9 New Keynesian Models of Aggregate Demand

Chapter 9 Contents

A. Topics and Tools

In many ways, life is easier now than it was for the previous generation. No doubt you have all been subjected to your elders' stories about "walking ten miles to school every morning through driving snow storms, uphill both ways." However, when it comes to learning macroeconomics, things have gotten much harder rather than easier. When I took macroeconomics in 1973, virtually all of the semester was devoted to the basic Keynesian *IS/LM* model and some close relatives. From the 1940s into the 1970s, this modeling framework was thought to be an adequate description of the macroeconomy. It had successfully explained the major events of macroeconomic history—particularly the Great Depression—and all that seemed to remain for macroeconomic research was to estimate the parameters of the consumption, investment, and money-demand functions with ever-greater precision as the passage of time provided us with more data points.

Subsequent events have shown that the basic Keynesian model by itself is far from an adequate representation of the macroeconomy. Nevertheless, many of the predictions of the model still hold true when *IS/LM* or its variants are viewed as a component of a more complex system involving both aggregate demand and aggregate supply. Those who criticize the basic Keynesian model tend to judge models by a standard of how well the model is grounded in utility- and profit-maximizing microeconomic behavior of agents. By this standard, the traditional *IS/LM* model seems inadequate even as a description of aggregate demand, when compared, for example, to the micro-based models of consumption and investment that we will develop in later chapters.

The new Keynesian school of macroeconomics takes on the challenge of explaining how it might be in the interest of profit-maximizing firms to keep prices constant when demand changes. It also examines how something similar to the *IS* and *LM* curves may be derived from individual maximizing behavior of households and firms, with the effects of rationally formed expectations of future variables being incorporated into the model.

B. Romer's New Keynesian *IS/LM* and *IS/MP*

Romer begins Chapter 6 by developing the "new Keynesian" *IS/LM* model. This model ends up looking similar to the traditional *IS/LM*, but is derived from an explicit utility-maximization decision by households.

Romer's version of this model ignores capital. While accumulation of capital is at the center of long-run economic growth, it plays a secondary role in short-run business cycles.[1] We may justify leaving capital out of the model by treating it as a "fixed factor of production" in the short run. This assumption leads us to Romer's production function (6.1) in which labor is the only (variable) input.

Utility maximization

In Coursebook Chapter 7, we described several ways in which a need for money can be introduced. Although it is most realistic to model the transaction process directly, the conclusions of these models are similar to simpler ones in which monetary services are placed directly in households' utility functions. Romer uses the money-in-the-utility-function approach in equation (6.2):

$$\mathcal{U} = \sum_{t=0}^{\infty} \beta^t \left[U(C_t) + \Gamma\left(\frac{M_t}{P_t}\right) - V(L_t) \right].$$

The overall nature of this utility function should be familiar, but several aspects warrant discussion.

- **Additivity.** The three components of utility enter the function additively. This simplifies the analysis greatly because the marginal utility of consumption at time t is $U'(C_t)$, which depends only on C_t and not on M_t/P_t or L_t. Similarly, the marginal utility of money holding depends only on the current real money balance and the marginal disutility of labor depends only on the current level of labor.
- **Discount rate.** Instead of $e^{-\rho t}$ or $1/(1+\rho)^t$, equation 6.2 has β^t as a discount factor. This is just a simplified, general notation to represent exactly the same

[1] Empirically, cyclical fluctuations in investment are both large and important, but we ignore them here to keep the model simple. Our emphasis in most of the analysis is on the short-run behavior of aggregate supply, with a simple quantity theory specification sitting in for aggregate demand.

kind of discounting we have used before. You can think either of $\beta = e^{-\rho}$ for continuously compounded discounting or $\beta = 1/(1+\rho)$ for annually compounded discounting to convert this notation into more familiar terms.

- **Marginal utilities.** The derivative conditions on the *U* function reflect the familiar assumption that the marginal utility of consumption is positive but diminishing. Nothing is new here, and Romer specifies a familiar functional form for *U* in (6.3). Similarly, the partial derivation Γ' is the marginal utility of an additional unit of real money held. (Γ is capital gamma.) The conditions $\Gamma' > 0$ and $\Gamma'' < 0$ reflect the assumption that people get positive but diminishing marginal utility from holding money. Labor is treated differently in (6.2) than in the real-business-cycle utility function of Chapter 5. Instead of adding positive utility from leisure, equation (6.2) subtracts the disutility of labor. The condition $V' > 0$ coupled with the minus sign in front of *V* assures that an increase in labor effort lowers utility. The second-derivative condition $V'' > 0$ appears asymmetric relative to the other second-derivative conditions, but it has the same implication: that the marginal disutility of work increases with more labor. This corresponds to a diminishing marginal utility of leisure, which would appear as a negative second derivative with respect to leisure if we wrote the utility function in terms of leisure rather than labor.

