investment. Nonresidential investment adds to the plant, equipment, and software that make up the capital stock for producing goods and services. Residential investment—housing—is also productive in that it produces housing services.

Although investment is a much smaller fraction of GDP than is consumption, investment plays a very important role in business cycles. Investment is much more variable than GDP or consumption, and some components of investment also tend to lead the business cycle. For example, an upward or downward blip in housing investment tends to precede an upward or downward blip in GDP. We study this phenomenon further in Chapter 3.

Net Exports As exports were less than imports in 2008, the United States ran a trade deficit in goods and services with the rest of the world—that is, **net exports** were negative (see Table 2.9). Exports were 13.0% of GDP in 2008 while imports were 17.7% of GDP. Trade with the rest of the world in goods and services, therefore, is quite important to the U.S. economy, as we noted in Chapter 1.

Government Expenditures **Government expenditures,** which consist of expenditures by federal, state, and local governments on final goods and services, were 20.2% of GDP in 2008, as seen in Table 2.9. The main components of government expenditures are federal defense spending (5.2% of GDP in 2008), federal nondefense spending (2.4% of GDP in 2008), and state and local spending (12.7% of GDP in 2008). The NIPA also makes the important distinction between government consumption and government gross investment, just as we distinguish between private consumption and private investment. An important point is that the government spending included in the NIPA is only the expenditures on final goods and services. This does not include **transfers,** which are very important in the government budget. These outlays essentially transfer purchasing power from one group of economic agents to another, and they include such items as Social Security payments and unemployment insurance payments. Transfers are not included in GDP, as they are simply money transfers from one group of people to another, or income redistribution rather than income creation.

Nominal and Real GDP and Price Indices

While the components of GDP for any specific time period give us the total dollar value of goods and services produced in the economy during that period, for many purposes we would like to make comparisons between GDP data in different time periods. This might tell us something about growth in the productive capacity of the economy over time and about growth in our standard of living. A problem, however, is that the average level of prices changes over time, so that generally part of the increase in GDP that we observe is the result of inflation. In this section, we show how to adjust for this effect of inflation on the growth in GDP and, in so doing, arrive at a measure of the price level and the inflation rate.

A **price index** is a weighted average of the prices of a set of the goods and services produced in the economy over a period of time. If the price index includes prices of all goods and services, then that price index is a measure of the general **price level,** or the average level of prices across goods and services. We use price indices to measure the **inflation rate,** which is the rate of change in the price level from one period of time to another. If we can measure the inflation rate, we can also determine how much of a change in GDP from one period to another is purely **nominal** and how much is **real.** A nominal change in GDP is a change in GDP that occurred only because the price level changed, whereas a real change in GDP is an increase in the actual quantity of goods and services (including, for example, the numbers of apples and oranges sold during a period of time), which is what ultimately matters for consumers.

Real GDP

To see how real GDP is calculated in the NIPA, it helps to consider an example. Imagine an economy in which the only goods produced are apples and oranges. In year 1, 50 apples and 100 oranges are produced, and the prices of apples and oranges are \$1.00 and \$0.80, respectively. In year 2, 80 apples and 120 oranges are produced, and the prices of apples and oranges are \$1.25 and \$1.60, respectively. These data are displayed in Table 2.10. For convenience in expressing the formulas for real GDP calculations, we let the quantities of apples and oranges, respectively, in year 1 be denoted by Q_1^a and Q_1^o with respective prices denoted by P_1^a and P_1^o. Quantities and prices in year 2 are represented similarly (see Table 2.10).

The calculation of nominal GDP in each year is straightforward here, as there are no intermediate goods. Year 1 nominal GDP is

$$GDP_1 = P_1^aQ_1^a + P_1^oQ_1^o = (\$1.00 \times 50) + (\$0.80 \times 100) = \$130.$$

Similarly, year 2 nominal GDP is

$$GDP_2 = P_2^aQ_2^a + P_2^oQ_2^o = (\$1.25 \times 80) + (\$1.60 \times 120) = \$292,$$

so the percentage increase in nominal GDP from year 1 to year 2 is equal to

$$\left(\frac{GDP_2}{GDP_1} - 1\right) \times 100\% = \left(\frac{292}{130} - 1\right) \times 100\% = 125\%.$$

That is, nominal GDP more than doubled from year 1 to year 2.

