Inflation, Activity, and Nominal Money Growth

CHAPTER 9

At the end of the 1970s, inflation in the United States reached 14% per year. In October 1979, the Fed decided to reduce inflation and, to do so, embarked on a major monetary contraction. Five years later, and after the deepest recession of the postwar period, inflation was down to 4% per year. It has remained under 4% since.

Why did the Fed decide to reduce inflation? How did it do it? Why was there a recession? More generally, what are the effects of nominal money growth on inflation and output? Our treatment of expectations in Chapter 7 was too simple to allow us to take up these questions. But, with our discussion of expectations and the introduction of the Phillips curve relation in Chapter 8, we now have the tools we need to answer them. This is what we do in this chapter:

- Section 9-1 extends the model of Chapter 7 and looks at the three relations between output, unemployment, and inflation: Okun's law, the Phillips curve, and the aggregate demand relation.

- Section 9-2 looks at the effects of money growth on output, unemployment, and inflation, in both the short and the medium run.

- Section 9-3 revisits disinflation, looking at the trade-off between unemployment and inflation and looking at how credibility of the central bank affects the adjustment of the economy to a decrease in nominal money growth. ■

9-1 Output, Unemployment, and Inflation

In Chapter 7, we examined the behavior of two variables: output and the price level. We characterized the economy by two relations: an aggregate supply relation and an aggregate demand relation. In this chapter, we extend the model of Chapter 7 to examine three variables: output, unemployment, and inflation. We characterize the economy by three relations:

- A relation between *output growth* and the *change in unemployment*, called Okun's law.
- A relation between *unemployment, inflation*, and *expected inflation*. This is the Phillips curve relation we developed in Chapter 8.
- An aggregate demand relation between *output growth, money growth*, and *inflation*. This relation follows from the aggregate demand relation we derived in Chapter 7.

In this section, we look at each of these relations on its own. In Section 9-2, we put them together and show their implications for movements in output, unemployment, and inflation.

Okun's Law

We discussed the relation between output and unemployment in Chapter 6. We did so, however, under two convenient but restrictive assumptions. We assumed that output moved one-for-one with employment, so changes in output led to equal changes in employment. We also assumed that the labor force was constant, so changes in employment were reflected one-for-one in opposite changes in unemployment.

We assumed that $Y = N$ was that L (the labor force) was constant.

We must now move beyond these assumptions. To see why, let's see what they imply for the relation between the rate of output growth and the unemployment rate. If output and employment moved together, a 1% increase in output would lead to a 1% increase in employment. And if movements in employment were reflected in opposite movements in unemployment, the 1% increase in employment would lead to a decrease of 1% in the unemployment rate. Let u_t denote the unemployment rate in year t, u_{t-1} the unemployment rate in year $t - 1$, and g_{yt} the growth rate of output from year $t - 1$ to year t. Then, under these two assumptions, the following relation would hold:

$$u_t - u_{t-1} = -g_{yt} \tag{9.1}$$

In words: The change in the unemployment rate would be equal to the negative of the growth rate of output. If output growth is, say, 4% for a year, then the unemployment rate should decline by 4% in that year.

Contrast this with the actual relation between output growth and the change in the unemployment rate, a relation called **Okun's law**. Figure 9-1 plots the change in the unemployment rate against the rate of output growth for each year since 1970. It also plots the regression line that best fits the scatter of points. The equation corresponding to the line is given by

The relation is named after Arthur Okun, an economist and an adviser to President Kennedy, who first characterized and interpreted this relation.

$$u_t - u_{t-1} = -0.4(g_{yt} - 3\%) \tag{9.2}$$

Like equation (9.1), equation (9.2) shows a negative relation between the change in unemployment and output growth. But it differs from equation (9.1) in two ways:

If $g_{yt} > 3\%$, then $u_t < u_{t-1}$
If $g_{yt} < 3\%$, then $u_t > u_{t-1}$
If $g_{yt} = 3\%$, then $u_t = u_{t-1}$

- Annual output growth has to be at least 3% to prevent the unemployment rate from rising. This is because of two factors we have neglected so far: labor force growth and labor productivity growth.

  To maintain a constant unemployment rate, employment must grow at the same rate as the labor force. Suppose the labor force grows at 1.7% per year; then

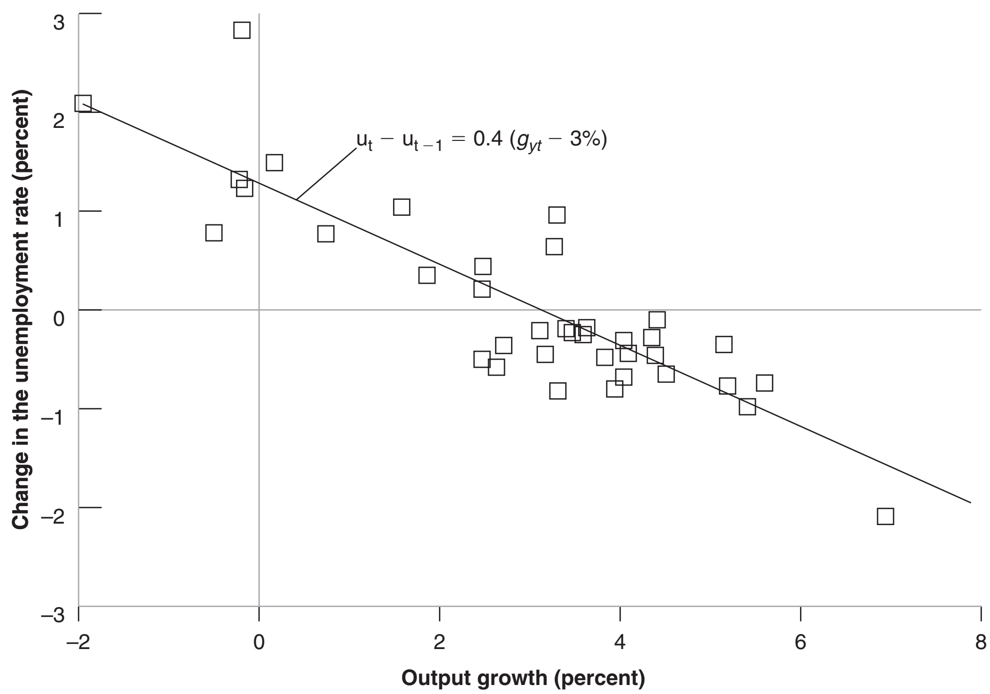

Figure 9-1

Changes in the Unemployment Rate versus Output Growth in the United States since 1970

High output growth is associated with a reduction in the unemployment rate; low output growth is associated with an increase in the unemployment rate.

employment must grow at 1.7% per year. If, in addition, labor productivity—output per worker—grows at 1.3% per year, this implies that output must grow at 1.7% + 1.3% = 3% per year. In other words, just to maintain a constant unemployment rate, output growth must be equal to the sum of labor force growth and labor productivity growth.

In the United States, the sum of the rate of labor force growth and of labor productivity growth has been roughly equal to 3% per year on average since 1960, and this is why the number 3% appears on the right side of equation (9.2). I shall call the rate of output growth needed to maintain a constant unemployment rate the **normal growth rate** in the following text.

Suppose productivity growth increases from 1.3% to 2.3%. What is now the growth rate of output required to maintain a constant unemployment rate? More on this when we discuss the U.S. "jobless recovery" of 2002 to 2004 in Chapter 13.

- The coefficient on the right side of equation (9.2) is −0.4, compared to −1.0 in equation (9.1). Put another way, output growth 1% above normal leads only to a 0.4% reduction in the unemployment rate in equation (9.2) rather than a 1% reduction in equation (9.1). There are two reasons:

1. Firms adjust employment less than one-for-one in response to deviations of output growth from normal. More specifically, output growth 1% above normal for one year leads to only a 0.6% increase in the employment rate.