The budget constraint (6.5) differs from our previous analyses because it is written in nominal (dollar) rather than real terms. The variable *A* measures the household's dollar assets here and is defined so that A_t is household nominal wealth at the beginning of period *t*. Since there is no capital in the model, each dollar of this wealth is held in one of two forms: as money or as bonds.

To understand equation (6.5), consider the choices a household makes during period *t*. It begins the period with financial assets A_t, earns W_tL_t in labor income during period *t*, and spends P_tC_t on consumption goods. Thus, $A_t + W_tL_t - P_tC_t$ is the amount that the household has left to allocate during period *t* between its holdings of money M_t and its holdings of bonds, the latter of which are $A_t + W_tL_t - P_tC_t - M_t$. The money holdings carry forward into the next period with no interest; the bond holdings earn interest at rate i_t, which gives us the expression in (6.5) for nominal assets at the beginning of period $t + 1$.[2]

---

[2] There is an awkwardness introduced into the budget constraint by the discrete-time assumption. Equation (6.3) treats M_t as the amount of assets allocated to money out of the wealth that is available *after* period *t* income and consumption have happened. The does not sit comfortably with the idea that money is held for the purpose of conducting these transactions and that the

In order to understand the utility-maximization decision and the relationship between the nominal interest rate i in (6.5) and the real interest rate r in (6.6), it is useful to examine the budget constraint in real terms rather than nominal. The real value of household assets at time t is A_t/P_t. Dividing each term on both sides of (6.5) by P_t yields

$$\frac{A_{t+1}}{P_t} = \frac{M_t}{P_t} + \left(\frac{A_t}{P_t} + \frac{W_t}{P_t} L_t - C_t - \frac{M_t}{P_t}\right)(1+i_t) \tag{1}$$

But real assets at time $t + 1$ are A_{t+1}/P_{t+1}. Working with the left-hand side of (1),

$$\frac{A_{t+1}}{P_t} = \frac{A_{t+1}}{P_{t+1}} \frac{P_{t+1}}{P_t} = \frac{A_{t+1}}{P_{t+1}}(1+\pi_{t+1}),$$

where $\pi_{t+1} \equiv \frac{P_{t+1}}{P_t} - 1 = \frac{P_{t+1} - P_t}{P_t}$ is the inflation rate from t to $t + 1$. Substituting into (1) yields

$$\frac{A_{t+1}}{P_{t+1}} = \frac{1}{1+\pi_{t+1}} \frac{M_t}{P_t} + \frac{1+i_t}{1+\pi_{t+1}}\left(\frac{A_t}{P_t} + \frac{W_t}{P_t} L_t - C_t - \frac{M_t}{P_t}\right). \tag{2}$$

Several aspects of equation (2) deserve special attention.

- The real interest rate r that measures the amount of real wealth in period $t + 1$ that one gets for each unit of real period t assets held as bonds is defined by

$$1 + r_t \equiv \frac{1+i_t}{1+\pi_{t+1}}. \tag{3}$$

  We can derive the more familiar formula by noting that

$$1 + i_t = (1+r_t)(1+\pi_{t+1}) = 1 + r_t + \pi_{t+1} + r_t \pi_{t+1}.$$

household's money balance should rise or fall through the period as it is earned or spent. (Consider, for example, the continuous-time Baumol-Tobin model discussed in Chapter 7.) To introduce intra-period fluctuations in money balances would complicate the model without fundamentally changing the results.

The final term in this expression is the product of two numbers that are (when the inflation rate is low) much smaller than one, so this term is order-of-magnitude smaller than the other terms in the equation. For example, if the real interest rate is 0.02 and the inflation rate is 0.03, the product is 0.0006. If we neglect this term and subtract one from both sides, we get the familiar condition $i_t = r_t + \pi_{t+1}$, or $r_t = i_t - \pi_{t+1}$.

- The expression $1 + r_t$ given by equation (3) is the amount of real, period $t + 1$ assets that is obtained if we reduce period t consumption by one unit. Thus, $1 + r_t$ is the price of period t consumption in terms of period $t + 1$ consumption—it is, as before, the slope of the budget constraint between C_t and C_{t+1}.
- Each unit of money holding at time t is worth $\frac{1}{1+\pi_{t+1}}$ units of real assets in period $t + 1$. If the inflation rate is positive, then this number is less than 1, which reflects the real depreciation of money through inflation. By a similar approximation as above, $\frac{1}{1+\pi_{t+1}} \approx 1 - \pi_{t+1}$. To see this, note that

$$\left(1-\pi_{t+1}\right)\left(1+\pi_{t+1}\right) = 1 - \pi_{t+1}^2 \approx 1$$

because for small rates of inflation the square of inflation is of a small order of magnitude. So each unit of real money holdings at time t translates to approximately $1 - \pi_{t+1}$ units of real assets in period $t + 1$, making the real rate of return on money approximately equal to $-\pi_{t+1}$: the rate of deflation.

