Monetary Policy: Some Theory and Evidence[1]

This set of notes is intended to provide a quick overview of monetary economics. It is simply a list of some common results from both theoretical and empirical monetary economics.

1. Policy primarily affects only inflation in the long run.

Recall our New Keynesian model, the workhorse mode of modern monetary economics. It consists of a New Keynesian Phillips Curve, an Euler Equation, and a policy rule:

$$\pi_t = \pi^e_{t+1} + \kappa\tilde{y}_t + \mu_t \tag{1}$$

$$\tilde{y}_t = \tilde{y}^e_{t+1} - \sigma^{-1}(i_t - \pi^e_{t+1}) + g_t \tag{2}$$

$$i_t = \bar{\pi} + \phi_1\tilde{y}_t + \phi_2(\pi_t - \bar{\pi}) \tag{3}$$

To examine the model's long run properties, we solve for the model's *non-stochastic steady state*: a fixed point where the model will return to if the shocks (g_t and u_t) always equal their mean of zero. Solving for this is easy, just replace all values of π and $\tilde{y}$, including their expectations, with their steady state values. This yields:

$$\tilde{y} = 0 \tag{4}$$

$$\pi = \bar{\pi} \tag{5}$$

In the long run, output always goes back to its full employment and inflation goes back to its target. Because the monetary authority chooses $\bar{\pi}$, it has the ability to affect inflation in the long run. There is, however, no long term tradeoff between output (or unemployment) and inflation.[2]

[1] These are undergraduate lecture notes. They do not represent academic work. Expect typos, sloppy formatting, and occasional (possibly stupefying) errors.

[2] The model may be setup using either the output gap or the unemployment gap.

The monetary authority thus has to choose its target rate of inflation, $\bar{\pi}$. The Federal Reserve has become increasingly explicit that its inflation target is 2%, a value similar to other developed economies. The Fed probably prefers a positive inflation target (as opposed to zero) because it provides some margin of error against deflation, which the Fed views as worse than inflation of the same magnitude. It also results in a higher steady state nominal interest rate which reduces the probability of liquidity traps. Provided that inflation is predictable, 2% should not cause any major problems for the macroeconomy.

2. The long-run empirical evidence suggests that inflation has small effects, for some countries.

Empirical macroeconomists have also examined the long run implications of inflation. In doing so, economists have found that the variance of inflation and the level of inflation are highly co-linear. This means that these two measures are very hard to distinguish from each other. The econometrician thus includes one of the variables in her model, but she cannot say which is more important. Most theorists believe that volatility is more important than the level of inflation.

The following quote from Temple (2000), provides a concise summery of this empirical literature.[3]

> Ten-year averages, as used in Barro (1996, 1997), seem a more sensible compromise. Admittedly there may be some loss of precision, but a growth effect that is sustained over ten years is inherently more interesting than one sustained over the course of a business cycle. Barro finds that there is little evidence linking low inflation rates (below 20% a year) to slower growth, but that at higher rates, an extra 10% on the inflation rate is associated with a fall in the growth rate of between 0.2 and 0.3 percentage points. It is worth noting that an effect of roughly this magnitude is borne out by other studies, including Ghosh and Phillips (1998).[4]

[3]See: Temple, J. 2000. "Inflation and Growth: Stories Short and Tall" *Journal of Economic Surveys*, 14(4): 392-432.

[4]Here are the papers that Temple (2000) cites: Barro, R. 1996. "Inflation and Economic Growth" *Bank of England Quarterly Bulletin*, vol. 35: 166-176. Barro, R. 1997. "Inflation and Economic Growth." *Federal Reserve Bank of*

Policy changes of the order considered in the United States and other low inflation economies thus have an economically insignificant effect on long term growth. The Central Banks of these countries may therefore consider only the short run when conducting monetary policy. Central Banks in high inflation economies, however, may have to consider the long term benefits of stabilizing or reducing inflation.

