Lecture Notes for DeLong-Olney (2e): Inflation, Unemployment, and Stabilization Policy

In the Phillips Curve-Monetary Policy Reaction Function framework, we collapse all behavior on the side of aggregate supply into four numbers: a natural rate of unemployment u*, a responsiveness of prices and inflation to excess or deficient demand β, an expected rate of inflation π^e, and a supply-shocks term ss. We pack all this information into a Phillips curve:

$$\pi = \pi^e - \beta(u - u^*) + ss$$

Similarly, we take all the information about monetary policy attitudes and about the sticky-price model determinants of aggregate demand and collapse them into four numbers: a belief on the part of the central bank as to what the "normal" interest rate is, a value u_0 of the unemployment rate when interest rates and thus output are at what the central bank regards as their "normal" values, a "target" inflation rate π^t that the central bank seeks to attain, and a responsiveness of central bank policy—either to raise or to lower the unemployment rate—to deviations of the inflation rate from its chosen target. We pack all this information into a Monetary Policy Reaction Function—MPRF:

$$u = u_0 + \phi\left(\pi - \pi^t\right)$$

We then use this framework to analyze the statics and dynamics of inflation and unemployment.

Statics

The position of the Phillips curve depends on the natural rate of unemployment u*, the expected rate of inflation π^e, and whether there are any current supply shocks affecting inflation, ss.

The position of the MPRF—the Monetary Policy Reaction Function—depends on the level of unemployment u_0 when the real interest rate r is at what the central bank thinks of as its normal baseline rate r_0, and the central bank's target level of inflation π^t.

All five of these factors together, along with the parameters ϕ and β—the slopes of the monetary policy reaction function and of the Phillips curve—determine the economy's equilibrium inflation and unemployment rates.

From our MPRF:

$$u = u_0 + \phi\left(\pi - \pi^t\right)$$

and our Phillips curve:

$$\pi = \pi^e - \beta(u - u^*) + ss$$

it is straightforward to obtain an algebraic solution for what the economy's unemployment rate and inflation rate are. Simply substitute the Phillips curve equation into the monetary policy reaction function and solve for the unemployment rate:

$$u = \left(\frac{1}{1+\phi\beta}u_0 + \frac{\phi\beta}{1+\phi\beta}u^*\right) + \frac{\phi}{1+\phi\beta}(\pi^e - \pi^t) + \frac{\phi}{1+\phi\beta}ss$$

And substitute the monetary policy reaction function equation into the Phillips curve equation and solve for the inflation rate:

$$\pi = \left(\frac{1}{1+\phi\beta}\pi^e + \frac{\phi\beta}{1+\phi\beta}\pi^t\right) + \frac{\beta}{1+\phi\beta}(u^* - u_0) + \frac{1}{1+\phi\beta}ss$$

We see that the unemployment rate is equal to:

- A weighted average of the unemployment rate u_0 when the central bank has set the real interest rate to its normal baseline value r_0 and the natural rate of unemployment u^* (the greater the product of the slope parameters ϕ and β, the higher the relative weight on the natural rate u^*).

- A term that depends on the difference between the expected rate of inflation π^e and the central bank's target rate of inflation π^t; when the expected inflation rate is higher than the central bank's target rate, unemployment is higher because the central bank has raised interest rates to fight inflation.

- A term that depends on current supply shocks ss.

We see that the inflation rate is equal to:

- A weighted average of the expected rate of inflation π^e and the central bank's target rate of inflation π^t (the greater the product of the slope parameters ϕ and β, the higher the relative weight on the target rate π^t).

- A term that depends on the difference between the natural rate of unemployment u* and unemployment rate u_0 when the central bank has set the real interest rate to its normal baseline value r_0. When the natural rate of unemployment is higher than u_0, inflation is higher because there is an inflationary bias to demand.

- A term that depends on current supply shocks ss.

We can use this framework to analyze, using comparative statics, the effects of a shift in economic policy or the economic environment on the economy's equilibrium.

