17 MONETARY POLICY

Chapter 17 Contents

A. Topics and Tools

Much of the material in this course has dealt with the effects of changes in the money supply on the economy. We have seen results ranging from the neutral link between money growth and inflation in the quantity theory and real-business-cycle models to the strong output effects of money in the *IS-LM* model. In this chapter, we put together some of the results that we have derived above and look in detail at some of the problems faced by the monetary authority in conducting monetary policy. The presumption in most of this analysis is that monetary policy has real effects in the short run as predicted by the *IS-LM* model, but is neutral in the long run.

In the first sections of Romer's Chapter 12, he reviews the basic links between money growth and inflation and between money growth and interest rates. He then carries the argument one step farther by discussing the term structure of interest rates, which is the fancy name that economists give to the relationship between short-term and long-term interest rates.

Section 12.3 considers a set of very basic monetary policy issues involving the desirability of using countercyclical policy at all, which instruments should be used, which variables should monetary policy use as targets, and whether the monetary authority should follow a fixed rule. These are issues about which macroeconomists disagree, but they are vitally important for central banks in deciding the course of monetary policy.

Sections 12.4 through 12.6 look at the literature on interest-rate rules and inflation targeting. Because most modern central banks use some form of interest-rate target, much attention has focused on the optimal design of such policy rules. These sections review that literature.

Section 12.7 provides a detailed look at the monetary-policy implications of the zero lower bound on nominal interest rates, a topic we examined in Chapter 8.

In sections 12.8 and 12.9, Romer examines an important issue in monetary policy analysis: dynamic inconsistency. This problem arises when the short-run objectives of the policy authority conflict with its long-run objectives. In the case of monetary policy, there is often temptation for the central bank to increase money growth in the short run to stimulate higher output and reduce unemployment. However, the long-run result of such a change is likely to be higher inflation. It may be very difficult for even a well-intentioned central bank to convince the public that it is a serious inflation-fighter, given the expansionary temptation of short-run objectives. This may lead to higher inflationary expectations in the economy and, through the policymaker's response to this, to higher actual inflation.

The final sections consider the benefits and costs of inflation. Faster expansion of the money supply can lead to greater revenue for the government through the process of seigniorage. This may allow other tax rates to be lower than if a zero-inflation policy is followed. However, higher inflation also inflicts costs on the economy. The costs of unanticipated inflation differ from those of correctly anticipated inflation. Moreover, the presence of uncertainty about inflation can sometimes inflict real costs on the economy.

It is worth noting that the subject matter of this chapter is examined in detail in Economics 341: Monetary and Fiscal Policy. Students interested in a closer look at these issues are advised to consider enrolling in Econ 341.

B. Issues in Monetary Policy

There are many distinct issues involved in the study of monetary policy. Some are central issues of macroeconomics, such as studying how monetary policy affects the economy. Others are more tangential to macroeconomics and relate to the policy process itself, the structure and stability of financial markets, and the regulation and supervision of the banking industry.

We shall direct our focus here on aspects of monetary policy that relate closely to the macroeconomic content of this course. The macroeconomic questions relating to monetary policy tend to fall into two major categories: long-run inflation control and short-run stabilization policy. However, as recent literature demonstrates, while it is convenient to separate the short run and the long run in theory, the same set of monetary policies must attempt to serve both sets of goals. The historical accumulation of short-run monetary policy actions become long-run monetary policy.

In this section, we shall introduce some of the major macroeconomic issues in monetary policy. The final section of this chapter lists some readings that allow you to learn more about topics that you find interesting.

Monetary policy and inflation

Few, if any, economists seriously question the causal connection between long-run growth in the money supply and long-run inflation. Milton Friedman once said that "inflation is always and everywhere a monetary phenomenon," and although some might quibble about short-run effects, nearly everyone accepts his assertion as a long-run fact. It is simply impossible to find examples of countries where high inflation has been sustained without rapid monetary expansion, or examples of rampant, ongoing money growth that have not eventually caused inflation.

Much of the study of inflation has focused on episodes of ***hyperinflation***. During hyperinflations, when prices are rising by hundreds or thousands of percent per year, monetary changes are so extreme that they totally dominate the effects of changes in real variables. Hyperinflations thus provide a laboratory in which we can see pure monetary effects at work without important influences from real fluctuations.

Philip Cagan's seminal study of six European hyperinflations after World War I demonstrated a close connection between monetary growth rates and inflation rates. Cagan (1956) also showed that higher inflation rates led to significant reductions in the demand for real money balances in the affected economies. Our usual money demand function, with nominal interest rates and real income, subsumes the effect of (expected) inflation in the nominal interest rate. However, in an economy where capital markets have broken down, bonds may not be an appropriate alternative asset for money-holders. In this case, the relevant opportunity cost of holding money may be the expected nominal return on real goods. Since real goods sell at the current prevailing price level, they increase in (nominal) value at the inflation rate. Thus, the expected inflation rate is probably a better measure of the opportunity cost of holding money in a hyperinflation economy.

