

of unemployment is sometimes called the Non-Accelerating Inflation Rate of Unemployment, or *NAIRU*.

The first term in this form of the Phillips curve, π_{-1} , implies that inflation has inertia. That is, like an object moving through space, inflation keeps going unless something acts to stop it. In particular, if unemployment is at the *NAIRU* and if there are no supply shocks, the continued rise in price level neither speeds up nor slows down. This inertia arises because past inflation influences expectations of future inflation, and because these expectations influence the wages and prices that people set. Robert Solow captured the concept of inflation inertia well when, during the high inflation of the 1970s, he wrote: ‘Why is our money ever less valuable? Perhaps it is simply that we have inflation because we expect inflation, and we expect inflation because we’ve had it.’

In the model of aggregate supply and aggregate demand, inflation inertia is interpreted as persistent upward shifts in both the aggregate supply curve and the aggregate demand curve. Consider, first, aggregate supply. If prices have been rising quickly, people will expect them to continue to rise quickly. Because the position of the short-run aggregate supply curve depends on the expected price level, the short-run aggregate supply curve will shift upward over time. It will continue to shift upward until some event, such as a recession or a supply shock, changes inflation and thereby changes expectations of inflation.

The aggregate demand curve must also shift upward to confirm the expectations of inflation. Most often, the continued rise in aggregate demand is due to persistent growth in the money supply. If the central bank suddenly halted money growth, aggregate demand would stabilize, and the upward shift in aggregate supply would cause a recession. The high unemployment in the recession would reduce inflation and expected inflation, causing inflation inertia to subside.

Two Causes of Rising and Falling Inflation

The second and third terms in the Phillips curve equation show the two forces that can change the rate of inflation.

The second term, $\beta(u - u^n)$, shows that cyclical unemployment – the deviation of unemployment from its natural rate – exerts upward or downward pressure on inflation. Low unemployment pulls the inflation rate up. This is called **demand-pull inflation** because high aggregate demand is responsible for this type of inflation. High unemployment pulls the inflation rate down. The parameter β measures how responsive inflation is to cyclical unemployment.

The third term, ν , shows that inflation also rises and falls because of supply shocks. An adverse supply shock, such as the rise in world oil prices in the 1970s, implies a positive value of ν and causes inflation to rise. This is called **cost-push inflation** because adverse supply shocks are typically events that push up the costs of production. A beneficial supply shock, such as the oil glut that led to a fall in oil prices in the 1980s, makes ν negative and causes inflation to fall.

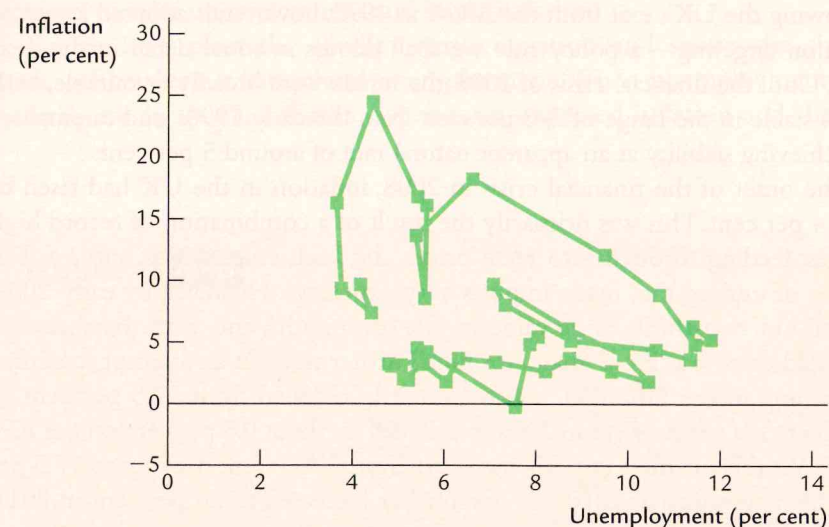
CASE STUDY

Inflation and Unemployment in the United Kingdom

Because inflation and unemployment are such important measures of economic performance, macroeconomic developments are often viewed through the lens of the Phillips curve. Figure 14-5 displays the history of inflation and unemployment in the United Kingdom since 1971. These four decades of data illustrate some of the causes of rising or falling inflation in terms of the demand-pull and cost-push influences that operate through the Phillips curve.