Employment responds less than one-for-one to movements in output.

One reason is that some workers are needed, no matter what the level of output. The accounting department of a firm, for example, needs roughly the same number of employees whether the firm is selling more or less than normal.

Another reason is that training new employees is costly; for this reason, firms prefer to keep current employees rather than lay them off when output is lower than normal and to ask them to work overtime rather than hire new employees when output is higher than normal. In bad times, firms in effect hoard labor—the labor they will need when times are better; this behavior of firms is therefore called **labor hoarding**.

2. An increase in the employment rate does not lead to a one-for-one decrease in the unemployment rate. More specifically, a 0.6% increase in the employment rate leads to only a 0.4% decrease in the unemployment rate. The reason is that

Employment responds less than one-for-one to movements in output.

labor force participation increases. When employment increases, not all the new jobs are filled by the unemployed. Some of the jobs go to people who were classified as *out of the labor force*, meaning they were not actively looking for jobs. Also, as labor market prospects improve for the unemployed, some discouraged workers—who were previously classified as out of the labor force—decide to start actively looking for jobs and become classified as unemployed. For both reasons, unemployment decreases less than employment increases.

Putting the two steps together: Unemployment responds less than one-for-one to movements in employment, which itself responds less than one-for-one to movements in output.

Let's write equation (9.2) using letters rather than numbers. Let $\bar{g}_y$ denote the normal growth rate (about 3% per year for the United States). Let the coefficient β (the Greek lowercase beta) measure the effect of output growth above normal on the change in the unemployment rate. As you saw in equation (9.2), in the United States, β equals 0.4. The evidence for other countries is given in the Focus box "Okun's Law across Countries." We can then write:

$$u_t - u_{t-1} = -\beta(g_{yt} - \bar{g}_y) \qquad (9.3)$$

Output growth above normal leads to a decrease in the unemployment rate; output growth below normal leads to an increase in the unemployment rate.

Okun's law:
$g_{yt} > \bar{g}_y \Rightarrow u_t < u_{t-1}$
$g_{yt} < \bar{g}_y \Rightarrow u_t > u_{t-1}$

The Phillips Curve

We saw in Chapter 8 that the aggregate supply relation can be expressed as a relation between inflation, expected inflation, and unemployment [equation (8.7)], the *Phillips curve*:

$$\pi_t = \pi_t^e - \alpha(u_t - u_n) \qquad (9.4)$$

Inflation depends on expected inflation and on the deviation of unemployment from the natural rate of unemployment.

We then argued that in the United States today, expected inflation is well approximated by last year's inflation. This means we can replace π_t^e with π_{t-1}. With this assumption, the relation between inflation and unemployment takes the form

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n) \qquad (9.5)$$

Unemployment below the natural rate leads to an increase in inflation; unemployment above the natural rate leads to a decrease in inflation. The parameter α gives the effect of unemployment on the change in inflation. We saw in Chapter 8 that, since 1970 in the United States, the natural unemployment rate has been on average equal to 6%, and α has been equal to 0.73. This value of α means that an unemployment rate of 1% above the natural rate for one year leads to a decrease in the inflation rate of about 0.73%.

Phillips curve:
$u_t < u_n \Rightarrow \pi_t > \pi_{t-1}$
$u_t > u_n \Rightarrow \pi_t < \pi_{t-1}$

The Aggregate Demand Relation

The third relation we will need is a relation between output growth, money growth, and inflation. We will now see that it follows from the aggregate demand relation we derived in Chapter 7.

In Chapter 7, we derived the aggregate demand relation as a relation between the level of output and the real money stock, government spending, and taxes [equation (7.3)], based on equilibrium in both goods and financial markets:

$$Y_t = Y\left(\frac{M_t}{P_t}, G_t, T_t\right)$$

Note that I have added time indexes, which we did not need in Chapter 7 but will need in this chapter. To simplify things, we will make two further assumptions here.

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Okun's Law across Countries

The coefficient β in Okun's law gives the effect on the unemployment rate of deviations of output growth from normal. A value of β of 0.4 tells us that output growth 1% above the normal growth rate for one year decreases the unemployment rate by 0.4%.

The coefficient β depends in part on how firms adjust their employment in response to fluctuations in their production. This adjustment of employment depends in turn on such factors as the internal organization of firms and the legal and social constraints on hiring and firing. As these differ across countries, we would therefore expect the coefficient β to differ across countries, and indeed it does. Table 1 gives the estimated coefficient β for a number of countries.

The first column gives estimates of β based on data from 1960 to 1980. The United States has the highest coefficient, 0.39, followed by Germany, 0.20; the United Kingdom, 0.15; and Japan, 0.02.

The ranking in the 1960 to 1980 column fits well with what we know about the behavior of firms and the structure of firing/hiring regulations across countries. Japanese firms have traditionally offered a high degree of job security to their workers, so variations in Japan's output have little effect on employment and, by implication, little effect on unemployment. So it is no surprise that β is smallest in Japan. It is no surprise either that β is largest in the United States, where there are few social and legal constraints on firms' adjustment of employment. A high degree of employment protection (see Chapter 8) explains why the coefficients estimated for the two European countries are in between those of Japan and the United States.

The last column gives estimates based on data from 1981 to 2006. The coefficient is nearly unchanged for the United States, but it becomes higher for the other three countries. This again fits with what we know about firms and regulations. Increased competition in goods markets since the early 1980s has led firms in these countries to reconsider and reduce their commitment to job security. And, at the urging of firms, legal restrictions on hiring and firing have been weakened in many countries. Both factors have led to a larger response of employment to fluctuations in output, thus to a larger value of β.

Table 1 Okun's Law Coefficients across Countries and Time

Country	1960 to 1980	1981 to 2006
United States	0.39	0.42
Germany	0.20	0.29
United Kingdom	0.15	0.51
Japan	0.02	0.11

First, to focus on the relation between the real money stock and output, we will ignore changes in factors other than real money here and write the aggregate demand relation simply as

$$Y_t = Y\left(\frac{M_t}{P_t}\right)$$

Second, we shall assume a linear relation between real money balances and output and rewrite the aggregate demand relation further as

$$Y_t = \gamma \frac{M_t}{P_t} \qquad (9.6)$$

where γ (the Greek lowercase gamma) is a positive parameter. This equation states that the demand for goods, and thus output, is proportional to the real money stock. You should keep in mind, however, that behind this simple relation hides the mechanism you saw in the *IS–LM* model:

- An increase in the real money stock leads to a decrease in the interest rate.
- The decrease in the interest rate leads to an increase in the demand for goods and, therefore, to an increase in output.

If a variable is the ratio of two variables, its growth rate is equal to the difference between the growth rates of these two variables. (See Proposition 8 in Appendix 2 at the end of the book.) So if $Y = \gamma M/P$ and γ is constant, $g_y = g_m - \pi$.

Equation (9.6) gives a relation between *levels*—the output level, the level of money, and the price level. We need to go from this relation to a relation between *growth rates*—the growth rate of output, the growth rate of money, and the inflation rate (the growth rate of the price level). Fortunately, this is easy:

Let g_{yt} be the growth rate of output. Let π_t be the growth rate of the price level—the rate of inflation—and g_{mt} be the growth rate of nominal money. Then, from equation (9.6), it follows that

$$g_{yt} = g_{mt} - \pi_t \tag{9.7}$$

Aggregate demand relation:
$g_{mt} > \pi_t \Rightarrow g_{yt} > 0$
$g_{mt} < \pi_t \Rightarrow g_{yt} < 0$

If nominal money growth exceeds inflation, real money growth is positive, and so is output growth. If nominal money growth is less than inflation, real money growth is negative, and so is output growth. In other words, given inflation, expansionary monetary policy (high nominal money growth) leads to high output growth; contractionary monetary policy (low nominal money growth) leads to low, possibly negative, output growth.