Another aspect of inflation that has received a great deal of attention from monetary and macroeconomists is the question of how to reduce it. The obvious answer is to slow the growth of the money supply, but much attention has been focused on whether it is better to do so gradually or suddenly and whether there are benefits to fixing exchange rates as a rule to discipline money growth.

Recall from our earlier analysis that some theories of business cycles claim that fully anticipated changes in monetary policy should have no effects on real variables, while unexpected reductions in money growth may induce real contractions. This suggests that the real costs (in terms of recessions or depressions) of disinflation may be lower if the lower money growth is fully announced in advance and widely believed.

Thomas Sargent (1982) found evidence from the European hyperinflations (some of the same ones Cagan used) in support of the proposition that credible disinflation need not lead to recessions. He found that the dramatic institutional reform associated with the end of these inflations was a sufficient shock to end inflationary momentum without a negative effect on output. However, the conventional wisdom is that most inflationary episodes end with substantial recessions, especially when the policy change is less dramatic. Laurence Ball (1994) looks explicitly at the costs of disinflation and finds that most reductions in inflation since World War II have been accompanied by significant slumps in real output and increases in unemployment.

The idea that fixing the exchange rate might reduce the costs of disinflation is closely related to the issue of credibility and expectations. A fixed exchange rate can only be achieved by restricting money growth sufficiently to preserve the exchange-rate peg. Individuals in the economy can easily monitor on a day-to-day basis whether the central bank is living up to its commitment to peg the exchange rate, so it is harder for the central bank to cheat and expand the money supply more rapidly than its announced plan. Thus, fixing the exchange rate may give people more faith in the central bank's announced disinflation policy and thus make more of the reduced money growth "expected."

Does monetary policy have real effects?

One of the major issues in our study of business cycles was whether changes in the money supply have real effects or whether they are neutral. There seem to be systematic positive correlations between money growth and output growth in most industrial countries. The conventional interpretation of this correlation is that monetary policy affects output.

However, the real-business-cycle theorists explain that correlation with the reverse causality. Rapid output growth leads to higher growth in the demand for money, which the central bank may accommodate with more rapid money creation if, as is often the case, it follows a rule of stabilizing interest rates. Thus, procyclical money growth may be an effect, rather than a cause, of output movements.

Only with rather extreme assumptions can econometricians attempt to distinguish causality in economic relationships. The evidence in the money-income case is mixed. Robert Barro looked at the effects of anticipated and unanticipated monetary growth and found that only his measure of unanticipated money affected real output and unemployment.[1] Most of the evidence from that literature suggests that unanticipated money does affect real variables. Anticipated monetary changes may also have real effects, though the effects may differ from those of unexpected shocks.

One famous study by Christina and David Romer avoided some of the difficulties of identifying causality by looking in the published minutes of Federal Open Market Committee meetings for dates on which the Fed intentionally initiated contractionary monetary policy in order to lower inflation.[2] Romer and Romer find that real output moved significantly below what one should have expected and that unemployment moved considerably above the expected trend after these "Romer dates."

Channels of transmission of monetary policy

Another topic of great interest to monetary economists is the process through which money influences aggregate demand. The "monetary transmission mechanism" has been the focus of a voluminous debate between those favoring the traditional "monetary" or "interest-rate" channel and others arguing in favor of a "credit channel" of transmission.

According to the credit channel argument, contractionary monetary policy forces banks to cut back on lending. Rather than raising interest rates, which is the effect emphasized in the traditional *IS*/*LM* model, they may instead ration credit to only the

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[1] See Chapter 13 of this Coursebook.

[2] See Romer and Romer (1989). This paper uses the same methodology as the paper assigned on the reading list for this section.

safest customers.[3] If the credit channel is important, then contractionary monetary policy should have much stronger effects on small firms that must rely on banks for credit than on large firms that can borrow directly from the public in the bond market or the commercial paper market.

For an extended discussion of the theoretical and empirical issues relating to the credit channel of monetary policy, see the symposium in the Fall 1995 issue of *Journal of Economic Perspectives.*[4]

Choosing the right targets, instruments, and operating rules

In a simplistic classroom model, making monetary policy is easy. You just decide what level of output, prices, or interest rates you would like to achieve and then shift the *LM* curve until you get it. However, in the real world, we never have the information that we need to conduct policy in this simple way. Macroeconomic variables respond slowly to changes in monetary policy, so the economy is still adjusting to policies put in place months or even years ago. Moreover, even the best econometric evidence about the magnitude of the effects of monetary policy variables on the rest of the economy is subject to great uncertainty.

Thus, "controlling" the economy with monetary policy is rather like driving blindfolded: you only find out whether you actually made the right moves a few years later, and then it is too late to correct them. Because of the lags and uncertainties of monetary policy, central banks usually use a multi-level collection of policy guidelines.