The 1970s was a period of economic turmoil. Inflation, as measured by the RPI, rose from 7.1 per cent in 1972 to 24.2 per cent in 1975. At the same time, unemployment rose from 4 per cent to just over 5 per cent. In part, this was due to the large negative supply shocks caused by the Organization of Petroleum Exporting Countries (OPEC), in the form of a quadrupling of oil prices in 1973–1974, a form of cost-push inflation. However, during the early 1970s, expansionary fiscal policy had strongly stimulated aggregate demand, pushing unemployment below its natural rate, so that unemployment was already set to rise back towards the natural rate. When the oil shock was piled on top of this, the combination led to simultaneously rising inflation and rising unemployment –

FIGURE 14-5



Inflation and Unemployment in the United Kingdom Since 1971 This figure uses annual data on the unemployment rate and the inflation rate (percentage change in the GDP deflator) to illustrate macroeconomic developments in almost a half-century of UK history.

Source: Lawrence H. Officer and Samuel H. Williamson, ‘What Was the UK GDP Then?’, MeasuringWorth, 2013 (www.measuringworth.com/ukgdp) and UK Office for National Statistics.

so-called stagflation. High unemployment during the ensuing recession reduced inflation somewhat, but further OPEC price hikes pushed inflation up again in the late 1970s.

The 1980s began with high inflation and high expectations of inflation. The newly elected Conservative government, led by Margaret Thatcher, doggedly pursued monetary policies aimed at reducing inflation. In 1983, the unemployment rate reached its highest level in 50 years. High unemployment and a consequent contraction in aggregate demand, aided by a fall in oil prices in 1980, pulled the inflation rate down from about 18 per cent in 1980 to about 5 per cent by 1984. By 1987, the unemployment rate of about 9.5 per cent was close to most estimates of the natural rate, and inflation was stable at a little over 4 per cent.

In the late 1980s, a combination of measures raised inflation again: tax cuts in 1987 and 1988, some relaxation of monetary policy, and rising asset prices all boosted aggregate demand and meant that the UK ended the decade with unemployment around 8 per cent and inflation around 10 per cent.

In the early 1990s, the UK tried to keep its exchange rate pegged against the German mark and other European currencies when it joined the European Exchange Rate Mechanism (ERM), but the UK had arguably set its rate against the mark at too high a level, making its exports uncompetitive and requiring high levels of interest rates. The result was a contraction in aggregate demand that ushered in the recession of the early 1990s, with unemployment back to around 10 per cent in 1991 and 1992, and inflation down below 4 per cent in 1992.

Following the UK's exit from the ERM in 1992, however, it adopted a regime of inflation targeting – a policy rule we shall discuss in some detail in the next chapter. Until the financial crisis of 2008, the results were broadly favourable, with inflation stable in the range of 2–3 per cent from the early 1990s, and unemployment achieving stability at an apparent natural rate of around 5 per cent.

By the onset of the financial crisis in 2008, inflation in the UK had risen to around 4 per cent. This was primarily the result of a combination of record high oil prices, feeding through into retail prices and high energy bills, and a fall in the value of sterling that made imports very expensive. However, by early 2009, crude oil lost two-thirds of its value in just six months, and with the recession taking hold there was less demand for fuel. Furthermore, in an attempt to stimulate spending in the UK, VAT was temporarily reduced from 17.5 per cent to 15 per cent. As a result, prices in 2009 actually fell by about 0.5 per cent on the RPI measure. Yet this inflation rate fall was short-lived: VAT went back up to 17.5 per cent at the beginning of 2010 and was further increased to 20 per cent in 2011. Also, significant rises in home energy bills, along with transport costs and food prices, pushed up prices even further. By 2011, inflation was at 5.2 per cent, the highest since 1991. Over the same period, unemployment rose steadily. When the financial crisis hit in 2008, the unemployment rate was a little over 5 per cent. Towards the end of 2009, with the UK struggling to recover from its severest recession since the 1930s, unemployment was up by two percentage points, and peaked at just over 8 per cent in mid-2012. The main driving force behind the increase in unemployment was reduced private and public spending. The

austerity measures, a lack of market confidence and increased financial uncertainty weakened aggregate demand and consequently the demand for labour as well. The latest figures for 2013 suggest that 7.7 per cent of the labour force are jobless. The fall in the jobless figures suggest that the UK economy has finally begun to emerge from the recession.