Now, the question is, how much of this increase in nominal GDP is accounted for by inflation and how much by an increase in the real quantity of aggregate output produced? Until 1996, the practice in the U.S. NIPA was first to choose a base year and then to calculate real GDP using these base year prices. That is, rather than multiplying the quantities produced in a given year by current year prices (which is what we do when calculating

Table 2.10 Data for Real GDP Example

	Apples	Oranges
Quantity in Year 1	$Q_1^a = 50$	$Q_1^o = 100$
Price in Year 1	$P_1^a = \$1.00$	$P_1^o = \$0.80$
Quantity in Year 2	$Q_2^a = 80$	$Q_2^o = 120$
Price in Year 2	$P_2^a = \$1.25$	$P_2^o = \$1.60$

nominal GDP), we multiply by base year prices to obtain real GDP. In the example, suppose that we use year 1 as the base year, and let $RGDP_1^1$ and $RGDP_2^1$ denote real GDP in years 1 and 2, respectively, calculated using year 1 as the base year. Then, real GDP in year 1 is the same as nominal GDP for that year, because year 1 is the base year, so we have

$$RGDP_1^1 = GDP_1 = \$130.$$

Now, for year 2 real GDP, we use year 2 quantities and year 1 prices to obtain

$$RGDP_2^1 = P_1^a Q_2^a + P_1^o Q_2^o = (\$1.00 \times 80) + (\$0.80 \times 120) = \$176.$$

Therefore, the ratio of real GDP in year 2 to real GDP in year 1, using year 1 as the base year is

$$g_1 = \frac{RGDP_2^1}{RGDP_1^1} = \frac{176}{130} = 1.354,$$

so the percentage increase in real GDP using this approach is $(1.354 - 1) \times 100\% = 35.4\%$. Alternatively, suppose that we use year 2 as the base year and let $RGDP_1^2$ and $RGDP_2^2$ denote real GDP in years 1 and 2, respectively, calculated using this approach. Then, year 2 real GDP is the same as year 2 nominal GDP, that is

$$RGDP_2^2 = GDP_2 = \$292.$$

Year 1 GDP, using year 1 quantities and year 2 prices, is

$$RGDP_1^2 = P_2^a Q_1^a + P_2^o Q_1^o = (\$1.25 \times 50) + (\$1.60 \times 100) = \$222.50.$$

Then, the ratio of real GDP in year 2 to real GDP in year 1, using year 2 as the base year, is

$$g_2 = \frac{RGDP_2^2}{RGDP_1^2} = \frac{292}{222.5} = 1.312,$$

and the percentage increase in GDP from year 1 to year 2 is $(1.312 - 1) \times 100\% = 31.2\%$.

A key message from the example is that the choice of the base year matters for the calculation of GDP. If year 1 is used as the base year, then the increase in real GDP is 35.4%, and if year 2 is the base year, real GDP is calculated to increase by 31.2%. The reason the choice of the base year matters in the example, and in reality, is that the relative prices of goods change over time. That is, the relative price of apples to oranges is $\frac{\$1.00}{\$0.80} = 1.25$ in year 1, and this relative price is $\frac{\$1.25}{\$1.60} = 0.78$ in year 2. Therefore, apples became cheaper relative to oranges from year 1 to year 2. If relative prices had remained the same between year 1 and year 2, then the choice of the base year would not matter. In calculating real GDP, the problem of changing relative prices would not be too great in calculating GDP close to the base year (say, 2008 or 2009 relative to a base year in 2007), because relative prices would typically not change much over a short period of time. Over many years, however, the problem could be severe, for example, in calculating real GDP in 2009 relative to a base year in 1982. The solution to this problem, adopted in the NIPA, is to use a **chain-weighting** scheme for calculating real GDP.

