

## 16 The Dynamics of Output, Unemployment, and Inflation

*We judge the economy – as we judge many areas of life – as much by how it is changing as by its current state. We want to know whether GDP, unemployment, or inflation are rising or falling, not just whether they are high or low. In this chapter we examine what determines whether unemployment or inflation or output are rising or falling at different stages of the business cycle. In earlier chapters, we examined aggregate demand and supply separately. Here we consider how they work together to change output, unemployment, and inflation.*

### 16.1 The Interaction of Aggregate Supply and Aggregate Demand

An easy way to distinguish supply factors from demand factors starts with the definition of **output scaled by POTENTIAL OUTPUT (SCALED OUTPUT)** developed in Chapter 6

(section 6.5.2):  $\tilde{Y} = \frac{Y}{Y^{pot}}$ . The theory of growth – that is, the theory of aggregate supply

in the long run – is really a theory of the development of potential output. The theory of aggregate demand is a theory of output relative to potential. A *pure aggregate-supply factor* can, therefore be thought of as one that changes potential output while holding scaled output ( $\tilde{Y}$ ) constant. A *pure aggregate-demand factor* can be thought of as one that changes scaled output while holding potential output constant.

Although actual economic factors often mix supply and a demand aspects, let us first look at the pure cases.

## 16.1.1 SUPPLY FLUCTUATIONS

### Adjustments to Supply Factors when Wages are Flexible

An economy at full employment (that is, with a clearing labor market) is not necessarily at the peak of the business cycle. Growth can continue, but only if the economy can use more capital or labor or use it more effectively because of technological improvement.

Any of these sources of growth might be called **SUPPLY FACTORS**.

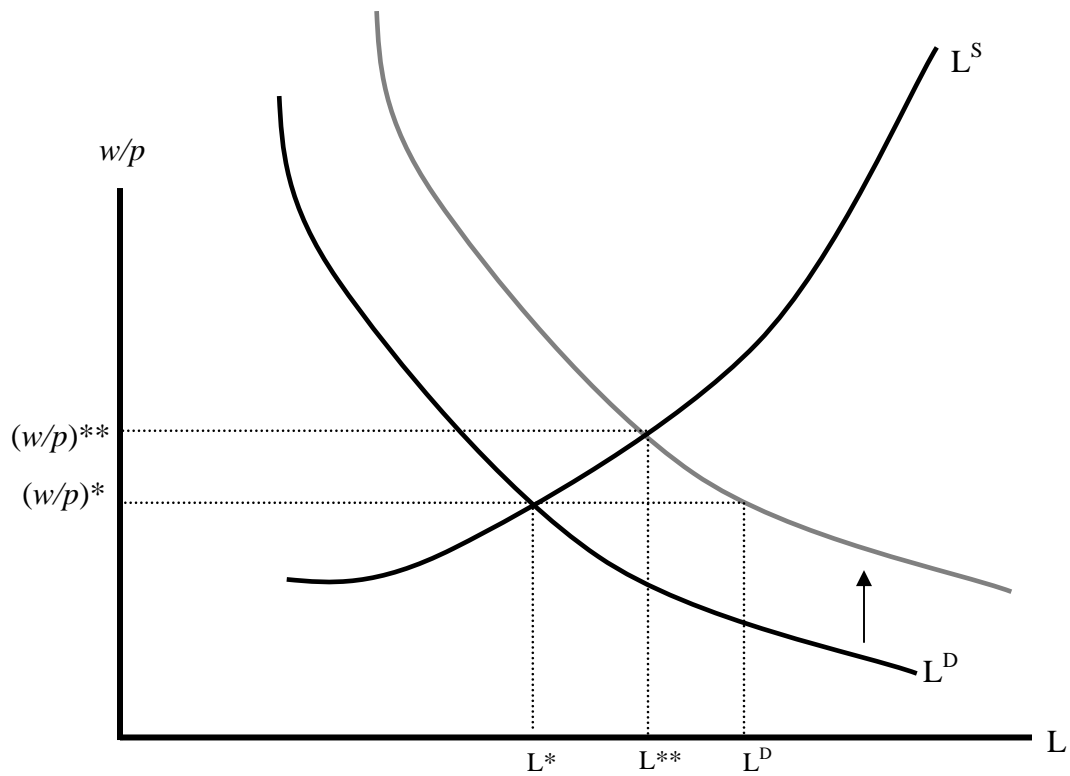
Starting from full employment, a favorable movement of supply factors other than labor (that is, an increase in the capital stock or a technological improvement) would shift the production function and the labor-demand curve upwards. Figure 16.1 shows just the shift in the labor-demand curve. The level of full employment increases from  $L^*$  to  $L^{**}$ . At the original real wage  $(w/p)^*$ , labor demand ( $L^D$ ) exceeds labor supply. Firms must raise wages to  $(w/p)^{**}$  to attract more workers. Higher labor (and greater labor productivity), of course, translate into higher real GDP – the expansion continues.

A less likely scenario in the United States, but one not historically unknown, is a fall in labor supply.<sup>1</sup> The analysis of this case, in which the labor-supply curve shifts inwards, is taken up in 16.1.

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<sup>1</sup> Because of death and emigration, the population of Ireland, which was about 8,400,000 at the beginning of the Potato Famine in 1844, fell to 6,600,000 by 1851. Emigration and low birth rates continued into the 20<sup>th</sup> century, so that at independence from Great Britain in 1921, its population was about half of its level before the famine. Similarly, the outbreak of bubonic plague in the 14<sup>th</sup> century known as the “Black Death” reduced the population of Europe by about a third over the five years from 1347 to 1352.

**Figure 16.1**  
**The Effect of a Favorable Shift in Aggregate Supply**  
**on the Labor Market**



*A favorable shift in aggregate supply (an upward shift of the labor production function) raises the marginal product of labor and shifts the labor-demand curve upwards. At the original real wage  $(w/p)^*$ , the demand for labor exceeds the supply. If wages are flexible, firms compete to attract labor through higher market wage rates, raising the real wage to  $(w/p)^{**}$  at which point labor supply again equals labor demand and the size of the labor force has increased from  $L^*$  to  $L^{**}$ .*

### Adjustments to Supply Factors when Wages are Inflexible

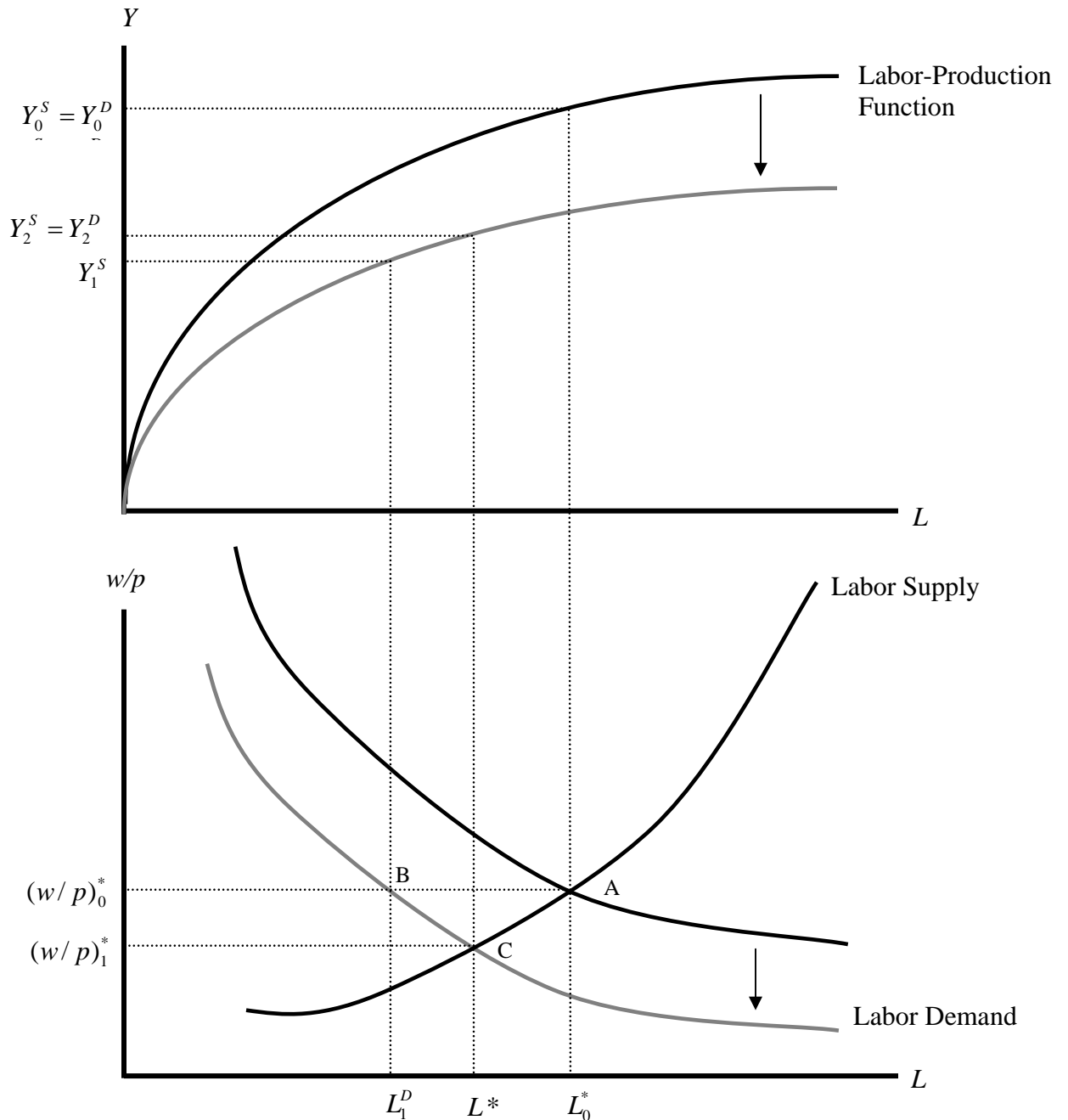
If labor markets were flexible and always cleared (as we assumed in Chapter 8, section 8.3), then the analysis of an unfavorable change in supply factors would just be the reverse of a favorable one. If nominal wages do not fall rapidly to clear markets (see Chapter 9, section 9.3), then the situation is more complicated.

It is helpful to distinguish clearly between aggregate demand (the expenditure side of GDP), indicated by a superscript  $D$  and aggregate supply (the production side of GDP), indicated by a superscript  $S$ . In Figure 16.2 at full employment at point A with a real wage  $(w/p)_0^*$  and employment  $(L_0^*)$ , aggregate demand  $(Y_0^D)$  equals aggregate supply  $(Y_0^S)$ . A negative supply shock shifts the production function and the labor-demand curve downward. To maintain full employment, the real wage would have to fall. If it remains at  $(w/p)_0^*$ , then labor demand falls to  $L_1^D$ , while labor supply remains at  $L_0^*$ . Firms lay off workers and the unemployment rate increases.

If nominal wages are not sufficiently flexible, then the real wage may be lowered and equilibrium restored by a relative increase in prices: price inflation must exceed wage inflation until the new full employment real wage  $(w/p)_1^*$  is established. What makes prices rise?

The lower panel shows that the fall in the labor-demand curve at the original wage would generate labor demand at point B of  $L_1^D$ , which (in the upper panel) would produce aggregate supply of  $Y_1^S$ . At this level, aggregate demand exceeds aggregate supply ( $Y_0^D > Y_1^S$ ). In such circumstances firms raise their prices – in this case, faster than the rate of

**Figure 16.2**  
**An Unfavorable Shift in Aggregate Supply**



*Unfavorable shift in aggregate supply is shown as the downward shift of the labor-production function, resulting in the fall of the marginal product of labor and the downward shift of the labor-demand curve. At the original real wage  $(w/p)_0^*$ , labor supply exceeds labor demand. If wages are flexible, the real wage will fall to re-establish equilibrium at point C. If wages are not flexible, then prices must rise (as aggregate demand  $(Y_0^D)$  exceeds aggregate supply  $(Y_1^S)$ ) until the real wage falls to  $(w/p)_1^*$ , again re-establishing equilibrium at point C, where there is full employment, but a smaller labor force and less output than at the original equilibrium (point A)..*

wage inflation – which lowers the real wage. Increasing prices and reduced employment lower labor income and, therefore, real aggregate demand. The adjustment is complete when aggregate demand and supply are equal once again at ( $Y_2^D = Y_2^S$ ), corresponding to the new equilibrium in the labor market at point C.

### Technological Progress and Capital Obsolescence

When we think of capital or technology generically, it is hard to think of circumstances in which they would fall and generate a decline in output and rising prices. Recall, however, that *capital* is a portmanteau term that includes every non-labor input into the production process. A large change in relative prices of particular factors of production may render the existing mix of physical inputs inappropriate and encourage firms to economize on them.

In earlier chapters we regarded capital and labor as **SUBSTITUTES IN PRODUCTION** – that is, *if the price of one of them rose, its demand would fall, and the demand for the other one would rise*. This is almost certainly true in the long run. But in the short run, labor and capital are likely to be **COMPLEMENTS IN PRODUCTION** – that is, *if the price of one of them rose, its demand would fall, and the demand for the other one would also fall*. When inputs are complements in production, we can look on a firm's retrenchment in the face of higher input prices as *either* an effective reduction in its capital *or* as a reduction in its productivity. Either way, the labor production function shifts downward.

Similarly, technological innovations or shifts in demand may render particular capital inputs obsolete. The introduction of audio compact disks (CDs) virtually

eliminated the value of machinery specialized in making long-playing, vinyl records (LPs). The technological innovation reduced the effective capital stock. When the physical instruments of production remain unchanged, economic statistics do not necessarily reflect such economic losses to capital accurately. If capital is measured as still available, even though it is obsolete, measured capital productivity will fall. Either way, the labor production function shifts downward.

### Cost-push Inflation

The price inflation that results from firms trying to adjust to increases in their underlying costs owing to shifting supply factors is sometimes called **COST-PUSH INFLATION**. Costs, seen as originating outside the firms, are passed through and push prices upwards from below. Cost-push inflation is usually considered a key element in the so-called **stagflation** (*stagnation + inflation*) of the 1970s: both unemployment and inflation were high, and the economy grew slowly even when it was not actually in recession.

