The Science of Monetary Policy: A New Keynesian Perspective

By

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This paper presents the basic model used by most central banks in discussing monetary policy.

It will build on much that we have discussed

- The IS-LM framework
- The theory of economic policy
- The choice of monetary policy instrument

Clarida, Gali, & Gertler note that there has been a resurgence in interest in how to conduct monetary policy.

Two factors:

1. Empirical work in the late 1980's established that monetary policy significantly influences the short term course of the real economy.

2. There has been considerable improvement in the underlying theoretical frameworks used for policy analysis.

Overview of First Three Sections

1. First we develop the baseline model. This is the modern version of the IS-LM model. Critical departures from traditional IS-LM model are discussed below.

2. The instrument of monetary policy is the short-term interest rate.

3. The policy design problem is to characterize how the interest rate should adjust to the current state of the economy.

Overview, continued

We sidestep the critical issue of credibility and analyze policy when the central bank can not commit to a policy (no credibility).

This is a reasonable place to start: No major central bank makes any type of binding commitment over the future course of its monetary policy.

Overview, continued

Results – optimal policy:

1. Embeds inflation targeting in the sense that it calls for gradual adjustment to the optimal inflation rate.

2. The short term rate should adjust more than one-for-one to changes in expected inflation.

3. How the central bank responds to output disturbances depends critically on the nature of the disturbances: offset demand shocks; accommodate supply shocks.

Section 2: The Model

A dynamic, general equilibrium model with money and temporary nominal price rigidities.

Widely used for theoretical analysis of monetary policy.

Has feature of IS-LM model, but reflects advances in methodological advances in modern macroeconomics.

Model overview

1. Monetary policy affects economy in the short run as in traditional IS-LM model.

2. But key behavioral equations reflect optimizing behavior of households and firms.

3. Current economic behavior depends critically on expectations of future policy.

Model Overview

The model consists of two behavioral equations:

An IS curve

An Aggregate Supply Curve

- **We will derive the IS curve. (AS curve is too difficult.)**

- **Policymakers have preferences over output and inflation volatility.**

- **Policymakers use the interest rate to implement policy.**

Deriving the IS curve

Introduce some notation:

y_t	$=$	the stochastic component of output (in logs)
z_t	$=$	the natural (full employment) level of output (in logs)

The define the "output gap" as:

$$x_t = y_t - z_t$$

That is – the output gap is the percentage difference between actual output and natural rate output.

Example: Y(t) = 110, Z(t) = 100, then

x(t) = ln(110) – ln(100) = 0.0953

IS curve continued

(2.1) $$x_t = -\varphi[i_t - E_t(\pi_{t+1})] + E_t(x_{t+1}) + g_t$$

g_t = represents a shock to output demand (such as government)

$i_t - E_t(\pi_{t+1})$ = the real interest rate

This implies that current output is

1. Negatively related to the real interest rate (price of current consumption).

2. Positively related to future output – permanent income hypothesis and implied consumption smoothing.

According to CGG: eq. (2.1) is obtained by log-linearizing the consumption euler equation that arises from the household's optimal saving decision, after imposing the equilibrium condition that consumption equals output minus government spending.

A mouthful!

1. What is the consumption euler equation?
2. What is meant by log-linearizing this equation.
3. Note that the model abstracts from investment.

The consumption Euler equation

Consider the maximization problem of choosing assets and consumption every period:

$$\max E\left[\sum_{t=1}^{\infty} \beta^{t-1} U(c_t)\right]$$

$$subject\ \ to\ y_t + A_{t-1}R_{t-1} = c_t + A_t$$

$$
\begin{aligned}
y_t &= income \\
A_{t-1} &= assets\ purchased\ in\ previous\ period \\
R_t &= return\ on\ assets\ (known\ at\ time\ t)
\end{aligned}
$$

The optimal choice of consumption and assets will be characterized by the following necessary condition – this is the Euler Equation:

$$U'(c_t) = \beta E_t[U'(c_{t+1})]R_t$$

What does this say? Suppose you want to buy 1 more asset. This means you reduce your consumption today by 1 – the cost is the current marginal utility. (The LHS).

The gain is the extra return next period, R(t). How much you value this in utils is given by the product of MU and the return. This is then discounted back to compare values.

At the optimum: MC = MB

As an aside – this is the starting point for modern finance theory.

Now – we know the Euler equation. What does log-linearize mean?

We want to use the Euler equation but this is difficult since it is inherently non-linear.

Convert to a linear expression by taking a first-order Taylor series approximation around full employment levels of consumption and returns (described below). This is the **linearize** part.

The **log** part means we will express all variables as percentage deviations from full employment.

Recall from your calculus that a function can be approximated by a Taylor series approximation:

$$f(x) = f(x_0) + f'(x_0)(x - x_0) + f''(x_0)\frac{(x-x_0)^2}{2} + .$$

We will use a first-order Taylor series approximation – this turns the equation into a linear equation.

The method: take the derivative of the expression and evaluate the derivative at the full employment levels. Then multiply this by the difference between the variable at time t and the full employment level.