At the top of the guidelines are the ***goals*** or ***targets*** of monetary policy. These are the variables, such as inflation, unemployment, or output growth, that the central bank ultimately aims to influence or control. Because monetary policy affects these variables with long lags, they may not provide sufficient short-run guidance to keep monetary policy on target in the face of shocks. Thus, policymakers often use ***intermediate targets or instruments*** as shorter-run benchmarks for policy. Rates of monetary growth have often been used as short-term instruments of monetary policy, as have various interest rates and exchange rates.

While these short-term instruments are observed frequently, they may not be directly and completely under the control of the central bank. For example, changes in banks' demand for reserves will affect the money supply unless the central bank intervenes to counteract them. At the shortest-run end of the policy guidelines is the central

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[3] Information imperfections in the credit market may make it better for banks to ration credit than to balance the market for loans by raising interest rates. That is because raising interest rates may attract a riskier pool of borrowers, which could end up reducing the bank's profits if repayment rates fall. See Stiglitz and Weiss (1981).

[4] The introductory article to this symposium is Mishkin (1995). See the list of references at the end of this chapter for the full set of papers.

bank's actual ***operating rule***. This defines the variable that the central bank chooses as its day-to-day handle for monetary policy. Choices for the operating rule include fixing the level of the monetary base, choosing to use open-market operations to "control" a particular short-term interest rate (such as the federal funds rate), or deciding to peg the exchange rate of its currency to a selected foreign currency.

There is a large theoretical and empirical literature on the optimal choice of targets, instruments, and operating rules. Operating rules based on monetary aggregates such as the monetary base or bank reserves were very popular in the 1980s, as major countries sought to reduce their rates of inflation. However, most central banks now operate on an immediate level with either an interest-rate rule or an exchange-rate peg. One cause of this change has been substantial instability in the demand for various monetary aggregates, which makes the effects on the economy of a given monetary growth rate harder to predict.

Balancing short-run and long-run policy goals

Most macroeconomists and central bankers now agree that the main aim of monetary policy should be to control long-run inflation. However, many also believe that monetary policy can have a short-run role in helping to stabilize business cycles. Thus, the ultimate target of a central bank is often a mixed signal based on inflation and the stage of the business cycle. This creates the potential for conflict between short-run and long-run goals.

Some have argued that the unreliability of the relationship between monetary policy actions and the resulting changes in the economy make it undesirable even to attempt to use monetary policy to stabilize business cycles. Mistimed policy actions may do more to increase the severity of the next phase of the cycle than to dampen the current phase. For example, if a strong expansionary policy is enacted toward the end of a recession, its effect is likely to be largely to augment the following boom rather than to offset the recession. Bad policy is often worse than no policy response at all.

However, most central banks respond to some degree to changes in real economic conditions. When they believe that a recession is coming, they are likely to expand money growth or lower their target interest rates (which amount to the same rightward shift in the *LM* curve). However, they may be less likely to step on the monetary brakes in a period of prosperity unless inflation begins to rise.

That is a source of conflict between short-run stabilization goals and the long-run aim of low inflation. If, over the course of several business cycles, the central bank raises the monetary growth rate in recessions to try to stimulate the economy but does not lower it during the ensuing boom, then the money growth rate and hence the inflation rate will gradually creep upward. After several cycles, the economy may find itself with a much higher inflation rate than the policymaker or the public would prefer. The literature on ***dynamic inconsistency*** of monetary policy, which is discussed in

Romer's sections 12.8 and 12.9, has examined the details of the tradeoff between optimal short-run and long-run policies.[5]

C. Understanding Romer's Chapter 12

Money and inflation

In the first sections of Chapter 12, Romer establishes that the only plausible explanation for sustained inflation is growth in the money supply at a faster rate than money demand is growing. As he shows with equation (12.2), if agents remain on a fixed money-demand function, an ongoing rise in the price level can occur only if there is some combination of (1) steady growth in the money supply, (2) steady growth in nominal interest rates, and (3) steady negative growth in real income. Any of these three possibilities would cause the nominal supply of money to grow faster than the demand for it. Which of these three is the most likely?

Extended periods of shrinkage in real income have (fortunately) been rare, so (3) does not appear to be relevant for most inflationary situations. As for (2), although nominal interest rates fluctuate a lot, they do not grow steadily and systematically over time as would be necessary to explain a sustained rise in the price level. That leaves only (1), steady monetary expansion, as the proximate cause of high inflation.[6] This supports Friedman's principle that inflation is "always and everywhere a monetary phenomenon."

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[5] Some key references are given in the last section of this chapter.