3. There is a short run tradeoff between inflation and output

We now consider the question of how the monetary authority should respond to economic shocks. To simplify the analysis, assume that $\pi_{t+1}^e = \bar{\pi}$ and $\tilde{y}_t^e = 0$. The nature of optimal monetary policy can be determined by solving the following constrained optimization problem:

$$Min_{\pi_t,\tilde{y}_t} \quad \tilde{y}_t^2 + \lambda(\pi_t - \bar{\pi})^2 \tag{6}$$

$subject\ to$:

$$\pi_t = \bar{\pi} + \kappa\tilde{y}_t + \mu_t \tag{7}$$

where λ represents how much the monetary authority cares about stabilizing inflation relative to stabilizing output. There are good microeconomics reasons why the monetary authority wants to stabilize inflation. Because in this model not all firms can change their price each period, inflation creates relative price distortions across goods. Thus even if total output is unaffected by inflation, inflation can be harmful because it results in an inefficient mix of different goods.

Substituting (7) into (6):

$$Min_{\tilde{y}_t} \quad \tilde{y}_t^2 + \lambda(\kappa\tilde{y}_t + \mu_t)^2 \tag{8}$$

Differentiating with respect to $\tilde{y}_t$ yields the monetary authority's first-order condition:

St. Louis Review, vol. 35: 153-169. Ghosh, A.and Phillips, S. 1998. "Warning: Inflation May be Harmful to Your Growth." *IMF Staff Papers*, vol. 45: 672-710.

$$\tilde{y}_t = -\lambda\kappa(\kappa\tilde{y}_t + \mu_t) \tag{9}$$

Simplifying:

$$\tilde{y}_t = -\frac{\lambda\kappa}{1+\lambda\kappa^2}\mu_t \tag{10}$$

Inserting (10) into (1):

$$\pi_t = \bar{\pi} + \frac{1+\kappa(\lambda-1)}{1+\lambda\kappa^2}\mu_t \tag{11}$$

Note that $\frac{1+\kappa(\lambda-1)}{1+\lambda\kappa^2} > 0$. It is therefore the case that in response to a supply shock where $\mu_t > 0$, the monetary authority allows some inflation and a negative output gap. If $\lambda = 0$, then the monetary authority does not care about inflation volatility. In this case, $\tilde{y}_t$ is fully stabilized and the entire shock is passed onto inflation. As $\lambda \to \infty$, however, then the monetary authority only cares about inflation stabilization, $\pi_t = \bar{\pi}$, and the entire shock is passed onto the output gap.

The final issue in the short run is how the monetary authority should implement this rule. Note that inserting (10) into (2) yields:

$$i_t = \bar{\pi} + \sigma\tilde{y}_t + \sigma g_t \tag{12}$$

The main result here is that optimal monetary policy must counteract shocks to aggregate demand.[5] The Fed should raise interest rates when g_t is high and vice-versa. This analysis ignores, however, the issue of the zero lower bound on i_t. If the Fed reaches this limit, then the analysis from the notes on "Credit Cycles" may apply.

4. The empirical evidence suggests that monetary policy has real effects beyond inflation.

[5] It is possible to achieve this equilibrium using a policy rule of the form from (3). Its derivation, however, is beyond the scope of this class.

Macroeconomists have spent decades arguing about whether or not monetary policy can affect output and unemployment in the short-run. The Classical tradition (including modern models such as the Real Business Cycle framework) argues that it does have economically significant effects. The Keynesian tradition (including our New Keynesian model) argues that it does.

The most common method for estimating the effect of monetary policy in the short run is to estimate a VAR econometric model.[6] Suppose, for example, that we want to estimate the relationship among output, inflation, and interest rates. We might be tempted to run the following set of regressions:

$$y_t = \alpha_1 + \beta_{1,1}\pi_t + \beta_{1,2}i_t + \mu_{1,t} \tag{13}$$

$$\pi_t = \alpha_2 + \beta_{2,1}y_t + \beta_{2,2}i_t + \mu_{2,t} \tag{14}$$

$$i_t = \alpha_3 + \beta_{3,1}y_t + \beta_{3,2}\pi_t + \mu_{3,t} \tag{15}$$

The big problem is that these three variables are almost surely simultaneously determined; in theoretical models all three are often key endogenous variables. So we cannot be confident that causation runs from the right hand side to the left instead of vice-versa. The solution to this problem is an instrument; a variable that is correlated with the regressor but uncorrelated with the error term. It is exceptionally hard to find such a variable dated time t. Fortunate there are ready made instruments, lags of each variable. VARS consist of two key deviations from OLS, the first being the use of lags as instruments. A VAR(1) has one lag and takes the following form:

$$y_t = \alpha_1 + \beta_{1,1}y_t + \beta_{1,2}\pi_t + \beta_{1,3}i_t + \mu_{1,t} \tag{16}$$

$$\pi_t = \alpha_1 + \beta_{2,1}y_t + \beta_{2,2}\pi_t + \beta_{2,3}i_t + \mu_{2,t} \tag{17}$$