Macroeconomists and economic historians offer a variety of explanations for stagflation. One of the most popular explanations points to the large, unexpected increases in the prices of imported commodities in the early 1970s, and in oil prices after late 1973, as having initiated a series of negative **supply shocks** – that is, *unfavorable (and unexpected) shifts in supply factors*. This explanation is likely to be a significant part of the truth. Still, we should also recognize that demand factors might have been involved as well. The United States – and, indeed, most of the developed world – are net importers of oil. A sudden increase in oil prices also raises import expenditure so that net exports decline – a fall in aggregate demand.

## 16.1.2 DEMAND FLUCTUATIONS

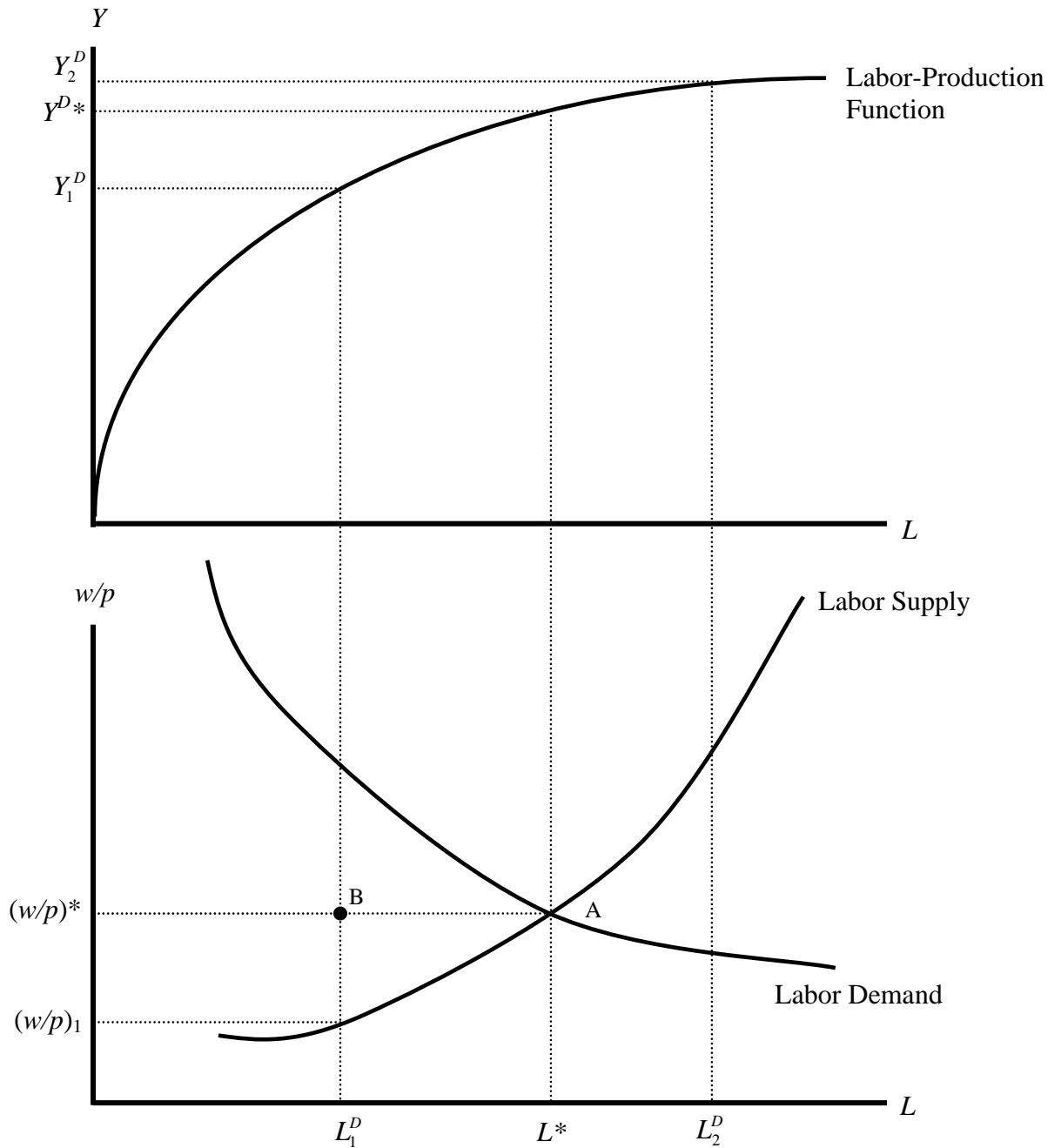
In order to isolate pure supply factors, we assumed that either wages or prices or both move in such a way that aggregate demand was always adjusted to keep it equal to a shifting aggregate supply that was itself always equal to potential output. To isolate pure **DEMAND FACTORS**, we assume that potential output is constant, so that changes in aggregate demand open up a gap between expenditure plans and output plans. In that sense, aggregate demand may be smaller or larger than (planned) aggregate supply or potential output.

### When Aggregate Demand Falls Short of Aggregate Supply

When we turn to aggregate-demand fluctuations, we must work backwards through the diagrams. We start with the level of aggregate demand and ask, given the technology, how much labor would it take to produce the required output? While potential output is unaffected, the actual output supplied, in this case, adjusts to aggregate demand.

In Figure 16.3, aggregate demand is initially at  $Y^D *$ . At this level, the labor market clears at point A with a real wage  $(w/p)^*$  and employment  $(L^*)$ . A reduction in demand to, say,  $Y_1^D$  reduces the demand for labor to  $L_1^D$ . If the wage does not adjust, the fall in aggregate demand creates involuntary unemployment at point B. Firms are off their labor-demand curves, and workers are off their labor-supply curves. That this situation could persist is, of course, the puzzle of unemployment discussed in Chapter 9, section 9.3.1.

**Figure 16.3**  
**Shifts in Aggregate Demand**



*A reduction in aggregate demand to  $Y_1^D$  reduces the demand for labor generating unemployment at the going wage (point B). Workers would willingly supply labor to meet labor demand ( $L_1^D$ ) at a wage below market clearing  $(w/p)_1$ , but a fall in the real wage to this level will not restore full employment unless aggregate demand also increases. An increase in aggregate demand to  $Y_2^D$  is infeasible because workers require a higher real wage than firms can profitably pay to meet demand for labor ( $L_2^D$ ). Firms that offer higher money wages to attract workers and pass on the prices to consumers ultimately increase the general price level and reduce real aggregate demand back to its market-clearing level.*

At the lower level of aggregate demand ( $Y_1^D$ ), firms could apparently increase their profits by reducing the real wage to  $(w/p)_1^*$ . Yet such an action would not, in itself, reestablish full employment. Only an increase in aggregate demand will increase employment.

### When Aggregate Demand Exceeds Aggregate Supply

Any attempt to increase aggregate demand above the full employment point is infeasible. Look again at Figure 16.3. At a higher level of aggregate demand,  $Y_2^D$ , firms wish to employ a larger number of workers ( $L_2^D$ ) than want to work at the market-clearing wage. Since slavery is illegal, they can attract additional workers only by bidding up the money wage.

But, of course, since workers are already being paid their marginal products, profit-maximizing firms would have to pass on the additional costs in the form of higher prices for their output, which would hold down the product-real wage. The net result of firms across the economy raising their product prices would be an increase in the general price level, reducing the consumption-real wage and, in general, the purchasing power of any given level of nominal income. Real aggregate demand must fall back to the full employment point.

This is an extremely important result:

- *Increases in aggregate demand cannot push the economy beyond the point of full employment; instead they drive up the general price level.*

Inflation that results from increases in aggregate demand beyond the levels compatible with full employment is sometimes referred to as **DEMAND-PULL INFLATION**: the forces of demand, standing above firms, are seen as pulling prices upwards.

### Distinguishing the Types of Inflation

Cost-push and demand-pull inflation are fundamentally different. Cost-push inflation arises because prices must rise *relative* to wages in order to adjust to a change in the underlying supply conditions. The inflation that results is temporary and lasts only long enough to move the price level sufficiently to obtain the new market-clearing real-wage rate.

In contrast, demand-pull inflation results from aggregate demand exceeding potential output. All prices (including wage rates) must rise in order to reduce expenditures to a level at which aggregate demand and supply are again compatible.

## **16.2 Unemployment and Output Fluctuations**

So far we have focused on snapshots of the economy in order to isolate pure supply and demand factors. In reality, these factors are generally mixed together, and we would like to understand how they interact. Economic growth is not a smooth process. Recessions and accompanying increases in unemployment punctuate a generally upward trend. We now turn to trying to understand the *process* behind these fluctuations – to construct a moving picture rather than a snapshot. We begin with unemployment: what determines the fluctuations of unemployment over time?

### 16.2.1 WHAT CHANGES THE UNEMPLOYMENT RATE?

Start with the definition of the unemployment rate (see Chapter 6, section 6.4.3). Writing  $LF$  for the *labor force* as a function of time and  $L$  for *the number of workers actually employed*, the unemployment rate at a particular time ( $t$ ) is

$$(16.1) \quad U_t = \frac{LF_t - L_t}{LF_t} = 1 - \frac{L_t}{LF_t} = 1 - EMP_t.$$

The *employment rate*,  $EMP (= L/LF)$ , in the right-hand term is the complement of the unemployment rate (that is,  $U + EMP = 1$  by definition).

How does the unemployment rate change through time? The growth rate of the employment rate is  $\hat{EMP} = \hat{L} - \hat{LF}$ . As is intuitively obvious, the employment rate increases and, therefore, the unemployment rate decreases when employment grows faster than the labor force, and *vice versa*. These relationships follow immediately from the definition of unemployment, but do not explain much economically. We need to dig deeper.

The first step is to make the previous observations more precise. Rewrite equation (16.1) as

$$(16.1') \quad 1 - U_t = \frac{L_t}{LF_t}.$$

Expressed in growth rates (16.1') becomes

$$\hat{(1-U)} \approx \frac{\Delta(1-U_t)}{1-U_t} = \hat{L} - \hat{LF}.$$

Notice that since 1 is a constant in the numerator, the middle term can be rewritten as  $-\Delta U_t$ . Substituting in this expression and multiplying the middle and right-hand side by  $-(1 - U_t)$  gives

$$(16.2) \quad \Delta U_t \approx (1-U_t)(\hat{LF} - \hat{L}).$$

The second term in parentheses on the right-hand side of this equation is just the difference in the growth rates of the labor force and employment. It tells us what we already knew: the unemployment rises when the labor force grows more quickly than employment and falls when employment grows more quickly than the labor force. The employment rate  $(1 - U_t)$  acts as a scaling factor that indicates the base on which the growth rates operate. It varies across the business cycle, although usually within a relatively narrow range. (The post-World War II maximum employment rate for the United States was 97.5 percent and the minimum was 89.2 percent, although in only two recessions did the employment rate fall below 92 percent.)

## 16.2.2 THE MODIFIED BALANCED GROWTH PATH

Although, equation (16.2) is more precise, it still adds little to what we already knew.

The next step is to explain the two growth rates. Recall that labor productivity was defined in Chapter 5 as  $\theta = Y/L$ , so that  $\hat{\theta} = \hat{Y} - \hat{L}$  or  $\hat{L} = \hat{Y} - \hat{\theta}$ . The participation rate was defined in Chapter 9 (section 9.2.2) as

$PR = LF/POP$ , where  $POP$  is the working-age population, so that  $\hat{PR} = \hat{LF} - \hat{POP}$  or  $\hat{LF} = \hat{PR} + \hat{POP}$ . Substituting these facts into equation (16.2') gives

$$\begin{aligned} \Delta U_t &\approx (1 - U_t)(\hat{PR}_t + \hat{POP}_t - \hat{Y}_t + \hat{\theta}_t) \\ (16.3) \quad &= (U_t - 1)\left[\hat{Y}_t - (\hat{PR}_t + \hat{POP}_t + \hat{\theta}_t)\right] \end{aligned}$$

The far right-hand expression is derived from the middle expression by rearrangement and by multiplying both of middle terms by  $-1$ .

It is helpful define  $\hat{Y}^* \equiv \hat{PR} + \hat{POP} + \hat{\theta}$ . Then equation (16.3) can be rewritten as

$$(16.3') \quad \Delta U_t \approx (U_t - 1)(\hat{Y}_t - \hat{Y}_t^*)$$

Notice that the term  $U_t - 1$  is negative, since  $U_t$  must lie between zero and one.

Equation (16.3'), then, says that there is a critical rate of growth:  $\hat{Y}_t^*$ . Whenever the growth rate of the economy is above this rate, unemployment falls; whenever it is below this rate unemployment rises. What is more, we know what determines the critical rate. It is the sum of the growth rates of participation, population, and labor productivity. The faster any one of these three is growing, the higher the critical rate.

Recall from Chapter 7 (section 7.4.1) that, along a balanced growth path,  $\hat{Y} = n + \hat{\theta}$ , where  $n$  is the rate of growth of population. The participation rate cannot grow indefinitely, because, by definition, it cannot exceed 100 percent; in practice, it cannot even come close to 100 percent. So, in the long-run, the rate of growth of the labor force is equal to the rate of growth of population ( $\hat{LF} = POP = n$ ). The long-run equality, notwithstanding, the participation rate may change considerably over the business cycle or, as has been true over the past 40 years, even over longer periods. The critical rate of growth  $\hat{Y}_t^*$  may therefore be seen as a **MODIFIED BALANCED RATE OF GROWTH**: *the growth rate sustainable along a balanced growth path modified for a changing participation rate.*

The modified balanced rate of growth carries both a promise and a challenge. Imagine that the economy is at full employment – a low, but non-zero, measured rate of unemployment. If GDP grew at exactly  $\hat{Y}_t^*$ , then the unemployment rate would remain constant at that full-employment rate. (Even if the unemployment rate is higher, if GDP grows at  $\hat{Y}_t^*$ , the unemployment rate remains constant.) The modified natural rate of

growth acts as a kind of speed limit for the economy (in just the same way as we observed in Chapter 7 that the balanced growth path acted as a speed limit).