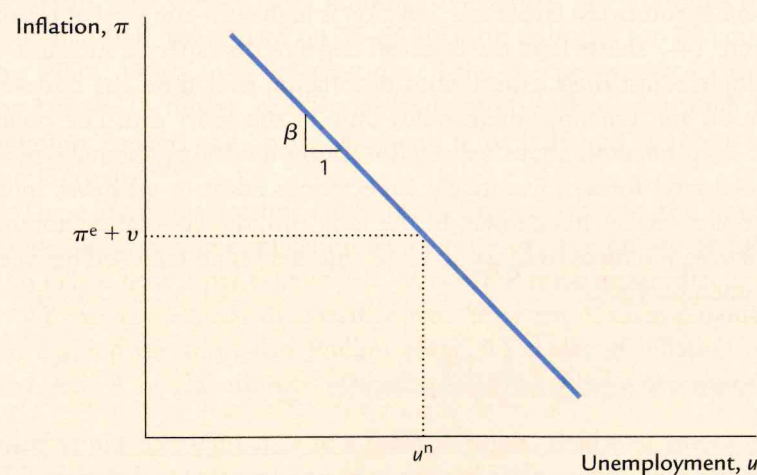
Thus, macroeconomic history illustrates the many forces working on the inflation rate, as described in the Phillips curve equation. The 1960s and 1980s show the two sides of demand–pull inflation: in the 1960s low unemployment pulled inflation up, and in the 1980s high unemployment pulled inflation down. The oil-price hikes of the 1970s show the effects of cost–push inflation. And the 2000s show that inflation sometimes surprises us, in part because changing expectations are not always easy to predict. ■

The Short-Run Trade-Off between Inflation and Unemployment

Consider the options the Phillips curve gives to a policy maker who can influence aggregate demand with monetary or fiscal policy. At any moment, expected inflation and supply shocks are beyond the policy maker's immediate control. Yet by changing aggregate demand, the policy maker can alter output, unemployment and inflation. The policy maker can expand aggregate demand to lower unemployment and raise inflation. Or the policy maker can depress aggregate demand to raise unemployment and lower inflation.

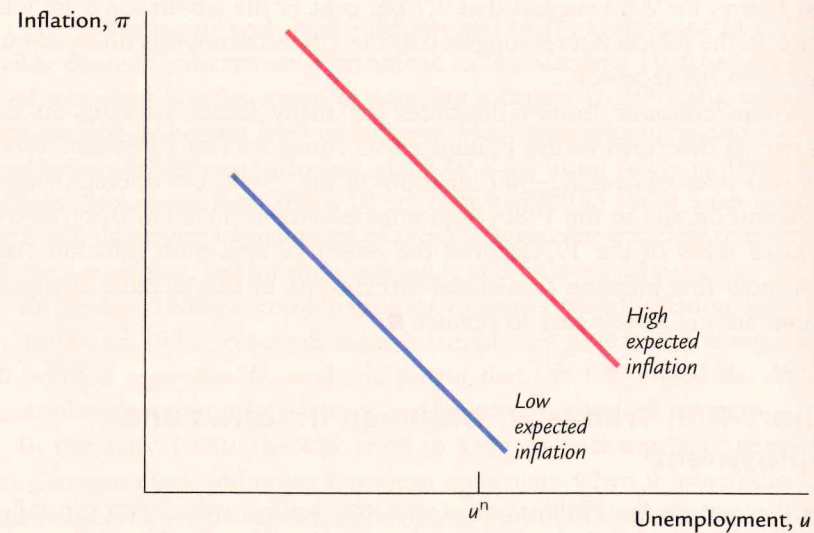
Figure 14-6 plots the Phillips curve equation and shows the short-run trade-off between inflation and unemployment. When unemployment is at its natural rate ($u = u^n$), inflation depends on expected inflation and the supply

FIGURE 14-6



The Short-Run Trade-Off Between Inflation and Unemployment In the short run, inflation and unemployment are negatively related. At any point in time, a policy maker who controls aggregate demand can choose a combination of inflation and unemployment on this short-run Phillips curve.

FIGURE 14-7



Shifts in the Short-Run Trade-Off The short-run trade-off between inflation and unemployment depends on expected inflation. The curve is higher when expected inflation is higher.

shock ($\pi = \pi^e + \nu$). The parameter β determines the slope of the trade-off between inflation and unemployment. In the short run, for a given level of expected inflation, policy makers can manipulate aggregate demand to choose any combination of inflation and unemployment on this curve, called the *short-run Phillips curve*.

