Lecture 21
More on Monetary Policy
The New Keynesian Model

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Economics 312
Figure 17.14 The Fed Exploits the Phillips Curve
This process stops only when $\pi_t = \pi_t^e$.

$$\pi_t^e = \frac{\omega(\pi_t^e + a(Y_t^* - Y_t^T))}{\omega + a^2} \Rightarrow \pi_t = \pi_t^e = \frac{\omega(Y_t^* - Y_t^T)}{a}$$

Moreover, since $\pi_t = \pi_t^e$, $Y_t = Y_t^T$ as well.

In the long-run, this yields higher inflation with no output gain.

Known as the time-consistency problem.

Under rational expectations, this process occurs immediately.

- If $\pi_t^e < \frac{\omega(Y_t^* - Y_t^T)}{a}$, households expect $\pi_t > \pi_t^e$.
- This is inconsistent with rational expectations.
- But this requires households to understand Fed’s incentives.
Figure 17.15 The Fed Attempts to Increase $Y$ Permanently
Remedies

- How can the Fed reduce inflationary expectations?
- Adaptive expectations: stop trying to exploit Phillips curve.
- Rational expectations: commit not to exploit the Phillips curve.

\[ \pi_t = \pi_t^e = \frac{\omega(Y_t^* - Y_t^T)}{a} \]

- Isolate the Fed from pressure to make \( Y_t^* > Y_t^T \).
- Appoint “conservative” central bankers (small \( \omega \)).
- Force the Fed to follow a narrow set of rules.
- Reputation may substitute for explicit commitment.

- Reality probably lies somewhere in between rational and adaptive.
  - It is possible but costly to simply lower money growth.
  - Disinflation is less costly if it is credibly pre-announced.
Figure 17.16  The Commitment Problem
The Taylor Rule

- Most influential policy rule due to John Taylor (1993).
- Simple rule for setting interest rate based on output gap, inflation target $i^* = 2\%$, $R^* = 4\%$.

$$R_t = R^* + 1.5(\pi_t - \pi^*) + 0.5x_t$$

- Originally proposed as an explanation of Fed behavior. Since has been shown to work well in a variety of models.
- Much academic literature focuses on the optimal design of interest rate rules similar to this.
- Even though Fed not explicitly rule based, analysis of rules is a key input in policy process.
Monetary policy rule in a graph

Interest rate when inflation is on target

Inflation target

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Figure 1  The Funds Rate Benchmark and Its Taylor Rule Predictions
Federal Funds Rate and Inflation Targets

Calculated federal funds rate is based on Taylor's rule.

Components of Taylor's Rule

Actual and Potential Real GDP
Billions of chain-weighted 2005 dollars

PCE Inflation
Percent change from year ago

Monetary Base Growth and Inflation Targets
Percent
A larger literature has now developed that has estimated the Taylor Rule, or similar simple rules, for a variety of countries and time periods.

- For example, Clarida, Galí, and Gertler (2000) do so for the Federal Reserve, the Bundesbank, and the Bank of Japan.
- Estimates for the United States under different Federal Reserve Chairman are reported by Judd and Rudebusch (2000).
- In general, the basic Taylor Rule, when supplemented by the addition of the lagged nominal interest rate, does quite well in matching the actual behavior of the policy interest rate.

The argument for simple rules relies not on their optimality but on their simplicity; they may serve as a useful benchmark for policy or aid in promoting policy transparency.
An Example Problem

Suppose that the only policy options available for the Fed are either (1) changing the money supply however much is necessary in order to keep interest rates constant or (2) using the Taylor rule in which nominal interest rates $R_t$ are increased when output $y_t$ is above its full employment level $y^*$ and reduced when output is below the full employment level, that is:

$$R_t = R^* + 0.5(i_t - i^*) + 0.5(y_t - y^*)$$

Using the Keynesian model with sticky prices and efficiency wages, suppose the economy begins in full employment and compare the performance of these options in returning the economy to full employment under the following scenarios.