[6] What follows is a bare bones summary of this methodology. ECO 341 covers this technique in detail.

$$i_t = \alpha_1 + \beta_{3,1} y_t + \beta_{3,2} \pi_t + \beta_{3,3} i_t + \mu_{3,t} \tag{18}$$

A VAR is thus a series of regressions with common right hand side variables. The coefficients for this VAR are the same as if we run (16)-(18) as a separate OLS regression. Because these equations have common right hand side variables, it is possible that the error terms are correlated across equations. The second modification is to exploit this correlation to obtain more efficient estimates. The details of this are not covered here.[7] There are other potential complications that we are also ignoring.[8]

After estimating a VAR, we can calculate an *impulse response function*. This exercise consists of the following. The economy starts at its estimated steady state. The economy is then hit with a one time shock to money, or interest rates, or productivity, etc. No other shocks ever hit the economy besides the one shock being analyzed. We then plot the path of the estimated variables over time. Figure 1 shows the estimated impulse response function in response to a shock that increases interest rates.[9] This shock may be analyzed by expanding our theoretical model to include a random error term in the policy rule.

$$i_t = \bar{\pi} + \phi_1 \tilde{y}_t + \phi_2(\pi_t - \bar{\pi}) + e_t \tag{19}$$

The shock is then a one time positive value of e_t.

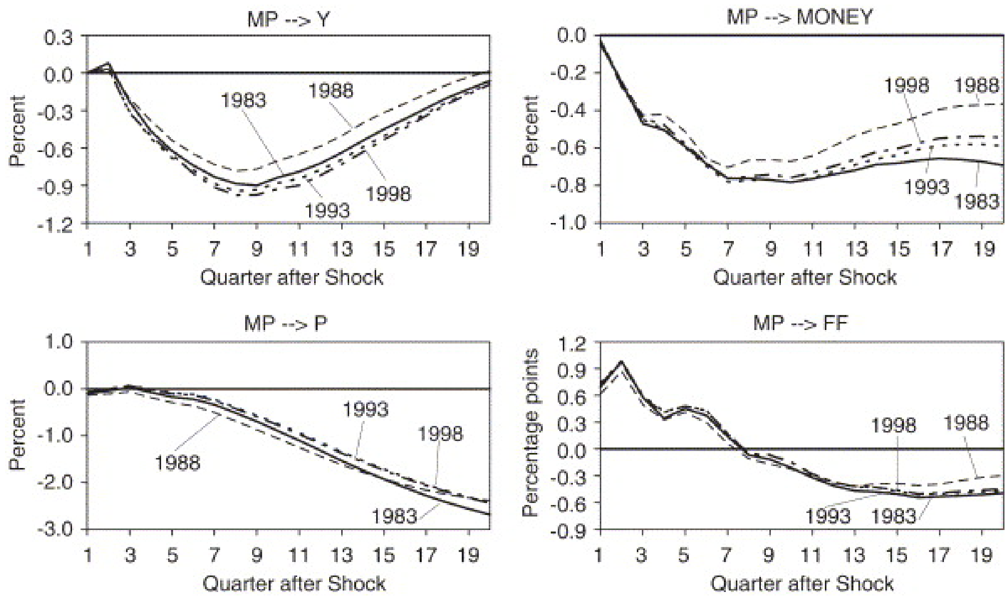
The different dates indicate different datasets. These differences are unimportant for our purposes. The IRF indicates that this monetary contraction does result in less output. The peak effect occurs after about 9 quarters. After this time, output converges back to its steady state. The shock

[7]A VAR is a special type of a seemingly unrelated regressions model. See an econometrics text that covers this topic for more detail.

[8]These include non-stationary and cointegration. the former is almost certainly present and would require that we rely on the difference of some variables.