We will repeatedly use this term:

$$f'(x_0)(x - x_0)$$

Assume that the utility function is:

$$U(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}$$

Then the marginal utility is: $c_t^{-\gamma}$

Take the first-order Taylor series approximation around c_f

$$approximation = c_t^{-\gamma} \approx -\gamma c_f^{-\gamma-1}(c_t - c_f)$$

Back to Euler equation

$$c_t^{-\gamma} = \beta E_t[c_{t+1}^{-\gamma}]R_t$$

Define the full employment interest rate as:

$$R_f = \text{full employment interest rate}$$

At full employment, the Euler equation becomes:

$$c_f^{-\gamma} = \beta[c_f^{-\gamma}]R_f \Rightarrow \beta R_f = 1$$

Linearize the Euler equation

$$c_t^{-\gamma} = \beta E_t[c_{t+1}^{-\gamma}]R_t$$

$$-\gamma c_f^{-\gamma-1}(c_t - c_f) = \beta R_f E_t\left[-\gamma c_f^{-\gamma-1}(c_{t+1} - c_f)\right] + \beta c_f^{-\gamma}(R_t - R_f)$$

Note this can be written as:

$$-\gamma c_f^{-\gamma}\frac{(c_t-c_f)}{c_f} = \beta R_f E_t\left[-\gamma c_f^{-\gamma}\frac{(c_{t+1}-c_f)}{c_f}\right] + \beta R_f c_f^{-\gamma}\frac{(R_t-R_f)}{R_f}$$

Define variables as percentage deviation from full employment:

$$\frac{(c_t-c_f)}{c_f} = \tilde{c}_t = \text{consumption as \% deviation from full employment}$$

Cancel common terms and use result from full employment interest rate.

Log-linearized Euler equation

$$-\gamma \tilde{c}_t = -\gamma E_t(\tilde{c}_{t+1}) + \tilde{R}_t$$

Or, dividing by gamma, we have:

$$\tilde{c}_t = E_t(\tilde{c}_{t+1}) - \varphi \tilde{R}_t$$

φ = intertemporal elasticity of substitution

Or, the sensitivity of current consumption to changes in the real interest rate.

Drop tildes for notational convenience:

$$c_t = E_t(c_{t+1}) - \varphi R_t$$

Recall IS curve:

(2.1) $$x_t = -\varphi[i_t - E_t(\pi_{t+1})] + E_t(x_{t+1}) + g_t$$

So we are close:
Real interest rate = nominal – expected inflation.

Now need to replace consumption with output.

Deriving the IS curve, cont.

From the good market equilibrium:

$$Y_t = C_t + E_t$$
$$E_t = \text{government expenditures}$$

Rewrite this as:

$$Y_t - E_t = Y_t\left(1 - \frac{E_t}{Y_t}\right) = Y_t\hat{E}_t = C_t$$

Linearize the last expression:

$$\hat{E}_f(Y_t - Y_f) + Y_f\left(\hat{E}_t - E_f\right) = (C_t - C_f)$$

Divide by E(f)*Y(f) = C(f)

$$y_t - e_t = \frac{(C_t - C_f)}{Y_f\hat{E}_f} = c_t$$

Deriving the IS curve, cont.

The log-linearized Euler equation is:

$$c_t = -\varphi R_t + E_t(c_{t+1})$$

Replace c(t) using: $c_t = y_t - e_t$

And R(t) using: $R_t = i_t - E_t(\pi_{t+1})$

$$y_t - e_t = -\varphi(i_t - E_t(\pi_{t+1})) + E_t(y_{t+1} - e_{t+1})$$

Recall the definition: $x_t = y_t - z_t$

Use this to yield:

$$x_t + z_t - e_t = -\varphi(i_t - E_t(\pi_{t+1})) + E_t(x_{t+1} + z_{t+1} - e_{t+1})$$

Replacing consumption in Euler eq.

Start with equilibrium in output:

$$Y_t = C_t + E_t$$

Rewrite as:

$$Y_t - E_t = Y_t\left(1 - \frac{E_t}{Y_t}\right) = Y_t\hat{E}_t = C_t$$

Linearize around full employment:

$$\hat{E}_f(Y_t - Y_f) + Y_f\left(\hat{E}_t - E_f\right) = (C_t - C_f)$$

Divide by Y(full) and E(full) and note Y*E=C(full)

$$y_t - e_t = \frac{(C_t - C_f)}{Y_f\hat{E}_f} = c_t$$

Deriving the IS curve, cont.

We have

$$x_t + z_t - e_t = -\varphi(i_t - E_t(\pi_{t+1})) + E_t(x_{t+1} + z_{t+1} - e_{t+1})$$

Re-arranging yields:

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

Where g(t) is defined by:

$$g_t \equiv E_t((z_{t+1} - z_t) - (e_{t+1} - e_t)) = E_t(\Delta z_{t+1} - \Delta e_{t+1})$$

THIS IS THE MODERN VERSION OF THE IS CURVE!!!!