9-2 The Effects of Money Growth

Let's collect the three relations between inflation, unemployment, and output growth we have just derived:

- Okun's law relates the change in the unemployment rate to the deviation of output growth from normal [equation (9.3)]:

$$u_t - u_{t-1} = -\beta(g_{yt} - \bar{g}_y)$$

- The Phillips curve—equivalently the aggregate supply relation—relates the change in inflation to the deviation of the unemployment rate from the natural rate [equation (9.5)]:

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$$

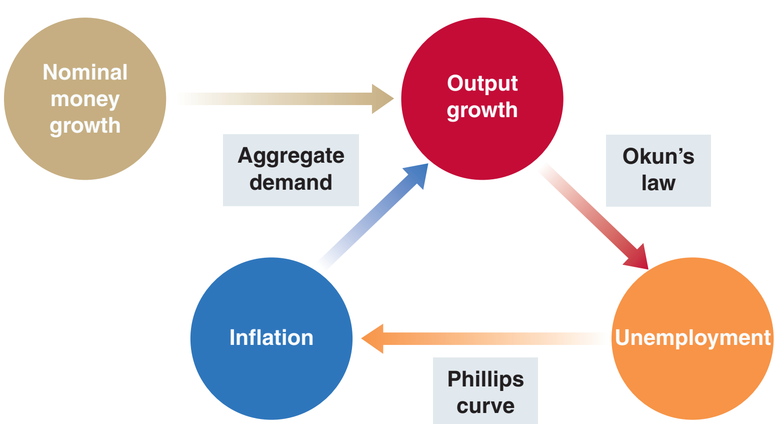
- The aggregate demand relation relates output growth to the difference between nominal money growth and inflation [equation (9.7)]:

$$g_{yt} = g_{mt} - \pi_t$$

These three relations are shown in Figure 9-2. Start on the left and follow the arrows. Through aggregate demand, nominal money growth and inflation determine output

Figure 9-2

Output Growth, Unemployment, Inflation, and Nominal Money Growth



growth. Through Okun's law, output growth determines the change in unemployment. And through the Phillips curve relation, unemployment determines the change in inflation.

Our task now is to see what these three relations imply for the effects of nominal money growth on output, unemployment, and inflation. The easiest way to proceed is to work backward in time—that is, to start by looking at the medium run (by looking at where the economy ends up when all the dynamics have worked themselves out) and then to turn to the dynamics themselves (that is, to see how the economy gets there).

The Medium Run

Assume that the central bank maintains a constant growth rate of nominal money, call it $\bar{g}_m$. In this case, what will be the values of output growth, unemployment, and inflation in the *medium run?*

- In the medium run, the unemployment rate must be constant: The unemployment rate cannot increase or decrease forever. Putting $u_t = u_{t-1}$ in Okun's law implies that $g_{yt} = \bar{g}_y$. In the medium run, output must grow at its normal rate of growth, $\bar{g}_y$.

Medium run: $g_y = \bar{g}_y$

- With nominal money growth equal to $\bar{g}_m$ and output growth equal to $\bar{g}_y$, the aggregate demand relation implies that inflation is constant and satisfies

$$\bar{g}_y = \bar{g}_m - \pi$$

Moving π to the left and $\bar{g}_y$ to the right gives an expression for inflation:

$$\pi = \bar{g}_m - \bar{g}_y \qquad (9.8)$$

In the medium run, inflation must be equal to nominal money growth minus normal output growth. If we define **adjusted nominal money growth** as equal to nominal money growth minus normal output growth, equation (9.8) can be stated as: *In the medium run, inflation equals adjusted nominal money growth.*

Medium run: $\pi = \bar{g}_m - \bar{g}_y$

The way to think about this result is as follows: A growing level of output implies a growing level of transactions and thus a growing demand for real money. So, if output is growing at 3%, the real money stock must also grow at 3% per year. If the nominal money stock grows at a rate different from 3% per year, the difference must show up in inflation (or deflation). For example, if nominal money growth is 8% per year, then inflation must be equal to 5% per year.

- If inflation is constant, then inflation this year is equal to inflation last year: $\pi_t = \pi_{t-1}$. Putting $\pi_t = \pi_{t-1}$ in the Phillips curve implies that $u_t = u_n$. *In the medium run, the unemployment rate must be equal to the natural rate of unemployment.*

Medium run: $u = u_n$

Let's summarize: In the medium run, output growth is equal to the normal growth rate. Unemployment is equal to the natural rate. And both are independent of nominal money growth. Nominal money growth affects only inflation.

These results are the natural extension of the results we derived in Chapter 7. There, we saw that *changes in the level of nominal money* were neutral in the medium run: They had no effect on either output or unemployment but were reflected one-for-one in changes in the price level. We see here that a similar neutrality result applies to *changes in the growth rate of nominal money*: Changes in nominal money growth have no effect on output or unemployment in the medium run but are reflected one-for-one in changes in the rate of inflation.

Another way to state this last result is that the only determinant of inflation in the medium run is nominal money growth. Milton Friedman put it this way: *Inflation is always and everywhere a monetary phenomenon.* Unless they lead to higher nominal money growth, factors such as the monopoly power of firms, strong unions, strikes, fiscal deficits, the price of oil, and so on, have no effect on inflation *in the medium run.*

The word *unless* is important. During episodes of very high inflation (see Chapter 23), fiscal deficits often lead to nominal money creation and to higher nominal money growth.

The Short Run

Let's now turn to dynamics. Suppose that the economy is initially at its medium-run equilibrium: Unemployment is equal to the natural rate. Output growth is equal to the normal growth rate. The inflation rate is equal to adjusted nominal money growth.

Suppose that the central bank decides to decrease nominal money growth. We saw earlier that, in the medium run, lower money growth will lead to lower inflation and unchanged output growth and unemployment. The question now is: What will happen in the short run?

Just by looking at our three relations, we can tell the beginning of the story:

- Look at the the aggregate demand relation—Given the initial rate of inflation, lower nominal money growth leads to lower real nominal money growth and thus to a decrease in output growth.
- Now, look at Okun's law—Output growth below normal leads to an increase in unemployment.
- Now, look at the Phillips curve relation—Unemployment above the natural rate leads to a decrease in inflation.

Lower $g_m \Rightarrow$ *Lower* $g_m - \pi$ $\Rightarrow$ *Lower* g_y

Lower $g_y \Rightarrow$ *Higher* u

Higher $u \Rightarrow$ *Lower* π

So we have our first result: Tighter monetary policy leads initially to lower output growth and lower inflation. If tight enough, it may lead to negative output growth and thus to a recesssion. What happens between this initial response and the medium run (when unemployment returns to the natural rate)? The answer depends on the path of monetary policy, and the best way to show what happens is to work out a simple example.

Suppose the economy starts in year 0 in medium-run equilibrium. Assume that normal output growth is 3%, the natural unemployment rate is 6%, and nominal money growth is 8%. Inflation is therefore equal to nominal money growth minus output growth, 8% − 3% = 5%. Real money growth is equal to nominal money growth minus inflation, 8% − 5% = 3%.

Suppose that the central bank decides to tighten monetary policy in the following way: It decides to decrease real money growth relative to trend by 2.5% in year 1 and to increase it relative to trend by 2.5% in year 2. (Why 2.5%? To make the arithmetic simple, as will be clear later on.) The path of the relevant macroeconomic variables is given in Table 9-1:

It would be more natural to describe monetary policy in terms of what happens to nominal money growth. The algebra would get more complicated, however. For our purposes, it is easier to describe it in terms of what happens to real money growth. We can do so without loss of generality: Given the inflation rate, the central bank can always choose nominal money growth to achieve the real money growth it wants.