Consumption behavior and the **IS** *curve*

The consumption decision in this model is very similar to the analysis we performed in the Diamond model in Romer's Chapter 2. Romer's equation (2.53) gives the Euler equation in the Diamond model as

$$\frac{1}{1+\rho} C_{2,t+1}^{-\theta} = \frac{1}{1+r_{t+1}} C_{1,t}^{-\theta}. \tag{4}$$

There are several small differences between the models that reconcile our equation (4) with Romer's equation (6.6). First, the discount factor in this model is β rather than $\frac{1}{1+\rho}$. Second, the real rate of return between periods t and $t + 1$ is now called r_t rather than r_{t+1} as in the Diamond model. Third, the time-of-life distinction in consumption that is necessary in the Diamond model is irrelevant here, so we drop the first subscript on C. Making these adjustments to our Diamond-model equation (4) gives us $\beta C_{t+1}^{-\theta} = \frac{1}{1+r_t} C_t^{-\theta}$, or $C_t^{-\theta} = (1+r_t)\beta C_{t+1}^{-\theta}$, which is Romer's equation (6.6).

Since we have no capital, no government, and no foreign section, $C = Y$ in this simple model, so we can rewrite the Euler equation in terms of Y. Taking logs, this gives $-\theta \ln Y_t = \ln(1+r_t) + \ln\beta - \theta \ln Y_{t+1}$. For small values of r_t, $\ln(1+r_t) \approx r_t$, so we can write this equation as $\ln Y_t = a + \ln Y_{t+1} - \frac{1}{\theta} r_t$, where $a \equiv -\left(\frac{1}{\theta}\right)\ln\beta$.

The new Keynesian *IS* curve of equation (6.8) shares a defining property with the Hicksian *IS* curve discussed in the previous section: it exhibits a negative relationship between desired current spending and the real interest rate. Equation (6.8) explicitly includes future income (presumably *expected* future income in any realistic application) as a determinant of the new Keynesian *IS* curve. In the earlier analysis we discussed expected future income as affecting the traditional *IS* curve through the consumption function, so this also is similar.

Perhaps the most obvious difference between the traditional and new Keynesian *IS* curves is the absence of any fiscal-policy variables from the latter. Operationally, this happened trivially because we neglected government spending and taxes in the consumption model that led to equation (6.8). But the introduction of government into the optimal consumption model is far from trivial, as we have seen. The effect of current government spending and taxes on current consumption is likely to depend on whether the underlying conditions for Ricardian equivalence hold—infinite lifetimes, lump-sum taxes, perfect capital markets, etc. While most new Keynesian economists would probably argue that increases in current government spending (without changing taxes) would increase spending, augmenting equation (6.8) to reflect this is a challenging enterprise.

The **LM** *curve in the new Keynesian model*

The budget constraint (6.5) shows us the tradeoff that households face between holding higher money balances and consuming more. Re-arranging terms from equation (1) above,

$$\frac{A_{t+1}}{P_{t+1}}(1+\pi_{t+1}) = \left(\frac{A_t}{P_t} + \frac{W_t}{P_t}L_t - C_t\right)(1+i_t) - i_t \frac{M_t}{P_t}. \tag{5}$$

Equation (5) shows that the household trades off money balances against consumption (holding future assets constant) according to $(1+i_t)\Delta C_t = -i_t \Delta\left(\frac{M_t}{P_t}\right)$, or

$$\Delta C_t = -\frac{i_t}{1+i_t}\Delta\left(\frac{M_t}{P_t}\right). \tag{6}$$

Equation (6) shows that each unit of real money balances held costs the household $\frac{i_t}{1+i_t}$ units of consumption goods.

If the household is maximizing utility, then the marginal utility of $\frac{i_t}{1+i_t}$ units of consumption must equal the marginal utility of one unit of real money balances, so $\frac{i_t}{1+i_t}U'(C_t) = \Gamma'\left(\frac{M_t}{P_t}\right)$. Given the functions forms shown in Romer's (6.3) and (6.4), $U'(C_t) = C_t^{-\theta}$ and $\Gamma'\left(\frac{M_t}{P_t}\right) = \left(\frac{M_t}{P_t}\right)^{-\chi}$.[3] Substituting, $\frac{i_t}{1+i_t}C_t^{-\theta} = \left(\frac{M_t}{P_t}\right)^{-\chi}$, which can be re-arranged (noting that $Y = C$) into Romer's money-demand function (6.11).

Equation (6.11) serves the role of the *LM* curve. Note that we can rewrite the i_t term to get

$$\frac{M_t}{P_t} = Y_t^{\theta/\chi}\left(\frac{1}{i_t}+1\right)^{1/\chi},$$

so

$$\frac{1}{i_t}+1 = \left(\frac{M_t}{P_t}\right)^{\chi} Y_t^{-\theta}$$

or

$$i_t = \left[\left(\frac{M_t}{P_t}\right)^{\chi} Y_t^{-\theta} - 1\right]^{-1}. \tag{7}$$

Equation (7) is the new Keynesian *LM* curve solved for i_t. It slopes upward in Y and shifts down to the right when there is an increase in M/P, just like the traditional *LM* curve.