Notice that the position of the short-run Phillips curve depends on the expected rate of inflation. If expected inflation rises, the curve shifts upward, and the policy maker's trade-off becomes less favourable: inflation is higher for any level of unemployment. Figure 14-7 shows how the trade-off depends on expected inflation.

Because people adjust their expectations of inflation over time, the trade-off between inflation and unemployment holds only in the short run. The policy maker cannot keep inflation above expected inflation (and thus unemployment below its natural rate) forever. Eventually, expectations adapt to whatever inflation rate the policy maker has chosen. In the long run, the classical dichotomy holds, unemployment returns to its natural rate, and there is no trade-off between inflation and unemployment.

Disinflation and the Sacrifice Ratio

Imagine an economy in which unemployment is at its natural rate and inflation is running at 6 per cent. What would happen to unemployment and output if the central bank pursued a policy to reduce inflation from 6 to 2 per cent?

F Y I

How Precise Are Estimates of the Natural Rate of Unemployment?

If you ask an astronomer how far a particular star is from our sun, he will give you a number, but it will not be accurate. Man's ability to measure astronomical distances is still limited. An astronomer might well take better measurements and conclude that a star is really twice or half as far away as he previously thought.

Estimates of the natural rate of unemployment, or NAIRU, are also far from precise. One problem is supply shocks. Shocks to oil supplies, farm harvests or technological progress can cause inflation to rise or fall in the short run. When we observe rising inflation, therefore, we cannot be sure if it is evidence that the unemployment rate is below the natural rate or

evidence that the economy is experiencing an adverse supply shock.

A second problem is that the natural rate changes over time. Demographic changes (such as the ageing of the baby-boom generation), policy changes (such as minimum-wage laws) and institutional changes (such as the declining role of unions) all influence the economy's normal level of unemployment. Estimating the natural rate is like hitting a moving target.

This conclusion has profound implications. Policy makers may want to keep unemployment close to its natural rate, but their ability to do so is limited by the fact that they cannot be sure what that natural rate is.

The Phillips curve shows that in the absence of a beneficial supply shock, lowering inflation requires a period of high unemployment and reduced output. But by how much and for how long would unemployment need to rise above the natural rate? Before deciding whether to reduce inflation, policy makers must know how much output would be lost during the transition to lower inflation. This cost can then be compared with the benefits of lower inflation.

Much research has used the available data to examine the Phillips curve quantitatively. The results of these studies are often summarized in a number called the **sacrifice ratio**, the percentage of a year's real GDP that must be forgone to reduce inflation by 1 percentage point. Estimates of the sacrifice ratio vary widely from country to country. For example, the economist Laurence Ball, using data on 25 disinflation episodes for 19 countries during the 1960s, 1970s and 1980s, estimated the average sacrifice ratio at around 2 for Austria, Denmark, the Netherlands and Sweden, at around 3 for the UK, Belgium, Ireland and Spain, at around 6 for Italy and at about 10 for the US and Germany.¹⁰

These estimates are not comforting. Even if we take the lower end of the estimated range, the implication is that for every percentage point that inflation is to fall, at least 2 per cent of one year's GDP must be sacrificed.

We can also express the sacrifice ratio in terms of unemployment. When we move along the short-run Phillips curve, we trade off inflation against unemployment. A typical estimate of this trade-off says that a change of 1 percentage

¹⁰ Laurence Ball, 'What Determines the Sacrifice Ratio?', in N. Gregory Mankiw, ed., *Monetary Policy*, Chicago: University of Chicago Press, 1994, pp. 153–193.

point in the unemployment rate translates into a change of 1.5 percentage points in GDP. Therefore, assuming an output–inflation sacrifice ratio of 2, reducing inflation by 1 percentage point requires about 3 percentage points of cyclical unemployment.¹¹

We can use the sacrifice ratio to estimate by how much and for how long unemployment must rise to reduce inflation. If reducing inflation by 1 percentage point requires a sacrifice of 2 per cent of a year's GDP, reducing inflation by 4 percentage points requires a sacrifice of 8 per cent of a year's GDP. Equivalently, this reduction in inflation requires a sacrifice of about 12 percentage points of cyclical unemployment.

This disinflation could take various forms, each totalling the same sacrifice of 8 per cent of a year's GDP. For example, a rapid disinflation would lower output by 4 per cent for two years: this is sometimes called the *cold-turkey* solution to inflation. A moderate disinflation would lower output by 2 per cent for four years. An even more gradual disinflation would depress output by just under 1 per cent for a decade.