To raise that speed limit, one of the elements that make up  $\hat{Y}_t^*$  (that is, one of the growth rates of the participation rate, population, or labor productivity) must increase. The promise is that if one of these elements – especially labor productivity – can be increased the economy can sustain higher rates of growth of GDP (and, as we have seen in Chapter 7, higher rates of growth of *per capita* GDP). The challenge is that the higher modified natural growth path raises the bar. When it was lower, a lower rate of growth would have been enough to keep the unemployment rate low. When it is higher, the same lower rate of growth would be associated with rising unemployment.

### 16.2.3 OKUN'S LAW

Equation (16.3') is written as an approximation. If the time interval over which we measure the change in unemployment were to shrink to an instant, then the equation would be exact. Each of the substitutions made to convert equation (16.2) into (16.3) are based on the definitions (rather than fallible estimates) and are exact for instantaneous change. Real data, however, are not sampled instantaneously but, in this case, at monthly, quarterly, or annual intervals.

Even if the average levels of  $\hat{P}\hat{R}$ ,  $\hat{P}\hat{O}\hat{P}$  and  $\hat{\theta}$  were constant, which they are not over long periods of time, their cyclical variation would ensure that equation (16.3') did not fit exactly. For example, labor productivity tends to decline in recessions (see Chapter 6, Problem 6.7). The fall in labor productivity (a negative  $\hat{\theta}$ ) would lower  $\hat{Y}_t^*$ .

All other things equal, a lower  $\hat{Y}_t^*$  would reduce the rise in the unemployment rate associated with the recession.

Over time, as the average levels of the elements of  $\hat{Y}_t^*$  change, so will its value. For example, the growth in the participation rate, which had been substantial in the United States after the mid-1960s, seems recently to have slowed, which should depress  $\hat{Y}_t^*$ . Similarly, the growth of labor productivity, which had slowed in the 1960s, picked up substantially after 1995, which should raise  $\hat{Y}_t^*$ .

Using annual data for the United States, we can form a direct estimate of  $\hat{Y}^*$  from data on the growth rate of real GDP and the change in the unemployment rate. (The omitted time subscript indicates that we estimate the *average* value rather than the period-specific value.) Figure 16.4 is a scatterplot of these data for the period 1974 to 1998. The period is chosen to reflect the observation made in Chapter 2 (section 2.5.2) that long-term GDP growth appeared to slow down significantly after the first oil crisis.

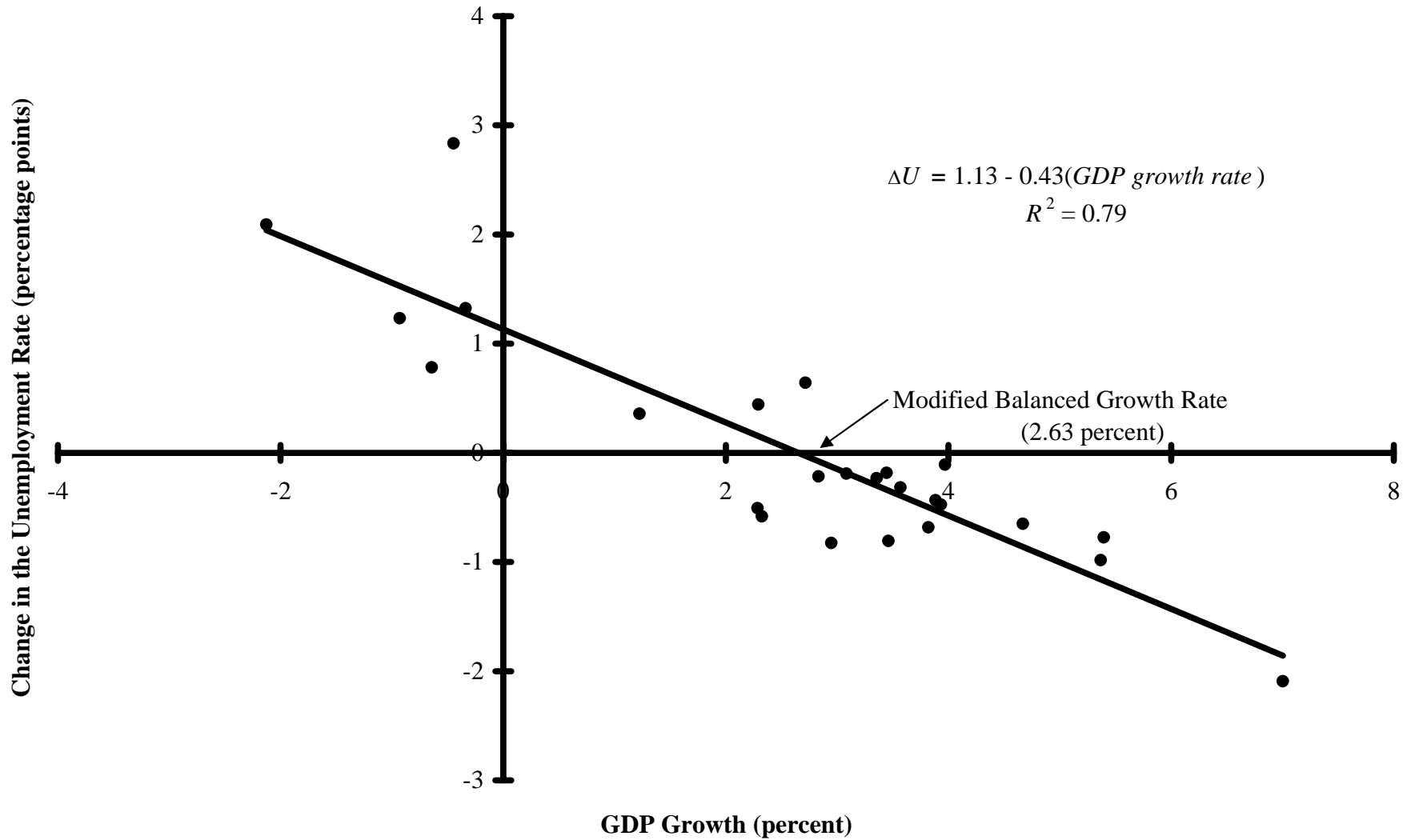
The regression line in Figure 16.4 can be described by an equation with the general form:

$$\Delta U_t = a + b\hat{Y}_t + error_t$$

Multiplying and dividing the first two terms on the right-hand side by  $b$ , yields

$$(16.4) \quad \Delta U_t = b(\hat{Y}_t + a/b) + error_t$$

**Figure 16.4.**  
**Okun's Law for the United States, 1974-1998**



Sources: Unemployment rate, Bureau of Labor Statistics; GDP growth rate, Bureau of Economic Analysis.

Since the slope of the regression line is negative,  $b$  is also negative, while  $a$  is positive.

Equation (16.4) can be rewritten

$$(16.4') \quad \Delta U_t = -\gamma(\hat{Y}_t - \hat{Y}^*) + error_t,$$

where  $\gamma = -b$  and  $\hat{Y}^* = -a/b$ . An empirical relationship in this form is known as **OKUN'S LAW**, named for Arthur Okun (1928-1980) who developed the analysis while serving on President Kennedy's Council of Economic Advisers.  $\hat{Y}^*$ , of course, measures the modified balanced rate of growth. The parameter  $\gamma$  measures how quickly deviations between the actual rate of growth and  $\hat{Y}^*$  are translated into changes in unemployment rates.

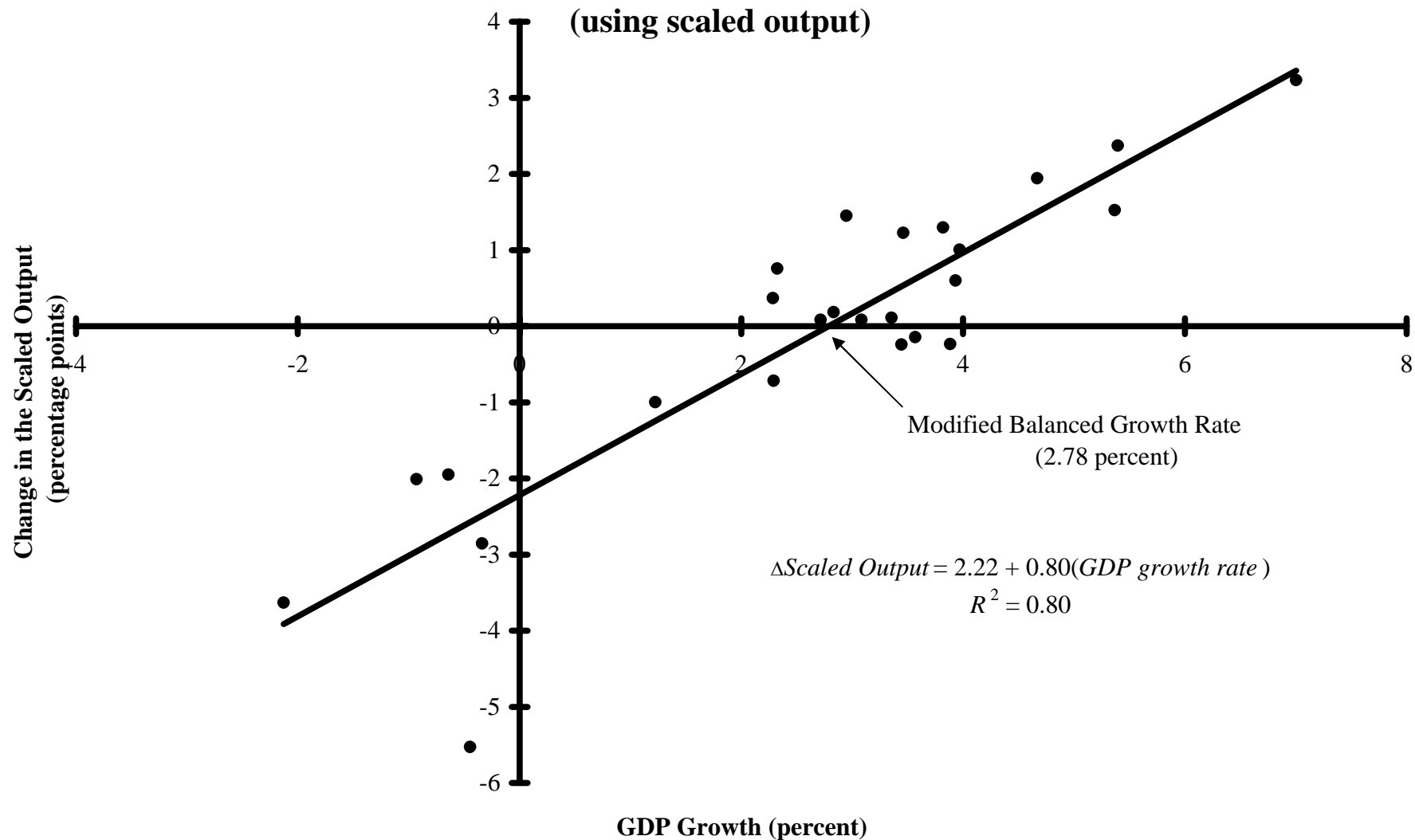
The actual estimated equation for the regression line in Figure 16.5 is

$$\Delta U_t = 1.13 - 0.43\hat{Y}_t + error_t, \text{ so that the parameters can be calculated: } \gamma = 0.43 \text{ and } \hat{Y}^* = -\frac{1.13}{-0.43} = 2.63 \text{ percent per year. Okun's law for 1974-98 is then}$$

$$(16.5) \quad \Delta U_t = -0.43(\hat{Y}_t - 2.63) + error_t$$

Notice that when  $\hat{Y}_t = \hat{Y}^*$ ,  $\Delta U_t = 0$ . Therefore, we can read  $\hat{Y}^*$  directly from Figure 16.4: it is the point at which the regression line crosses the horizontal axis.

**Figure 16.5**  
**Okun's Law for the United States, 1974-1998**  
**(using scaled output)**



Sources: GDP growth rate, Bureau of Economic Analysis; scaled output, based on the unemployment rate, Bureau of Labor Statistics, and the capacity utilization rate, Federal Reserve), see text for calculations.

To give an example, imagine that in a recession real GDP growth falls 0.5 percent over a one-year period. Equation (16.5) predicts that the rate of unemployment will rise:  $\Delta U_t = -0.43(-0.5 - 2.63) = -0.43(-3.13) = 1.35$  percentage points over the course of that year.

A more positive example: if in the middle of an expansion, real GDP grows at a rate of 4.5 percent per year, equation (16.5) predicts that rate of unemployment will fall:  $\Delta U_t = -0.43(4.5 - 2.63) = -0.43(1.87) = -0.8$  percentage points over a year.

Okun's law clarifies the phenomenon of **growth recessions** in which the economy grows, so there is no official recession, but slowly enough that unemployment rises. Any GDP growth rate greater than zero but less than  $\hat{Y}^*$  results in a rising unemployment rate, even though there is no recession.

Okun's law is an empirical relationship, that does not explain every aspect of changing unemployment. That is why there is an error term. It is, nevertheless, one of the most robust empirical relationships in macroeconomics. With an  $R^2 = 0.79$  in equation (16.5), changes in the growth rate of real GDP account for 79 percent of the variance of changes in the unemployment rate. This corresponds to a correlation between the two time-series of 0.89 – which is high.

## 16.2.4 THE DYNAMICS OF RESOURCE UTILIZATION

The unemployment rate is a measure of the degree of utilization of the labor force.

Output scaled by potential output ( $\tilde{Y}$ ) provide as more general measure of resource

utilization in the economy. Just as with unemployment, we can ask what determines the changes in scaled output. The analysis is based on Figure 16.5.

The figure plots the change in scaled output against the growth rate of real GDP. In contrast to the case of unemployment (Figure 16.4), the regression line is upward sloping. Scaled output is procyclical; while unemployment is countercyclical. Good economic times are associated with high scaled output and low unemployment.