In Romer's Figure 6.1, he plots this *LM* curve together with the new Keynesian *IS* curve. However, in order to do this, we must translate the *LM* curve to a form that uses the real interest rate r rather than the nominal rate i. This is most easily done using the approximation $r_t \approx i_t - \pi_{t+1}$ as discussed above. Applying this to (7) yields

[3] The parameter χ is Greek letter chi, not Roman letter x. They can be difficult to distinguish.

$$r_t = \left[\left(\frac{M_t}{P_t} \right)^{\chi} Y_t^{-\theta} - 1 \right]^{-1} - \pi_{t+1}.$$

As Romer shows in Figures 6.1 and 6.2, we can perform comparative static analysis using the new Keynesian *IS/LM* model. The results are basically identical to those examined in Chapter 7 for the traditional, Hicksian model.

Romer's* MP *curve

The *LM* curve assumes that the monetary-policy authority (the central bank) follows a policy of setting the money supply at a fixed level and allowing interest rates to be determined entirely by market forces. This kind of policy was typical in the gold-standard world in which Hicks (and Keynes) lived, but it has been abandoned by most modern central banks in favor of policies that set a key benchmark interest rate (the federal funds rate in the United States) in response to the levels of output and inflation. Romer reflects this change by replacing the traditional *LM* curve with an *MP* curve that reflects the more responsive monetary-policy strategy.

If, instead of fixing the money supply, central banks follow the now-common policy of targeting interest rates, then it is more natural to express the asset-market equilibrium condition by the *MP* curve, which makes the interest rate depend on the policy rule established by the central bank. Whereas the exogenous level of *M* is the main determinant of the position of the *LM* curve, the position of the *MP* curve will depend on the factors that influence the central bank in setting its target interest rate. The supply of money is endogenously determined as the amount that is required to achieve the central bank's interest-rate target.

The mechanism of monetary policy is the same under either system: the central bank buys or sells government securities to expand or contract the monetary base and the supply of bank reserves. If it targets the money supply as in the model of the *LM* curve, then it adds to or subtracts from the monetary base until the money supply is at the targeted level. If it targets the interest rate, then it expands or contracts the supply of reserves until the interest rate is at its target level.

In the United States, the Federal Reserve targets the federal-funds interest rate. This is the rate on overnight loans of reserves between large banks, so it is very sensitive to the supply of and demand for reserves. By adding to the supply of reserves, the Fed can easily push the federal-funds rate down; by draining reserves from the banking system it can drive the rate upward.

Replacing the *LM* curve with the *MP* curve changes the monetary side of the model in several important ways. The quantity of money is now an endogenous variable rather than being exogenously determined by the central bank, but it no longer plays a key role in the determination of output. Given the level of output and the interest rate set by the central bank's policy rule, the quantity of money is just whatever amount satisfies the public's demand for money. The quantity of money essentially becomes an afterthought and disappears from the model.

A second important change introduced by the *MP* curve is that we now incorporate into the model the policy rule by which the central bank sets its policy instrument. In the *LM* framework, *M* is exogenous: we do not build a model of how the central bank chooses *M*, we just accept its choice as given. In the *MP* setup, rather than simply taking the central bank's interest-rate target as exogenously give, we build the policy response to economic conditions into the model endogenously. Therefore the *MP* curve, rather than just being a horizontal line at a given, policy-determined *r*, represents the policymaker's response to current economic conditions—in particular, to the current level of real output *Y*. Modeling the *MP* curve thus requires that we model how the central bank's interest-rate target depends on other variables.

Most modern central banks worry about two economic outcomes: the rate of inflation and the level of economic activity. In the long run, the value of a currency (the inverse of the price level) depends on its supply relative to the demand for it. Thus, as we saw in the previous chapter, sustained money-supply growth in excess of the growth in money demand will cause inflation. Most central banks respond to rising inflation by raising interest rates to curtail aggregate demand and put downward pressure on inflation.

Central banks often also pursue *countercyclical* monetary policy, decreasing interest rates during recessions to try to increase spending. This would mean that target interest rates would be low when real output falls below the natural, full-employment level and high when output rises above the natural level. This leads to a positive relationship between the interest rate and real output, which Romer represents by the monetary-policy, or *MP*, function of equation (6.27), where $r = r\left(\ln Y - \ln \bar{Y}, \pi\right)$, with $r_1 > 0$ and $r_2 > 0$.[4] A rule of this kind has come to be called a "Taylor Rule" after Taylor (1993).

If we plot the resulting equilibria in (Y, r) space, we get an upward-sloping curve whose position depends on the rate of inflation. An increase in π would shift the *MP* curve upward. The operation of the *IS/MP* model is similar to the *IS/LM* model.