[6] Romer's equation (12.2) obscures a fourth possible explanation that has some empirical relevance. If technological advances such as ATMs and telephone transfer accounts continue to reduce the general level of money demand over time, then the whole L function could fall despite a stable level of i and rising Y. Such decreases in money demand tend to raise prices and, if money demand continues to fall each year indefinitely (rather than just staying at a fixed lower level), to raise inflation. Although empirical evidence supports the general tendency for money demand to decline over time, the rate of decline is probably no more than about 1 percent per year, which means that this factor can explain only a small amount of inflation.

Inflation and interest rates

In his section on inflation and interest rates, Romer considers (strictly intuitively) the behavior of a simple monetary growth model.[7] This model is not really a "growth" model since the growth rate of real output is assumed to be zero, but we shall generalize this case below to account for the possibility of positive growth.

Romer's Figure 12.2 describes the temporal behavior of the major variables in a non-growing economy when the rate of money growth increases. This figure assumes that the increase in money growth is fully anticipated. Since inflation is fundamentally a long-run phenomenon, we will ignore short-run non-neutralities and focus on a full-employment equilibrium of a classical variety. Our analysis will focus on three time periods: the original steady-state equilibrium path (before t_0), the new equilibrium path (after t_0), and the moment of transition (at t_0).

On the original equilibrium path, the money supply is growing at a lower rate, say 3% per year. Prices grow at the same rate (because real output, and therefore the real demand for money, is fixed), so inflation is 3% and is fully expected. Since $\pi^e = 3\%$, the nominal interest rate is 3% higher than the real rate, which is determined on the "real side" of the economy and is not affected by changes in inflation.

The equilibrium path after t_0 is qualitatively identical to the original, expect that the money supply is growing faster, say at 7%. This raises actual and expected inflation to 7% after t_0 and causes the nominal interest rate to rise by 4 percentage points so that it is now 7 points higher than the (unchanged) real rate.

The most striking feature of this model occurs at the moment of transition from low to high inflation. Consider the behavior of prices at the instant t_0. Since we are considering an instant in time, the money supply is at a particular level $M(t_0)$ and the price level associated with that level of M can be calculated from equation (11.4). At the instant t_0, everyone correctly anticipates a rise in inflation from 3% to 7%, which means that the expected inflation rate leaps 4 percentage points at that instant. With the real interest rate unaffected, the nominal interest must also leap 4 points, which depresses the real demand for money abruptly. To maintain equilibrium, the price level must leap upward at t_0 to maintain equation (11.4), in which the denominator jumps downward. Note, however, that this is a "level effect" on the price level, not a change in its rate of growth (inflation).

Because of this one-time jump in prices at t_0, the time path of prices will have a discontinuity that is not present in the path of the money supply. Romer shows this in the top and bottom panels of Figure 11.2. As the price level jumps with the money

[7] There is a substantial literature on monetary growth models that we have not touched. In this section, we are studying one of the main results. Some of the standard (though dated) references are Sidrauski (1967), Stein (1970), and Brock (1975).

supply fixed, the real quantity of money jumps downward from the higher figure associated with low inflation to a lower value. As money is depreciating faster, it is more costly to hold and agents reduce their real money holdings.[8] This negative relationship is clearly demonstrated by a famous study of hyperinflations by Phillip Cagan (described in the previous section).

How would this story be different if real output was growing over time? Qualitatively nothing would be very different. However, since output growth leads to steady growth in money demand over time, the denominator of equation (12.4) will be increasing as well as the numerator. Suppose that real output is growing at rate g_Y and that each increase of one percentage point in output (which equals income) leads to an increase of η percent in money demand.[9] Then the rate of growth of money demand will be ηg_Y. Since the growth rate of a ratio is the growth rate of the numerator minus the growth rate of the denominator, the steady-state inflation rate is $\mu - \eta g_Y$. If $\eta \approx 1$, then this simplifies to $\pi \approx \mu - g_Y$.

Term structure of interest rates

Given the vast potential profits that can be made in financial markets by someone who is able to predict asset prices, it is not surprising that stock, bond, and foreign-exchange markets have attracted plenty of attention from economists.[10] As with many topics, we will only scratch the surface of a large and complex literature on the term structure of interest rates, which is defined as the relationship between interest rates on otherwise-identical bonds or loans that have different maturity (repayment) dates. The theory we shall study is the "expectations" theory of the term structure, which is a familiar benchmark in finance theory. Most other work on the term structure relates to it by trying to explain why the term structure might deviate from the prediction of the expectations theory.

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[8] Notice that because the interest rate on bonds rises to compensate for the higher inflation, the attractiveness of bonds is not diminished despite the fact that they also pay a return in dollars. Thus, it is reasonable to suppose that people are substituting bonds for money to avoid the effects of inflation. At some times and in some countries, controls on interest rates prevent nominal rates from rising to compensate for inflation. In this case, people often try to withdraw their wealth from both money and bonds in favor of *inflation hedges* such as real estate and gold.