For example, consider a depression abroad that lowers demand for exports. This change in the economic environment causes a decrease in planned expenditure which leads to a rise in u_0, the unemployment rate when the real interest rate is at its normal baseline value r_0, by an amount Δu_0. Since none of the other parameters of the inflation-unemployment framework change, the effect on the equilibrium levels of unemployment and inflation can be calculated immediately as:

$$\Delta u = \frac{1}{1+\phi\beta}\Delta u_0$$

And:

$$\Delta \pi = \frac{-\beta}{1+\phi\beta}\Delta u_0$$

Dynamics

Recall our three types of inflation expectations: static, adaptive, and rational.

Static Expectations:

In the case of *static expectations* expected inflation is a set, unchanging number. So inflation and unemployment at time t are:

$$u_t = \left(\frac{1}{1+\phi\beta}u_0 + \frac{\phi\beta}{1+\phi\beta}u^*\right) + \frac{\phi}{1+\phi\beta}(\pi^e - \pi^t) + \frac{\phi}{1+\phi\beta}ss_t$$

And substitute the monetary policy reaction function equation into the Phillips curve equation and solve for the inflation rate:

$$\pi_t = \left(\frac{1}{1+\phi\beta}\pi^e + \frac{\phi\beta}{1+\phi\beta}\pi^t\right) + \frac{\beta}{1+\phi\beta}(u^* - u_0) + \frac{1}{1+\phi\beta}ss_t$$

If the Federal Reserve raises (lowers) its target inflation rate, then inflation rises (falls) and unemployment falls (rises). If changes in economic policy or the economic environment raise (lower) the unemployment rate u_0 that corresponds to what the Federal Reserve regards as "normal" interest rates, inflation falls (rises) and unemployment rises (falls). If an adverse (favorable) supply shock occurs, inflation rises (falls) and unemployment rises (falls).

As long as the principal shocks are to the demand side—shocks to spending or to policy—the economy will move back and forth along a stable downward-sloping Phillips curve. Supply shocks will temporarily push inflation and unemployment either up or down together.

In the case of static expectations, we might as well throw the analysis of chapters 6 through 8 out the window: at the aggregate level, prices are never flexible enough for its assumptions to be satisfied. (Of course, we would only expect inflations to be and remain static if fluctuations in inflation were small, and thus not enough to push the economy far enough away from full employment for it to matter which model we use.) We stick with the analysis of the sticky-price model of chapters 9 through 12.

Rational Expectations:

In the case of *rational expectations*, agents in the economy are as smart as (or smarter than) the economic forecaster. Let's assume that the government cannot act and that shocks cannot affect the economy rapidly enough to keep inflation expectations from adjusting. (If shocks can do so, see—for the time before firms, workers, and investors can respond—the subsection on *static expectations*.)

Our inflation equation then becomes:

$$\pi_t = \pi^t + \frac{(u^* - u_0)}{\phi} + \frac{ss_t}{\phi\beta}$$

And our unemployment equation becomes:

$$u_t = u^* + \frac{ss_t}{\beta}$$

Now we don't see any downward-sloping Phillips curve at all. Supply shocks still push inflation and unemployment up together or down together. But demand-side shocks have effects only on the inflation rate—not on the rate of unemployment.

A rise (fall) in the central bank's inflation target? It raises (lowers) inflation, but has no effect on unemployment. A rise (fall) in the unemployment rate u_0 that corresponds to the central bank's "normal" interest rate? It lowers (raises) inflation, but has no effect on unemployment.

In the case of rational expectations, we have no occasion to ever use the sticky-price model of chapters 9 through 12 at all. We might as well stay in the flexible-price model all the time.