Rational Expectations and the Possibility of Painless Disinflation

Because the expectation of inflation influences the short-run trade-off between inflation and unemployment, it is crucial to understand how people form expectations. So far, we have been assuming that expected inflation depends on recently observed inflation. Although this assumption of adaptive expectations is plausible, it is probably too simple to apply in all circumstances.

An alternative approach is to assume that people have **rational expectations**. That is, we might assume that people optimally use all the available information, including information about current government policies, to forecast the future. Because monetary and fiscal policies influence inflation, expected inflation should also depend on the monetary and fiscal policies in effect. According to the theory of rational expectations, a change in monetary or fiscal policy will change expectations, and an evaluation of any policy change must incorporate this effect on expectations. If people do form their expectations rationally, then inflation may have less inertia than it first appears.

¹¹ A simple estimate of this trade-off can be derived from the Cobb–Douglas production function, $Y = AK^\alpha L^{1-\alpha}$. As we discussed in Chapter 3, the Cobb–Douglas production function is not a bad description of aggregate production in many advanced economies. Moreover, α , capital's share in income, is fairly constant at around 0.3 for advanced economies, and labour's share, $1 - \alpha$, is fairly constant at around 0.7. But note that $1 - \alpha$ can also be interpreted as an elasticity – it tells us the percentage change in output that results from a 1 per cent change in labour input, holding the capital stock and total factor productivity constant. Hence, a good rule of thumb is that a 1 per cent reduction in employment leads to a 0.7 per cent reduction in output. If employment and unemployment are closely linked so that, to a first approximation, increases in unemployment are equal to reductions in employment, this means that a 1 per cent increase in unemployment will be associated with a 0.7 per cent fall in output, or, alternatively expressed, that a 1 per cent fall in output will be associated with a $1/0.7 \approx 1.5$ per cent increase in unemployment.

Here is how Thomas Sargent, a prominent advocate of rational expectations and a 2011 Nobel laureate in economics, describes its implications for the Phillips curve:

An alternative 'rational expectations' view denies that there is any inherent momentum to the present process of inflation. This view maintains that firms and workers have now come to expect high rates of inflation in the future and that they strike inflationary bargains in light of these expectations. However, it is held that people expect high rates of inflation in the future precisely because the government's current and prospective monetary and fiscal policies warrant those expectations . . . Thus inflation only seems to have a momentum of its own; it is actually the long-term government policy of persistently running large deficits and creating money at high rates which imparts the momentum to the inflation rate. An implication of this view is that inflation can be stopped much more quickly than advocates of the 'momentum' view have indicated and that their estimates of the length of time and the costs of stopping inflation in terms of foregone output are erroneous . . . [Stopping inflation] would require a change in the policy regime: there must be an abrupt change in the continuing government policy, or strategy, for setting deficits now and in the future that is sufficiently binding as to be widely believed . . . How costly such a move would be in terms of foregone output and how long it would be in taking effect would depend partly on how resolute and evident the government's commitment was.¹²

Thus, advocates of rational expectations argue that the short-run Phillips curve does not accurately represent the options that policy makers have available. They believe that if policy makers are credibly committed to reducing inflation, rational people will understand the commitment and will quickly lower their expectations of inflation. Inflation can then come down without a rise in unemployment and fall in output. According to the theory of rational expectations, traditional estimates of the sacrifice ratio are not useful for evaluating the impact of alternative policies. Under a credible policy, the costs of reducing inflation may be much lower than estimates of the sacrifice ratio suggest.

In the most extreme case, one can imagine reducing the rate of inflation without causing any recession at all. A painless disinflation has two requirements. First, the plan to reduce inflation must be announced before the workers and firms who set wages and prices have formed their expectations. Second, the workers and firms must believe the announcement; otherwise, they will not reduce their expectations of inflation. If both requirements are met, the announcement will immediately shift the short-run trade-off between inflation and unemployment downward, permitting a lower rate of inflation without higher unemployment.

Although the rational-expectations approach remains controversial, almost all economists agree that expectations of inflation influence the short-run trade-off between inflation and unemployment. The credibility of a policy to reduce inflation is therefore one determinant of how costly the policy will be. Unfortunately, it is often difficult to predict whether the public will view the announcement of

¹² Thomas J. Sargent, 'The Ends of Four Big Inflation', in Robert E. Hall, ed., *Inflation: Causes and Effects*, Chicago: University of Chicago Press, 1982, pp. 41–98.

a new policy as credible. The central role of expectations makes forecasting the results of alternative policies far more difficult.