- Line 1 shows the path of real money growth. In year 0 (before the change in policy), real money growth is equal to 3%. Under the assumptions we have just made, the change in monetary policy leads to real money growth of 0.5% (2.5% below normal) in year 1, 5.5% (2.5% above normal) in year 2, and 3% thereafter.
- Line 2 shows the path of output growth. From the aggregate demand relation, real money growth of 0.5% in year 1 leads to output growth of 0.5% (2.5% below

Table 9-1 The Effects of a Monetary Tightening

			Year 0	Year 1	Year 2	Year 3
1	Real money growth %	$(g_m - \pi)$	3.0	0.5	5.5	3.0
2	Output growth %	(g_y)	3.0	0.5	5.5	3.0
3	Unemployment rate %	(u)	6.0	7.0	6.0	6.0
4	Inflation rate %	(π)	5.0	4.0	4.0	4.0
5	(Nominal money growth) %	(g_m)	8.0	4.5	9.5	7.0

normal); real money growth of 5.5% in year 2 leads to output growth of 5.5% (2.5% above normal); thereafter, output growth is equal to the normal growth rate, 3%.

- Line 3 shows the path of the unemployment rate. Okun's law implies that output growth of 2.5% below normal for one year leads to an increase in the unemployment rate of 1 percentage point (2.5% multiplied by 0.4, the coefficient in Okun's law). So, in year 1, the unemployment rate increases from 6% to 7%. In year 2, output growth of 2.5% above normal for one year leads to a decrease in the unemployment rate of 1 percentage point. So, in year 2, the unemployment rate decreases from 7% back to 6%. The unemployment rate remains equal to 6% thereafter.
- Line 4 shows the path of the inflation rate. For this computation, let's assume that α is equal to 1.0 rather than its estimated value of 0.73 that we saw in Chapter 8. This assumption will simplify our computations. From the Phillips curve relation, an unemployment rate of 7%, which is 1% above the natural rate, leads to a decrease in inflation from 5% to 4% in year 1. In year 2 and thereafter, the unemployment rate is equal to the natural rate, and, therefore, inflation remains constant at 4%.
- For completeness, line 5 shows the behavior of nominal money growth consistent with the path of real money growth we assumed in line 1. Nominal money growth is equal to real money growth plus inflation. Adding the numbers for real money growth in line 1 and for inflation in line 4 gives the numbers in line 5. This implies a decrease in the rate of nominal money growth from 8% to 4.5% in year 1, an increase to 9.5% in year 2, and a decrease to 7% thereafter.

In words: In the short run, monetary tightening leads to a slowdown in growth and a temporary increase in unemployment. In the medium run, output growth returns to normal, and the unemployment rate returns to the natural rate. Money growth and inflation are both permanently lower.

Put less formally: The temporary increase in unemployment buys a permanent decrease in inflation.

9-3 Disinflation

To better understand the mechanics and the implications of our model, let's return to a situation not unlike that faced by the Fed in 1979: The economy is in medium-run equilibrium: Unemployment is at the natural rate of unemployment; output growth is equal to the normal growth rate. The inflation rate is equal to adjusted nominal money growth. The rate of nominal money growth and, by implication, the inflation rate, are high however, and there is a consensus among policymakers that inflation must be reduced.

At this point, you might ask: What is so bad about high inflation if growth is proceeding at a normal rate, and unemployment is at the natural rate of unemployment? To answer, we need to discuss the costs of inflation. We shall do so in Chapter 23.

We know from the previous section that lower inflation requires lower money growth. We also know that lower money growth implies an increase in unemployment for some time. For the central bank, the question now is: Having decided to act, at what pace should it proceed?

A First Pass

A first pass at the answer can be given by using the Phillips curve relation [equation (9.5)]:

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$$

The relation makes it clear that **disinflation**—the decrease in inflation—can only be obtained at the cost of higher unemployment: For the left side of the equation to be negative—that is, for inflation to decrease—the term $(u_t - u_n)$ must be positive. In other words, the unemployment rate must exceed the natural rate.

Make sure to distinguish between
Deflation: Decrease in the price level (equivalently, negative inflation)
Disinflation: Decrease in the inflation rate

The equation, however, has a stronger and more striking implication: The total amount of unemployment required for a given decrease in inflation does not depend on the speed at which disinflation is achieved. In other words, disinflation can be

When should you use *percentage point* rather than *percent*? Suppose you are told that the unemployment rate, which was equal to 10%, has increased by 5%. Is it 5% of itself, in which case the unemployment rate is (1.05) × 10% = 10.5%? Or is it 5 percentage points, in which case it is 10% + 5% = 15%? The use of *percentage point* rather than *percent* helps avoid the ambiguity. If you are told the unemployment rate has increased by 5 percentage points, this means that the unemployment rate is 10% + 5% = 15%.

achieved quickly, at the cost of high unemployment for a few years. Or, alternatively, it can be achieved more slowly, with a smaller increase in unemployment spread over many years. In both cases, the total amount of unemployment, summed over the years, will be the same.

Let's see why. First, define a **point-year of excess unemployment** as the difference between the actual and the natural unemployment rates of 1 percentage point for one year. While the expression may sound a bit strange, the concept is simple: For example, if the natural rate of unemployment is 6%, an unemployment rate of 8% four years in a row corresponds to 4 times $(8 - 6) = 8$ point-years of excess unemployment.

Now look at a central bank that wants to reduce inflation by x percentage points. To make things simpler, let's use specific numbers: Assume that the central bank wants to reduce inflation from 14% to 4%, so that x is equal to 10. Let's also make the convenient, if not quite correct, assumption that α equals 1; again, this will simplify computations:

- Suppose the central bank wants to achieve the reduction in inflation in one year. Equation (9.5) tells us that what is required is one year of unemployment at 10% above the natural rate. In this case, the right side of the equation is equal to –10%, and the inflation rate decreases by 10% within a year.
- Suppose the central bank wants to achieve the reduction in inflation over two years. Equation (9.5) tells us that what is required is 2 years of unemployment at 5% above the natural rate. During each of the 2 years, the right side of the equation is equal to –5%, so the inflation rate decreases by 5% each year, thus by $2 \times 5\% = 10\%$ over 2 years.
- By the same reasoning, reducing inflation over 5 years requires 5 years of unemployment at 2% above the natural rate ($5 \times 2\% = 10\%$); reducing inflation over 10 years requires 10 years of unemployment at 1% above the natural rate ($10 \times 1\% = 10\%$), and so on.

Note that in each case the number of point-years of excess unemployment required to decrease inflation is the same, namely ten: 1 year times 10% excess unemployment in the first scenario, 2 years times 5% in the second, 10 years times 1% in the last. The implication is straightforward: The central bank can choose the distribution of excess unemployment over time, but it cannot change the total number of point-years of excess unemployment.

We can state this conclusion another way: Define the **sacrifice ratio** as the number of point-years of excess unemployment needed to achieve a decrease in inflation of 1%:

$$\text{Sacrifice ratio} = \frac{\text{Point-years of excess unemployment}}{\text{Decrease in inflation}}$$

From equation (9.5), excess unemployment of 1% for one year decreases the inflation rate by α times 1%. Put the other way, to reduce the inflation rate by 1%, excess unemployment must be equal to $1/\alpha$ for one year.

Equation (9.5) then implies that this ratio is independent of policy and simply equal to $(1/\alpha)$.