Translated into the form of Okun's law, the equation for the regression line in Figure 16.5 is

$$(16.6) \quad \Delta \tilde{Y}_t = 0.80(\hat{Y}_t - 2.78).$$

The modified natural-growth rate  $\hat{Y}_t^* = 2.78 (= 2.22/0.80)$  per year. This estimate for  $\hat{Y}_t^*$  is only a little higher than the estimate formed using the usual approach to Okun's law, which equation (16.5) gave as 2.63 percent per year. The  $R^2$  for the regression is 0.80, which is only slightly larger than the  $R^2 = 0.79$  for equation (16.5). Either estimate will make little difference to our understanding of the potential of the economy for growth in the medium term.

### **16.3 Inflation and Unemployment**

Okun's law is useful because it gives us some idea about how aggregate demand and supply interact to determine changes in the rates of unemployment or resource utilization. Unfortunately, it does not tell us everything we might want to know about the dynamics

of macroeconomics aggregates. Because it focuses on changes, it does not tell us what level of unemployment we might expect. For that we need a starting place. If we know the level, we can predict how demand will change it. If the growth rate of aggregate demand ( $\hat{Y}$ ) is equal to the growth rate of aggregate supply (that is, to the modified balanced growth path,  $\hat{Y}^*$ ), the rates of unemployment and resource utilization remain constant – whatever its level. We would also like to know what determines that level. Equally, Okun's law focuses on the *real* economy. And we would like to know what determines *nominal* quantities, such as the rate of inflation. Thinking about how prices get set in aggregate sheds light both on the level of unemployment and on the determination of the rate of inflation.

### 16.3.1 PRICING BEHAVIOR

As is often the case, the behavior of individual firms provides some insight into aggregate outcomes. We know from microeconomics (discussed in Chapter 6, section 6.1.2) that, theoretically, a perfectly competitive, profit-maximizing firm takes the price at which it can sell its output, and the wages and other prices it must pay for its inputs, as given. Competition ensures that the price it can charge will just cover its costs, including normal profits, and will be the same as that charged by its competitors.

From the point of view of the buyer of its output, the important thing is not the nominal price of the output but the real price – that is, the price of the good relative to the price of other goods. Call the price of a particular good  $j$ ,  $p_j$ . The price of other goods can be summarized in a price index (call it  $p$ ), so that the real price or relative price of

good  $j$  can be expressed as  $p_j/p$ . If demand and supply conditions are constant, then the real price will itself be constant. An increase in demand or a decrease in supply (for example, because of rising costs of materials or other factors of production) will raise the real price of the good.

Although perfect competition is a good approximation for many purposes – and we have relied heavily on it in discussions of growth and labor markets in previous chapters – it is rare to find strict perfect competition in actual economies. In reality, goods are not exactly alike: an increase in the price of a Honda sedan does not drive every customer to buy a Nissan instead – as it should if the market were perfectly competitive. Nor is there an auction market in which Honda and Nissan can observe the going price for sedans before they make their supply decisions.

In reality, many actual markets are **imperfectly competitive**. Car companies – and producers of most goods – must choose both the price at which they sell their goods and the amounts they wish to supply at that price. This does not mean that firms have a free hand. What a firm charges is clearly limited by demand. And it is limited by its competitors. I may prefer a Honda, but if Honda charges too high a price, I will choose the Nissan instead, despite the fact that I do not like its features quite so much.

Imperfect competition is difficult to analyze – and usually best left to a course in microeconomics. The rules of perfect competition help us to analyze actual economies in many cases, because the competition between firms is great enough that their supply decisions are close to what perfect competition suggests. Nevertheless, strict application of the rules of perfect competition is sometimes misleading. In particular, to understand aggregate inflation, it is best to think of firms as choosing their own prices.

The question, then, is how to set the price. When supply and demand conditions remain unchanged, firms should set a constant real price ( $p_j/p$ ). Of course, if there is general price inflation, then the price of the particular good would have to rise at the rate of inflation in order to keep the real price constant. The growth rate of the real price is  $\hat{p}_j - \hat{p}$ ; it is zero when  $\hat{p}_j = \hat{p}$ .

Decisions in economics are necessarily forward-looking. A firm may, for instance, set its prices at monthly, quarterly or even annual intervals. To do so, it must anticipate how general prices will change over the month, quarter, or year – that is, it needs to form an expectation about future prices and needs to change its own price in line with expected inflation ( $\hat{p}^e$ ), not with past inflation. If supply and demand conditions remain unchanged, then the firm should follow the rule:  $\hat{p}_{j,t} = {}_{t-1}\hat{p}_t^e$ . This rule says that a firm at the end of the previous period ( $t - 1$ ) forms an expectation of what general price inflation will be during the current period ( $t$ ), and adjusts the price of its own good to inflate at the same rate.<sup>2</sup> (Of course, this is an approximation to firm behavior, because most firms will not find it convenient to change prices continuously, but may in fact select a single price such that the average price over the period grows at the appropriate rate.)

Demand and supply conditions are unlikely to be constant. If demand increases during the period, a firm would want to raise its real price. To do so, the price of its good must rise more quickly than general price inflation. Similarly, if real factor prices rise or

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<sup>2</sup> The expectation could equally be thought of as being formed at the very beginning of an period with the decision governing the changes of prices during the period.

if conditions of production become unfavorable (for example, a drought would reduce agricultural productivity), then a firm would also want to raise its real price. This suggests that the price-setting rule should be modified to account for these factors:

$$(16.6) \quad \hat{p}_{j,t} = {}_{t-1}\hat{p}_t^e + f(\text{demand factors}) + g(\text{supply factors}).$$

The two functions  $f(\cdot)$  and  $g(\cdot)$  determine how demand and supply factors affect the pricing decision. For the time being, we let them remain indefinite, general functions.

### 16.3.2 THE PHILLIPS CURVE

Equation (16.6) applies to a single firm. If we average over all firms, the variable on the left-hand side will become the general rate of inflation  $\hat{p}_t$ . Demand and supply factors that are unique to particular firms or products will tend to average out. What will be left are factors that affect the economy as a whole. The result of averaging can be written:

$$(16.7) \quad \hat{p}_t = {}_{t-1}\hat{p}_t^e + f(\text{aggregate-demand factors}) + g(\text{aggregate-supply factors}).$$

The expected inflation term in equation (16.6) was the individual firm's expectation of general price inflation. In equation (16.7) it is the average expectation of general price inflation for all firms. The function  $f(\cdot)$ , in the terminology of Section 16.1, captures demand-pull inflation, while the function  $g(\cdot)$  captures cost-push inflation.

Equation (16.7) is known to economists as the **expectations-augmented Phillips curve** (or just the **PHILLIPS CURVE** for short). It is named for the New Zealand economist A.W.H. Phillips (1914-1975), who in 1958 published an important empirical study of the relationship of wage inflation to the unemployment rate in the United Kingdom from which other versions of the Phillips curve have descended.

To apply the Phillips curve to actual data requires definite measures for the aggregate-demand and aggregate-supply factors and definite functional forms for  $f(\cdot)$  and  $g(\cdot)$ . Since the first Phillips curve in 1958, the usual measure of aggregate demand has been the rate of unemployment. We know that unemployment is a strongly countercyclical variable – high in recessions, when we expect demand to be low, and low in expansions when we expect demand to be high. Other measures of demand could equally well be used, as we shall see in the next section.

On the assumption that the relationship between demand and unemployment is linear, we can write

$$f(\text{aggregate demand}) = a + bU$$

The coefficient  $b$  is assumed to be negative, since demand and unemployment are inversely related. Substituting into equation (16.7) yields

$$(16.7') \quad \hat{p}_t = {}_{t-1}\hat{p}_t^e + a + bU_t + g(\text{aggregate supply}_t).$$

### 16.3.3 THE NATURAL RATE OF UNEMPLOYMENT AND NAIRU

#### The Concept of the Natural Rate

Assume for the moment that the aggregate-supply factors can be ignored. What rate of unemployment would make *actual* inflation  $\hat{p}_t$  equal to *expected* inflation  ${}_{t-1}\hat{p}_t^e$ ? That is, what rate of unemployment would leave firms satisfied that their pricing strategies were correct? Expressed algebraically, the question is when does

$$\hat{p}_t - {}_{t-1}\hat{p}_t^e = a - bU_t = 0?$$

Indicate the solution by  $U_t^*$ , so that

$$U_t^* = -a/b.$$

$U_t^*$  is known as the **NATURAL RATE OF UNEMPLOYMENT** and can be defined as *that rate of unemployment that, if maintained, would result in an actual rate of inflation rate equal to the average expected rate of inflation.*

So long as  $a$  and  $b$  remain constant,  $U_t^*$  will itself remain constant and can be indicated by  $U^*$  without a time subscript. The two coefficients are not necessarily constant. The function  $f(\cdot)$  represents the relationship between aggregate-demand factors and the firms' relative pricing decisions, which may depend on the detailed structure of the production process. The relationship between the unemployment rate and aggregate

demand may itself depend on the organization of labor markets. Changes in either sets of relationships may result in changes in  $a$  and  $b$  and, therefore, in changes in the natural rate of unemployment. We shall consider the variability of the natural rate further later in a later subsection. For now we assume that it is constant.

Using the natural rate of unemployment, the Phillips curve (equation (16.7')) can be rewritten

$$(16.8) \quad \hat{p}_t - {}_{t-1}\hat{p}_t^e = -\beta(U_t - U^*) + g(\text{aggregate-supply factors}_t),$$

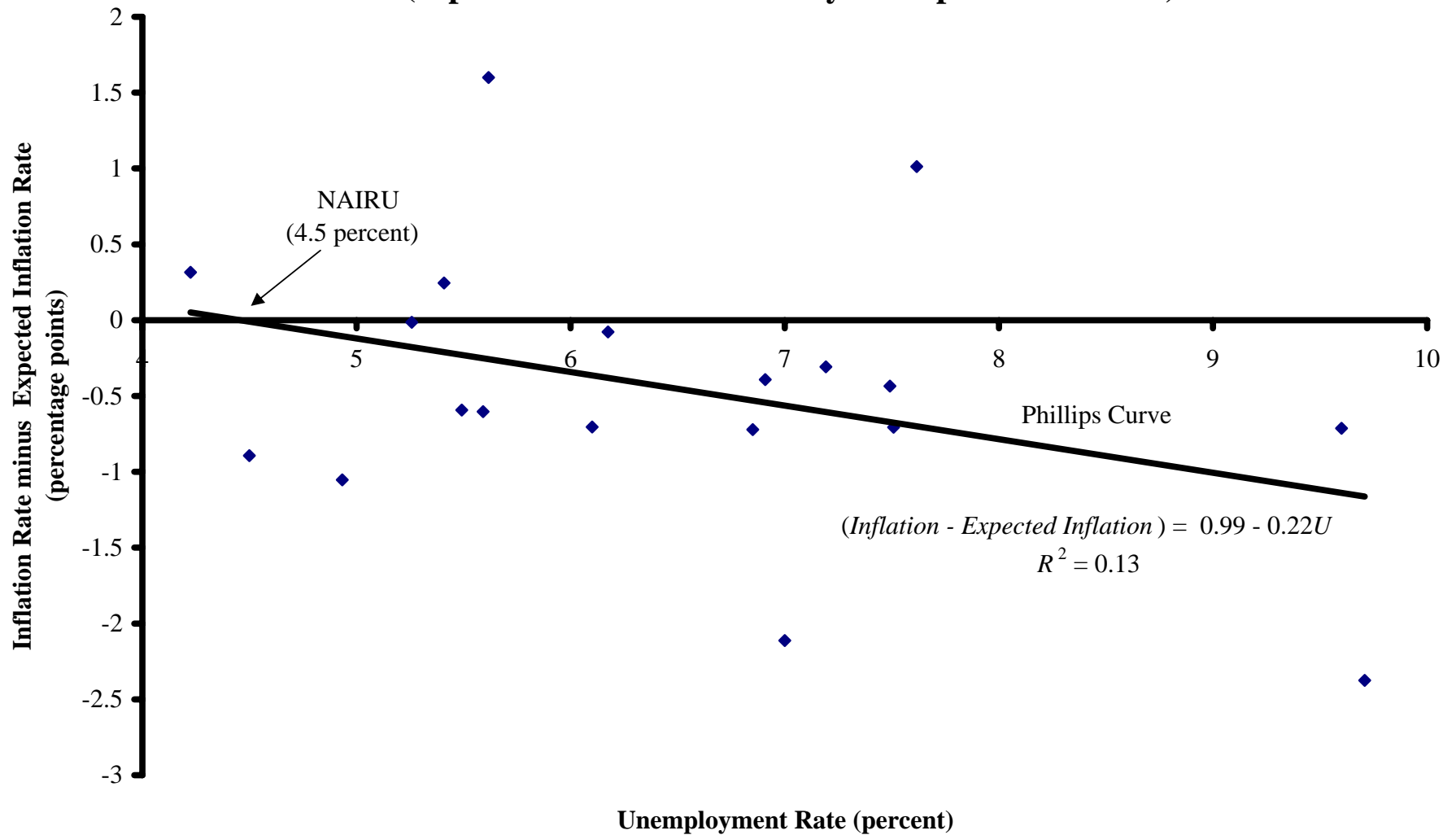
where  $\beta$  (the lower-case Greek letter “beta”) =  $-b$ . ( $\beta$  is assumed to be positive, and the minus sign helps to remind us that the relationship is inverse.) Equation (16.8) says that when the unemployment rate is below the natural rate, inflation tends to rise faster than expected and when the unemployment rate is higher than the natural rate, it tends to rise slower than expected.

### An Estimate of the Natural Rate of Unemployment

Empirical macroeconomists have estimated Phillips curves for many periods and many countries. They use sophisticated econometric techniques to take account of the variety of demand and supply factors that might influence prices. As valuable as such sophisticated studies are, there is much to be learned from simpler approaches.

To estimate  $\beta$  and  $U^*$ , we must have data on the expectations of inflation. Fortunately, several surveys provide such data. Figure 16.6 is based on equation (16.8).