With the chain-weighting approach, a *Fisher index* is used, and the approach is essentially like using a rolling base period. The chain-weighted ratio of real GDP in year 2 to real GDP in year 1 is

$$g_c = \sqrt{g_1 \times g_2} = \sqrt{1.354 \times 1.312} = 1.333,$$

so that the chain-weighted ratio of real GDP in the two years is a geometric average of the ratios calculated using each of years 1 and 2 as base years.[2] In the example, we calculate the percentage growth rate in real GDP from year 1 to year 2 using the chain-weighting method to be $(1.333 - 1) \times 100\% = 33.3\%$. The growth rate in this case falls between the growth rates we calculated using the other two approaches, which is of course what we should get given that chain-weighting effectively averages (geometrically) the growth rates calculated using years 1 and 2 as base years.

Now, once we have the chain-weighted ratio of real GDP in one year relative to another (g_c in this case), we can calculate real GDP in terms of the dollars of any year we choose. For example, in our example, if we want real GDP in year 1 dollars, then real GDP in year 1 is the same as nominal GDP or $GDP_1 = \$130$, and real GDP in year 2 is equal to $GDP_1 \times g_c = \$130 \times 1.333 = \$173.29$. Alternatively, if we want real GDP in year 2 dollars, then real GDP in year 2 is $GDP_2 = \$292$, and real GDP in year 1 is $\frac{GDP_2}{g_c} = \frac{\$292}{1.333} = \$219.05$.

In practice, the growth rates in real GDP in adjacent years are calculated just as we have done it here, and then real GDP is "chained" together from one year to the next. Chain-weighting should in principle give a more accurate measure of the year-to-year, or quarter-to-quarter, changes in real GDP. In Figure 2.1 we show nominal GDP and real GDP, calculated using the chain-weighting approach, for the United States over the period 1947–2009. Real GDP is measured here in 2000 dollars, so that real GDP is equal to nominal GDP in 2000. Because the inflation rate was generally positive over the period 1947–2009, and was particularly high in the 1970s, real GDP grows in Figure 2.1 at a lower rate than does nominal GDP.

Measures of the Price Level

There are two commonly used measures of the price level. The first is the **implicit GDP price deflator**, and the second is the **consumer price index (CPI)**. The implicit GDP price deflator is measured as

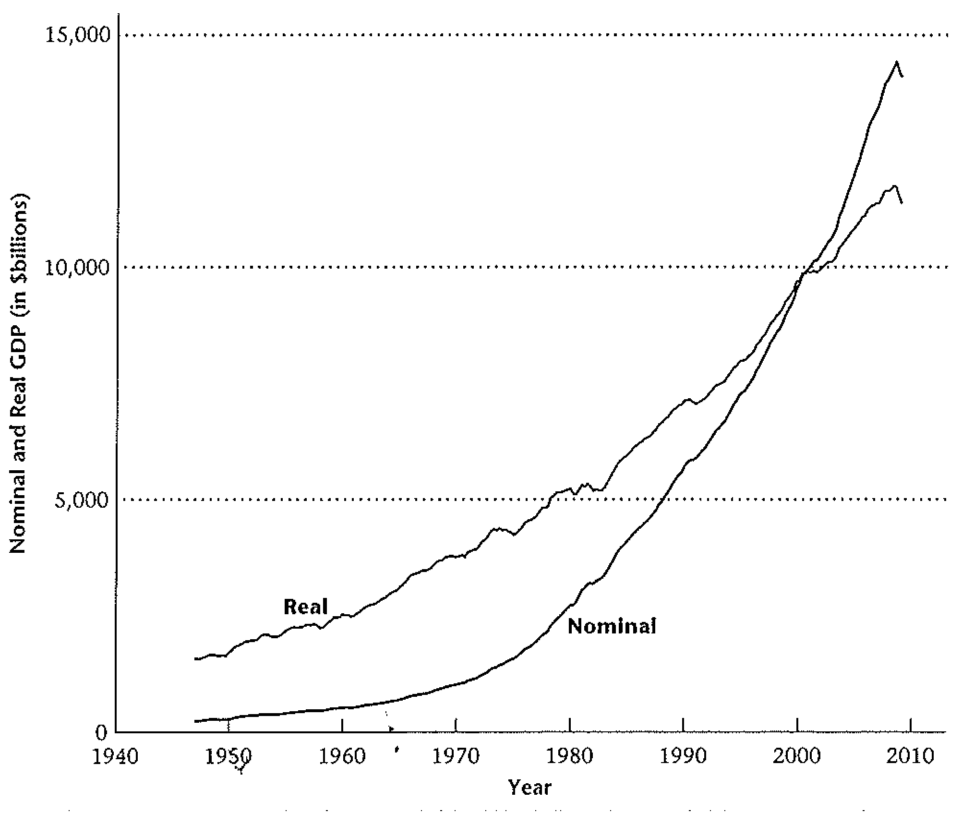
$$\text{Implicit GDP Price deflator} = \frac{\text{Nominal GDP}}{\text{Real GDP}} \times 100.$$