Adaptive Expectations:

The world, however, is not made out of polar cases. Suppose that inflation expectations do adapt over time to shifts in the inflation rate, but don't adapt immediately and fully in a manner that anticipates changes in economic policy and the economic environment. What then? To get a rough idea, let's propose *adaptive expectations*:

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

Our inflation and unemployment equations then become:

$$u_t = \left(\frac{1}{1+\phi\beta}u_0 + \frac{\phi\beta}{1+\phi\beta}u^*\right) + \frac{\phi}{1+\phi\beta}(\pi_{t-1} - \pi^t) + \frac{\phi}{1+\phi\beta}ss_t$$

And:

$$\pi_t = \left(\frac{1}{1+\phi\beta}\pi_{t-1} + \frac{\phi\beta}{1+\phi\beta}\pi^t\right) + \frac{\beta}{1+\phi\beta}(u^* - u_0) + \frac{1}{1+\phi\beta}ss_t$$

Starting from the inflation equation, we can derive:

$$(1+\phi\beta)\left(\pi_t - \left[\pi^t + \frac{(u^* - u_0)}{\phi}\right]\right) = \left(\pi_{t-1} - \left[\pi^t + \frac{(u^* - u_0)}{\phi}\right]\right) + ss_t$$

And then an expression for how the inflation rate evolves over time:

$$\pi_t = \left[\pi^t + \frac{(u^* - u_0)}{\phi}\right] + \left(\frac{1}{1+\phi\beta}\right)\left(\pi_{t-1} - \left[\pi^t + \frac{(u^* - u_0)}{\phi}\right]\right) + \frac{ss_t}{1+\phi\beta}$$

If we are willing to make the auxiliary assumption that (a) we know what inflation was at some time in the past, say time zero, and (b) there are no supply shocks after time zero, we can derive a very simple expression for the path of the inflation rate over time:

$$\pi_t = \left[\pi^t + \frac{(u^* - u_0)}{\phi}\right] + \left(\frac{1}{1+\phi\beta}\right)^t\left(\pi_0 - \left[\pi^t + \frac{(u^* - u_0)}{\phi}\right]\right)$$

The inflation rate starts out at value π_0 at time zero, and thereafter converges over time to its rational expectations-equilibrium value, shrinking the divergence by a factor of $(1/(1+\beta\phi))$ each period.

Associated with this is a path for the unemployment rate:

$$u_t = u^* + \left(\frac{\phi}{1+\phi\beta}\right)^t\left(\pi_0 - \left[\pi^t + \frac{(u^* - u_0)}{\phi}\right]\right)$$

which at time one starts out above (below) the natural rate of unemployment if inflation is higher (lower) than its rational-expectations equilibrium value, and thereafter converges to its natural rate u* in the same manner as the inflation rate converges.

We thus see that, if expectations of inflation are adaptive, in the short run it is the sticky-price model of chapters 9 through 12 that is relevant, but as time passes the effects of shocks to economic policy or the economic environment die off, unemployment and output get closer to their natural rates and potential output levels, and the flexible-price analysis of chapters 6 through 8 becomes more and more relevant.

Dynamics: Responding to Supply Shocks

How should the central bank respond to supply shocks, like the double whammy of Hurricane Katrina and the spike in oil prices that affected the economy in the summer of 2005? Here's one analysis that mirrors the views of at least some members of the Federal Reserve's principal policy-making body, the Federal Open Market Committee—FOMC:

Begin with an assumption that inflation expectations are mostly adaptive but somewhat rationale. That is, begin with:

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

for some parameter λ reasonably close to one. Assume that the Federal Reserve's beliefs about normal interest rates are correct and that its u_0 is equal to the natural rate of unemployment u^*. And assume that the Fed's target inflation rate π^t is the actual inflation rate prevailing in period t-1. This gives us an inflation equation:

$$\pi_t = \left(\frac{\left(\lambda\pi_{t-1} + (1-\lambda)\pi_t\right)}{1+\phi\beta} + \frac{\phi\beta}{1+\phi\beta}\pi^t\right) + \frac{ss_t}{1+\phi\beta}$$

with an associated MPRF-derived unemployment equation:

$$u_t = u^* + \phi\left(\pi - \pi^t\right)$$

And assume that there is a big adverse supply shock S in period zero, and thereafter there are no supply-side disturbances.