**Figure 16.6**  
**The Expectations-Augmented Phillips Curve, 1981-98**  
 (expectations based on surveys of expected inflation)



Sources: Inflation (CPI-U) and unemployment rates, Bureau of Labor Statistics; expected annual inflation rates, Survey of Professional Forecasters, Federal Reserve Bank of Philadelphia.

The vertical axis measures the difference between the actual inflation rate for each year and the rate expected at the end of the previous year by professional forecasters (who, of course, advise firms) for inflation over the year. The horizontal axis measures the rate of unemployment. The forecast data are available only from 1981. The equation of the regression line is

$$\hat{p}_t - {}_{t-1}\hat{p}_t^e = 0.99 - 0.22U_t + error_t.$$

We assume that aggregate-supply factors can be ignored. In terms of the equation, this is the equivalent of setting  $g(\text{aggregate-supply factors}_t)$  to zero. In terms of the regression, it means that any deviations of  $g(\text{aggregate-supply factors}_t)$  from zero show up as part of the error – that is, in the fact that the points in the scatter plot do not lie exactly on the regression line.

Multiplying and dividing by  $-0.22$  transforms the equation into the form of equation (16.8):

$$(16.9) \quad \hat{p}_t - {}_{t-1}\hat{p}_t^e = -0.22 \left( U_t - \frac{0.99}{0.22} \right) = -0.22(U_t - 4.5).$$

The adjustment parameter is  $\beta = 0.22$ , and NAIRU is  $U^* = 4.5$  percent. Analogously to Okun's law, when  $U_t = U^*$ ,  $\hat{p}_t - {}_{t-1}\hat{p}_t^e = 0$ , and we can read NAIRU ( $U^*$ ) directly from Figure 16.6 as the point at which the regression line crosses the horizontal axis.

### NAIRU and the Formation of Expectations

Surveys have not always been available; and, in any case, economists are often skeptical of survey data. More often than not, macroeconomists eschew surveys of expected inflation and try instead to model the process through which expectations are formed.

Although there are many ways to model expectations of inflation, the most simple, and perhaps the most common, way is to assume that whatever rate of inflation was *actually* observed last period is expected to obtain this period:  ${}_{t-1}\hat{p}_t^e = \hat{p}_{t-1}$ .

Substituting into equation (16.8) yields

$$(16.10) \quad \hat{p}_t - \hat{p}_{t-1} = \Delta \hat{p}_t = -\beta(U_t - U^*) + g(\text{aggregate supply}_t).$$

Here an unemployment rate below the natural rate increases the rate of inflation, while an unemployment rate above the natural rate reduces it.

The inflation rate is the (percentage) change in the price level, so the change in the inflation rate is the *acceleration* in the price level. Equation (16.9) says that when the actual and natural rates of unemployment are equal, the price level will not accelerate (or decelerate). Consequently, the natural rate estimated from such an equation is frequently known as the **NON-ACCELERATING INFLATION RATE OF UNEMPLOYMENT** (or **NAIRU**).<sup>3</sup>

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<sup>3</sup> Properly speaking NAIRU is misnamed because it is the *price level* that accelerates. The rate of inflation rises or falls, but does not accelerate. Be that as it may, the term *NAIRU* is now cast-iron idiom among macroeconomists.

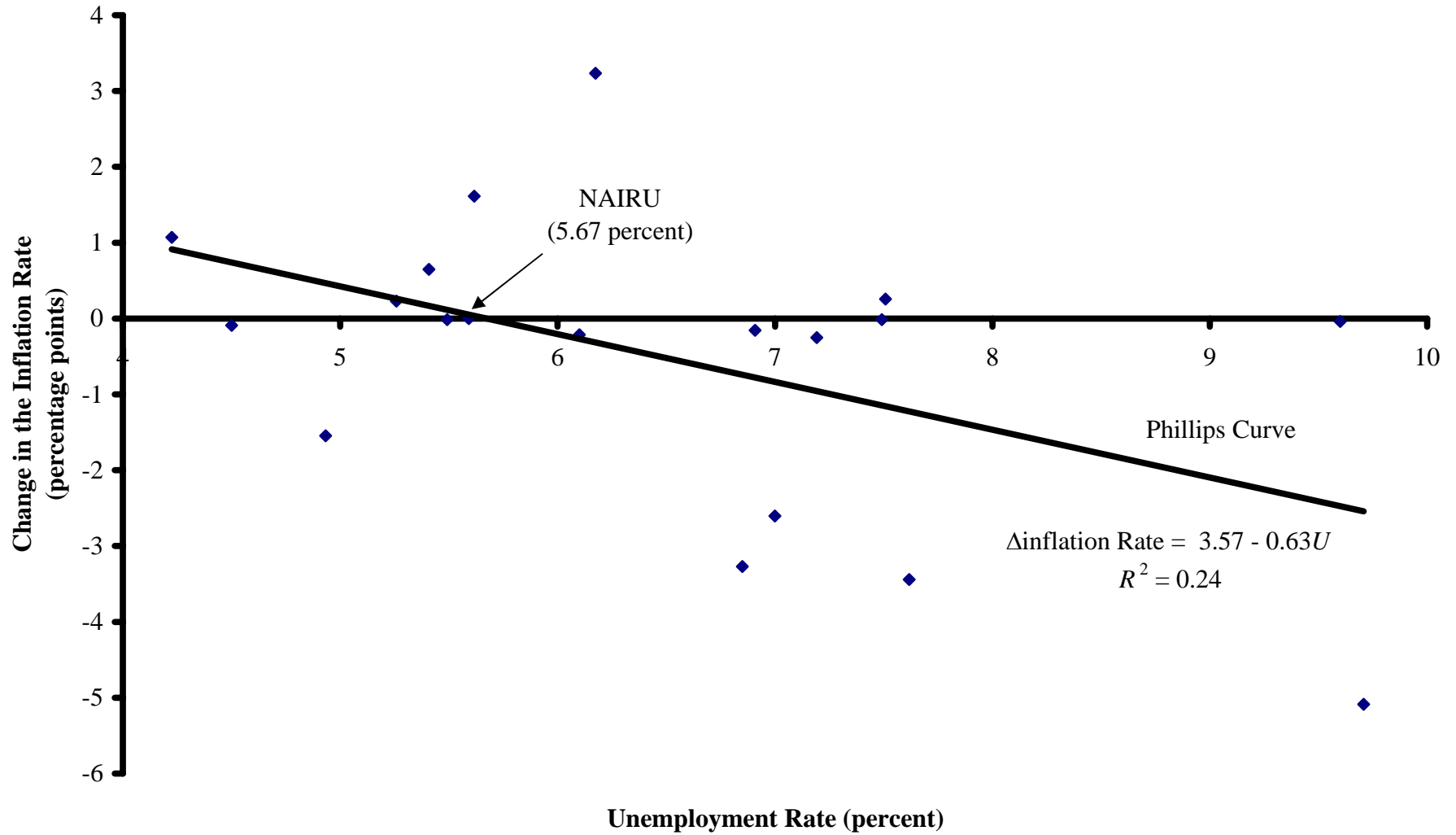
Some economists distinguish between NAIRU and the natural rate of unemployment. Milton Friedman (formerly of the University of Chicago and winner of the Nobel Prize in Economics in 1976) and Edmund Phelps (of Columbia University), who independently developed the expectations-augmented version of the Phillips curve in the late 1960s, thought of the natural rate as the equivalent to full employment. What is more they thought of markets as having a strong tendency to return to full employment if left alone. “Natural rate” was a clever coinage aimed at converting us to faith in the smooth functioning of markets and to the view that full employment is what generally occurs in markets if they are left alone.

One reason to prefer term “NAIRU” to the “natural rate of unemployment” is that NAIRU is the more ideologically neutral term. While virtually every economist would agree that there is some level of aggregate demand (and, therefore, some level of unemployment) that at any time implies a stable rate of inflation, there is considerable disagreement about whether that rate is stable over time and whether the economy has any strong tendency to return to it.

### An Estimate of NAIRU

Instead of using survey estimates of expectations, we can use equation (16.9), which forms expectations based on past inflation. Figure 16.8 measures the *change* in the inflation rate ( $\Delta \hat{p}_t = \hat{p}_t - \hat{p}_{t-1}$ ) on the vertical axis and the rate of unemployment on the horizontal axis. The equation for the regression line is

**Figure 16.7**  
**The Expectations-Augmented Phillips Curve, 1981-98**  
 (expectations based on past inflation rates)



Sources: Inflation (CPI-U) and unemployment rate, Bureau of Labor Statistics.

$$\Delta \hat{p}_t = 3.57 - 0.63U_t + error_t$$

The adjustment parameter is  $\beta = 0.63$  and NAIRU is  $U^* = 5.67$  percent.

As before, this may be transformed into the form of a Phillips curve – this time into the form of equation (16.9)

$$(16.11) \quad \Delta \hat{p}_t = -0.63 \left( U_t - \frac{3.57}{0.63} \right) = -0.63(U_t - 5.67).$$

To understand what the estimated Phillips curve means, consider an example. Suppose that the inflation rate is 7.5 percent and that the unemployment rate is 8 percent. Substituting the unemployment rate for  $U_t$  in (16.11) gives us  $\Delta \hat{p}_t = -0.63(8.0 - 5.67) = -1.47$  percent per year. So after a year of steady 8 percent rate of unemployment, on average one would expect the inflation rate to fall from 7.5 to 6.03 percent per year. The relatively poor fit of the estimate on which this prediction is based should remind us that particular forecasts may often be wrong and hardly accurate to two decimal places. Many other factors matter, and the result is likely to hold on average and not for each particular year.

Both the estimates based on surveys of expectations and on the past rate of inflation follow the general pattern of a Phillips curve: high unemployment is associated with falling rates of inflation (decelerating prices) and low rates of unemployment with rising rates of inflation (accelerating prices). There are two caveats. First, both

regression lines explain only a small fraction of the variation in prices as measured by  $R^2$ . Second, the estimates of NAIRU and the adjustment parameter are different between the two estimates. What should we make of these caveats?

The low fit shows that supply factors – or other factors not adequately captured by the unemployment rate – are relatively important. The tendency of high demand to accelerate prices and low demand to decelerate them is definitely an enduring fact about the economy, but there are important non-demand factors as well.

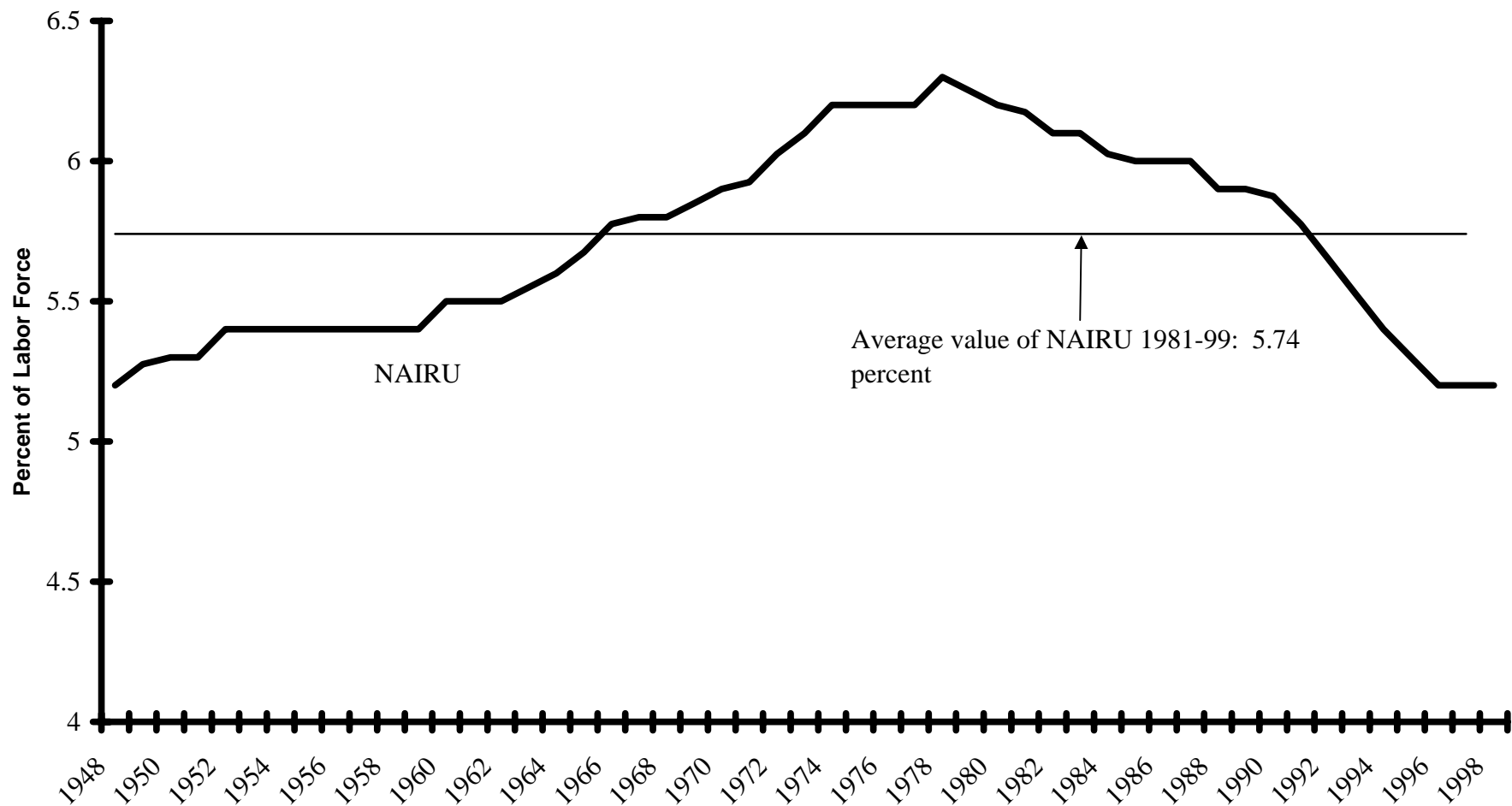
The difference in the estimates is to be expected. We do not know for certain whether the survey data or the past inflation rates provides a more accurate estimate of actual expectations of inflation. Detailed research into the Phillips curve displays a wide variety of estimates of NAIRU. Such uncertainty may arise because the true relationship between demand and inflation may not be linear as the regression line suggests.

