The New Keynesian Model: An IS-LM Introduction

Integral

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Abstract

These are notes on the New Keynesian model of Clarida, Galí, and Gertler (1999) The first section reviews some ideas from intermediate macro. The remaining sections follow the paper fairly closely.

1 IS-LM Review

Clarida, Gali, and Gertler's article is organized around the New Keynesian model and discusses monetary policy largely in terms of that model. Hence I will spend the first few pages of this review examining the New Keynesian model and drawing out its similarities and differences from its predecessor, the IS-LM-AS model.

Both the Old Keynesian and New Keynesian models can be summarized by three equations. The two share an "IS" equation (Investment-Saving) that relates real output negatively to the real interest rate. The two share an "AS" equation (Aggregate Supply) which relates inflation or the price level positively with output. The two differ somewhat on their final equation: Old Keynesian models have an "LM" curve (Liquidity preference-Money supply) which relates the money stock to output and interest rates; the New Keynesian model instead has a Taylor Rule which relates interest rates to inflation and output.

Suppose the components of demand are characterized by the following equations:

$$\begin{aligned} Y_t &= C_t + I_t + G_t \\ C_t &= c_0 + c_y(Y_t - T_t) \\ I_t &= d_0 - d_r r_t \end{aligned}$$

The variables are standard: Y is income, C is consumption, I is investment, T is taxes, and G is government purchases of goods and services. The various parameters have natural interpretations. c_0 is autonomous consumption. c_y is the marginal propensity to consume out of income. d_r is the responses of investment to interest rates. (Exercise: add c_r and d_y terms. Not much changes.)

We can combine these three equations:

$$Y_t = [c_0 + c_y(Y_t - T_t)] + [d_0 - d_r r_t] + G_t$$

which rearranges into the usual IS curve:

$$Y_t = \frac{c_0 + d_0}{1 - c_y} - \frac{d_r}{1 - c_y} r_t + \frac{1}{1 - c_y} G_t - \frac{c_y}{1 - c_y} T_t \qquad \text{(Old Keynesian IS)}$$

which looks a lot like what you'd see in Econ 201. Note the autonomous component, $(c_0 + d_0)/(1 - c_y)$. Note the spending and tax multipliers. Note the parameters that define the slope of the IS curve.

Suppose the money demand function is also fairly typical:

$$\frac{M_t}{P_t} = M_0 + L_y Y_t - L_r r_t$$

We have introduced some new notation: M is the money stock and P is the price level. We can rearrange this equation to get an LM curve:

$$Y_t = \frac{1}{L_y}\left(\frac{M_t}{P_t} - M_0\right) + \frac{L_r}{L_y} r_t \qquad \text{(Old Keynesian LM)}$$

The model's policy variables are (G, T, M); its endogenous variables are (Y, r, P). We currently have two equations, and so need one more equation to tie everything down. If we assumed a constant price level, $P = \bar{P}$, we could go forward solving for (Y, r) in terms of (G, T, M). Less crudely, let us suppose there is an aggregate supply curve:

$$P_t = \bar{P} + a_y(Y_t - Y^*) + u_t \qquad \text{(Old Keynesian AS)}$$

which relates the price level to deviations of output from its natural level and a supply shock u_t. Now we have three equations in three unknowns. This is the *IS-LM-AS* model.

2 New Keynesian Model

2.1 Setup

Look at the Old Keynesian IS curve: it has an autonomous component, an interest-sensitive component, and a government spending shock. The *New Keynesian IS curve* is:

$$(y_t - y_t^*) = E_t(y_{t+1} - y_{t+1}^*) - \varphi(r_t - r_t^n) + g_t$$

where we have made two changes to the Old Keynesian IS equation. First, we now look at output relative to its efficient level, $y - y^*$ and interest rates relative to their natural rate, $r - r^n$; second, we have put more care into the autonomous portion and linked it to expected future output. The variable $y - y^*$ is called the output gap and deserves its own symbol; let's call it x_t. Hence we can write:

$$x_t = E_t x_{t+1} - \varphi(r_t - r_t^n) + g_t \qquad \text{(NKIS)}$$

and this is the New Keynesian equivalent of the IS curve. It still has the interest-sensitive component and still has that trailing g term; relative to the IS-LM model, it adds the expectations term.