[9] The parameter η is the elasticity of money demand with respect to income. Empirical estimates place this parameter in the general vicinity of one.

[10] The study of asset markets lies on the border between the academic fields of economics and finance. Schools of business have departments of finance whose faculty members specialize in this kind of research. Results from the finance literature often overlap with macroeconomics, as in the case of the term structure of interest rates, international interest rate parity under perfect capital mobility, and the Modigliani-Miller theorem.

To see the logic of the expectations theory in its simplest form, consider the following example. Suppose that the interest rate on one-period loans beginning in period t (and repaid in $t + 1$) is i_t^1 and that the rate on two-period loans made in time t is i_t^2. An individual who wants to lend money for two periods has a choice. She can buy a two-period bond and hold it to maturity or buy a one-period bond, hold it to maturity, then buy another one-period bond for the second period. Assuming annual compounding of interest, the amount of money she gets back (for each dollar invested) if she invests in the "long" bond is $\left(1+i_t^2\right)^2$. Investing in a "short" bond gives her $\left(1+i_t^1\right)$ at the end of the first period, which grows to $(1 + i_t^1)(1 + i_{t+1}^1)$ by the end of the second. However, i_{t+1}^1 is not known at time t, so she must base her decision on $E_t(i_{t+1}^1)$ rather than the actual value.

In order for the two investment strategies to yield the same return (so that investors are indifferent between following either one), $\left(1+i_t^2\right)^2$ must equal $(1 + i_t^1)(1 + E_t i_{t+1}^1)$. Expanding out the polynomial products gives $1 + 2i_t^2 + \left(i_t^2\right)^2 = 1 + i_t^1 + E_t i_{t+1}^1 + i_t^1 E_t i_{t+1}^1$. The ones cancel from both sides of this equation and the last term on each side is of a smaller order of magnitude than the other terms.[11] Thus, the expectations theory is usually simplified as $2i_t^2 = i_t^1 + E_t i_{t+1}^1$, or $i_t^2 = ½(i_t^1 + E_t i_{t+1}^1)$. This last formula says that the interest rate on a long-term bond should equal the average of the expected interest rates on a sequence of short-term bonds covering the same time period.[12]

Although this last equation is only an approximation when we use annually compounded interest rates (because of the square and cross-product terms that we neglect), it holds exactly for continuously compounded interest rates. This is the approach that Romer takes on page 584.

Romer's equation (12.6) adds θ_t to the traditional term-structure equation. The presence of this term reflects the possibility that risk considerations may make short-term bonds more or less attractive relative to long-term bonds. This term is called the

[11] As we have noted before, when interest rates are small, the product of two interest rates is very small. If the interest rates are 3% = 0.03, then the squares and products are 0.0009, which can safely be neglected.

[12] Although we will not go through the algebra, you can derive the same equation by looking at the rates of return of agents who plan to hold their bonds for only one period. Such agents have a choice of holding a one-period bond to maturity or buying a two-period bond now and selling it (as a one-period bond) a year from now. Although the rate-of-return calculations lead to identical results, there may be differences between one-period bond-holders and two-period bond-holders in how risk affects the desirability of long and short bonds. See Palmon and Parker (1991).

term premium or ***liquidity premium*** and is often found to be positive. Financial economists spend lots of effort trying to estimate the term premium and to predict its future course.

Optimal monetary policy in a backward-looking model

In Sections 12.4 and 12.5, Romer examines the optimal monetary-policy rule in a typical "backward-looking" model and a "forward-looking" model. We consider first the backward-looking model.

Equations (12.15) through (12.19) define a simple stochastic model of the economy. Several features of this model warrant explanation. First, you will notice that the model has three different output variables, all measured in logs: y is the log of actual output, y^n is the log of "natural" or flexible-price output, and y^* is the log of optimal or "Walrasian" output. The distinction between natural and optimal output is one that is common in modern models of optimal monetary policy. Optimal or Walrasian output is the output that would be produced in a perfect, Pareto-efficient world in which markets operated perfectly to map individual preferences into decisions about how much to work and produce. Natural output takes account of the imperfections in the model due to such factors as imperfect competition.[13] Equation (11.19) reflects the assumption that natural output is lower than optimal output by a non-negative amount Δ.

The *IS* curve in equation (11.15) has a backward-looking dynamic in that current equilibrium expenditures depend on last period's real interest rate, which is set by the central bank's monetary policy rule. The *IS* disturbance term u^{IS} represents deviations from normal spending that do not result from central-bank changes, such as unusually high or low investment or consumption expenditures. Equation (11.17) describes how these disturbance terms evolve over time according to a "first-order autoregressive process."[14] The coefficient ρ_{IS} measures the fraction of last period's disturbance that carries over into the current period, while ε^{IS} is a new shock to spending that is uncorrelated with any past variables ("white noise").