Our empirical estimates also implicitly assume that NAIRU is constant during the estimation period. This assumption is not true in general, although it may be approximately true for particular periods. Economists using more sophisticated statistical techniques that allow NAIRU to change every period have estimated a time series.

Figure 16.8 shows one such estimate – prepared by the Congressional Budget Office (CBO). The value of NAIRU changes slowly over time. Nonetheless, the average value for the period 1981-1999 is 5.74 percent – very close to the value estimated for that period (5.67 percent) based on Figure 16.7.

Changing demographics explain much of the change in NAIRU. In particular, variations in the proportions of teenagers in the labor force accounts for much of the rise and fall of NAIRU. Because teenagers typically have a higher unemployment rate than

**Figure 16.8**  
**The Non-accelerating Inflation Rate of Unemployment**  
**for the United States**



Source: Congressional Budget Office.

prime-age employees – whatever the state of the economy – the greater the proportion of teenagers, the higher the unemployment rate that corresponds to a given level of aggregate demand.

### The Phillips Curve and Resource Utilization

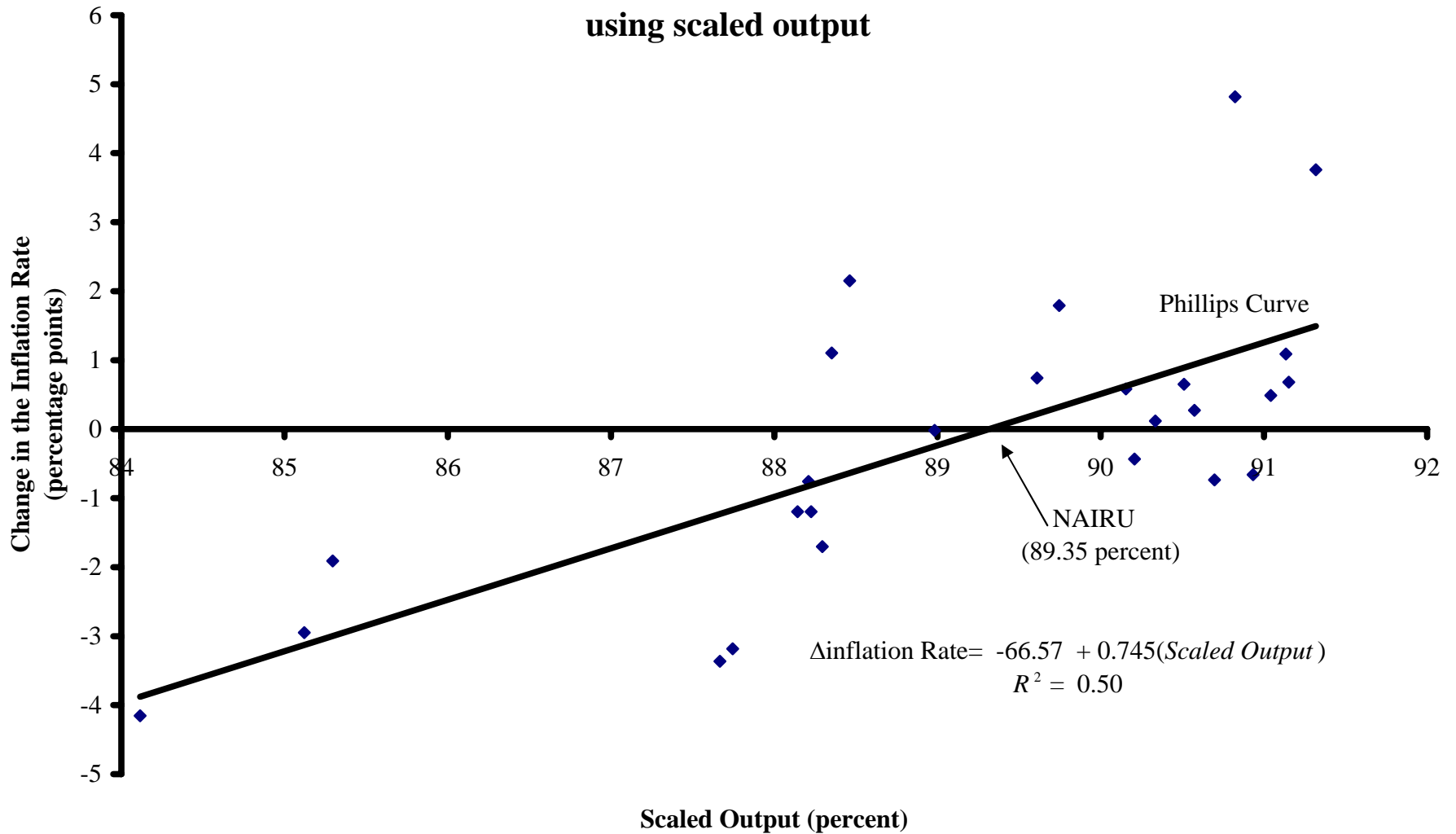
The unemployment rate has traditionally been used as the measure of aggregate-demand factors in the Phillips curve. It is not, however, necessarily the best measure, and another is readily available: *output scaled by potential output* ( $\tilde{Y}$ ).

Figure 16.9 estimates a Phillips curve using scaled output instead of unemployment for the period 1974-98. Because scaled output is a procyclical variable, while the unemployment rate was a countercyclical variable, the Phillips curve slopes up. Translated into the standard Phillips-curve form, its equation is

$$(16.12) \quad \Delta \hat{p}_t = 0.745(\tilde{Y}_t - 89.35)$$

The point at which the Phillips curve crosses the  $\tilde{Y}$ -axis indicates NAIRU – but now we must redefine NAIRU as the *Non-Accelerating Inflation Rate of Resource Utilization* equal to about 89 percent of potential GDP (= 66.567/0.745). The simple Phillips curve relationship fits better using scaled output than using unemployment over the same period: the  $R^2$  for equation (16.12) is 0.50, while that for equation (16.11) was only 0.24.

**Figure 16.9**  
**The Expectations-Augmented Phillips Curve**  
**for the United States, 1981-98**  
**using scaled output**



Sources: Inflation (CPI-U), Bureau of Labor Statistics; scaled output, based on the unemployment rate, Bureau of Labor Statistics, and the capacity utilization rate, Federal Reserve), see text for calculations.

The better fit suggests that scaled output is more informative about inflationary pressures than the unemployment rate alone. Recall that scaled output can be thought of as a geometrically weighted average of the employment rate and the capacity utilization rate (Chapter 6, section 6.5.2, equation (6.25)). Capacity utilization and employment rates tend to move broadly together. Yet, at some points of the cycle they pull in different directions.

Late in the boom, capacity utilization rates are typically below their peaks (see Chapter 6, Figure 6.17) and work to offset some of the inflationary pressure of tight labor markets. Capacity utilization rates typically peak in mid-expansion, because firms invest more heavily to accommodate increased demand. Their plans are not coordinated with those of their competitors; so, it generally happens that they invest more than demand requires. With more capacity than demand, and capacity utilization rates fall. Low rates of utilization are less profitable and firms hold prices down to stimulate demand. Tight labor markets are met by relatively slack use of capital, which moderates – or even offsets – the acceleration in prices.

The fact that the Phillips curve using scaled output better reflects the variety of factors influencing inflation is evident from a comparison of Figure 16.9 with the usual Phillips curve based on unemployment rates (Figure 16.7). Notice that the points at low levels of unemployment are scattered much more widely about the regression line than those at high levels of capacity utilization. As the economy nears the peak of the boom, the Phillips curve using scaled output characterizes its behavior well, while the Phillips curve using unemployment is much less informative.

### NAIRU and Full Employment

Should we think of NAIRU as the equivalent of full employment? Probably not. Recall that the labor market is heterogeneous – a large number of overlapping, but somewhat independent labor markets (Chapter 9). Equally, product markets are themselves heterogeneous. As aggregate demand rises, it will not be spread evenly across all product markets. Certain industries and certain labor skills will have high demand and others somewhat less. As unemployment falls toward its full employment level, some markets will find themselves short of labor sooner than others. They will raise their prices earlier and faster than in markets in which demand is lower and unemployment rates higher. As a result prices accelerate *before* the economy as a whole reaches full employment, and the rate of unemployment consistent with stable prices is likely to *higher* than the rate corresponding to full employment. If the economy stabilizes at NAIRU, then some people will remain involuntarily unemployed; while if it stabilizes at true full employment, then there will inevitably be some (possibly rising) inflation.

This gives us another reason, besides its ideological neutrality, to prefer “NAIRU” to the “natural rate.” The term “natural rate” suggests a kind of equilibrium, so that it is easily, but mistakenly, identified with full employment in the sense of labor supply equaling labor demand.

### 16.3.4 INFLATION AND SUPPLY FACTORS

#### Wage Inflation and Labor Productivity

A profit-maximizing, perfectly competitive firm produces at the point that the real wage equals the marginal product of labor. If a Cobb-Douglas production function describes the firm, this rule is expressed as  $w/p = \alpha\theta$ , where  $\alpha$  is the labor share and  $\theta$  is labor productivity (see Chapter 7, section 7.4.1). Since  $\alpha$  is nearly constant, this can be written in growth rates as  $\hat{w} - \hat{p} = \hat{\theta}$  or as  $\hat{w} = \hat{\theta} + \hat{p}$ . The message of this relationship is that, so long as wages rise no faster than price inflation plus the rate of growth of labor productivity, firms can continue to produce at profit-maximizing rates. At this rate of wage inflation, real wages rise at the rate of labor productivity growth, and firms can afford to accommodate these real wage increases without loss.

What happens if unions or the government act to make wages inflate faster than  $\hat{\theta} + \hat{p}$ ? Firms then face an increase in real **unit labor costs** defined as *the real wage (and other compensation and benefits) per unit of output*. If nothing is done, their profits would fall. A firm whose competitive position permitted it to set prices would pass these costs on to the consumer. Even though perfectly (or even highly) competitive firms cannot pass the costs on directly, since they cannot successfully charge a higher price than their competitors, the losses would cause some firms to leave the market, lowering supply and raising prices.

If firms successfully pass through the increased costs of production in the form of higher prices, then real wages do not rise. Unions that once pushed wages higher might be tempted to try to do so again, trying to establish a real wage higher than firms found

sustainable. And again, firms would try to raise prices to compensate. Such a pattern of competitive inflation was in the 1950s and 1960s frequently discussed under the name **wage-price spiral**. It is less likely to be relevant in a time when unions are relatively weaker.

### Supply Shocks

Increased real wages provide only one example of aggregate-supply factors that might affect inflation. In general, firms might pass on changes in the real prices of any factor of production. Ideally, of course, much of the increased cost would be mitigated through factor substitution – choosing a technological mix better adapted to new relative prices. Such adaptation is unlikely to occur in the short run and, even in the longer run, is not unlimited.

Increases in real factor prices may be permanent or transitory. If they are permanent the technological mix will adapt over time. Even if they are transitory, the effects on prices may last for some time for at least two reasons. First, if the higher inflation gets built into the firms' expectations of future inflation, as the version of the Phillips curve represented by equation (16.6) suggests they will, there will be a sort of ratchet effect raising the underlying inflationary trend. Working against the upward push, however, is the fact that higher prices caused by aggregate-supply shocks will reduce aggregate demand unless nominal incomes rise proportionally. Real output would then fall, and unemployment would rise.

Similarly, to the extent that firms are unable to pass the costs on, they would reduce employment in the face of higher real wage rates. According to the Phillips curve,

higher unemployment rates would moderate the acceleration of prices to some extent. Policymakers might resist the rising unemployment through actions designed to raise aggregate demand. So the second reason that supply shocks might have long lasting effects is that they encourage aggregate-demand-management policies that, in effect, ratify the increase in the inflation rate.

The 1970s provide a possible illustration of the way in which real price increases translated into general inflation. The rising commodity prices in the early years of the decade followed by the oil-price increases following the Yom Kippur War, added to inflation in the United States and induced a recession. Monetary and fiscal policy acted to offset the recession, which to some extent limited the inflation-moderating influence of the higher unemployment.

Macroeconomists and economic historians vigorously debate the causes of the stagflation of the 1970s and 1980s, the possibility that policymakers raised the rate of inflation and slowed down desirable adjustments to higher oil prices by using demand management to combat the decline in output is a real possibility. Japan adopted a less expansionary policy response to the oil price shock – even though it was more dependent on foreign oil than the United States – and displayed a smaller increase of its inflation rate.

### 16.3.5 STAGFLATION AND CREDIBILITY

The expectations-augmented Phillips curve helps us to understand how high levels of inflation are compatible with high levels of unemployment as observed in the 1970s and

early 1980s. Throughout the long expansion of the 1960s demand was high, pushing the unemployment rate below NAIRU. Prices accelerated so that firms came to expect high levels of general price inflation and, therefore, inflated their own prices at similar high rates. Once such an expectation is embedded in the economy, it is hard to dislodge. It may take a concerted effort to reduce aggregate demand (and raise unemployment rates) over a long time to reduce inflation to moderate levels.

The supply shocks of the early 1970s and the subsequent inflation, of course, entrenched expectations of future inflation. There were severe recessions in the 1970s, but these were not enough to reduce inflation and entrenched expectations of inflation back to the levels of the 1950s and 1960s. So, high inflation coexisted with high unemployment – this was the period of *stagflation*. No policymaker was willing to bear the real costs of even higher unemployment and lost output in order to reduce inflation.

The expectations-augmented Phillips curve singles out firms' expectations as a critical factor in the control of inflation. The fact that firms understood the reluctance of policymakers to reduce aggregate demand meant that they were unlikely to revise their expectations of inflation downward. When inflation was finally reduced in the 1980s, the process began with the two severe recessions of 1980-1982. It was made easier by the **CREDIBILITY** of Paul Volcker and Alan Greenspan, the two chairmen of the Federal Reserve System, who were widely seen as single-minded in their determination to use monetary policy to reduce inflation.