CASE STUDY

The Sacrifice Ratio in Practice: The Thatcher Disinflation

The Phillips curve with adaptive expectations implies that reducing inflation requires a period of high unemployment and low output. By contrast, the rational-expectations approach suggests that reducing inflation can be much less costly. What happens during actual disinflations?

Consider the UK disinflation in the early 1980s. This decade began with some of the highest rates of inflation in UK history. Yet because of the tight monetary policies the government pursued under Prime Minister Margaret Thatcher, the rate of inflation fell substantially in the first few years of the decade. This episode provides a natural experiment with which to estimate how much output is lost during the process of disinflation.

The first question is: How much did inflation fall? As measured by the GDP deflator, inflation reached a peak of about 18 per cent in 1980. It is natural to end the episode in 1985 because oil prices plunged in 1986 – a large, beneficial supply shock unrelated to government policy. In 1985, UK inflation was about 6 per cent, so we can estimate that the Thatcher administration engineered a reduction in inflation of 12 percentage points over five years.

The second question is: How much output was lost during this period? Table 14-1 shows the unemployment rate from 1981 to 1985. Assuming that the natural rate of unemployment was 9.5 per cent over this period, we can compute the amount of cyclical unemployment in each year. In total over this period, there were 8.7 percentage points of cyclical unemployment.

Now we can compute the sacrifice ratio for this episode. We know that about 9 percentage points of cyclical unemployment were generated and that inflation fell by about 12 points. Hence, $9/12$ or about 0.75 percentage points of cyclical

TABLE 14-1

UK Unemployment During the Thatcher Disinflation

Year	Unemployment Rate u (%)	Natural Rate u^n (%)	Cyclical Unemployment $u - u^n$ (%)
1981	10.4	9.5	0.9
1982	11.2	9.5	1.7
1983	11.8	9.5	2.3
1984	11.5	9.5	2.0
1985	11.3	9.5	1.8
			Total 8.7%

unemployment were generated for each percentage-point reduction in inflation. Alternatively, if we use the rule of thumb that each 1.5 per cent increase in cyclical unemployment reduces output by 1 per cent, then the 9 percentage points of cyclical unemployment translate into $9/1.5 = 6$ percentage points of GDP, and the sacrifice ratio is estimated as $6/12$, or 0.5.

This estimate of the sacrifice ratio is actually very much smaller than had been expected – as we discussed earlier, estimates of the UK sacrifice ratio tended to put it at around 3. Thus, Thatcher reduced inflation at a smaller cost than many economists had predicted. One explanation is that Thatcher's tough stand, both on monetary policy and on labour market reform, was credible enough to influence expectations of inflation directly. Yet the change in expectations was not large enough to make the disinflation painless: the UK unemployment rates of the early 1980s were at their highest levels since the Great Depression of the 1930s.

Although the Thatcher disinflation is only one historical episode, this kind of analysis can be applied to other disinflations. Laurence Ball's study of the sacrifice ratio and disinflation episodes, which we discussed earlier, found that in almost all cases the reduction in inflation came at the cost of temporarily lower output. Yet the size of the output loss varied from episode to episode. Rapid disinflations usually had smaller sacrifice ratios than slower ones. That is, in contrast to what the Phillips curve with adaptive expectations suggests, a cold-turkey approach appears less costly than a gradual one. Moreover, countries with more flexible wage-setting institutions, such as shorter labour contracts, had smaller sacrifice ratios. These findings indicate that reducing inflation always has some cost, but that policies and institutions can affect its magnitude. ■

Hysteresis and the Challenge to the Natural-Rate Hypothesis

Our discussion of the cost of disinflation – and indeed our entire discussion of economic fluctuations in the past four chapters – has been based on an assumption called the **natural-rate hypothesis**. This hypothesis is summarized in the following statement: *Fluctuations in aggregate demand affect output and employment only in the short run. In the long run, the economy returns to the levels of output, employment and unemployment described by the classical model.*

The natural-rate hypothesis allows macroeconomists to study separately short-run and long-run developments in the economy. It is one expression of the classical dichotomy.

