

23 Aggregate Supply and the Phillips Curve

In this appendix, we examine how economists' view of aggregate supply has evolved over time and how the concept called the *Phillips curve*, which described the relationship between unemployment and inflation, fits into the analysis of aggregate supply.

The classical economists, who predated Keynes, believed that wages and prices were extremely flexible, so the economy would always adjust quickly to the natural rate level of output Y_n . This view is equivalent to assuming that the aggregate supply curve is vertical at an output level of Y_n even in the short run.

With the advent of the Great Depression in 1929 and the subsequent long period of high unemployment, the classical view of an economy that adjusts quickly to the natural rate level of output became less tenable. The teachings of John Maynard Keynes emerged as the dominant way of thinking about the determination of aggregate output, and the view that aggregate supply is vertical was abandoned. Instead, Keynesians in the 1930s, 1940s, and 1950s assumed that for all practical purposes, the price level could be treated as fixed. They viewed aggregate supply as a horizontal curve along which aggregate output could increase without an increase in the price level.

In 1958, A. W. Phillips published a famous paper that outlined a relationship between unemployment and inflation.¹ This relationship was popularized by Paul Samuelson and Robert Solow of the Massachusetts Institute of Technology in the early 1960s, and naturally enough, it became known as the *Phillips curve*, after its discoverer. The Phillips curve indicates that the rate of change of wages $\Delta w/w$, called *wage inflation*, is negatively related to the difference between the actual unemployment rate U and the natural rate of unemployment U_n :

$$\Delta w/w = -h(U - U_n)$$

where h is a constant that indicates how much wage inflation changes for a given change in $U - U_n$. If h were 2, for example, a 1 percent increase in the unemployment rate relative to the natural rate would result in a 2 percent decline in wage inflation.

The Phillips curve provides a view of aggregate supply because it indicates that a rise in aggregate output that lowers the unemployment rate will raise wage inflation and thus lead to a higher level of wages and the price level. In other words, the Phillips curve implies that the aggregate supply curve will be upward-sloping. In addition, it indicates that when $U > U_n$ (the labor market is slack), $\Delta w/w$ is negative and wages

¹A. W. Phillips, "The Relationship Between Unemployment and the Rate of Change of Money Wages in the United Kingdom, 1861–1957," *Economica* 25 (1958): 283–299.

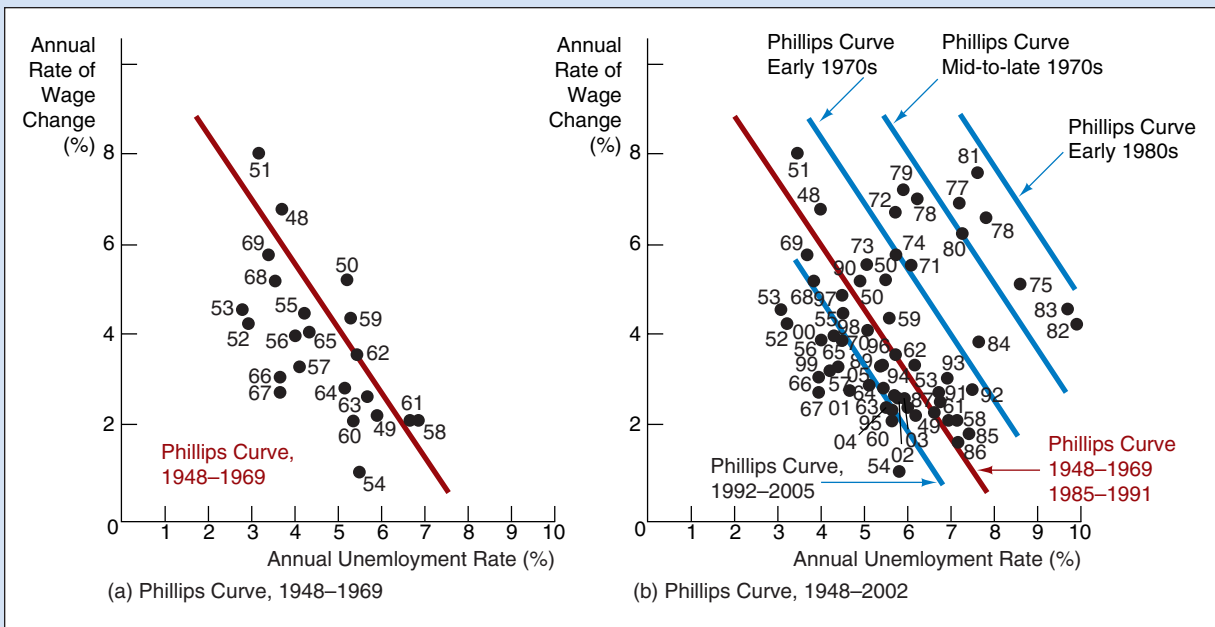


FIGURE 1 Phillips Curve in the United States

Although the Phillips curve relationship worked fairly well from 1948 to 1969, after this period it appeared to shift upward, as is clear from panel (b). Looking at the whole period after World War II, there is no apparent trade-off between unemployment and inflation.