When firms believe that policymakers will act successfully to reduce inflation, they revise their expectations downward, and this makes it easier for the policymakers to succeed with a smaller loss to output and unemployment. A reputation as an inflation

fighter is self-fulfilling. Volcker and Greenspan's success is the reverse side of the policy problem of the 1970s. When no one believed that policymakers would truly pay the price for reducing inflation, high inflation was a self-fulfilling prophecy and the costs of reducing it were increased.

## **16.4 Another Look at the Limits of Demand Management**

We will study the details of aggregate-demand management and macroeconomic policy in Chapters 17 and 18. For now, it is enough to recognize that the government (including the Federal Reserve or other central banks) can use the tools of monetary and fiscal policy to affect the level and the growth rate of aggregate demand. Okun's law tells us that higher growth rates of aggregate demand reduce unemployment, so why would the government not exploit Okun's law to eliminate unemployment altogether? Or, to put it differently, what limits might there be on government demand-management policies?

Think about the estimate of Okun's law given in equation (16.5). Imagine that the unemployment rate is 6 percent and the government wants to reduce it to 2 percent. To do so, it engineers a growth rate of aggregate demand of, say, 4.5 percent per year. At this rate, we would expect the unemployment rate to fall at 0.8 percentage points per year ( $= -0.43(4.5 - 2.63)$ ). To fall from 6 percent to 2 percent unemployment would then take 5 years ( $= (6 - 2)/0.8$ ). So, why not do it?

One problem can be easily seen by consulting the Phillips curve. Consider equation (16.11), where NAIRU is estimated to be 5.67 percent. So, inflation is likely to rise once the unemployment rate falls below NAIRU (in the first year of the policy!). By

the end of the fifth year, we would expect the inflation rate to rise by 2.31 percentage points per year ( $= -0.63(2.00 - 5.67)$ ). Continuation of such a policy for a long period of time would result in a very high inflation rate. Not wanting to increase the rate of inflation so much, policymakers are unlikely to persist in the attempt to lower the unemployment rate so far.

The desire of policymakers to avoid deliberately raising the inflation rate too much is not the only limit on the useful effects of an expansionary policy. The 2 percent unemployment rate in the example is below what anyone reasonably believes economically full employment to be. Since workers may choose not to work, once *involuntary* unemployment has been eliminated, the unemployment rate cannot fall further. Except for frictional unemployment, involuntary unemployment is effectively zero at some *measured* rate of unemployment well above 2 percent. There is, then, a limit to the scope of Okun's law.

In the end, real aggregate demand cannot exceed real aggregate supply. How is the attempt to push aggregate demand above aggregate supply thwarted? At least three elements are important.

- First, if policy actions push *nominal* aggregate demand upwards faster than prices are rising, real aggregate demand will rise. But if this results in accelerating prices, the increase in *real* aggregate demand will be moderated.
- Second, if real aggregate demand exceeds production, firms will supply the demand from stocks of goods already produced. Such inventory disinvestment is itself a fall in *ex post* real aggregate demand.

- Finally, if demand cannot be met from domestic production, people will increase imports (and reduce exports). The resulting fall in net exports again reduces real aggregate demand.

## 16.5 Aggregate Supply and Demand: Putting It Together

### 16.5.1 A STEADY STATE

We can summarize what we have learned in this chapter about the interaction of aggregate supply and demand by combining two diagrams: Figure 16.10 stacks the IS curve above the Phillips curve – both expressed as functions of scaled output. The point  $\tilde{Y}_N$  indicates NAIRU. Let the middle, black IS curve represent the initial state of aggregate demand and  $rr_N$ , a long-term real rate of interest that is compatible with NAIRU. This configuration represents a halcyon economy – a steady state:

- the rate of resource utilization (scaled output) is constant because both aggregate demand and aggregate supply are growing at the balanced growth rate

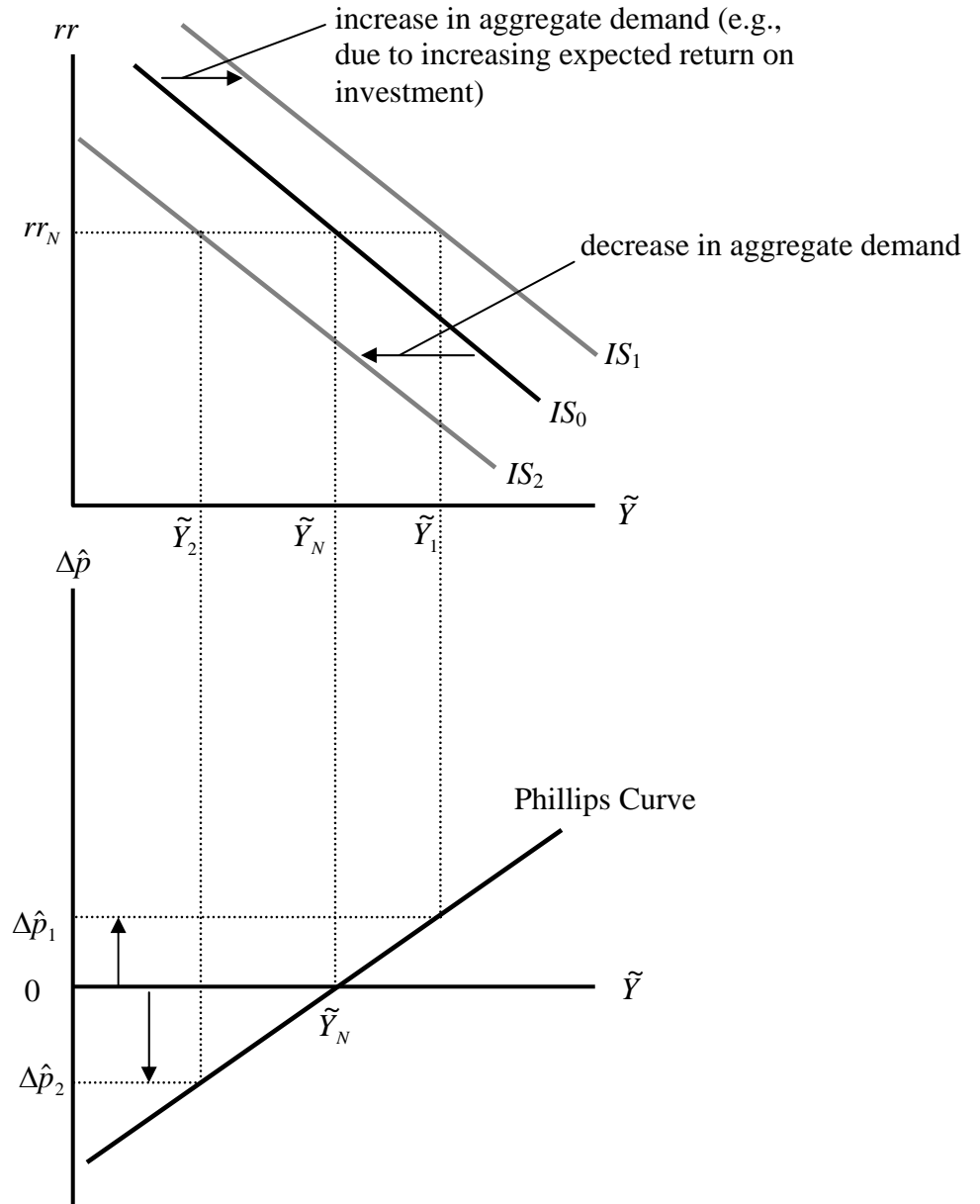
$$(n + \hat{\theta} + \hat{PR});$$

- the unemployment rate is, itself, constant; and
- prices are inflating at a constant rate.

To maintain such a steady state, the economy must be harmonized on three margins:

- first, aggregate demand must equal aggregate supply;
- second, financial and real markets must be compatible – in particular, the long-term real rate of interest must be right; and

**Figure 16.10**  
**The Output and Price Effects of Shifting Aggregate Demand**



*Shifts in aggregate demand (e.g., due to changing expected returns on investment across the business) shift the IS curve back and forth. The level of real interest rates  $rr_N$  holds aggregate demand at NAIRU and the inflation rate steady when the IS curve is  $IS_0$ . Increases in aggregate demand (rightward shifts of IS) ceteris paribus increase rates of resource utilization ( $\tilde{Y}$ ) and accelerate prices ( $\Delta \hat{p}$ ). Decreases in aggregate demand have the opposite effect.*

- third, government policy must be compatible with private sector plans – fiscal policy must not shift the IS curve in either direction; monetary policy (typically operating through short-term interest rates) must not push long-term interest rates up or down.

### 16.5.2 SHIFTS IN AGGREGATE DEMAND

Shifts in aggregate demand or supply will upset the steady state. Let us first look at aggregate demand. Anything that shifts the IS curve, while not disturbing the underlying growth path of potential output is a pure aggregate-demand factor. One such factor that is likely to be important over the course of the business cycle is the rate of return on investment ( $\rho$ ). As we saw in Chapter 12, section 12.3, an increase in  $\rho$  lowers the opportunity cost of investment and shifts the IS curve to the right. One factor that may initiate the recovery from recession is an increase in the return on investment. This is shown in Figure 16.10 as the rightward shift of the IS curve to  $IS_1$ . If financial markets are unaffected (and monetary policy holds steady), the real rate of interest remains constant at  $rr_N$ . Scaled output rises to  $\tilde{Y}_1$ : the unemployment rate will fall and capacity utilization rates will rise. And the inflation rate will increase by  $\Delta\hat{p}_1$  per year. These are, as we have seen in earlier chapters, the typical patterns of the upswing of the business cycle.

As the recovery continues, the best investment opportunities tend to be played out or more than optimal amounts of resources are directed towards them, and the rate of return falls, raising the opportunity cost of further investment. As a result, the IS curve

shifts leftward, perhaps as far as  $IS_2$ . The economy slumps. Scaled output falls to  $\tilde{Y}_2$ : the unemployment rate rises and capacity utilization rates fall. The inflation rate declines by  $\Delta\hat{p}_2$  per year. And, once again, these are the typical patterns of the downswing of the business cycle.

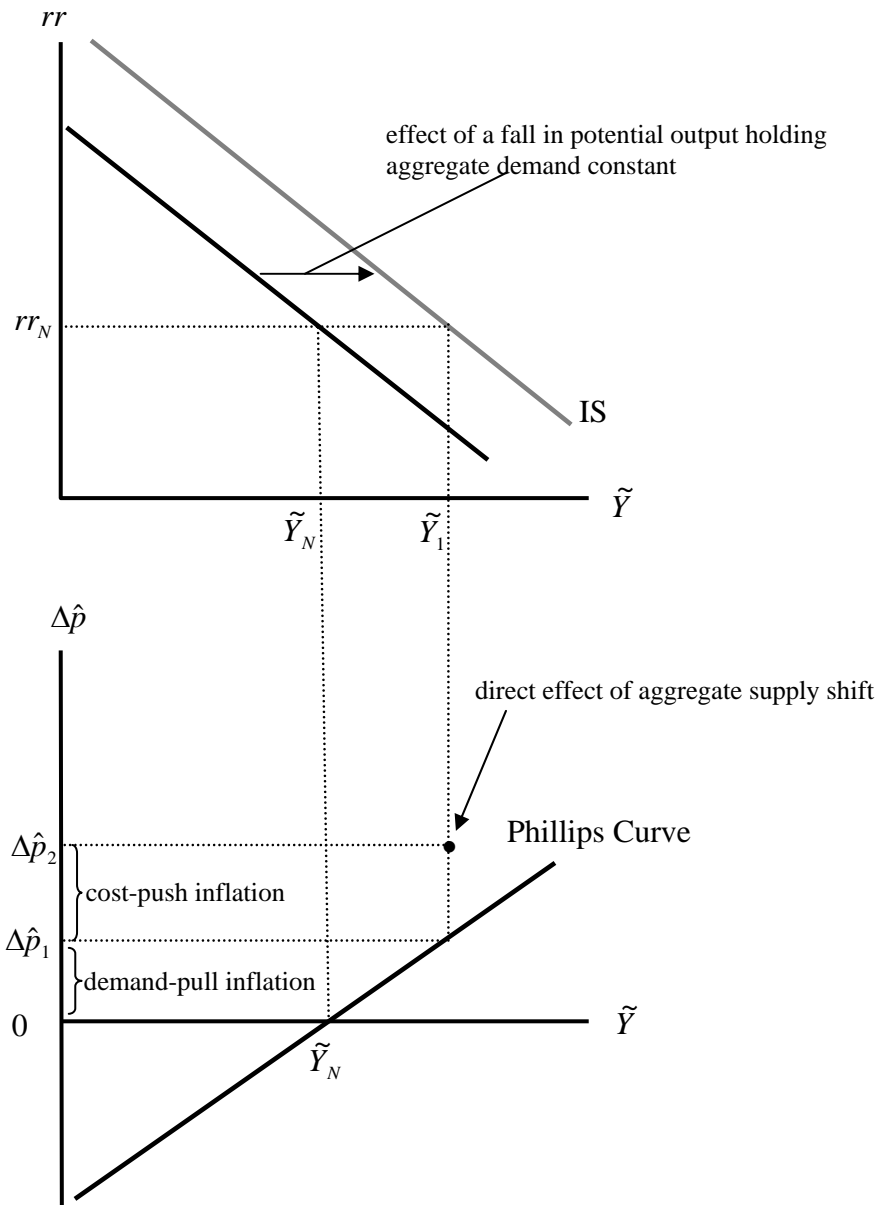
Fluctuations in the rate of return on investment are only one possible cause of business-cycle fluctuations. Anything that shifts the IS curve: cycles in government spending, consumption, or foreign trade; cycles in long-term interest rates – either endemic to financial markets or the result of monetary policy actions – could equal well generate similar patterns.