Equation (11.16) is a standard, backward-looking Phillips curve or aggregate-supply curve relating the current change in inflation to last period's "output gap," the (positive or negative) difference between actual and natural output, which we will call $\tilde{y}$. Equation (11.18) describes the evolution of natural output over time, which is an autoregressive process similar to that for the *IS* disturbance.

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[13] In Romer's Chapter 6 we developed a model with imperfect competition and demonstrated in equation (6.59) that equilibrium output with flexible prices was less than the optimal value of one. This mirrors the distinction here between optimal output and natural output.

[14] Recall that we used this kind of stochastic process to model the deviations of technology and government spending from their trends in the real-business-cycle model of Romer's Chapter 5.

Our analysis of the model consists of finding an optimal rule for setting monetary policy to minimize the central bank's "loss function," which is defined in text at the top of page 598 to be $E\left[\left(y-y^*\right)^2\right]+\lambda E\left[\pi^2\right]$. This loss function reflects the "dual objectives" of output stabilization and inflation control that are common among modern central banks. The first term is the expected squared deviation of output from its optimal (not natural) level. The central bank would like to keep output as close as possible to the Walrasian level. Deviations above as well as below optimal output are undesirable, though recall that if $\Delta > 0$ the economy tends to a long-run equilibrium that is below y^*.

The second term in the central bank's loss function is $\lambda E\left[\pi^2\right]$. As with output, inflation either above or below its optimal rate (assumed to be zero) is assumed to be bad. The coefficient λ represents the weight that the central bank attaches to minimizing inflation relative to output deviations. A central bank that is a strong inflation hawk would have a large value of λ, attaching great importance to inflation control. A bank that viewed minimizing output movements as more important would have a smaller λ.

The analysis pages 598-601 shows that the optimal monetary-policy rule can be summarized by equation (12.33), which gives the optimal real interest rate. When there is no inflation or output gap, the central bank sets the interest rate at its "natural" level—the level that will keep inflation stable and not change the output gap. When either inflation is positive or output is above natural output, the central bank's optimal response is to raise the real interest rate above its natural level. This model provides a theoretical justification for the *MP* curve of equation (6.26). It also reflects the conventional wisdom about how actual central banks conduct their policy that is often called the Taylor Rule.

Monetary policy in a forward-looking model

How is optimal monetary policy different when agents are forward-looking? Section 12.5 looks at a model that uses the (forward-looking) new Keynesian *IS* and Phillips curves, described in equations (12.34) and (12.35). Romer showed in Chapter 6 that the forward-looking model has "sun-spot" properties that can lead to unstable, self-fulfilling equilibria. These are reflected in the monetary-policy implications of the model as well.

The simplest form of the monetary-policy rule suggests that by "divine coincidence" monetary policy is able simultaneously to minimize both terms of the central bank's loss function: there is no tradeoff between minimizing inflation and keeping output near the natural level because the policy that does one also does the other.

On pages 604-607, Romer discusses the stability conditions necessary in order to rule out sun-spot equilibria. He also discusses the assumptions leading to the divine-coincidence property and why that property might not hold.

Dynamic inconsistency

The important role played by inflationary expectations in modern macroeconomic models leads to an important corollary: it may be in the interest of the central bank in the short run to "fool" the public by increasing the money supply more rapidly than people expect. However, agents with rational expectations cannot be fooled forever, so eventually the short-run gain achieved by fooling the public is dissipated. Moreover, since inflation increases as monetary growth accelerates, the long-run cost of such short-run stimulative policy actions is higher inflation.[15]

This is the problem of ***dynamic inconsistency*** (or time inconsistency): the optimal short-run policy strategy has detrimental long-run effects. Thus, the policy authority is in constant tension between short-run and long-run objectives and the public, when it forms its expectations, must constantly guess which objective the policymaker will pursue.

In order to model dynamic inconsistency, we must define precisely the goal or objective of the policy authority and the constraints under which it operates. The ***policy objective function***, which may or may not correspond to the true social welfare function of the agents in the economy, is like a utility function for policymakers. This function expresses a cardinal preference measure for the policymaker as a function of major economic variables. In the present example, it is a function of output and inflation, though unemployment is often used in place of output.

The constraints on the policymaker's actions are imposed by the structure of the economy itself. For example, the Phillips curve (traditional or modern) may impose limitations on the ability of the policymaker to achieve desired levels of both inflation and unemployment at the same time. Once we have the policymaker's objective function and her constraint specified, the problem reduces to a simple constrained maximization problem. However, we shall see that the endogeneity of expectations in the long run puts a different twist on the analysis.

In the present case, it is more convenient to express the policymaker's preferences in terms of minimizing a ***loss function*** rather than maximizing an objective function. The *only* difference between a positive objective function and a loss function is whether it is defined in a way that makes increases in the function good or bad. In the objective

[15] Romer describes these not in terms of short-run and long-run objectives but rather in terms of whether or not the policymaker can pre-commit to a particular inflation policy. The implications are the same.

function case, increases in the function are good and the policymaker attempts to maximize the function; with the loss function, increases in the function are bad and the policymaker's goal is to minimize the function. Multiplying a loss function by minus one turns it into an equivalent (positive) objective function, and vice versa.