Source: Economic Report of the President. <http://w3.access.gpo.gov/usbudget/>

decline over time. Hence the Phillips curve supports the view of aggregate supply in Chapter 23 that when the labor market is slack, production costs will fall and the aggregate supply curve will shift to the right.²

Figure 1 shows what the Phillips curve relationship looks like for the United States. As we can see from panel (a), the relationship works well until 1969 and seems to indicate an apparent trade-off between unemployment and wage inflation: If the public wants to have a lower unemployment rate, it can “buy” this by accepting a higher rate of wage inflation.

In 1967, however, Milton Friedman pointed out a severe flaw in the Phillips curve analysis: It left out an important factor that affects wage changes: workers’ expectations

²Because workers normally become more productive over time as a result of new technology and increases in physical capital, their real wages grow over time even when the economy is at the natural rate of unemployment. To reflect this, the Phillips curve should include a term that reflects the growth in real wages due to higher worker productivity. We have left this term out of the equation in the text, because higher productivity that results in higher real wages will not cause the aggregate supply curve to shift. If, for example, workers become 3 percent more productive every year and their real wages grow at 3 percent per year, the effective cost of workers to the firm (called *unit labor costs*) remains unchanged, and the aggregate supply curve does not shift. Thus the $\Delta w/w$ term in the Phillips curve is more accurately thought of as the change in the unit labor costs.

of inflation.³ Friedman noted that firms and workers are concerned with real wages, not nominal wages; they are concerned with the wage adjusted for any expected increase in the price level—that is, they look at the rate of change of wages minus expected inflation. When unemployment is high relative to the natural rate, real (not nominal) wages should fall ($\Delta w/w - \pi^e < 0$); when unemployment is low relative to the natural state, real wages should rise ($\Delta w/w - \pi^e > 0$). The Phillips curve relationship thus needs to be modified by replacing $\Delta w/w$ by $\Delta w/w - \pi^e$. This results in an *expectations-augmented Phillips curve*, expressed as:

$$\Delta w/w - \pi^e = -h(U - U_n) \quad \text{or} \quad \Delta w/w = -h(U - U_n) + \pi^e$$

The expectations-augmented Phillips curve implies that as expected inflation rises, nominal wages will be increased to prevent real wages from falling, and the Phillips curve will shift upward. The resulting rise in production costs will then shift the aggregate supply curve leftward. The conclusion from Friedman's modification of the Phillips curve is therefore that the higher inflation is expected to be, the larger the leftward shift in the aggregate supply curve; this conclusion is built into the analysis of the aggregate supply curve in the chapter.

Friedman's modifications of the Phillips curve analysis was remarkably clairvoyant: As inflation increased in the late 1960s, the Phillips curve did indeed begin to shift upward, as we can see from panel (b). An important feature of panel (b) is that a trade-off between unemployment and wage inflation is no longer apparent; there is no clear-cut relationship between unemployment and wage inflation—a high rate of wage inflation does not mean that unemployment is low, nor does a low rate of wage inflation mean that unemployment is high. This is exactly what the expectations-augmented Phillips curve predicts: A rate of unemployment permanently below the natural rate of unemployment cannot be “bought” by accepting a higher rate of inflation because no long-run trade-off between unemployment and wage inflation exists.⁴

A further refinement of the concept of aggregate supply came from research by Milton Friedman, Edmund Phelps, and Robert Lucas, who explored the implications of the expectations-augmented Phillips curve for the behavior of unemployment. Solving the expectations-augmented Phillips curve for U leads to the following expression:

$$U = U_n - (\Delta w/w - \pi^e)/h$$

Because wage inflation and price inflation are closely tied to each other, π can be substituted for $\Delta w/w$ in this expression to obtain:

$$U = U_n - (\pi - \pi^e)/h$$

³This criticism of the Phillips curve was outlined in Milton Friedman's famous presidential address to the American Economic Association: Milton Friedman, “The Role of Monetary Policy,” *American Economic Review* 58 (1968): 1–17.

⁴This prediction can be derived from the expectations-augmented Phillips curve as follows. When wage inflation is held at a constant level, inflation and expected inflation will eventually equal wage inflation. Thus in the long run, $\pi^e = \Delta w/w$. Substituting the long-run value of π^e into the expectations-augmented Phillips curve gives:

$$\Delta w/w = -h(U - U_n) + \Delta w/w$$

Subtracting $\Delta w/w$ from both sides of the equation gives $0 = -h(U - U_n)$, which implies that $U = U_n$. This tells us that in the long run, for any level of wage inflation, unemployment will settle to its natural rate level; hence the long-run Phillips curve is vertical, and there is no long-run trade-off between unemployment and wage inflation.

This expression, often referred to as the *Lucas supply function*, indicates that deviations of unemployment and aggregate output from the natural rate levels respond to unanticipated inflation (actual inflation minus expected inflation, $\pi - \pi^e$). When inflation is greater than anticipated, unemployment will be below the natural rate (and aggregate output above the natural rate). When inflation is below its anticipated value, unemployment will rise above the natural rate level. The conclusion from this view of aggregate supply is that only unanticipated policy can cause deviations from the natural rate of unemployment and output.