### 16.5.3 SHIFTS IN AGGREGATE SUPPLY

Supply-shocks affect potential output ( $Y^{Pot}$ ). Since scaled output is defined as  $\tilde{Y} = \frac{Y}{Y^{Pot}}$ , a fall in potential output for the same level of aggregate demand ( $Y$ ) increases scaled output. All other things equal, at the same level of the real interest the IS curve must shift to the right as shown in Figure 16.11 because aggregate demand *relative* to potential output is now higher. The fact that the fall in potential output shifts the IS curve shows that changes in aggregate supply do not typically have only a supply-side effect, but also have an induced effect on aggregate demand.

Notice that, despite the higher level of resource utilization, the induced increase in aggregate demand is not a good thing. At the same level of real interest rates, scaled output is higher, but the full-employment point now corresponds to a lower level of GDP, full-employment real-wage rates must be lower, so that labor supply and the level of full

**Figure 16.11**  
**The Output and Price Effects of Shifting Aggregate Supply**



*A fall in aggregate-supply shock shifts the IS curve rightward as potential output falls in the face of unchanged aggregate demand. Prices accelerate as aggregate demand exceeds NAIRU. There is also a transient direct effect (shown as the points off the Phillips curve) as the price level must rise to reduce the real wage in response to the now lower marginal product of labor.*

employment will fall. Although fewer people are working at NAIRU, the actual NAIRU rate of unemployment may not be any higher. With the old level of aggregate demand, aggregate demand is greater than NAIRU ( $\tilde{Y}_1 > \tilde{Y}_N$ ), so that prices accelerate.

While the resulting rise in prices in cost-push inflation, we can think of the acceleration in prices having two parts. The *direct effect* is any additional increase in the price level that can be attributed to the supply shock itself. So, for example, when oil prices rise, and oil is one of the prices in the major indices, then those indices increase. The direct effect is shown by point A, lying above the Phillips curve. There is also an *indirect effect*: the mismatch of the old level of aggregate demand with the now lower level of aggregate supply leads prices to accelerate by  $\Delta\hat{p}_1$ . The indirect acts exactly like demand-pull inflation except that it burns itself out automatically: as prices rise, the existing nominal aggregate demand corresponds to a lower and lower real aggregate demand until NAIRU is restored. The direct effect ( $\Delta\hat{p}_2 - \Delta\hat{p}_1$ ) is strictly temporary and disappears as soon as real wages have adjusted to the new supply conditions.

## Summary

1. Supply factors alter potential output holding aggregate demand constant; demand factors change aggregate demand relative to potential output.
2. Changes in aggregate supply generally result in a change in relative prices (particularly of the general price level relative to the wage rate) even at full employment. Shortfalls in aggregate demand lead to unemployment (or workers and other resources) with or

without price changes; while increases in aggregate demand above potential output lead to inflation.

3. Changes in the general price level that result from the relative price adjustments due to supply factors are known as *cost-push inflation*; changes due to demand factors are known as *demand-pull inflation*. Cost-push inflation is strictly transitory. Demand-pull inflation can continue, so long as pressure exists pushing aggregate demand above potential output.

4. The unemployment rate rises whenever the growth rate of the labor force exceeds the growth rate of employment. This situation will occur whenever the growth rate of aggregate demand falls short of the *modified balance growth rate* defined as

$\hat{Y}^* \equiv \hat{P}R + \hat{P}OP + \hat{\theta}$ . This is the balance growth rate adjusted for changes in participation rates. The relationship between changes in the unemployment rate and the growth rate of aggregate demand is known as *Okun's Law*.

5. An Okun's-law-like relationship also exists between output scaled by potential output ( $\tilde{Y}$ ) and the growth rate of aggregate demand. Empirical estimates of  $\hat{Y}^*$  are similar whether based on changes in the unemployment rate or changes in scaled output.

6. Price-setting firms choose optimal prices relative to the general price level. In order to achieve the desired relative price, they must set prices in anticipation of future inflation. Their relative prices are likely to be modified to take account of cost pressures (supply) or demand pressures.

7. The (expectations-augmented) Phillips curve aggregates the price-setting behavior of firms to find a relationship between inflation, relative to expected inflation, and a

measure of aggregate demand (aggregate-supply factors may also be considered).

Aggregate demand (relative to aggregate supply) is often measured by the unemployment rate. The Phillips curve may be written as:

$$\hat{p}_t - {}_{t-1}\hat{p}_t^e = -\beta(U_t - U^*) + g(\text{aggregate-supply factors}_t),$$

where  $U^*$  is the *natural rate of unemployment*, defined as the rate that keeps actual and expected inflation in agreement.

8. Expectations are frequently measured on the assumption that this period's inflation rate will be the same as last period's. Then the Phillips curve may be written as:

$$\Delta \hat{p}_t = -\beta(U_t - U^*) + g(\text{aggregate supply}_t).$$

In this version,  $U^*$  is frequently referred to as *NAIRU*, the non-accelerating inflation rate of unemployment.

9. Other measures of aggregate demand relative to supply can be used in the Phillips curve, such as scaled output. Then *NAIRU* would be interpreted to mean non-accelerating inflation rate of resource utilization.
10. *NAIRU* (or the natural rate of unemployment) are not constant over time, but may vary with changes in real factors, such as demographics or the organization of labor markets.
11. The role of expectations in the Phillips curve highlights the importance of credibility in demand-management policy: reducing inflation is less costly in terms of unemployment or other unused resources if the public believes that policymakers will actually be successful in reducing it.

12. While Okun's law suggests that a growth in aggregate demand can reduce unemployment any amount over enough time, in fact full employment (labor supply equals labor demand) sets a limit. Any attempt to breach the full employment level results in rising prices, reducing real aggregate demand for a constant nominal level, falling inventories and falling net exports, both reducing real aggregate demand.

### Key Concepts

potential output  
scaled output  
supply factors  
substitutes in production  
complements in production  
cost-push inflation  
demand factors  
demand-pull inflation

modified balanced rate of growth  
Okun's Law  
Phillips curve  
natural rate of unemployment  
non-accelerating inflation rate of unemployment (NAIRU)  
credibility

### Suggestions for Further Reading

James Tobin, "Okun's Law: How Policy and Research Helped Each Other," in *Full Employment and Growth: Further Keynesian Essays on Policy*. Cheltenham, U.K.: Edward Elgar, 1996; pp. 56-65.

A. W. H. Phillips, "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957." *Economica* NS 25, no. 2 (1958): 283-99.

Milton Friedman, "The Role of Monetary Policy." *American Economic Review* 58, no. 1 (1968): 1-17.

"Symposium: The Natural Rate of Unemployment," [with contributions by various authors] in *Journal of Economic Perspectives* 11, no. 1 (1997): 3-108.

Kevin D. Hoover, "The Phillips Curve," in David R. Henderson, editor. *The Concise Encyclopedia of Economics*. Indianapolis, IN: Liberty Press.

## Problems

Data for this exercise are available on the course website under the link for Chapter 16 (**insert web link here**). Before starting these exercises, the student should review the relevant portions of the *Guide to Working with Economic Data*: section G.15.

**Problem 16.1.** Imagine the unfortunate event of a new plague that kills a quarter of the population of a country (some people fear that AIDs may prove to be such a plague in some countries). Use labor supply/labor demand analysis to determine what the effects of such a misfortune would be on real wages, employment, and real GDP.

**Problem 16.2.** Think of some concrete examples of cases in which particular economic developments lower the economic stock of capital while leaving the physical stock of capital intact.

**Problem 16.3.** The growth rates of labor productivity and participation rates are important elements in determining the modified natural rate of growth ( $\hat{Y}^*$ ). How they change over time will determine how  $\hat{Y}^*$  changes. Based on your understanding of the history of labor productivity and of participation rates (Chapters 6 and 8 and some of their problems are relevant) choose some dates (not too many or too close together or else there will not be enough data points to estimate a useful regression) that are likely to divide the post-World War II data into subperiods with different values for  $\hat{Y}^*$ . Explain your choices. Following the example of Figure 16.4, make a scatterplot for each of these subperiods. Fit a regression line to each scatterplot and calculate  $\hat{Y}^*$ . Do your estimates change in the way you anticipated?

**Problem 16.4.** Calculate the average growth rates for the labor productivity, participation rates and working-age population and use them to calculate  $\hat{Y}^*$  for each of the periods identified in Problem 16.3. How close do these estimates come to estimates based on the regression of changes in unemployment on growth rates?

**Problem 16.5.** It has been argued that labor productivity has risen substantially in the late 1990s. Either using a scatterplot and regression line (as in Problem 16.3) or using the underlying growth rates (as in Problem 16.4) use the U.S. data after 1992 to estimate  $\hat{Y}^*$ . Has the “speed limit” been raised? By how much? Is there any reason to believe your estimates might systematically over or underestimate the true modified balance growth path? (Hint: think about how labor productivity behaves over the business cycle and where in the business cycle your data come from.)

**Problem 16.6.** Reestimate Okun’s law for each of the subperiods identified in Problem 16.3 using the change in scaled output in the place of the change in unemployment. Put each equation into standard form. Compare your estimates to those in Problem 16.3. In particular, how do your estimates of the modified natural rate of growth differ from the earlier estimates?

**Problem 16.7.** Using data for each of the G-7 countries 1985-2004, estimate Okun's law and  $\hat{Y}^*$ . How does it compare to  $\hat{Y}^*$  for the United States? What factors account for the difference? Suggest what further investigations that you might undertake to test your conjectures.

**Problem 16.8.** Assume that equation (16.5) is the true Okun's law for the U.S. economy today. Locate data on GDP and unemployment rates for the past two years. Based on your data, what does Okun's law predict should have happened to the unemployment rate over the past year? What has in fact happened? Discuss any disparity.

**Problem 16.9.** To get some idea of how well surveys compare to using past inflation rates to estimate expected inflation:

- (a) Plot the data for the Survey of Professional Forecasters used in Figure 16.6 on the same graph with the inflation rate lagged one year (used in Figure 16.7) and the current inflation rate.
- (b) Form a quantitative measure of the inaccuracy by creating two new series: from each expectations series subtract the current rate of inflation. What is the standard deviation of each of the new series? Which series is most accurate on this measure? By how much? Plot these two series on a separate chart.
- (c) Based on your charts and calculations: Which of the expectations series predicts current inflation best? Do either or both systematically underpredict or overpredict for any relatively long period? If so, can you speculate on why this might occur? (For example, is it likely to be the measurements do not capture people's true expectations or is it likely that people make systematic errors? And, if they make systematic errors, is there any pattern their mistakes?)

**Problem 16.10.** Estimate Phillips curves for the United States like that in Figure 16.7 for the periods 1948-1970, 1971-1986, and 1987-present. Write the equation for each in standard form. Compare your estimates of NAIRU to those of the CBO in Figure 16.8. How well do they agree?

**Problem 16.11.** Reestimate the Phillips curve using scaled output instead of unemployment for each of the subperiods identified in equation Problem 16.10. Write each equation in standard form. Compare them to the estimates using unemployment for each period. What are your estimates of the nonaccelerating inflation rates of scaled output? Are they more or less stable than your estimates of NAIRU?

**Problem 16.12.** To get some idea of why NAIRU might shift over time make two charts. On the first plot the percentage share of prime-age men, women, and teenagers in the labor force for the United States. On the other plot the unemployment rates for prime-age men, women and teenagers and the CBO's estimate of NAIRU. Calculate and report in a table the average values of each of each of these seven series for each of the subperiods in Problem 16.10. Based on these data why do you think NAIRU shifts over time? Relate your reasons carefully to the data.

**Problem 16.13.** Some researchers have suggested that one way to account for changing demographics in the Phillips curve is to use the unemployment rate for a

demographically homogeneous group of workers. Estimate the Phillips curve (1981-98) and write in standard form using the unemployment rate for prime-age male workers as the measure of demand. What is NAIRU for prime-age male workers? Find the most recently available annual unemployment rate and use it to estimate the change in the inflation rate using your equation. Compare this estimate to one made using equation (16.7). How close are these estimates? Which is more accurate?

**Problem 16.14.** We know from Chapter 4 that the food and energy prices are a highly volatile component of the CPI. Since both are more subject to supply shocks than many other consumer goods, the CPI may not be the most informative measure of inflation resulting from demand pressures. Estimate the Phillips curve using both the usual CPI and the “core” CPI – that is the CPI exclusive of food and energy prices – for the period 1981-present and write them in standard form. Which Phillips curve appears to better explain changing rates of inflation? How does the estimate of NAIRU for all workers compare to the estimate of NAIRU for prime-age male workers?

**Problem 16.15.** The CPI is tailored to consumer expenditure and may not be the best measure of inflation overall. To see how a broader measure would affect the analysis of inflation, estimate a Phillips curve using the GDP deflator in place of the CPI for the period 1981-present and write it in standard form. How does your estimate compare to the one using the CPI in Problem 16.13. In particular, is there any significant difference in the estimate of NAIRU? Comment on the reasons for any significant differences.

**Problem 16.16.** Using CPI and unemployment data estimate a Phillips curve for each of the G-7 countries for the period 1985-present. How does NAIRU compare among these countries? What factors might account for the differences?

**Problem 16.17.** Divide the period 1985-present into two subperiods. Using CPI and unemployment data estimate a Phillips curve for each of the G-7 countries for each period. How does NAIRU change in each country? What factors might account for the differences? How would you test your conjecture?

**Problem 16.18.** In the U.S. recession of 2001, GDP never actually fell. Using actual unemployment and inflation data, taking 1999 as your starting point. Use the estimates of the Okun’s law given in equation (16.5) and the Phillips curve in equation (16.11) compute the implied unemployment rates and inflation rates. Explain your calculations. Compare these to the actual unemployment and inflation rates. How good were your estimates? What light do they shed on the phenomenon of the *growth recession*.

**Problem 16.19.** Repeat Problem 16.17 using scaled output rather than unemployment in both Okun’s law (equation (16.6)) and the Phillips curve (equation (16.12)). Compare your estimates to those in Problem 16.17 and to the actual scaled output and inflation rates. Which set of equations does a better job at matching the actual data?