Here, multiplying by 100 just normalizes the price deflator to 100 in the year we are choosing nominal GDP to be equal to real GDP. For the example above, the price deflator we calculate would depend on whether we use year 1 or year 2 as a base year,

[2]For more detail on the calculation of real GDP using the chain-weighting method, see *A Guide to the NIPA's*, available from the Bureau of Economic Analysis at http://www.bea.doc.gov/bea/an/nipaguid.htm.

Figure 2.1 Nominal GDP (black line) and Chain-Weighted Real GDP (colored line) for the Period 1947–2009. Note that the two time series cross in 2000 because real GDP is measured in year 2000 dollars. The growth rate in real GDP is smaller than the growth rate for nominal GDP because of positive inflation over this period.

Source: U.S. Department of Commerce, Bureau of Economic Analysis.



or compute chain-weighted real GDP. We give the results in Table 2.11, and arbitrarily choose chain-weighted real GDP to be in year 1 dollars. Note in Table 2.11 that the answers we get for the percentage rate of inflation between year 1 and year 2 depend critically on how we measure real GDP.

The alternative measure of the price level, the CPI, is not as broadly based as the implicit GDP price deflator, because it includes only goods and services that are purchased by consumers. Further, the CPI is a fixed-weight price index, which takes the quantities in some base year as being the typical goods bought by the average consumer during that base year, and then uses those quantities as weights to calculate the index in each year. Thus, the CPI in the current year would be

$$\text{Current year CPI} = \frac{\text{Cost of base year quantities at current prices}}{\text{Cost of base year quantities at base year prices}} \times 100.$$

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Table 2.11 Implicit GDP Price Deflators, Example

	Year 1	Year 2	% Increase
Year 1 = base year	100	165.9	65.9
Year 2 = base year	58.4	100	71.2
Chain-weighting	100	168.5	68.5