If the sacrifice ratio is constant, does this mean that the speed of disinflation is irrelevant? No. Suppose that the central bank tried to achieve the decrease in inflation in one year. As you have just seen, this would require an unemployment rate of 10% above the natural rate for one year. With a natural unemployment rate of 6%, this would require increasing the actual unemployment rate to 16% for one year. From Okun's law, using a value of 0.4 for β and a normal output growth rate of 3%, output growth would have to satisfy

$$u_t - u_{t-1} = -\beta(g_{yt} - \bar{g}_y)$$
$$16\% - 6\% = -0.4(g_{yt} - 3\%)$$

This implies a value for $g_{yt} = -(10\%)/0.4 + 3\% = -22\%$. In words, output growth would have to equal –22% for a year! In comparison, the largest negative growth rate ever in the United States in the twentieth century was –15%. It occurred in 1931, during the Great Depression. It is fair to say that macroeconomists do not know with great confidence what would happen if monetary policy were aimed at inducing such a large negative growth rate. But they would surely be unwilling to try. The increase in the overall unemployment rate would lead to extremely high unemployment rates for some groups—specifically the young and the unskilled, whose unemployment typically increases more than the average unemployment rate. The associated sharp drop in output would most likely also lead to a large number of bankruptcies. This suggests that the central bank will want to go more slowly and to achieve disinflation over a number of years rather than do it all in one year.

The analysis we have just developed is close to the type of analysis economists at the Fed were conducting in the late 1970s. The econometric model they used, as well as most econometric models in use at the time, shared our simple model's property that policy could change the timing but not the number of point-years of excess unemployment. I shall call this the *traditional approach* in the following text. The traditional approach was challenged, however, by two separate groups of macroeconomists. The focus of both groups was the role of expectations and how changes in expectation formation might affect the unemployment cost of disinflation. But despite this common focus, they reached quite different conclusions.

Expectations and Credibility: The Lucas Critique

The conclusions of the first group were based on the work of Robert Lucas and Thomas Sargent, then at the University of Chicago. In what has become known as the **Lucas critique**, Lucas pointed out that when trying to predict the effects of a major policy change—such as the change considered by the Fed at the time—it could be very misleading to take as given the relations estimated from past data.

Robert Lucas was awarded the Nobel Prize in 1995 and is still at the University of Chicago. Thomas Sargent is now at New York University.

In the case of the Phillips curve, taking equation (9.5) as given was equivalent to assuming that wage setters would keep expecting inflation in the future to be the same as it was in the past, that the way wage setters formed their expectations would not change in response to the change in policy. This was an unwarranted assumption, Lucas argued: Why shouldn't wage setters take policy changes directly into account? If wage setters believed that the Fed was committed to lowering inflation, they might well expect inflation to be lower in the future than in the past. If they lowered their expectations of inflation, then actual inflation would decline without the need for a protracted recession.

The logic of Lucas's argument can be seen by returning to equation (9.4), the Phillips curve with expected inflation on the right:

$$\pi_t = \pi_t^e - \alpha(u_t - u_n)$$

If wage setters kept forming expectations of inflation by looking at the previous year's inflation (if $\pi_t^e = \pi_{t-1}$), then the only way to decrease inflation would be to accept higher unemployment for some time; we explored the implications of this assumption in the preceding subsection.

If $\pi_t^e = \pi_{t-1}$, the Phillips curve is given by $\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$. To achieve $\pi_t < \pi_{t-1}$, it must be that $u_t > u_n$.

But if wage setters could be convinced that inflation was indeed going to be lower than in the past, they would decrease their expectations of inflation. This would in turn reduce actual inflation, without any change in the unemployment rate. For example, if wage setters were convinced that inflation, which had been running at 14% in the past, would be only 4% in the future, and if they formed their expectations accordingly, then inflation would fall to 4% *even if unemployment remained at the natural rate of unemployment*:

$$\pi_t = \pi_t^e - \alpha(u_t - u_n)$$
$$4\% = 4\% - 0\%$$

Nominal money growth, inflation, and expected inflation could all be reduced without the need for a recession. Put another way, decreases in nominal money growth could be neutral not only in the medium run but also in the short run.

Lucas and Sargent did not believe that disinflation could really take place without some increase in unemployment. But Sargent, looking at the historical evidence on the end of several very high inflations, concluded that the increase in unemployment could be small. The sacrifice ratio—the amount of excess unemployment needed to achieve disinflation—might be much lower than suggested by the traditional approach. The essential ingredient of successful disinflation, he argued, was **credibility** of monetary policy—the belief by wage setters that the central bank was truly committed to reducing inflation. Only credibility would cause wage setters to change the way they formed their expectations. Furthermore, he argued, a clear and quick disinflation program was much more likely to be credible than a protracted one that offered plenty of opportunities for reversal and political infighting along the way.

The *credibility view* is that fast disinflation is likely to be more credible than slow disinflation. Credibility decreases the unemployment cost of disinflation. So the central bank should go for fast disinflation.

Nominal Rigidities and Contracts

A contrary view was taken by Stanley Fischer, then from MIT, and John Taylor, then at Columbia University. Both emphasized the presence of **nominal rigidities**, meaning that, in modern economies, many wages and prices are set in nominal terms for some time and are typically not readjusted when there is a change in policy.

Fischer is now the Governor of the Central Bank of Israel. Taylor was undersecretary for international affairs in the G. W. Bush administration and is now a professor at Stanford University. More on both in Chapter 28.

Fischer argued that even with credibility, too rapid a decrease in nominal money growth would lead to higher unemployment. Even if the Fed fully convinced workers and firms that nominal money growth was going to be lower, the wages set before the change in policy would still reflect the expectations of inflation prior to the policy change. In effect, inflation would already be built into existing wage agreements and could not be reduced instantaneously and without cost. At the very least, Fischer said, a policy of disinflation should be announced sufficiently in advance of its actual implementation to allow wage setters to take it into account when setting wages.

Taylor's argument went one step further. An important characteristic of wage contracts, he argued, is that they are not all signed at the same time. Instead, they are staggered over time. He showed that this **staggering of wage decisions** imposed strong limits on how fast disinflation could proceed without triggering higher unemployment, even if the Fed's commitment to inflation was fully credible. Why the limits? If workers cared about their wage relative to the wages of other workers, each wage contract would choose a wage not very different from the wages in the other contracts in force at the time. Too rapid a decrease in nominal money growth would therefore not lead to a proportional decrease in inflation. As a result, the real money stock would decrease, triggering a recession and an increase in the unemployment rate.

Taking into account the time pattern of wage contracts in the United States, Taylor then showed that, under full credibility of monetary policy, there *was* a path of disinflation consistent *with no increase in unemployment*. This path is shown in Figure 9-3.

In Figure 9-3, disinflation starts in quarter 1 and lasts for 16 quarters. Once it is achieved, the inflation rate, which started at 10%, is 3%. The striking feature is how slowly disinflation proceeds at the beginning. One year (four quarters) after the announcement of the change in policy, inflation is still 9.9%. But then disinflation

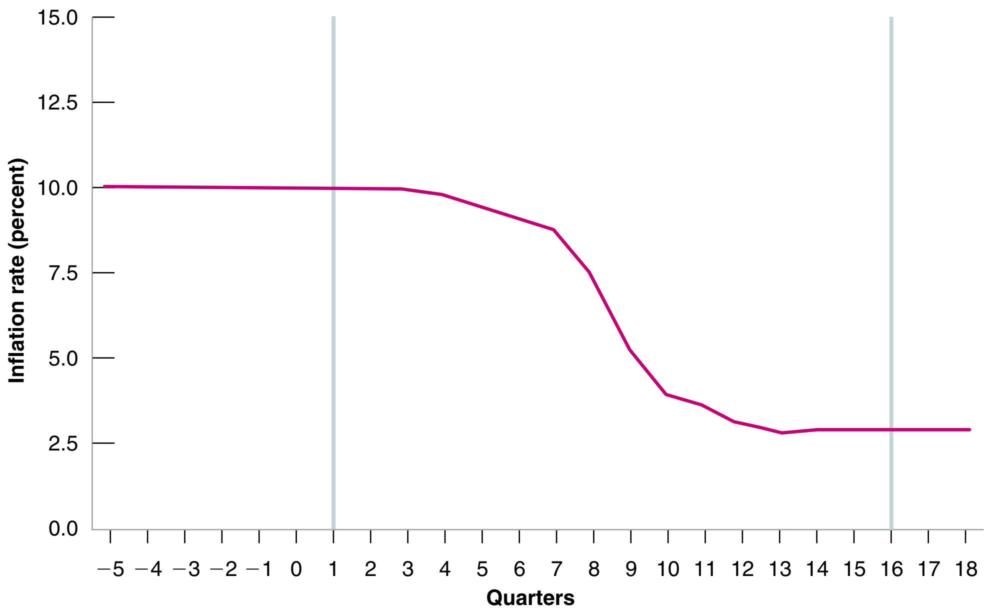


Figure 9-3

Disinflation without Unemployment in the Taylor Model

If wage decisions are staggered, disinflation must be phased in slowly to avoid an increase in unemployment.

proceeds more quickly. By the end of the third year, inflation is down to 4%, and by the end of the fourth year, the desired disinflation is achieved.