[4] The Federal Reserve, like most central banks, sets its official interest-rate target in nominal rather than real terms. If the nominal rate is the real rate plus the rate of inflation (ignoring the difference between actual and expected inflation) then this possibility can be easily accommodated within Romer's equation (6.26). The real-interest-rate rule is just the nominal-interest-rate rule minus the inflation rate. In order for real interest rates to rise to counteract an increase in inflation, the central bank's nominal interest rate target must go up *more than one-for-one* with an increase in inflation. Clarida, Galí, and Gertler (2000) show that U.S. Federal Reserve policy failed this condition prior to 1979, which presumably helped fuel rising inflation.

Prices affect *IS/MP* equilibrium through the effect of the inflation rate on the central bank's real-interest-rate target.

IS/LM, IS/MP*, and aggregate demand*

We can derive an ***aggregate-demand curve*** by exploring the effects of a change in the price level on the *IS* and *LM* curves—either traditional or new Keynesian. An increase in the price level reduces the real value of the existing supply of money, so if M stays constant, M/P must fall. This leaves households and firms with less money than they want given the current (and so far unchanged) values of income and the interest rate. To re-establish asset equilibrium, people will attempt to acquire additional money by selling interest-bearing assets. But since everyone is trying to sell bonds and no one is buying them, something must change in order to make bonds more attractive. The obvious outcome is that the interest rate must rise, making bonds more attractive relative to money and reversing the desire to exchange bonds for money. Thus, the *LM* curve must shift up and to the left in response to an increase in prices, which lowers the equilibrium quantity of output.

This negative relationship between the quantity of output demanded and the price level (for given values of G, T, and M) can be drawn in (Y, P) space as a downward-sloping aggregate-demand curve.

For the *IS/MP* model, the vertical axis of the *AD* curve must be the inflation rate rather than the price level. An increase in the inflation rate causes the central bank to raise its real-interest-rate target, pushing the *MP* curve up to the left and lowering the demand for goods and services. Thus, the *AD* curve based on the *IS/MP* model also slopes downward.

C. Some Simple Aggregate-Supply Models

Romer's Chapter 6 and much of the remainder of this course are devoted to models in which the microfoundations of aggregate supply are carefully specified. In Section 6.2, Romer presents four sets of assumptions and the aggregate-supply curves that would result. We consider the intuition of these cases, along with another important reference case, in this section.

Before discussing Romer's four cases we begin with one that I will call Case 0. This is the case where, as in the real-business-cycle model and our growth models, there are no imperfections in the adjustment of wages or prices. In this case, the level of real output Y is determined solely by applying the aggregate production function to the equilibrium amounts of labor and capital in the economy. In Case 0, the *AS* curve is vertical at the natural level of output, as shown in Figure 1.

In Case 0, a change in monetary policy that shifts the MP and AD curves simply results in a change in the rate of inflation: money is "neutral" and output is unaffected. Similarly, a change in expenditures due to fiscal policy that shifts the *IS* curve and the *AD* curve would leave output unchanged and affect only inflation. In order for aggregate demand to have any effect on real output, we must introduce some imperfection into the price/wage adjustment process. This is what Romer does in an *ad-hoc* way in Section 6.2 and more rigorously in Chapter 6 Part B.

Case 1: Nominal-wage stickiness

Keynes clearly believed in the stickiness of nominal, but not real, wages. He argues that a worker would accept a reduction in her real wage through an increase in prices, but not through a decline in her nominal wage.[5] Modern Keynesians bring this kind of wage stickiness into the model through nominal-wage contracts.[6]

As Romer discusses on page 245, an increase in inflation for any given nominal wage leads to a lower real wage: the more P goes up for given W, the lower W/P is. This lower real wage causes firms to hire additional labor, increasing their output via the production function. Thus, nominal-wage stickiness can provide a rationale for an upward-sloping aggregate-supply curve. Increases in inflation lead to increases in output by lowering the real wage.

Sticky-wage models have one serious counterfactual implication. They work precisely because output moves in the opposite direction as real wages. Firms produce a lot when real wages are low. This implies that real wages should be strongly countercyclical. However, most evidence suggests that real wages are mildly procyclical—exactly opposite to the predictions of the sticky-wage model. This empirical contradiction has eroded the support for this class of aggregate-supply models.

[5] This clearly conflicts with traditional notions of economic rationality, in which only the purchasing power of the wage should matter. Keynes anticipates some modern theories of fairness, envy, and altruism by suggesting that any single worker would resist a reduction in her nominal wage because that would imply a lowering (at least for a time) in her wage relative to others. In contrast, a decline in real wages due to an increase in prices affects all workers symmetrically, so there is no change in her relative wage.

[6] Examples of modern Keynesian models built around contracts are Fischer (1977) and Taylor (1979). In Romer's Chapter 7, we study variants of these models in which prices rather than wages are assumed to be sticky.