Second, look at the AS curve. It has an autonomous component $\bar{P}$ and an output-sensitive component a_1. Similarly, the New Keynesian Phillips Curve is:

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t + u_t \qquad \text{(NKPC)}$$

where we have made two changes to the Old Keynesian AS equation. First, we now think in terms of inflation π rather than the price level P. This is a relatively minor change. Second, we have put more care into the autonomous portion and linked it to expected future inflation. As in the Old Keynesian model, we think about the output gap, rather than just output, on the right-hand side.

The above discussion describes how you should relate Clarida, Gali, and Gertler's equations (2.1) and (2.2) to the IS-LM model of intermediate macroeconomics. The IS-PC model ought to be at least somewhat recognizable as an evolution of the IS and AS equations.

Third, we need to figure out what we're going to do with the LM curve. Typically we replace it with a Taylor Rule which relates the central bank's choice of interest rate to ouptut and inflation. We could write down:

$$r_t = \gamma_\pi(\pi_t - \pi^*) + \gamma_x x_t \tag{TR}$$

so that the central bank raises interest rates when inflation is above target, and reduces rates when inflation is below target. The three labelled equations form the New Keynesian IS-PC-TR model. CGG discuss monetary policy as a problem of choosing different functions and parameter values for the Taylor Rule.

2.2 Solving the Model

Solving the Old Keynesian model is fairly simple. You have three linear equations in three unknowns. You can do the required tedious algebra to write $Y = Y(G, T, M)$, $P = P(G, T, M)$, and $r = r(G, T, M)$. Then you can do policy analysis. But how do we solve the New Keynesian model, given that there are pesky expectations terms everywhere? One way to solve the model, and one which makes CGG's results clear, is the forward-iteration method.

Look back at the New Keynesian IS Curve. We can write:

$$\begin{aligned} x_t &= E_t x_{t+1} - \varphi(r_t - r_t^n) + g_t \\ &= E_t\left[E_{t+1}x_{t+2} - \varphi(r_{t+1} - r_{t+1}^n) + g_{t+1}\right] - \varphi(r_t - r_t^n) + g_t \\ &\dots \\ \implies x_t &= E_t \sum_{s=0}^{\infty}\left[-\varphi(r_{t+s} - r_{t+s}^n) + g_{t+s}\right] \end{aligned} \tag{CGG (2.5)}$$

Okay, this is a useful expression. It says that the output gap *today* depends on the entire expected future path of interest rates, relative to the natural rate r_{t+s}^n and the government shock g_{t+s}.

Similarly, we can write the New Keynesian Phillips Curve as:

$$\pi_t = E_t \sum_{s=0}^{\infty} \beta^s \left[\lambda x_{t+s} + u_{t+s}\right] \tag{CGG (2.6)}$$

which states that inflation *today* depends on the entire expected future path of output gaps and supply shocks.

Therefore the New Keynesian model has a nice recursive structure. First, the central bank chooses a path for interest rates, r_{t+s}. Second, the path for interest rates determines the current output gap, x_t. Third, the path of output gaps x_{t+s} determine inflation.

From here, the key idea emerges: the central bank should offset the natural rate shock and the demand shock. Consider a case where the expected natural rate rises. Then the central bank should also increase the interest rate it sets so as to reduce the interest-rate gap. Suppose next that government spending rises. Again, the central bank can offset the spending shock and close the output gap. *The effect of government spending on the output gap depends on how the central bank responds to government spending.* The multiplier is whatever the Fed wants it to be.

For those two shocks, the implication is fairly clear. *Completely* offsetting natural rate and government spending shocks will close the output gap, which in turn implies inflation will be on target; the Fed can achieve both full employment and price stability. The optimal policy in the face of a supply shock is less clear, because it pushes the output gap and inflation in opposing directions. The proper action may be to "do nothing," or may be something else, depending on how the central bank weighs output gaps and inflation. I summarize these ideas in the next section.