1. There is an exogenous increase in the demand for money.
2. There is a temporary increase in government purchases.
3. There is an increase in current total factor productivity.
The LM curve shifts to the left so that the output is below the full employment level. With the Taylor rule, the central bank (CB) would have to lower the interest rate relative to where it would be after the shift in demand. So the CB will make the LM shift back to the right (by increasing the money supply). On the other hand, if the CB wanted to keep interest rates constant from the outset, the LM also must shift back to the right. Therefore the two options of monetary policies would have similar effects on the economy.
When $G$ increases, IS shifts to the right resulting in output above the full employment level. To keep interest rates constant, the LM must shift to the right, making output even further away from full employment. On the other hand, with output above full employment, the Taylor rule raises interest rates and so the LM shifts to the left. Therefore the Taylor rule is better in achieving the full employment level.
When $z$ increases, the FE line shifts to the right making the initial output below the full employment level. For the constant interest rate policy option, the LM curve is unchanged and short-run output remains below full employment. With the Taylor rule, the LM curve shifts to the right. Therefore the Taylor rule is better in achieving the full employment level.
How are Changes in Policy Transmitted?

Fed funds rate is very short term. In itself has little effect, as long-term rates are key determinant of spending decisions.

But long rate depends on future path of short rate. So not just current policy matters, but expected future policy matters.

Modern theory emphasizes the role of nominal rigidities. Some prices and wages are pre-set in nominal terms.

So in short run Fed has some influence over aggregate demand. By lowering rates, it makes borrowing cheaper for households which boosts aggregate demand. Raising rates opposite.

But prices and wages set understanding Fed behavior, hence importance of expectations.
CPI Inflation and 1-Year-Ahead CPI Inflation Expectations

The shaded region shows the Humphrey-Hawkins CPI inflation range. Beginning in January 2000, the Humphrey-Hawkins inflation range was reported using the PCE price index and therefore is not shown on this graph.

10-Year Ahead PCE Inflation Expectations and Realized Inflation

See the notes section for an explanation of the chart.

Treasury Security Yield Spreads

Yield to maturity

Real Interest Rates

Percent, Real rate = Nominal rate less year-over-year CPI inflation
Monetary Trends updated through 04/17/12

**Implied One-Year Forward Rates**
Percent

- Week Ending: 04/13/12
- 03/16/12
- 04/15/11

**Rates on 3-Month Eurodollar Futures**
Percent, daily data

- Jun 2012
- Apr 2012
- May 2012

**Rates on Selected Federal Funds Futures Contracts**
Percent, daily data

- Jun 2012
- May 2012
- Apr 2012

**Rates on Federal Funds Futures on Selected Dates**
Percent

- 04/02/2012
- 02/03/2012

**Inflation-Indexed Treasury Securities**
Weekly data

- Note: Yields are inflation-indexed constant maturity U.S. Treasury securities

**Inflation-Indexed Treasury Yield Spreads**
Weekly data

- Note: Yield spread is between nominal and inflation-indexed constant maturity U.S. Treasury securities.
An Optimizing Model with Nominal Rigidities

- The model consists of households who supply labor, purchase goods for consumption, and hold money and bonds, and firms who hire labor and produce and sell differentiated products in monopolistically competitive goods markets.
- The basic model of monopolistic competition is drawn from Dixit and Stiglitz (1977).
- Each firm set the price of the good it produces, but not all firms reset their price each period.
- Households and firms behave optimally: households maximize the expected present value of utility and firms maximize profits.
Each period, the firms that adjust their price are randomly selected: a fraction $1 - \xi$ of all firms adjust while the remaining $\xi$ fraction do not adjust.

- The parameter $\xi$ is a measure of the degree of nominal rigidity; a larger $\xi$ implies fewer firms adjust each period and the expected time between price changes is longer.

For those firms who do adjust their price at time $t$, they do so to maximize the expected discounted value of current and future profits.

- Profits at some future date $t + s$ are affected by the choice of price at time $t$ only if the firm has not received another opportunity to adjust between $t$ and $t + s$. The probability of this is $\xi^s$. 

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Basic New Keynesian Model of Transmission

- Can be derived from primitives: household consumption decisions, firm pricing decisions. Assumes monopolistic competition, sticky prices. Only labor input, $C_t = Y_t$.

- Unlike old Keynesian literature, assumes rational expectations. When firms set prices, forecast future demand and policy. Households also forecast future conditions when choosing consumption.

