LECTURE 7: PHILLIPS CURVE, NATURAL RATE OF UNEMPLOYMENT, AND INFLATION*

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This lecture provides a way to think about how inflation rate and unemployment rate are related in the short and medium run. Since the 1970s, the U.S. data can be characterized as a negative relationship between unemployment rate and the change in inflation rate. This implies the existence of the so-called natural rate of unemployment for which the inflation rate remains constant. When the unemployment rate is below the natural rate, the inflation rate rises; when the unemployment rate is above the natural rate, the inflation rate falls. Therefore, the economy cannot operate at an unemployment rate below the natural rate without a continual increase in the inflation rate, which limits the central bank's ability to stimulate the economy. By the same token, if the central bank wishes to reduce the inflation rate, it cannot do so without increasing the unemployment rate above the natural rate.

1 INFLATION, EXPECTED INFLATION, AND UNEMPLOYMENT

Recall from the last lecture that the aggregate supply (AS) relation among the price level, expected price level, and unemployment rate in year t can be written as

$$P_t = P_t^e(1+m)F(u_t, z) \tag{1.1}$$

where we take both m and z as constant over time. For convenience, we assume that $F(u_t, z) = 1 - \alpha u_t + z$, where the parameter $\alpha > 0$ captures the strength of the effect of unemployment on nominal wage. Let π_t be the inflation rate in year t and π_t^e be the expected inflation rate in year t. Then the AS relation can be rewritten as

$$\pi_t = \pi_t^e + (m+z) - \alpha u_t \tag{1.2}$$

which is a relation among inflation, expected inflation, and unemployment rate. See the appendix of this lecture for a detailed derivation. Here are three remarks:

- Higher expected inflation π^e leads to higher actual inflation π. This is a restatement of the fact that higher expected price level leads to higher actual price level.

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These are notes that I used by myself to lecture from and for educational purposes only. The material presented here is largely based upon the undergraduate textbook by Blanchard and Johnson (2012), *Macroeconomics*, 6th Edition, Prentice Hall. Please do NOT circulate.

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- Given expected inflation π^e, an increase in markup m or catchall factor z leads to higher actual inflation π. This is a restatement of the fact that given P^e, an increase in either m or z increases the actual price level.
- Given expected inflation π^e, higher unemployment rate u leads to lower actual inflation π. This is a restatement of the fact that given P^e, higher unemployment rate leads to lower actual price level.

2 THE PHILLIPS CURVE

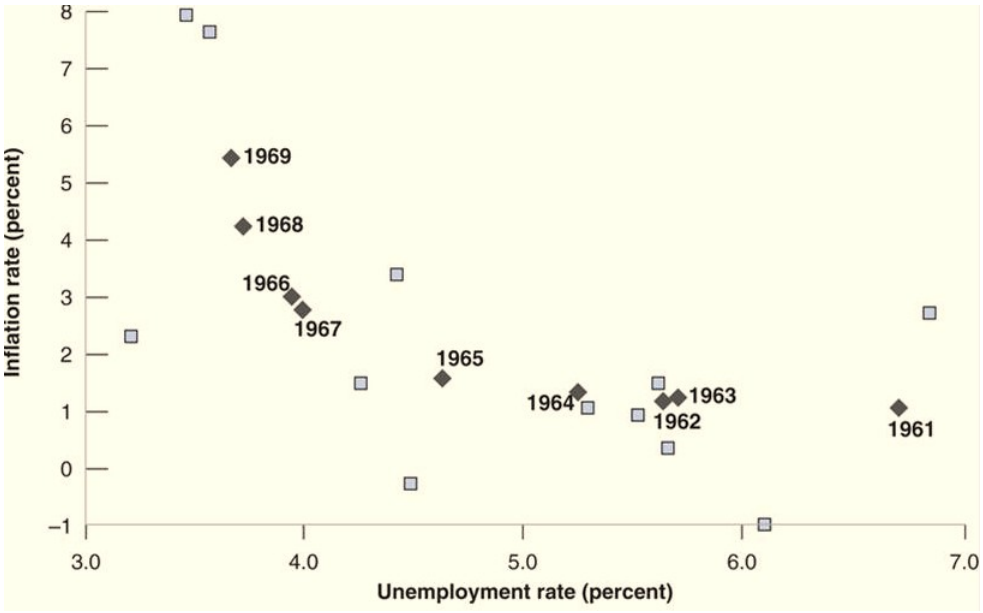

Figure 1. Inflation versus unemployment in the U.S.

The early incarnation. During much of the period prior to the 1960s, the average inflation rate was close to zero. Thus, it is reasonable to assume that wage setters expect inflation to be zero over the next year, i.e. $\pi^e = 0$. Then (1.2) reduces to

$$\pi_t = (m + z) - \alpha u_t \tag{2.1}$$

which is precisely the negative relation between unemployment and inflation that Phillips found for the U.K. and Solow and Samuelson found for the U.S. See Figure 1 below. This mechanism is called the **wage-price spiral**:

- Low unemployment leads to higher nominal wage, making firms increase their prices.
- In response to the higher price level, workers ask for higher nominal wage when it is set the next time, leading firms to further increase their prices.