The loss function that Romer chooses in equation (12.64) is a common one. It makes the policymaker's loss a quadratic function of the deviations of output and inflation from their optimal levels.[16] Since the derivatives of a quadratic function are linear, quadratic loss functions lead to linear policy functions when we maximize (or minimize) by differentiating.

There are two crucial assumptions that are necessary to support that main result of this model. The first is that inflation is undesirable above some value π^*. The second is that the optimal level of output y^* is greater than the natural level y^n to which the economy gravitates in long-run equilibrium with correct expectations. This situation arises if there are imperfections in the economy (such as imperfect competition as in the model of Romer's section 6.9) that cause equilibrium output to be sub-optimal.

The control variable that the policymaker uses to try to minimize loss is, presumably, money growth, which in this context is equal to inflation. Rather than introducing a money-growth variable explicitly, we simply assume that the monetary authority is able to control inflation. In the long run, this assumption is reasonable, though it is less so in the short run.

Romer analyzes the model in terms of two different ways that the policymaker could approach the choice of policy. In the first, she takes a long-run perspective by recognizing that whatever rate of inflation she sets will be matched by the expectations of agents in the economy. Thus, in addition to the "dynamic Lucas supply curve" given in (11.63), she takes as a constraint the condition $\pi = \pi^e$, which implies that $y = y^n$. When $y = y^n$, minimization of (11.64) is trivial; she sets $\pi = \pi^*$. Given that she cannot fool the public forever, this is the best she can do in the long run and is the best sustainable outcome for the economy, period. If the optimal inflation rate is zero, then this policy corresponds to choosing long-run price stability and *not* choosing to increase output to a level closer to the desired level y^* by fooling the public in the short run.

However, in any particular year, the policymaker can reduce losses (increase welfare) by breaking the optimal long-run rule and stimulating increased output. In that case, she would minimize loss taking expected inflation as fixed, which is the problem that Romer solves in equation (11.67). If expected inflation were to remain constant, the policymaker would achieve lower loss by following this short-run rule than with the $\pi = \pi^*$ rule. For any given level of inflationary expectations, one can calculate the

[16] It is important to remember that these "optimal" levels are defined relative to the preferences of the policymaker.

policymaker's optimal short-run response. This is the "reaction function" that is represented by the flatter upward-sloping curve in Figure 12.7.

In the long run, however, agents will catch on to any higher inflation and adjust their expectations. That means that any level of inflation that is higher (or lower) than the expected rate will not be sustainable. Suppose that the economy begins from an initial, low inflation rate equal to π^* in Figure 12.7. If the policymaker succumbs to short-run temptation, she can improve welfare by raising inflation, moving vertically upward to the point on the reaction function where $\pi^e = \pi^*$. However, when expected inflation "catches up" to the higher actual rate, the economy will move directly to the right to the 45-degree line. At this point, the policymaker may try the experiment again, moving directly upward again from the 45-degree line to the reaction function. But again expectations will catch up and push the economy to the right and back to the 45-degree line. Eventually (and immediately if rational expectations allows the public to foresee the eventual outcome at the start of the process), the economy ends up at π^{EQ} in Figure 12.7. At this point, inflation is so high that the policy authority is unwilling to raise inflation in the short run in order to get any increase in y above y^n.

The problem of the policymaker is that the optimal long-run outcome occurs *only* if she can commit to low inflation so the economy remains at π^*. However, the public will rightfully expect that she will be tempted to opt for higher inflation, especially if she is a politician trying to get reelected in the short run. Thus, if the policymaker cannot credibly commit to π^*, the economy may end up at π^{EQ}, which is a worse position.

How do policymakers attempt to gain anti-inflationary credibility? Romer discusses a model in which they "earn" their reputation with actual anti-inflationary policies. Alan Greenspan has succeeded in gaining credibility in this way and so far Ben Bernanke has maintained a strong reputation. However, besides having good central bankers, there are also institutional arrangements that make long-run low inflation more credible. One is independence of decision-making for the central bank. If central bankers (who tend to be economists rather than politicians) are not subject to the control of politicians (who may have shorter time horizons), then they may be more likely to eschew short-run high-inflation strategies and be more successful in keeping inflationary expectations low.[17]

Another strategy is to fix the exchange rate with respect to one or more foreign currencies. As we saw earlier in the course, following a fixed-exchange-rate policy implies that the monetary authority must keep the domestic inflation rate aligned with that of the country (or countries) to whose currencies the rate is pegged. By pegging to a low-inflation country such as Germany or the United States, a country may be able

[17] For evidence that countries with more independent central banks tend to experience lower inflation, see Alesina and Summers (1993). See also Romer's discussion on pages 637–639.

to "import" inflationary credibility. An example of a country that has followed such a strategy quite successfully is Italy, which joined the European Exchange Rate Mechanism in order to gain inflationary credibility from its neighbors and now has joined into permanent currency union with ten of its EU partners. However, this strategy can backfire spectacularly, since doubts about the willingness or ability of the central bank to sustain the fixed exchange rate can lead to a currency crisis and a massive loss of foreign-exchange reserves. Recent experiences in Thailand and other Asian economies testify to the costs of failed attempts at fixing exchange rates.