3 Monetary Policy Design

Monetary policy design in CGG takes the form of two decisions:

1. The choice of which variables should go into the TR reaction function
2. The coefficients on those variables

Results 1-4 in the paper discuss these issues. CGG use the following methodology to investigate optimal policy:

1. Take the private sector (the IS and PC equations) as given
2. Take the nominal interest rate as the central bank's policy instrument
3. Impose a loss function on the central bank, which governs how the central bank views output and inflation deviations from steady-state. In a more deeply specified model, the loss function would be related to consumers' utility and serve as the social welfare function.
4. Derive interest rate rules that minimize the loss function, subject to the private sector. These rules will describe the conduct of monetary policy: the variables it responds to and the degree to which it responds to them.

Without going through the mathematics, I'll re-state their four key results here:

Result 1. To the extent cost push inflation is present, there exists a short run trade-off between inflation and output variability.

Result 2. The optimal policy incorporates inflation targeting in the sense that it requires to aim for convergence of inflation to its target over time.

Result 3. Under the optimal policy, in response to a rise in expected inflation, nominal rates should rise sufficiently to increase real rates. Put differently, in the optimal rule for the nominal rate, the coefficient on expected inflation should exceed unity.

Result 4. The optimal policy calls for adjusting the interest rate to perfectly offset demand shocks but perfectly accommodate shocks to potential output by keeping the nominal rate constant.

Results 3 and 4 are the most important. Result 3 is the so-called "Taylor principle" and states that central banks ought to respond aggressively to inflation. Result 4 describes how the central bank should respond to natural rate and demand shocks: optimal policy accommodates natural rate shocks but offsets demand shocks.

4 Gains from Commitment

This section rehashes some results that had been obtained in simpler models during the 1980s. The punchline (Results 5-6) is that central banks that commit to inflation targeting will be able to build credibility with the public, with the end result being lower inflation on average than could be obtained otherwise. Barro and Gordon (1983) first pointed this out in a simple model; CGG restate the result in a full-blown New Keynesian model.

They also restate the well-known result that the central bank cannot consistently force output to be above its natural rate, and that a central bank which tries to do this will instead simply end up with excessively high inflation. Section 4.2 describes some interesting gains from commitment even if the central bank is *not* tempted to try to raise output above its natural level.

5 Practical Concerns

Now we leave the world of theory and begin discussing practical monetary policy. The discussion of policy under uncertainty is straightforward, as is Result 9. The discussion of instrument choice builds on Poole (1970) and essentially restates his results in modern notation. Result 10 is straightforward given Result 4. The authors are quite damning of Monetarism in any form:

> The analysis thus makes clear why the new Federal Reserve Board model does not even bother to include a money aggregate of any form (see Flint Brayton et al. 1997). Narrow aggregates are not good policy instruments due to the implied interest rate volatility. Broad aggregates are not good intermediate targets because of their unstable relation with aggregate activity. (p.1687)

so that New Keynesian monetary theory lacks a role for money.

Sections 5.2 and 5.3 contain interesting discussion of parameter uncertainty, gradualism, and the notion of "opportunistic deflation." Parameter uncertainty and imperfect information both lead to caution and gradualism in interest rate movements. I'll use this section to talk about what we gain from the New Keynesian model relative to its IS-LM counterpart.

First, the New Keynesian model is written throughout in terms of deviations from some efficient state: deviations of output from potential, $y - y^*$, deviations of inflation from target, $\pi - \pi^*$, and deviations of interest from the natural rate, $r - r^n$. The "natural" numbers y^* and r^n are derived from underlying technology, preferences, and endowments; they emphasize that the Keynesian model exists within a larger model and that larger model governs the longer-run behavior of real economic variables. Hence the New Keynesian model is explicitly a model of the short run, built on the scaffolding of a long-run model.

Second, the New Keynesian model emphasizes the role of private agents' expectations of the future as a determinant of the economy today. With expectations put at the forefront, the model is able to tell us about the possible gains from central bank commitment, announcements of inflation (or other) targets, and the feedback between private expectations and realized outcomes. None of this is possible with the static IS-LM model.