- Basic model has 2 key equations: a Euler equation which gives an IS relation between output and interest rates, and a Phillips curve which results from price setting decisions. Gives a relation between output and inflation.

- Along with a specification of monetary policy, these determine the evolution of output, inflation, and interest rates.

Let $\pi_t$ be inflation, $E_t \pi_{t+1}$ expected inflation, $x_t = y_t - y_t^p$ the “output gap” (deviation of output from “potential”), $R_t$ the nominal interest rate.

First equation relates output gap to real interest rate:

$$x_t = -\phi (R_t - E_t \pi_{t+1}) + E_t x_{t+1} + g_t$$

Linearized consumption Euler equation/IS curve.

Second equation is the New Keynesian Phillips curve relating inflation and real activity:

$$\pi_t = \kappa x_t + \beta E_t \pi_{t+1} + u_t$$

Linearized pricing decisions of firms with staggered price setting.
• $g_t$ and $u_t$ are exogenous shocks. Demand (such as government spending) and “cost-push” (such as wage or markup fluctuations) Assume they’re serially correlated:

$$g_t = \rho_g g_{t-1} + \epsilon^g_t$$

$$u_t = \rho_u u_{t-1} + \epsilon^u_t$$

• Note that timing of Phillips curve is different from previous expectations-augmented (Lucas suprise model): here inflation is fully forward looking.

• Can close model via an $LM$ curve once we specify money demand. But since we’ll analyze policy via setting interest rate $R_t$, this will only pin down the stock of money.
The basic new Keynesian inflation adjustment equation without cost shocks is:

\[ \pi_t = \kappa x_t + \beta E_t \pi_{t+1} \]

We can solve this equation forward to get an expression for inflation:

\[ \pi_t = \kappa \sum_{i=0}^{\infty} \beta^i E_t x_{t+i} \]

Inflation is a function of the present discounted value of current and future output gaps.

The absence of a stochastic disturbance implies there is no conflict between a policy designed to maintain inflation at zero and a policy designed to keep the output gap equal to zero.

Just set \( x_{t+i} = 0 \) for all \( i \); keeps inflation equal to zero.
Optimal Policy

- Thus, the key implication of the basic new Keynesian model is that price stability is the appropriate objective of monetary policy.
- No policy conflicts.
- When prices are sticky but wages are flexible, the nominal wage can adjust to ensure labor market equilibrium is maintained in the face of productivity shocks. Optimal policy should then aim to keep the price level stable.
Policy Implications of Price Stickiness

- Models that combine optimizing agents and sticky prices have very strong policy implications.
- When the price level fluctuates, and not all firms are able to adjust, price dispersion results. This causes the relative prices of the different goods to vary. If the price level rises, for example, two things happen.
  1. The relative price of firms who have not set their prices for a while falls. They experience an increase in demand and raise output, while firms who have just reset their prices reduce output. This production dispersion is inefficient.
  2. Consumers increase their consumption of the goods whose relative price has fallen and reduce consumption of those goods whose relative price has risen. This dispersion in consumption reduces welfare.
The solution is to prevent price dispersion by stabilizing the price level.

What is critical for this result is that nominal wages are assumed to be completely flexible.

But the same argument would apply if wages are sticky and prices flexible. With sticky wages and flexible prices, monetary policy should stabilize the nominal wage.
The basic new Keynesian model suggests price stability (i.e., zero inflation) is optimal.

- Zero inflation eliminates inefficient price dispersion.

Friedman rule: zero nominal rate of interest is optimal.

- Zero nominal rate eliminates inefficiency in money holdings.
- Optimal inflation is negative (deflation) at rate equal to real rate of interest.

Khan, King, and Wolman (2000) analysis model with both distortions.