Some economists have challenged the natural-rate hypothesis by suggesting that aggregate demand may affect output and employment even in the long run. They have pointed out a number of mechanisms through which recessions might leave permanent scars on the economy by altering the natural rate of unemployment. **Hysteresis** is the term used to describe the long-lasting influence of history on the natural rate.

A recession can have permanent effects if it changes the people who become unemployed. For instance, workers might lose valuable job skills when unemployed,

lowering their ability to find a job even after the recession ends. Alternatively, a long period of unemployment may change an individual's attitude towards work and reduce his or her desire to find employment. In either case, the recession permanently inhibits the process of job search and raises the amount of frictional unemployment.

Another way in which a recession can permanently affect the economy is by changing the process that determines wages. Those who become unemployed may lose their influence on the wage-setting process. Unemployed workers may lose their status as union members, for example. More generally, some of the *insiders* in the wage-setting process become *outsiders*. If the smaller group of insiders cares more about high real wages and less about high employment, then the recession may permanently push real wages further above the equilibrium level and raise the amount of structural unemployment.

Hysteresis remains a controversial theory. Some economists believe the theory helps explain persistently high unemployment in Europe, because the rise in European unemployment starting in the early 1980s coincided with disinflation but continued after inflation stabilized. Moreover, the increase in unemployment tended to be larger for those countries that experienced the greatest reductions in inflations, such as Ireland, Italy and Spain. Yet there is still no consensus on whether the hysteresis phenomenon is significant, or why it might be more pronounced in some countries than in others. (Other explanations of high European unemployment, discussed in Chapter 7, give little role to disinflation.) If it is true, however, the theory is important, because hysteresis greatly increases the cost of recessions. Put another way, hysteresis raises the sacrifice ratio, because output is lost even after the period of disinflation is over.

This issue rose to prominence once again in the aftermath of the great recession of 2008–2009. Many economists wondered whether or not the extraordinarily high levels of long-term unemployment (discussed in Chapter 7) would increase the natural rate of unemployment for years to come. If so, it would mean that, as the economy recovered and unemployment fell, inflation might start rising more quickly than one might have otherwise expected. It would also mean that the cost of recession in terms of reduced incomes and human suffering would be long-lasting. These issues were not resolved as this book was going to press.¹³

14-3 Conclusion

We began this chapter by discussing three models of aggregate supply, each of which focuses on a different reason why, in the short run, output rises above its natural level when the price level rises above the level that people had expected.

¹³ Olivier J. Blanchard and Lawrence H. Summers, 'Beyond the Natural Rate Hypothesis', *American Economic Review*, May 1988, vol. 78, pp. 182–187; Laurence Ball, 'Disinflation and the NAIRU', in Christina D. Romer and David H. Romer, eds, *Reducing Inflation: Motivation and Strategy*, Chicago: University of Chicago Press, 1997, pp. 167–185.

All three models explain why the short-run aggregate supply curve is upward sloping, and all of them yield a short-run trade-off between inflation and unemployment. A convenient way to express and analyse that trade-off is with the Phillips-curve equation, according to which inflation depends on expected inflation, cyclical unemployment and supply shocks.

Keep in mind that not all economists endorse all the ideas discussed here. There is widespread disagreement, for instance, about the practical importance of rational expectations and the relevance of hysteresis. If you find it difficult to fit all the pieces together, you are not alone. The study of aggregate supply remains one of the most unsettled – and therefore one of the most exciting – research areas in macroeconomics.

Summary

1. The three theories of aggregate supply – the sticky-price, sticky-wage and imperfect-information models – attribute deviations of output and employment from their natural levels to various market imperfections. According to all three theories, output rises above its natural level when the price level exceeds the expected price level, and output falls below its natural level when the price level is less than the expected price level.
2. Economists often express aggregate supply in a relationship called the Phillips curve. The Phillips curve says that inflation depends on expected inflation, the deviation of unemployment from its natural rate and supply shocks. According to the Phillips curve, policy makers who control aggregate demand face a short-run trade-off between inflation and unemployment.
3. If expected inflation depends on recently observed inflation, then inflation has inertia, which means that reducing inflation requires either a beneficial supply shock or a period of high unemployment and reduced output. If people have rational expectations, however, then a credible announcement of a change in policy might be able to influence expectations directly, and therefore reduce inflation without causing a recession.
4. Most economists accept the natural-rate hypothesis, according to which fluctuations in aggregate demand have only short-run effects on output and unemployment. Yet some economists have suggested ways in which recessions can leave permanent scars on the economy by raising the natural rate of unemployment.