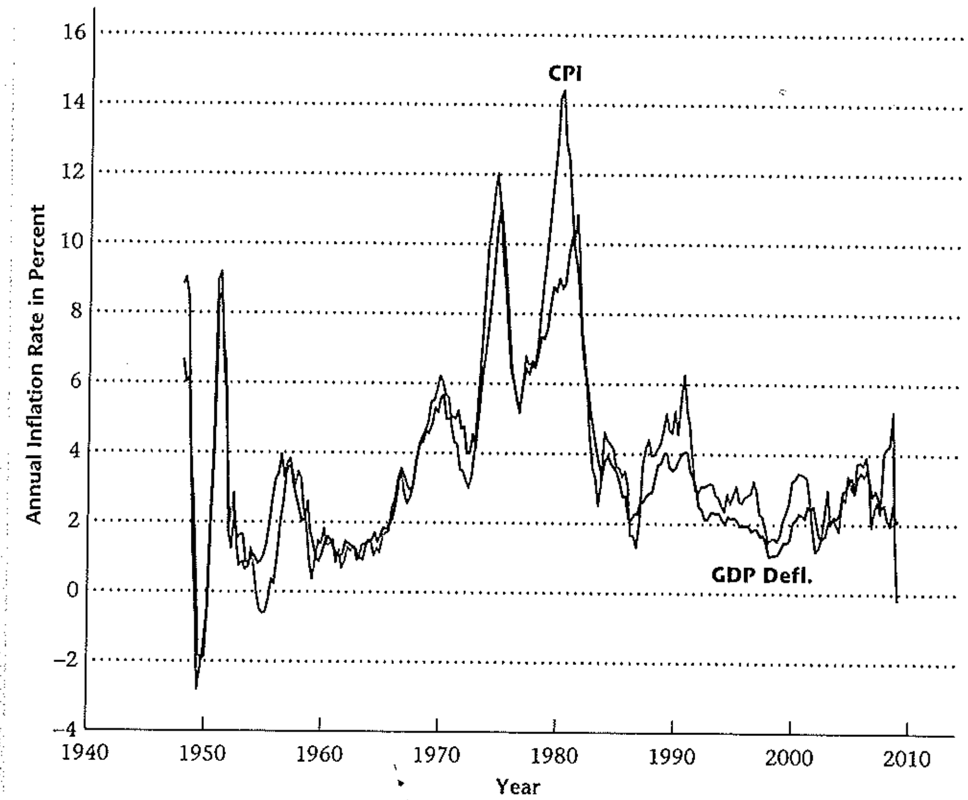
In the example, if we take year 1 as the base year, then the year 1 (base year) CPI is 100, and the year 2 CPI is $\frac{222.5}{130} \times 100 = 171.2$, so that the percentage increase in the CPI from year 1 to year 2 is 71.2%.

In practice, there can be substantial differences between the inflation rates calculated using the implicit GDP price deflator and those calculated using the CPI. Figure 2.2 shows the GDP deflator inflation rate (the black line) and CPI inflation rate (the blue line), calculated quarter by quarter, for the United States over the period 1947–2009. The two measures of the inflation rate track each other broadly, but the CPI inflation rate tends to be more volatile than the GDP deflator inflation rate. At times, there can be large differences between the two measures. For example, in late 1979, the CPI inflation rate exceeded 14%, while the GDP deflator inflation rate was about a bit more than 10%. These differences in inflation rate measures could matter greatly for contracts (for example, labor contracts) that are geared to the inflation rate or for the formulation of monetary policy, where close attention is paid to inflation performance.

Figure 2.2 shows the differences we can observe in measured inflation rates, depending on whether we use the CPI or the implicit GDP price deflator as a measure of the price level. As well, over long periods of time there can be very large differences in the rates of inflation calculated using the two alternative price level measures. To see this, in Figure 2.3 we show the CPI and GDP price deflator in levels for the period 1947–2009, normalizing by setting each measure equal to 100 in the first quarter of 1947. What the picture tells us is that, if we accept the CPI as a good measure of the price level, then the cost of living increased by a factor of 9.85 over 62 years. However, the GDP price deflator indicates an increase in the cost of living by a factor of only 8.22. Put another way, the average annual inflation rate between 1947 and 2006 was 3.76% as measured by the CPI, and 3.46% as measured by the implicit GDP price deflator. These differences reflect a well-known upward bias in the CPI measure of inflation.

The GDP price deflator tends to yield a better measure of the inflation rate than does the CPI. However, in some cases there are alternatives to either the GDP price deflator or the CPI, which serve the purpose better. For example, if we are interested only in measuring the cost of living for consumers living in the United States, then it may be preferable to use the implicit consumption deflator rather than the implicit GDP price deflator as a measure of the price level. The implicit consumption deflator is a price index including only the goods and services that are included in consumption

Figure 2.2 Inflation Rate Calculated from the CPI and from the Implicit GDP Price Deflator
These measures are broadly similar, but at times there can be substantial differences.



expenditures. The GDP price deflator includes the prices of investment goods, exports, and goods and services sold to the government, none of which would matter directly for consumers. However, if we are looking for a price index reflecting the price of aggregate output produced in the United States, then the GDP price deflator is the appropriate measure.