- This process continues and the race between prices and wages results in steady wage and price inflation.

Mutations. The negative relation between inflation rate and unemployment rate in the U.S. seemed to break down during the 1970s. There are two main reasons:

- The U.S. was hit twice by a large increase in oil price. The effect of this increase in nonlabor costs was to increase the markup m, which by (2.1) leads to higher inflation rate, even at a given unemployment rate.
- Since the 1960s, the inflation rate became not only consistently positive, but also more persistent as opposed to being sometimes positive and sometimes negative before the 1960s. This changed the way wage setters formed their expectations.

To reconcile these facts, suppose now expectations of inflation are formed according to

$$\pi_t^e = \theta \pi_{t-1} \tag{2.2}$$

where the parameter θ captures the effect of last year's inflation rate π_{t-1} on this year's expected inflation rate π_t^e. Then we can think of what happened in the 1970s as an increase in the value of θ over time:

- For the period that Samuelson and Solow studied, inflation was low and not persistent, so $\theta \approx 0$ and expectations were given by $\pi_t^e = 0$. Thus, from (1.2) we have

  $$\pi_t = (m + z) - \alpha u_t \tag{2.3}$$

  which gives the original Phillips curve—a relation between inflation and unemployment.
- As inflation became higher and more persistent, workers and firms started changing the way they formed expectations. As a result, θ became positive and from equation (1.2) we have

  $$\pi_t = \theta \pi_{t-1} + (m + z) - \alpha u_t \tag{2.4}$$

- By the mid-1970s, people expected this year's inflation to be the same as last year's inflation. That is, $\theta \approx 1$ and from (1.2) we have

  $$\pi_t - \pi_{t-1} = (m + z) - \alpha u_t \tag{2.5}$$

  which gives a new relation between unemployment rate and the change in inflation rate: high (low) unemployment leads to decreasing (increasing) inflation. It roughly

described what had happened since 1970 and is called the **modified Phillips curve** or the **expectations-augmented Phillips curve**. See Figure 2 below.

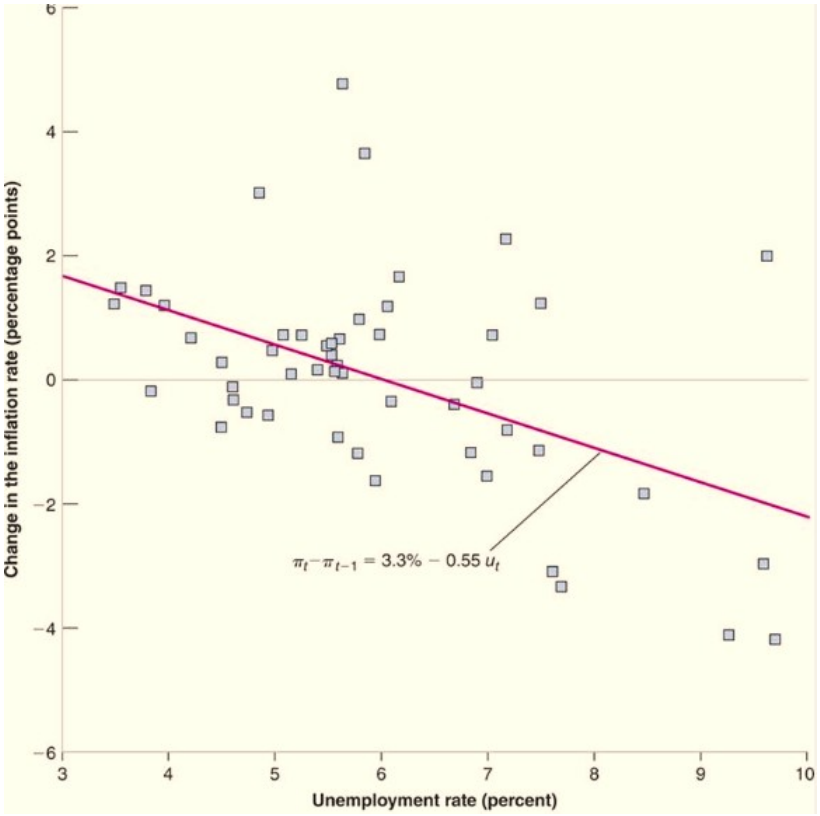

Figure 2. Change in inflation versus unemployment in the U.S.

The Phillips curve and the natural rate of unemployment. We make explicit the connection between the Phillips curve and the natural rate of unemployment, which can be defined equivalently as the unemployment rate such that the actual inflation rate is equal to the expected inflation rate.[1] Imposing the condition $\pi_t = \pi_t^e$ on (1.2) and solving for u_n give

$$u_n = \frac{m + z}{\alpha} \tag{2.6}$$

Now (2.5) can be rewritten as

$$\pi_t - \pi_{t-1} = -\alpha \left(u_t - \frac{m + z}{\alpha} \right) = -\alpha (u_t - u_n) \tag{2.7}$$

which roughly characterizes the case in the U.S. today. Here are two remarks:

[1] In the late 1960s, Milton Friedman and Edmund Phelps questioned the existence of the trade-off between unemployment and inflation—if policy makers were willing to tolerate a higher inflation rate, they could maintain a lower unemployment rate forever. They argued that such a trade-off could exist only if wage setters systematically underpredicted inflation and would ultimately disappear.