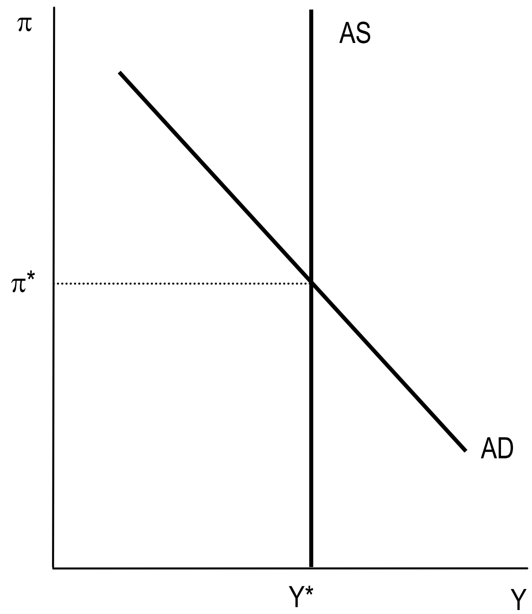

Figure 1. Aggregate supply with no market imperfections.

Case 2: Inflation stickiness with a competitive labor market

Romer's second case assumes that inflation is sticky but the wage adjusts perfectly to equate supply and demand in the labor market. One rationale for such a model would be if firms set prices in advance and commit to them through contracts with buyers. In that case, the current price level or inflation rate would be predetermined and unresponsive to changes in current output Y.

The behavior of the labor market in this model is shown in Romer's Figure 6.4. The vertical segment of the kinked labor-demand curve shows that for most levels of the real wage, firms' level of employment is independent of the wage. They hire the amount of labor needed to produce the level of output demanded by their customers, $F^{-1}(Y)$, where $F^{-1}(\bullet)$ is the inverse of the production function and tells how much labor is required to produce a given Y. However, if the real wage gets high enough, firms are unwilling to produce even that much output and they are on the downward-sloping part of their labor-demand curves. An increase in aggregate demand shifts the labor-demand curve as shown in Figure 6.4, leading to a strongly procyclical real wage and a countercyclical markup of prices over marginal cost.

Case 3: Inflation stickiness with labor-market imperfections

Romer's Case 3 differs little from Case 2. In fact, from the standpoint of the determination of output and inflation, there is no essential difference. The distinction lies in the assumption of some kind of labor-market imperfection that leads to non-zero unemployment.

There are many reasons why firms might pay wages in excess of the competitive-equilibrium real wage. We discuss some in the chapter on unemployment later in the course. If firms pay an "efficiency wage" in order to reduce turnover, motivate workers, or for some other reason, there will be a general excess supply of labor in the market. Incorporating labor-market imperfections into the model allows the flexible-wage model of Case 2 to be reconciled with the existence of countercyclical unemployment in the labor market.

Case 4: Sticky wages with imperfect competition

Case 4 extends Case 1, the basic wage-stickiness model. It allows for imperfect competition in the product market, so that firms' prices are higher than marginal cost. This markup rate μ is assumed to depend positively on employment L so that firms reduce markups in recessions and increase them in booms.[7] The chief benefit of this model is that it rescues the sticky-wage model from the counterfactual prediction that real wages are strongly countercyclical.

D. The Open Economy

[Note: Romer has eliminated the open-economy analysis of the Mundell-Fleming and related models from the fourth and fifth editions of his text. I am retaining this section in the course-book for the use of any students who want to go back to the third edition and study this material. All references in this section are to Romer's third edition.]

Extending the basic Keynesian model to the open economy involves modeling two kinds of international connections. First, we must bring net exports (exports minus imports) into aggregate demand. Second, we must take account of international flows of borrowing and lending.

[7] In standard models of monopoly, the markup depends on the elasticity of demand. The more elastic demand is, the smaller the markup. Thus, the assumption being made here follows if customers' demand curves become more elastic in recessions and less elastic in booms.

Both the flow of goods and the flow of capital[8] between economies are often constrained. Some governments impose high tariffs or restrictive quotas on imports (or, rarely, exports) that prevent international transactions. Sometimes there are restrictions placed on the ability of domestic residents to hold foreign assets (*i.e.,* to lend abroad) or to borrow from foreigners.

The workhorse model of international macroeconomics, analogous to the *IS/LM* model of the closed economy, is the ***Mundell-Fleming model***. This model corresponds closely to the model with floating exchange rates and perfect capital mobility in Romer's Section 5.2 (3rd ed.).

Expenditures in an open economy

In an economy with international trade, we must account for the desired expenditures of foreigners on domestic goods (and for the desired imports of foreign goods by domestic buyers). Both domestic and foreign buyers of tradable goods face a choice between goods produced in the home country (America, for convenience) and goods produced abroad. There are many factors that will determine the amount someone spends on domestic vs. foreign goods. Preferences, differences in quality, and other factors will certainly play a part, but their choice should also depend partially on the relative price of American goods and foreign goods. This relative price is the ***real exchange rate*** ε.