The reason for the slow decrease in inflation at the beginning—and, behind the scenes, for the slow decrease in nominal money growth—is straightforward: Wages in force at the time of the policy change are the result of decisions made before the policy change occurred. Because of this, the path of inflation in the near future is largely predetermined. If nominal money growth were to decrease sharply, inflation could not fall very much right away, and the result would be a decrease in real money and a recession. So the best policy is for the Fed to proceed slowly at the beginning of the process while announcing it will proceed faster in the future. This announcement leads new wage settlements to take into account the new policy. When most wage decisions in the economy are based on decisions made after the change in policy, disinflation can proceed much more quickly. This is what happens in the third year following the policy change.

Like Lucas and Sargent, Taylor did not believe that disinflation could really be implemented without an increase in unemployment. For one thing, he realized that the path of disinflation drawn in Figure 9-3 might not be credible. Announcing this year that the Fed will decrease nominal money growth two years from now is likely to cause a serious credibility problem. Wage setters are likely to ask: If the decision has been made to disinflate, why does the central bank want to wait two years? Without credibility, inflation expectations might not change, defeating the hope of disinflation without an increase in the unemployment rate. But Taylor's analysis had two clear messages. First, like Lucas and Sargent, Taylor's analysis emphasized the role of expectations. Second, it suggested that a slow but credible disinflation might have a cost lower than the one implied by the traditional approach.

The *nominal rigidities view* is that many wages are set in nominal terms, sometimes for many years. The way to decrease the unemployment cost of disinflation is to give wage setters time to take into account the change in policy. So the central bank should go for slow disinflation.

Who turned out to be right? The traditional approach, the Sargent–Lucas approach, or the Fischer–Taylor approach? The answer is given in the Focus box "U.S. Disinflation, 1979–1985," and is easy to summarize: The disinflation of about 10% triggered a deep recession and about 12 point-years of excess unemployment. In other words, there were no obvious credibility gains, and the sacrifice ratio turned out to be roughly what was predicted by the traditional approach.

Was this outcome due to a lack of credibility of the change in monetary policy or to the fact that credibility is not enough to substantially reduce the cost of disinflation?

U.S. Disinflation, 1979–1985

FOCUS

In 1979, U.S. unemployment was 5.8%, roughly equal to the natural rate at the time. GDP growth was 2.5%, roughly equal to the normal growth rate. The inflation rate (measured using the CPI), however, was a high 13.3%. The question the Federal Reserve faced was no longer whether it should reduce inflation but how fast it should reduce it. In August 1979, President Carter appointed Paul Volcker as chairman of the Federal Reserve Board. Volcker, who had served in the Nixon administration, was considered an extremely qualified chairman who would and could lead the fight against inflation.

In October 1979, the Fed announced a number of changes in its operating procedures. In particular, it indicated that it would shift from targeting a given level of the short-term interest rate to targeting the growth rate of nominal money.

This change would hardly seem to be the stuff of history books. The Fed made no announcement of a major battle against inflation, nor of a targeted path of disinflation, nor of various other ambitious-sounding plans. Nevertheless, financial markets widely interpreted this technical change as a sign of a major shift in monetary policy. In particular, the change was interpreted as indicating that the Fed had become committed to reduce money growth and inflation and that, if needed, it would let interest rates increase, perhaps to very high levels.

Over the following seven months, the Fed let the federal funds rate increase by more than 6 percentage points, from 11.4% in September 1979 to 17.6% in April 1980. But then there was a halt, followed by a rapid reversal. By July 1980, the rate was back down to 9%, dropping 8.6 percentage points in four months. This roller-coaster movement of the federal funds rate is shown in Figure 1, which plots the federal funds rate and the inflation rate, measured as the rate of change of the CPI over the previous 12 months, for the period January 1979 to December 1984.

The reason the Fed lowered the federal funds rate in mid-1980 was because signs were accumulating that the economy was entering a sharp recession. In March 1980, believing that high consumer spending was one of the causes of inflation, the Carter administration had imposed controls on consumer credit—limits on how much consumers could borrow to buy some durable goods. The effect of these controls turned out to be much larger than the Carter administration had anticipated. The combination of the fear of a sharp recession

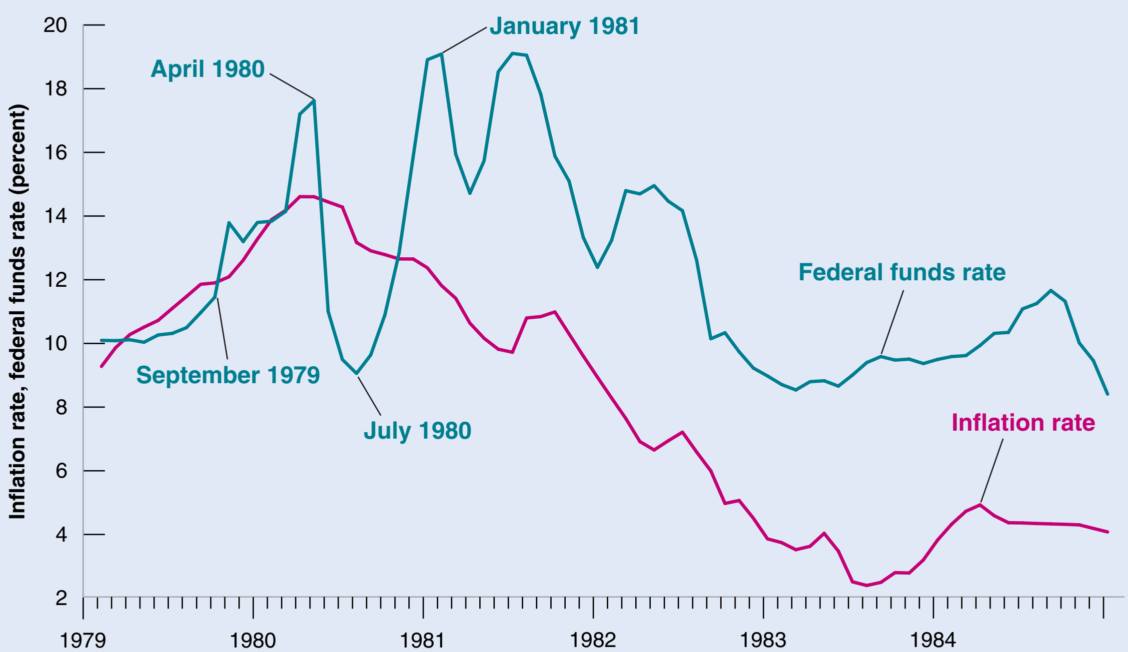


Figure 1 ***The Federal Funds Rate and Inflation, 1979 to 1984***
A sharp increase in the federal funds rate from September 1979 to April 1980 was followed by a sharp decline in mid-1980 and then a second and sustained increase from January 1981 on, lasting for most of 1981 and 1982.