Now what does the Federal Reserve want to do in response to this supply shock? It wants to minimize the amount of unemployment as a result of the supply shock, and it wants to eventually return the economy's inflation rate to its target level of π^t. Within the MPRF framework, it has to set u_0=u* in order to eventually return the inflation rate to π^t. So let's examine how the amount of excess unemployment would vary were the Federal Reserve to choose different values of its "aggressiveness" parameter ϕ.

Let's start by solving the inflation equation. We obtain:

$$\pi_t = \frac{\lambda\pi_{t-1} + \phi\beta\pi^t + ss_t}{(\lambda + \phi\beta)}$$

Which implies that initially:

$$\pi_0 = \pi^t + \frac{S}{(\lambda + \phi\beta)}$$

And thereafter:

$$\pi_t = \pi^t + \left(\frac{\lambda}{\lambda + \phi\beta}\right)(\pi_{t-1} - \pi^t)$$

Which gives us unemployment rates of:

$$u_{t=0} = u^* + \phi\left(\frac{S}{(\lambda + \phi\beta)}\right)$$

initially, and:

$$u_t = u^* + \left(\frac{\lambda}{\lambda + \phi\beta}\right)(u_{t-1} - u^*)$$

thereafter. Adding up all of the excess unemployment over the natural rate:

$$\sum_{t=0}^{\infty}(u_t - u^*) = \phi\left(\frac{S}{(\lambda + \phi\beta)}\right)\left(1 + \left(\frac{\lambda}{\lambda + \phi\beta}\right) + \left(\frac{\lambda}{\lambda + \phi\beta}\right)^2 + \left(\frac{\lambda}{\lambda + \phi\beta}\right)^3 + \ldots\right)$$

$$\sum_{t=0}^{\infty}(u_t - u^*) = \phi\left(\frac{S}{(\lambda + \phi\beta)}\right)\left(\frac{\lambda + \phi\beta}{\phi\beta}\right) = \frac{\phi S}{\phi\beta} = \frac{S}{\beta}$$

We see that the amount of excess unemployment does not depend on the value of ϕ. Whatever value of ϕ the Federal Reserve chooses, there still needs to be excess unemployment of S/β percentage point-years in order to return inflation to its target value of π^t after a supply shock of magnitude S. And the Federal Reserve regards it as very important to keep its promises—to actually return inflation to its target level.

So if the Federal Reserve cannot affect the total amount of excess unemployment—can only (with a high value of φ) make that unemployment come quickly and (with a low value of φ) put that unemployment off for a while—can the Federal Reserve affect the total amount of inflation? Let's see:

Let's add up all the excess inflation as a result of the supply shock, and obtain:

$$\sum_{t=0}^{\infty}\left(\pi_t - \pi^t\right) = \left(\frac{S}{(\lambda + \phi\beta)}\right)\left(1 + \left(\frac{\lambda}{\lambda + \phi\beta}\right) + \left(\frac{\lambda}{\lambda + \phi\beta}\right)^2 + \ldots\right)$$

$$\sum_{t=0}^{\infty}\left(\pi_t - \pi^t\right) = \left(\frac{S}{(\lambda + \phi\beta)}\right)\left(\frac{\lambda + \phi\beta}{\phi\beta}\right) = \frac{S}{\phi\beta}$$

The more aggressive is the Federal Reserve in reacting to increases in inflation above its target by raising interest rates and raising unemployment, the less total inflation will be produced by the supply shock.

This is the basic argument underlying the proposition that the Federal Reserve does us no favors by delaying its response to an adverse supply shock—that the best policy is one of being "cruel to be kind" by giving first priority to fighting inflation by keeping it as close to its target level as possible. The higher the value of φ, the better—in this model, that is.