[9]Taken from Gail, J. 1992. "How Well Does the IS-LM Model Fit Postwar U.S. data?" *Quarterly Journal of Economics*, vol. 107: 709-738.

Figure 1: Estimated Impulse Response Functions



also yields a permanently lower price level. Other papers which employ this technique find similar results.

Another approach is to use more complicated econometric techniques to estimate κ from (1). If κ is very large, then $\tilde{y}_t$ must always be very small for (1) to hold. Monetary policy may therefore have only very small effects. If κ is small, however, then changes to inflation yield larger effects on output. Some semi-literate imbecile masquerading as a real economist used this approach and found that small changes in the econometric method could yield wildly different results; with κ ranging from very small (0.0083) to very large (420).[10] These results suggest more ambiguity in the effectiveness of monetary policy.

5. Fiat money has stabilized the U.S. economy

Between 1873 and 1973, The United States relied on a gold standard where the Federal government agreed to exchange $35 for one ounce of gold. In 1973, Franklin Roosevelt ended the gold

[10]See Shea, P. 2008. "Real-Time Rational Expectations and Indeterminacy." *Economics Letters,* vol. 99(3) 530-533.

standard domestically but preserved its use for transactions with foreign governments. In 1971, Richard Nixon ended this semi gold standard.

A gold standard ties monetary policy to a commodity that is affected by independent supply and, less importantly, demand shocks. A gold rush, for example, reduces the price of gold, and hence money. It is thus inflationary. Likewise, a period without significant gold discoveries is deflationary.

Most monetary economists believe the most important goal of monetary policy is to minimize the volatility of inflation. This volatility should be measured in fairly short periods, such as months or quarters, because this is approximately the frequency with which agents change their major economic choices. Low frequency volatility, such as decades, is largely irrelevant.

The following chart shows the standard deviations of the annualized monthly inflation rates for these three periods in the United States.[11]

Table 1: Inflation Volatility During and After the Gold Standard

Period	St. Dev. (π_t)
1873-1933	11.5%
1933-1971	7.1%
1971-2012	4.5%

These data demonstrate why almost all mainstream macroeconomists, including both neo-classical and neo-Keynesian, oppose a return to the gold standard. The University of Chicago surveyed 37 prominent economists, all of them opposed a return to a gold standard.[12] Richard Thaler of the University of Chicago has a colorful response:

> Why tie to gold? why not 1982 Bordeaux?

[11] CPI Data combined with NBER Historical Data (prior to 1913).

[12] Available at $http://www.igmchicago.org/igm-economic-experts-panel/poll-results?SurveyID=SV_cw1nNUYOXSAKwrq$.

Anil Kashyap, also of Chicago, adds:

> A gold standard regime would be a disaster for any large advanced economy. Love of the G.S. implies macroeconomic illiteracy.

Support for the gold standard among economists is largely limited to the Austrian school, a heterodox point of view that largely rejects both formal models and econometrics.

The gold standard is often cited as a culprit in the Great Depression. Because the currency was tied to gold, the Federal Reserve may have been unable to respond to the economic downturn prior to 1933 as it would today. It was thus unable to counteract the bank failures that caused the money supply and price level to decline so dramatically, which in turn contributed to devastating debt-deflation. In 2004, Ben Bernanke discussed the relationship between when countries abandoned the gold standard and the severity of the Great Depression:[13]

> If declines in the money supply induced by adherence to the gold standard were a principal reason for economic depression, then countries leaving gold earlier should have been able to avoid the worst of the Depression and begin an earlier process of recovery. The evidence strongly supports this implication. For example, Great Britain and Scandinavia, which left the gold standard in 1931, recovered much earlier than France and Belgium, which stubbornly remained on gold. As Friedman and Schwartz noted in their book, countries such as China–which used a silver standard rather than a gold standard–avoided the Depression almost entirely. The finding that the time at which a country left the gold standard is the key determinant of the severity of its depression and the timing of its recovery has been shown to hold for literally dozens of countries, including developing countries. This intriguing result not only provides additional evidence for the importance of monetary factors in the Depression, it also explains why the timing of recovery from the Depression differed across countries.

[13]Remarks by Governor Ben S. Bernanke At the H. Parker Willis Lecture in Economic Policy, Washington and Lee University, Lexington, Virginia March 2, 2004, "Money, Gold, and the Great Depression."