Table 1 Inflation and Unemployment, 1979 to 1985

		1979	1980	1981	1982	1983	1984	1985
1	GDP growth (%)	2.5	–0.5	1.8	–2.2	3.9	6.2	3.2
2	Unemployment rate (%)	5.8	7.1	7.6	9.7	9.6	7.5	7.2
3	CPI inflation (%)	13.3	12.5	8.9	3.8	3.8	3.9	3.8
4	Cumulative unemployment		1.0	2.6	6.3	9.9	11.4	12.6
5	Cumulative disinflation		0.8	4.4	9.5	9.5	9.4	9.5
6	Sacrifice ratio		1.25	0.59	0.66	1.04	1.21	1.32

Cumulative unemployment is the sum of point-years of excess unemployment from 1980 on, assuming a natural rate of unemployment of 6.0%. Cumulative disinflation is the difference between inflation in a given year and inflation in 1979. The sacrifice ratio is the ratio of cumulative unemployment to cumulative disinflation.

and the political pressure coming from the proximity of presidential elections was enough to lead the Fed to decrease interest rates sharply.

By the end of 1980, with the economy apparently in recovery, the Fed again increased the federal funds rate sharply. Cumulative increases in the federal funds rate of 3 percentage points just before the 1980 election surely did not improve Carter's reelection prospects. By January 1981, the rate was back up to 19%.

By the end of 1981, signs accumulated that the very high interest rates were triggering a second recession. The Fed decided not to repeat its 1980 mistake of abandoning its disinflation target in the face of a recession. In contrast to its actions in 1980, it kept interest rates high. The federal funds rate was decreased to 12.3% in December 1981 but then increased back to 14.9% in April 1982.

Was the commitment of the Fed to disinflation credible, in the sense defined by Lucas and Sargent? Paul Volcker had credibility when he became the Fed chairman. However, the credibility of the Fed's disinflation stance was surely eroded by the Fed's behavior in 1980. Credibility was progressively reestablished in 1981 and 1982, especially when, despite clear indications that the economy was in recession, the Fed increased the federal funds rate in the spring of 1982.

Did this credibility of the Fed—to the extent that it was present—lead to a more favorable trade-off between unemployment and disinflation than implied by the traditional approach? Table 1 gives the relevant numbers.

The upper half of the table makes clear that there was no credibility miracle: Line 2 shows that disinflation was associated with substantial unemployment. The average unemployment rate was above 9% in both 1982 and 1983, peaking at 10.8% in December 1982.

The answer to whether the unemployment cost was lower than implied by the traditional approach is given in the bottom half of the table. Under the traditional approach, each point of disinflation is predicted to require about $(1/\alpha) = 1/0.73 = 1.36$ point-years of excess unemployment. Line 4 computes the cumulative number of point-years of excess unemployment from 1980 onward, assuming a natural rate of unemployment of 6%. Line 5 computes cumulative disinflation—the decrease in inflation starting from its 1979 level. Line 6 gives the sacrifice ratio, the ratio of the cumulative point-years of unemployment above the natural rate of unemployment to cumulative disinflation.

The table shows there were no obvious "credibility gains." By 1982, the sacrifice ratio looked quite attractive: The cumulative decrease in inflation since 1979 was nearly 9.5%, at a cost of 6.3 point-years of unemployment—a sacrifice ratio of 0.66, relative to the sacrifice ratio of 1.36 predicted by the traditional approach. But by 1985, the sacrifice ratio had reached 1.32. A 10% disinflation had been achieved with 13.2 point-years of excess unemployment, an outcome close to the outcome predicted by the traditional approach.

In short: The U.S. disinflation of the early 1980s was associated with a substantial increase in unemployment. The Phillips curve relation between the change in inflation and the deviation of the unemployment rate from the natural rate proved more robust than many economists had anticipated.

One way of learning more is to look at other disinflation episodes. This is the approach followed by Laurence Ball, from The Johns Hopkins University, who estimated sacrifice ratios for 65 disinflation episodes in 19 OECD countries over the past 30 years. He reached three main conclusions:

- Disinflations typically lead to a period of higher unemployment. Put another way, even if a decrease in nominal money growth is neutral in the medium run, unemployment increases for some time before returning to the natural rate of unemployment.
- Faster disinflations are associated with smaller sacrifice ratios. This conclusion provides some evidence to support the expectation and credibility effects emphasized by Lucas and Sargent.
- Sacrifice ratios are smaller in countries that have shorter wage contracts. This provides some evidence to support Fischer and Taylor's emphasis on the structure of wage settlements.

Let's summarize: Policymakers face a trade-off between unemployment and inflation. In particular, to permanently lower inflation requires higher unemployment for some time. One might have hoped that, with credible policies, the trade-off would be much more favorable. The evidence can be read as saying that credibility gains may be present, but they are small.

We shall return to the role of credibility in monetary policy in Chapter 25.

Summary

- Three relations link inflation, output, and unemployment:
  1. Okun's law, which relates the change in the unemployment rate to the deviation of the rate of growth of output from the normal growth rate. In the United States today, output growth of 1% above normal for a year leads to a decrease in the unemployment rate of about 0.4%.
  2. The aggregate supply relation—the Phillips curve—which relates the change in the inflation rate to the deviation of the actual unemployment rate from the natural rate of unemployment. In the United States today, an unemployment rate 1% below the natural rate of unemployment for a year leads to an increase in inflation of about 1%.
  3. The aggregate demand relation, which relates the rate of growth of output to the rate of growth of real money. The growth rate of output is equal to the growth rate of nominal money minus the rate of inflation. Given nominal money growth, higher inflation leads to a decrease in output growth.
- In the medium run, the unemployment rate is equal to the natural rate of unemployment, and output grows at its normal growth rate. Nominal money growth determines the inflation rate: A 1% increase in nominal money growth leads to a 1% increase in the inflation rate. As Milton Friedman put it: Inflation is always and everywhere a monetary phenomenon.
- In the short run, a decrease in nominal money growth leads to a slowdown in growth and an increase in unemployment for some time.
- Disinflation (a decrease in the inflation rate) can be achieved only at the cost of more unemployment. How much unemployment is required is a controversial issue. The traditional approach assumes that people do not change the way they form expectations when monetary policy changes, so the relation between inflation and unemployment is unaffected by the change in policy. This approach implies that disinflation can be achieved by a short but large increase in unemployment or by a longer and smaller increase in unemployment. But policy cannot affect the total number of point-years of excess unemployment.
- An alternative view is that, if the change in monetary policy is credible, expectation formation may change, leading to a smaller increase in unemployment than predicted by the traditional approach. In its extreme form, this alternative view implies that if policy is fully credible, it can achieve disinflation at no cost in unemployment. A less extreme form recognizes that while expectation formation may change, the presence of nominal rigidities is likely to result in some increase in unemployment, but less than that implied by the traditional approach.
- The U.S. disinflation of the early 1980s, during which inflation fell by approximately 10%, was associated with a large recession. The unemployment cost was close to the predictions of the traditional approach.