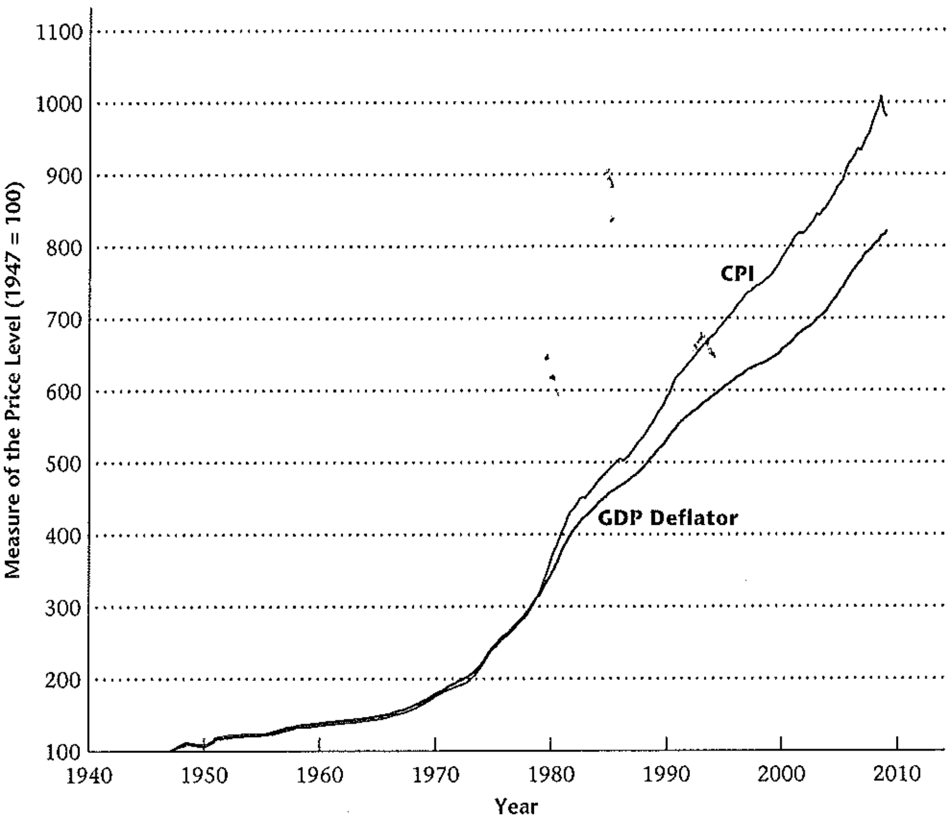
Problems with Measuring Real GDP and the Price Level

As we saw above, particularly in how the implicit GDP price deflator is derived, the measurement of real GDP and the measurement of the price level are intimately related. If a particular measure of real GDP underestimates growth in real GDP, then the rate of inflation is overestimated. In practice, there are three important problems with measuring real GDP and the price level.

Figure 2.3 The Price Level as Measured by the CPI and the Implicit GDP Price Deflator, 1947–2009

In the figure, each price level measure is set to 100 in the first quarter of 1947. The CPI increases by a factor of 9.85 over the whole period, while the implicit GDP price deflator increases by a factor of 8.22.

Source: The U.S. Department of Commerce and the Bureau of Labor Statistics.



The first problem was mentioned above, which is that relative prices change over time. We showed how chain-weighting corrects for this problem in the measurement of real GDP and, therefore, corrects for the bias that relative price changes would introduce in the measurement of inflation using the implicit GDP price deflator. Changes in relative prices can also introduce severe bias in how the CPI measures inflation. When there is a relative price change, consumers typically purchase less of the goods that have become more expensive and more of those that have become relatively cheap. In the previous example, apples became cheaper relative to oranges in year 2, and the ratio of apples consumed to oranges consumed increased. In computing the CPI, the implicit assumption is that consumers do not change their buying habits when relative price changes occur, which is clearly false. As a result, goods that become relatively