- The change in inflation rate depends negatively on the deviation of actual unemployment rate from its natural rate, i.e.

$$u_t < u_n \Rightarrow \pi_t > \pi_{t-1} \tag{2.8}$$

$$u_t > u_n \Rightarrow \pi_t < \pi_{t-1} \tag{2.9}$$

- The natural rate of unemployment can be viewed as the unemployment rate required to keep the inflation rate constant. ($u_n \approx 6\%$ in the U.S. since 1970.)

The neutrality of money revisited. We consider the effects of changes in the growth rate of nominal money on unemployment and inflation in the medium run.

- In the medium run, expected inflation must be equal to actual inflation and hence the unemployment rate must return to its natural rate, which is independent of the growth rate of nominal money.

- In the medium run, since $u = u_n$, output must return to its natural level given by

$$Y_n = Y\left(\frac{M}{P}, G, T\right) = (1 - u_n)L \tag{2.10}$$

  which is a constant. With unchanged fiscal policy (i.e. constant G and T), M/P must be a constant and hence

$$\pi = g_M \tag{2.11}$$

  which says that in the medium run, the inflation rate is determined by the nominal money growth rate.[2] As Milton Friedman put it: *inflation is always and everywhere a monetary phenomenon.*

3 MANY WARNINGS

There are a number of warnings on the relation between inflation and unemployment:

- Variations in the natural rate across countries. Since the natural rate of unemployment depends on (z, m, α), whose values may differ across countries, there is no reason to expect all countries to have the same natural rate of unemployment.

[2] Here we have ignored output growth. If output is growing at rate g_Y, then (2.11) takes the form

$$\pi = g_M - g_Y$$

See this full version and its derivation from the quantity theory of money in the appendix of this lecture.

- Variations in the natural rate over time. The degree of monopoly power of firms, the structure of wage bargaining, the system of unemployment benefits, and so on are likely to change over time, leading to changes in either m or z and hence changes in the natural rate of unemployment.

- Disinflation, credibility, and unemployment. For example, Thomas Sargent argued that the key of successful disinflation was credibility of monetary contraction in reducing inflation.[3] If the Fed were fully credible and wage setters expected inflation to be lower, then $\pi_t^e < \pi_{t-1}$ and (1.2), rewritten as

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

  implies that disinflation can be less costly in terms of higher unemployment rate.

- The Phillips curve relation is likely to change with the level and persistence of inflation. For example, in countries with high and volatile inflation, the higher the proportion of labor contracts with **wage indexation**—a provision that automatically increases wages in line with inflation, the larger the effect of unemployment on inflation.

- Deflation and the Phillips curve relation. When the economy starts experiencing deflation, the Phillips curve relation may break down due to the reluctance of workers to accept decreases in their nominal wages.

4 APPENDIX

Approximation of the aggregate supply relation. Define the inflation rate and the expected inflation rate in year t respectively by $\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$ and $\pi_t^e = \frac{P_t^e - P_{t-1}}{P_{t-1}}$. Then the aggregate supply relation can be rewritten as

$$\begin{aligned} 1 + \pi_t &= \frac{P_t}{P_{t-1}} \\ &= \frac{P_t^e}{P_{t-1}}(1+m)(1-\alpha u_t + z) \\ &= (1+\pi_t^e)(1+m)(1-\alpha u_t + z) \end{aligned}$$

For small values of π_t, π_t^e, and m, we can approximate the above equation by

$$\begin{aligned} 1 - \alpha u_t + z &= \frac{1+\pi_t}{(1+\pi_t^e)(1+m)} \\ &\approx 1 + \pi_t - \pi_t^e - m \end{aligned}$$

[3] Disinflation means a decrease in the inflation rate while deflation means a decrease in the price level.

Rearranging yields

$$\pi_t = \pi_t^e + (m + z) - \alpha u_t$$

which gives (1.2).

The Quantity theory of money. In monetary economics, the quantity theory of money asserts that money supply has a direct, proportional relationship with the price level. This theory begins with the equation of exchange

$$M \times V = P \times Y \tag{4.1}$$

where V is the velocity of money, i.e. the average frequency across all transactions with which a unit of money is spent. Monetarists assume that the velocity of money is unaffected by monetary policy at least in the medium run and hence V is a constant. The above relation can be approximated as

$$g_M + g_V \approx g_P + g_Y$$

where g_X refers to the growth rate of variable X. Because $g_V = 0$ and $g_P = \pi$, we have

$$\pi = g_M - g_Y \tag{4.2}$$

which says that in the medium run, inflation is determined by the nominal money growth rate and the real output growth rate, where the latter is determined by the rate of technological progress and the rate of population growth, as shown in the subsequent lectures.