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Key Terms

- Okun's law, 184
- normal growth rate, 185
- labor hoarding, 185
- adjusted nominal money growth, 189
- disinflation, 191
- point-year of excess unemployment, 192
- sacrifice ratio, 192
- Lucas critique, 193
- credibility, 194
- nominal rigidities, 194
- staggering of wage decisions, 194

Questions and Problems

Quick Check

1. Using the information in this chapter, label each of the following statements true, false, or uncertain. Explain briefly.

a. The U.S. unemployment rate will remain constant as long as there is positive output growth.

b. Many firms prefer to keep workers around when demand is low (rather than lay them off) even if the workers are underutilized.

c. The behavior of Okun's law across countries and across decades is consistent with our knowledge of firms' behavior and labor market regulations.

d. There is a reliable negative relation between the rate of inflation and the growth rate of output.

e. In the medium run, the rate of inflation is equal to the rate of nominal money growth.

f. According to the Phillips curve relation, the sacrifice ratio is independent of the speed of disinflation.

g. If Lucas and Sargent were right, and if monetary policy was fully credible, there would be no relation between inflation and unemployment—i.e., no Phillips curve relation.

h. Contrary to the traditional Phillips curve analysis, Taylor's analysis of staggered wage contracts makes the case for a slow approach to disinflation.

i. Ball's analysis of disinflation episodes provides some support for both the credibility effects of Lucas and Sargent and the wage-contract effects of Fischer and Taylor.

2. As shown by equation (9.2), the estimated Okun's law for the United States is given by

$$u_t - u_{t-1} = -0.4(g_{yt} - 3\%)$$

a. What growth rate of output leads to an increase in the unemployment rate of 1% per year? How can the unemployment rate increase even though the growth rate of output is positive?

b. Suppose output growth is constant for the next four years. What growth rate would reduce the unemployment rate by 2 percentage points over the next four years?

c. How would you expect Okun's law to change if the rate of growth of the labor force was higher by 2 percentage points? How do you expect Okun's law to change if the rate of growth of the labor force increases by 2 percentage points?

3. Suppose that an economy can be described by the following three equations:

$$u_t - u_{t-1} = -0.4(g_{yt} - 3\%) \quad \text{Okun's law}$$
$$\pi_t - \pi_{t-1} = -(u_t - 5\%) \quad \text{Phillips curve}$$
$$g_{yt} = g_{mt} - \pi_t \quad \text{Aggregate demand}$$

a. What is the natural rate of unemployment for this economy?

b. Suppose that the unemployment rate is equal to the natural rate and that the inflation rate is 8%. What is the growth rate of output? What is the growth rate of the money supply?

c. Suppose that conditions are as in (b), when, in year t, the authorities use monetary policy to reduce the inflation rate to 4% in year t and keep it there. Given this inflation rate and using the Phillips curve, what must happen to the unemployment rate in years t, $t + 1$, $t + 2$, and so on? Given the unemployment rate and using Okun's law, what must happen to the rate of growth of output in years t, $t + 1$, $t + 2$, and so on? Given the rate of growth of output and using the aggregate demand equation, what must be the rate of nominal money growth in years t, $t + 1$, $t + 2$, and so on?

4. Suppose that you are advising a government that wants to reduce the inflation rate. It is considering two options: a gradual reduction over several years or an immediate reduction.

a. Lay out the arguments for and against each option.

b. Considering only the sacrifice ratio, which option is preferable? Why might you want to consider criteria other than the sacrifice ratio?

c. What particular features of the economy would you want to consider before giving your advice?

5. Markups, unemployment, and inflation

Suppose that the Phillips curve is given by

$$\pi_t - \pi_{t-1} = -(u_t - 5\%) + 0.1\mu$$

where μ is the markup.

Suppose that unemployment is initially at its natural rate. Suppose now that μ increases as a result of an oil price shock, but that the monetary authority continues to keep the unemployment rate at its previous value.

a. What will happen to inflation?
b. What should the monetary authority do instead of trying to keep the unemployment rate at its previous value?

Dig Deeper

6. Credibility and disinflation

Suppose that the Phillips curve is given by

$$\pi_t = \pi_t^e - (u_t - 5\%)$$

and expected inflation is given by

$$\pi_t^e = \pi_{t-1}$$

a. What is the sacrifice ratio in this economy?

Suppose that unemployment is initially equal to the natural rate and $\pi = 12\%$*. The central bank decides that 12% inflation is too high and that, starting in year* t*, it will maintain the unemployment rate 1 percentage point above the natural rate of unemployment until the inflation rate has decreased to 2%.*

b. Compute the rate of inflation for years t, $t + 1$, $t + 2$, and so on .
c. For how many years must the central bank keep the unemployment rate above the natural rate of unemployment? Is the implied sacrifice ratio consistent with your answer to (a)?

Now suppose that people know that the central bank wants to lower inflation to 2%, but they are not sure about the central bank's willingness to accept an unemployment rate above the natural rate of unemployment. As a result, their expectation of inflation is a weighted average of the target of 2% and last year's inflation—i.e,

$$\pi_t^e = \lambda\, 2\% + (1 - \lambda)\pi_{t-1}$$

where λ *is the weight they put on the central bank's target of 2%.*

d. Let $\lambda = 0.25$. How long will it take before the inflation rate is equal to 2%? What is the sacrifice ratio? Why is it different from the answer in (c)?

Suppose that after the policy has been in effect for one year, people believe that the central bank is indeed committed to reducing inflation to 2%. As a result, they now set their expectations according to

$$\pi_t^e = 2\%$$

e. From what year onward can the central bank let the unemployment rate return to the natural rate? What is the sacrifice ratio now?
f. What advice would you give to a central bank that wants to lower the rate of inflation by increasing the rate of unemployment as little and for as short a time period as possible?

7. The effects of a permanent decrease in the rate of nominal money growth

Suppose that the economy can be described by the following three equations:

$$u_t - u_{t-1} = -0.4(g_{yt} - 3\%) \quad \text{Okun's law}$$
$$\pi_t - \pi_{t-1} = -(u_t - 5\%) \quad \text{Phillips curve}$$
$$g_{yt} = g_{mt} - \pi_t \quad \text{Aggregate demand}$$

a. Reduce the three equations to two by substituting g_{yt} from the aggregate demand equation into Okun's law.

Assume initially that $u_t = u_{t-1} = 5\%$, $g_{mt} = 13\%$*, and* $\pi_t = 10\%$*. Now suppose that money growth is permanently reduced from 13% to 3%, starting in year* t.

b. Compute (using a calculator or a spreadsheet program) unemployment and inflation in year t, $t + 1$, $\ldots$, $t + 10$.
c. Does inflation decline smoothly from 10% to 3%? Why or why not?
d. Compute the values of the unemployment rate and the inflation rate in the medium run.

Explore Further

*8. Go to the Web site of the Bureau of Economic Analysis (***www.bea.gov***) and retrieve quarterly data on real chained gross domestic product for 2002 and 2003. Go to the Web site of the Bureau of Labor Statistics (***www.bls.gov***) and retrieve data on monthly unemployment rates and monthly employment levels for 2002 and 2003.*

a. Was output growth positive throughout 2002 and 2003?
b. What happened to the unemployment rate over the period January 2002 to June 2003?
c. How do you reconcile your answers to parts (a) and (b)?
d. Now consider the employment level. Compare the monthly employment levels from September 2002 and December 2002. What happened to employment over the last quarter of 2002?
e. Was output growth positive in the last quarter of 2002?
f. How do you reconcile your answers to parts (d) and (e)?

*9. Go the Web site of the Bureau of Labor Statistics (***www.bls.gov***) and retrieve monthly data on the level of employment and unemployment for 2001. You will notice that the level of unemployment rose in every month of 2001.*

a. Did the level of employment rise in any month(s) in 2001?
b. How is it possible that both employment and unemployment could rise in the same month?

We invite you to visit the Blanchard page on the Prentice Hall Web site, at:
www.prenhall.com/blanchard
for this chapter's World Wide Web exercises.

Further Readings

- A description of U.S. monetary policy in the 1980s is given by Michael Mussa in Chapter 2 of Martin Feldstein, ed., *American Economic Policy in the 1980s*, University of Chicago Press and NBER, Chicago, 1994, pp. 81–164. One of the comments on the chapter is by Paul Volcker, who was chairman of the Fed from 1979 to 1987.