A numerical example should clarify the definition of the real exchange rate. The relative price of foreign goods (in terms of American goods) is the amount of American goods you must give up in order to get one unit of foreign goods. To buy one foreign good you need P^* units of foreign currency, where P^* is the foreign price level. The nominal exchange rate e measures the price of foreign currency (in terms of dollars), so each unit of foreign currency costs e dollars. Thus, you need eP^* dollars in order to buy one unit of foreign goods. Since each American good costs P dollars, you need to give up $1/P$ American goods to obtain a dollar. Therefore, to get eP^* dollars you have to give up eP^*/P units of American goods; the real and nominal exchange rates are linked by the formula $\varepsilon = eP^*/P$.

The higher is the real exchange rate, the more expensive foreign goods are relative to domestic ones, so the more inclined both foreign and domestic buyers are to buy domestic goods. Thus, desired expenditures on domestic goods should depend positively on ε, as shown by Romer's modified expenditure function (5.14).

[8] We are talking about "financial capital" here, not fixed capital goods. In the international macroeconomic literature, flows of borrowing and lending across borders are called international capital flows.

Capital flows and interest-rate parity

The other major form of macroeconomic interaction between countries is in the capital market, where domestic residents may lend to foreigners (a capital outflow) or foreigners may lend to domestic households, firms, and governments (capital inflow). There are many considerations that go into choosing whether to lend money at home or abroad. Both the expected rate of return on the loan and the risk involved will generally be important.

A special case that has attracted the attention of macroeconomists is the case of ***perfect capital mobility***. This is a situation in which risk is either symmetric across countries or unimportant to lenders, so all wealth-holders choose to lend in the country that offers the highest rate of return. If expected rates of return are higher in the United States than in Europe, then everyone will want to lend in the United States and financial capital will flow rapidly from Europe to the U.S. If returns are higher in Europe then capital will flow the other way. Only when the expected rates of return on American and European assets are equal will there be no tendency for capital to flood one way or the other. So when there is perfect capital mobility, equilibrium in the international asset market requires expected rates of return to be equal.

The expected real return for an American lender on an American asset such as a bond is just the real interest rate r. Buying a European bond is more complicated for the American lender because it involves first exchanging dollars for euros, then buying the European bond, then exchanging the euros back for dollars when the bond matures. The real rate of return on the European bond for an American investor is given by Romer's equation (5.20). It is equal to the European real rate of interest plus the expected rate of appreciation of the real exchange rate over the period of the bond. Thus, if there is no expected change in the real exchange rate, perfect capital mobility will lead to the equality of real interest rates across countries: $r = r^*$. This is known as the ***interest-rate parity condition*** in terms of real interest rates.

As Romer shows at the top of page 235, the interest-rate parity condition can be written either in terms of the real interest rate as above or in terms of nominal interest rates. The simplest case is one in which the nominal exchange rate is expected to remain unchanged. In this case, the nominal interest rates (as well as real rates) in the two countries must be equal under perfect capital mobility, $i = i^*$.

However, suppose that the exchange rate is expected to increase at rate x, so that each euro will be worth more dollars when the bonds mature than it is worth now. If the euro is expected to appreciate against the dollar, then the U.S. bond will have to pay higher interest than the euro bond in order to compensate for the expected depreciation in the dollars to be received at maturity. In nominal terms, $i = i^* + x$, which is approximately equivalent to Romer's equation (5.21). In real terms, the interest-rate parity condition becomes Romer's equation (5.20) when we consider the possibility of expected change in the real exchange rate.

Floating and fixed exchange rates

The central bank in an open economy has an additional option for its policy target beyond the simple money-supply and interest-rate targets discussed above. Many central banks choose to target the exchange rate with monetary policy. This leads to ***fixed exchange rates***, in which the exchange rate is decided upon by the central bank. Romer chooses not to analyze fixed exchange rates with perfect capital mobility, but instead postpones the analysis to the imperfect-capital-mobility case.

The Mundell-Fleming model

With the opening of the economy, we now have three key endogenous variables in play: output, the real interest rate, and the real exchange rate. We can only work in two dimensions at a time, so Romer chooses to analyze the economy in (Y, ε) space, with the exchange-rate equivalents of the *IS* and *MP* curves designated as *IS** and *MP**. One can equally well to the analysis in (Y,r) space corresponding to the *IS/MP* model.

Under perfect capital mobility with no expected real currency depreciation, the domestic real interest rate must be equal to the foreign (world) rate. Thus, the *MP** curve is given by Romer's equation (5.16), which does not involve ε and thus is vertical in (Y, ε) space. The *IS** curve slopes upward in (Y,ε) space because an increase in ε (a real depreciation of the dollar) causes an increase in net exports and thus in aggregate demand. Romer considers the case of an increase in government spending, which shifts the *IS** curve to the right. With the vertical *MP** curve, this leads to an appreciation of the domestic currency (a decrease in ε) with no change in output demanded.