In short, we may say that credibility matters; that monetary policy, while a strong force in the short run, is limited in its ability to influence the economy in the long run; that inflation targeting is a good real-world approximation of optimal policy; and that the stance of policy is captured by movements in (current and expected future) interest rates, relative to their natural rate.

6 A Hybrid Model

The basic NK model is entirely forward-looking. In this section CGG set up a hybrid model, like so:

$$x_t = \alpha_x x_{t-1} + (1 - \alpha_x) E_t x_{t+1} - \varphi(r_t - r_t^n) + g_t$$
$$\pi_t = \alpha_\pi \pi_{t-1} + (1 - \alpha_\pi) \beta E_t \pi_{t+1} + \lambda x_t + u_t$$

so that inflation and the output gap depend on forward-looking and backward-looking components. This richer model is closer to what applied researchers actually use when analyzing monetary policy; see, for example, Jensen (2002). Hence CGG bring this model up to compare it to the baseline NKIS-NKPC model. Fortunately, optimal policy as described in Results 1-4 is qualitatively the same under the hybrid model; this is CGG's Result 13. We can rest assured that the optimal policy results are robust across model specifications. Indeed robustness is an important element of policy design: the true model is unknown, after all.

7 Simple Monetary Policy Rules

This section covers empirical evidence on interest-rate rules, alternative nominal targets, and some technical issues related to indeterminacy.

Section 7.1 discusses the Taylor Rule as both a useful empirical characterization of monetary policy and as an approximation to optimal policy. As mentioned above, a key part of the Taylor Rule is its inflation coefficient γ_π. If $\gamma_\pi > 1$, then the Fed responds to an increase in inflation by decreasing the real interest rate, which in turn contracts aggregate demand and moderates inflation. If $\gamma_\pi < 1$, then monetary policy is destabilizing. Hence it is important to know whether Federal Reserve policy achieves the Taylor Principle in practice. CGG's Table 1 (p.1697) shows results from an econometric exercise that reveals that monetary policy was destabilizing in the pre-Volcker period, but stabilizing after.

Section 7.2 discusses some alternate nominal targets: inflation targeting, price level targeting, and nominal income growth targeting. The authors find the gains of price level targeting to be small. Similarly, the authors find the gains of nominal income targeting to be small or non-existent.

8 Conclusion: What is the Science of Monetary Policy?

The science of monetary policy consists of the close link between (1) macroeconomic models to analyze policy options and (2) practical, simple policy rules to be implemented in the real world. We have a better understanding of the proper scope of monetary policy, the limits of monetary policy, the choice of instrument, and the quantitative tradeoffs involved than we did when Friedman gave his speech on "The Role of Monetary Policy" in 1968. As Eric Leeper put it in 2010:

> Ten years ago Clarida et al. (1999) proclaimed the arrival of "The Science of Monetary Policy." Although the past few years' experiences may have raised some questions about the robustness of the science, the paper's general theme continues to resonate: modern monetary analysis has progressed markedly from the days of monetary metaphors like "removing the punch bowl" and "pushing on a string." Key elements in the progress include modelling dynamic behavior and expectations, understanding some of the critical economic frictions in the economy, discussing explicitly central banks' objectives, communicating policy intentions to the public, developing operational rules that characterize good monetary policy, and deriving general principles about optimal monetary policy.
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> In a surprising twist of fate, the practice of monetary policy marched along side the theory. Central banks around the world have adopted clearly understood objectives – such as inflation targeting and output stabilization – and central bankers espouse and articulate the science in public discussions about managing expectations, the transmission mechanism of monetary policy, and the role of uncertainty in policymaking. Modern monetary research and practical policymaking are united in aiming to make monetary policy scientific.

CGG's paper leaves out two major issues that would come to the fore in 2009: the zero lower bound on interest rates and the role, if any, of financial factors in monetary policymaking. The paper assumes that shocks are small enough, or policy adjusts enough, that the zero lower bound is not a binding concern. They note that this assumption could be relaxed and that it is a key area of future research. The paper also assumes frictionless financial markets, though many of the lessons go through even with financial frictions; see Bernanke, Gertler, and Gilchrist (1999).

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