 2009 in the table that follows. Compute a weighted aggregate quantity index for the data. Comment on what this quantity index means.

	Quantities		
Product	2005	2009	Values ($)
A	800	1200	30.00
B	600	500	20.00
C	200	500	25.00