KEY CONCEPTS

Sticky-price model	Adaptive expectations	Rational expectations
Sticky-wage model	Demand-pull inflation	Natural-rate hypothesis
Imperfect-information model	Cost-push inflation	Hysteresis
Phillips curve	Sacrifice ratio	

QUESTIONS FOR REVIEW

1. Explain the three theories of aggregate supply. On what market imperfection does each theory rely? What do the theories have in common?
2. How is the Phillips curve related to aggregate supply?
3. Why might inflation be inertial?
4. Explain the differences between demand-pull inflation and cost-push inflation.
5. Under what circumstances might it be possible to reduce inflation without causing a recession?
6. Explain two ways in which a recession might raise the natural rate of unemployment.

PROBLEMS AND APPLICATIONS

1. In the sticky-price model, describe the aggregate supply curve in the following special cases. How do these cases compare to the short-run aggregate supply curve we discussed in Chapter 10?
 - a. No firms have flexible prices ($s = 1$).
 - b. The desired price does not depend on aggregate output ($a = 0$).
2. Consider the following changes in the sticky-wage model.
 - a. Suppose that labour contracts specify that the nominal wage be fully indexed for inflation. That is, the nominal wage is to be adjusted to fully compensate for changes in the consumer price index. How does full indexation alter the aggregate supply curve in this model?
 - b. Suppose now that indexation is only partial. That is, for every increase in the CPI, the nominal wage rises, but by a smaller percentage. How does partial indexation alter the aggregate supply curve in this model?
3. Suppose that an economy has the Phillips curve

$$\pi = \pi_{-1} - 0.5(u - 0.06).$$
 - a. What is the natural rate of unemployment?
 - b. Graph the short-run and long-run relationships between inflation and unemployment.
 - c. How much cyclical unemployment is necessary to reduce inflation by 5 percentage points?
 - d. Inflation is running at 10 per cent. The central bank wants to reduce it to 5 per cent. Give two scenarios that will achieve that goal.
4. According to the rational-expectations approach, if everyone believes that policy makers are committed to reducing inflation, the cost of reducing inflation – the sacrifice ratio – will be lower than if the public is sceptical about the policy makers' intentions. Why might this be true? How might credibility be achieved?
5. Assume that people have rational expectations and that the economy is described by the sticky-wage or sticky-price model. Explain why each of the following propositions is true:
 - a. Only unanticipated changes in the money supply affect real GDP. Changes in the money supply that were anticipated when wages and prices were set do not have any real effects.

- b. If the central bank chooses the money supply at the same time as people are setting wages and prices, so that everyone has the same information about the state of the economy, then monetary policy cannot be used systematically to stabilize output. Hence, a policy of keeping the money supply constant will have the same real effects as a policy of adjusting the money supply in response to the state of the economy. (This is called the *policy irrelevance proposition*.)
 - c. If the central bank sets the money supply well after people have set wages and prices, so that the central bank has collected more information about the state of the economy, then monetary policy can be used systematically to stabilize output.
6. Suppose that an economy has the Phillips curve

$$\pi = \pi_{-1} - 0.5(u - u^n),$$
 and that the natural rate of unemployment is given by an average of the past two years' unemployment:

$$u^n = 0.5(u_{-1} + u_{-2}).$$
 - a. Why might the natural rate of unemployment depend on recent unemployment (as is assumed in the preceding equation)?
 - b. Suppose that the central bank follows a policy to reduce permanently the inflation rate by 1 percentage point. What effect will that policy have on the unemployment rate over time?
 - c. What is the sacrifice ratio in this economy? Explain.
 - d. What do these equations imply about the short-run and long-run trade-offs between inflation and unemployment?
 7. Some economists believe that taxes have an important effect on labour supply. They argue that higher taxes cause people to want to work less, and that lower taxes cause them to want to work more. Consider how this effect alters the macroeconomic analysis of tax changes.
 - a. If this view is correct, how does a tax cut affect the natural level of output?
 - b. How does a tax cut affect the aggregate demand curve? The long-run aggregate supply curve? The short-run aggregate supply curve?
 - c. What is the short-run impact of a tax cut on output and the price level? How does your answer differ from the case without the labour-supply effect?
 - d. What is the long-run impact of a tax cut on output and the price level? How does your answer differ from the case without the labour-supply effect?