Federal-funds market

Most contemporary central banks set monetary policy by targeting a benchmark interest rate. For example, in the United States, the Federal Reserve intervenes in the federal-funds market to achieve its target level of the federal-funds rate. It is worth reminding that despite its name, the federal-funds market does not involve borrowing or lending by the Federal Reserve itself. Instead it is an interbank market for extremely short-term (overnight) loans among large banks.

Banks are required to hold reserves by the Federal Reserve (and would hold some anyway). The Fed's reserve requirement is calculated on average daily deposits over a two-week "reserve maintenance" period and average daily reserves over a corresponding two-week "reserve computation" period that starts and ends a couple of days after the maintenance period. The normal flow of transactions will affect each bank's reserves in ways that cannot always be predicted. As the reserve computation period moves on, if a bank sees its reserves falling short of the requirement it will need to acquire additional reserves to fulfill its reserve requirement. Alternatively, a bank that sees its reserves begin to run above the requirement may seek to lower its reserve position. The quickest and easiest way for banks to exchange reserves is through the overnight loan market: the federal-funds market.[18]

The interest rate in the federal-funds market (the federal-funds rate) will depend on the amount of desired borrowing by banks that are short of reserves and the amount of lending by banks with excess reserves. The funds rate is thus highly sensitive to the overall balance of reserve demand and supply. If reserves are scarce, the funds rate will creep upward. Under a funds-rate target, the Fed would respond to this upward movement in the funds rate by making open-market purchases to increase banks' supply of reserves and lower the funds rate. Similarly, if reserves are plentiful and the funds rate

[18] In cases of extreme general reserve shortage, banks may borrow directly from the Federal Reserve through what is called "the discount window." The interest rate on such loans is the "discount rate." The Fed attached sufficient conditions to loans through the discount window that large banks general try to avoid borrowing from the Fed. Thus, the federal funds market and the discount window are not close substitutes and the federal-funds rate and the discount rate can differ.

starts downward, the Fed can conduct open-market sales and reduce reserves, pushing the rate back up. Thus, although it is not a party to the loans in the federal-funds market, the Fed can effectively move the federal-funds interest rate to any target level it chooses.

Seigniorage

The issuance of new money is a very profitable enterprise. Newly created money can be used to purchase goods and services, thus it conveys "income" to its issuer. However, if the economy is at full employment and money is neutral, then the issuance of new money does not directly lead to the production of additional goods and services. Thus, the purchasing power that is gained by the central bank must be at the expense of someone else who would otherwise have been able to buy the goods that the central bank buys. Since the central bank usually issues new money by purchasing government bonds or (which is the same thing) making loans directly to the government, this "income" is typically transferred from the central bank to the government and becomes the ***inflation tax***.

Who pays the inflation tax? Under the assumed conditions of neutrality the rise in the money supply increases the price level proportionally. But increases in the price level cause the value of *previously existing* money to decline in proportion to the rise in money and prices. Thus, the inflation tax is borne by everyone who holds money at the time that the new money is issued.

As Romer's equation (12.72) shows, an increase in inflation leads to a reduction in the desired (and actual) level of real money balances. Since the inflation tax is a tax on money balances (called the "tax base"), this is nothing more than the familiar principle of taxation that an increase in a tax rate will cause people to reduce the tax base. If an increase in the tax rate (the inflation rate in this case) causes the tax base (real money balances) to decline by enough, it is possible that the amount of revenue would actually decline. This is represented by the inverse-**U**-shaped inflation-tax Laffer curve in Romer's Figure 12.11.

Seigniorage via inflation is a source of government revenue just like income taxes, sales taxes, property taxes, import tariffs, etc. How do governments decide whether to use the inflation tax or other taxes to finance their expenditures? Generally, governments tend to use whatever tax methods are easiest to collect in their economies. In some economies, it is very difficult for the government to monitor income and sales well enough to collect taxes reliably. In such situations, governments are likely to put pressure on the central bank to resort to the inflation tax. The inflation tax is relatively easy to collect since it is difficult for residents to avoid. High inflation in Russia and other states of the former Soviet Union are closely related to the government's need for revenue and the extreme difficulty of collecting other kinds of taxes.

D. Suggestions for Further Reading

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