The conclude optimal inflation is closer to zero than to the Friedman rule.
Now assume

\[ \pi_t = \kappa x_t + \beta E_t \pi_{t+1} + u_t \]

where \( u_t \) represents an inflation or cost shock, which is serially correlated:

\[ u_t = \rho u_{t-1} + \epsilon_t^u \]

Then

\[ \pi_t = \kappa \sum_{i=0}^{\infty} \beta^i E_t x_{t+i} + \sum_{i=0}^{\infty} \beta^i E_t u_{t+i} \]

Cannot keep both \( x \) and \( \pi \) equal to zero. Trade-offs must be made.
Objective of Policy

- Policy objective in general is to maximize welfare of agents. In this model, can derive approximation of welfare giving loss function:

\[ L_t = \frac{1}{2} \left( \omega x_t^2 + \pi_t^2 \right) \]

- Penalizes deviations of output relative potential, deviation of inflation from target (zero): Price stability and Full Employment goals.

- In deriving this expression, weight on output \( \omega \) can be related to underlying parameters.

- If there are distortions in the economy (such as monopoly power), optimal level of output gap is positive so loss is:

\[ L_t = \frac{1}{2} \left( \omega (x_t - \bar{x})^2 + \pi_t^2 \right) \]
Policy Problem

- Suppose central bank targets positive output gap $\bar{x} > 0$. Chooses interest rate policy each period to minimize loss, taking as given private expectations.
- Easiest here to suppose central bank directly controls inflation and output gap, then use IS to back out optimal interest rate choice.
- Represent the central bank’s problem as a Lagrangian:

$$\mathcal{L} = \frac{1}{2} (\omega(x_t - \bar{x})^2 + \pi_t^2) + \mu (\kappa x_t + \beta E_t \pi_{t+1} + u_t - \pi_t)$$

- The first order conditions are:

$$\omega(x_t - \bar{x}) + \mu \omega = 0 \text{ and } \pi_t = \mu$$

or

$$x_t = -\frac{\kappa}{\omega} \pi_t + \bar{x}$$
\[ x_t = -\frac{\lambda}{\alpha} \pi_t + \bar{x} \]

- Substitute back into Phillips:

\[
\begin{align*}
\pi_t &= \kappa x_t + \beta E_t \pi_{t+1} + u_t \\
(1 + \kappa^2 / \omega) \pi_t &= \kappa \bar{x} + \beta E_t \pi_{t+1} + u_t
\end{align*}
\]

- Guess \( \pi_t = k_0 + k_1 u_t \). Then
\[
E_t \pi_{t+1} = k_0 + k_1 E_t u_{t+1} = k_0 + k_1 \rho_u u_{t-1}.
\]
Substitute and solve:

\[
\pi_t = \frac{\omega}{\kappa^2 + \omega (1 - \beta \rho)} u_t + \frac{\omega}{\kappa} \bar{x}
\]

- Then from optimality get:

\[
x_t = -\frac{\kappa}{\omega} \pi_t + \bar{x} = -\frac{\kappa}{\kappa^2 + \omega (1 - \beta \rho)} u_t
\]
Note $E\pi_t = \frac{\omega}{\kappa} \bar{x}$ but $E x_t = 0$. Target gap $\bar{x}$ only affects mean inflation rate.

- Government tries to push output above potential, in equilibrium only leads to higher inflation.

- This is just as in the earlier model, but more direct/explicit.

- Policymakers have an incentive to announce they will be tough on inflation to affect people’s expectations, then actually to pursue loose policy.

- In equilibrium, people will come to expect this. With rational expectations (as we’ve used), this only leads to higher inflation.
Optimal Discretionary Policy

- With $\bar{x} = 0$:

  \[
  \pi_t = \frac{\omega}{\kappa^2 + \omega(1 - \beta \rho)} u_t, \quad -\frac{\kappa}{\kappa^2 + \omega(1 - \beta \rho)} u_t
  \]

- Can then get optimal interest rate response from IS:

  \[
  x_t = -\phi (R_t - E_t \pi_{t+1}) + E_t x_{t+1} + g_t \\
  R_t = E_t \pi_{t+1} + (1/\phi) (E_t x_{t+1} - x_t + g_t) \\
  = \gamma E_t \pi_{t+1} + (1/\phi) g_t, \text{ where } \gamma > 1.
  \]

- (i) Cost push shocks $u_t$ imply inflation/output tradeoff.
  (ii) If expected inflation rises, nominal interest rates should rise by more ($\gamma > 1$) so real rates increase.
  (iii) Policy should offset demand shocks $g_t$, accommodate movements in potential output (say productivity shocks).