The intuition of this result is somewhat opaque in (Y, ε) space, so let's think about it in (Y, r) space. Figure 2 shows the resulting equilibrium. The economy starts at point *e*. Then government spending increases, which shifts the *IS* curve to the right to *IS'*. In a closed economy, this increase in demand and output would cause the central bank to raise real interest rates to r', establishing a new equilibrium at point *c*. However, in an open economy with perfect capital mobility, the real exchange rate cannot stay above the world rate r^*. As the domestic interest rate begins to increase, capital will flood in from the rest of the world, pushing up the value of the domestic currency (reducing ε) and causing net exports to decrease. This decrease in net exports drives the *IS* curve back to where it started and output returns to Y_0 with a lower exchange rate. With perfect capital mobility, fiscal policy has no effect on aggregate demand under floating exchange rates. Any increase in government spending completely "crowds out" an equal amount of net exports.

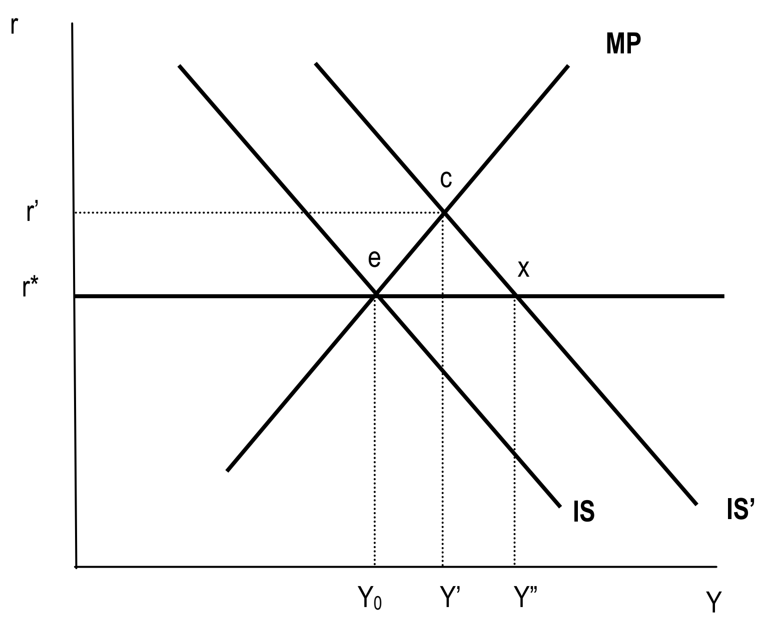

Figure 2. Expansionary fiscal policy in an open economy

It is worth noting that the monetary authority could have decided to keep the exchange rate fixed, buying up all the foreign currency that people wanted to sell in order to get dollars. Had they done so, the *MP* curve would have shifted to the right and equilibrium could have been restored at *x*. If the central bank follows a fixed-exchange-rate policy then fiscal policy has a very powerful effect on aggregate demand. This is one reason why some analysts have argued that fiscal policy is especially important in a monetary union such as the euro-area.

Imperfect capital mobility

Capital is highly mobile among the advanced countries of the world, but even there it is unlikely that it is *perfectly* mobile. We noted above that the dollar return that an American earns on a foreign bond depends on the future exchange rate. Because future exchange rates are not known with certainty, this makes holding foreign bonds riskier than holding American bonds for someone who wants to earn a return in terms of dollars.[9] If wealth-holders have some degree of preference for one currency over another, then domestic and foreign bonds are less-than-perfect substitutes.

---

[9] It is worth noting however that the *real* return on the foreign bond could be less risky if the domestic inflation rate is highly uncertain while the foreign inflation rate is stable.

Romer models imperfect capital mobility with a ***capital-flow function*** given by his equation (5.22). Capital will tend to flow into the domestic country when interest rates are high relative to foreign rates and flow out when domestic interest rates are low. You can think of the *CF* function as a net demand curve for the domestic country's assets. The case of perfect capital mobility is the special case in which $CF' \to \infty$ at $r = r^*$. In this case, the domestic and foreign bonds are perfect substitutes so the demand curve is perfectly elastic.

E. Unemployment and the Phillips curve

The aggregate-supply models surveyed above typically imply that aggregate demand shocks lead to a positive short-run relationship between prices (or inflation) and real output. Does this imply a negative relationship between inflation and unemployment? Conventional wisdom suggests that unemployment is strongly and inversely correlated with output over the business cycle. It is tempting, then, to simply leap from an upward-sloping short-run aggregate supply curve to a downward-sloping short-run ***Phillips curve*** relating unemployment and inflation. In this section, we consider whether this is a reasonable inference and review some of the history of the Phillips curve.

Output, employment, and unemployment

We typically model firms as being "on their production functions," meaning that they are producing the maximum output that they can, given the inputs they are using and the technology that they have. If technology (the production function itself plus any *A* parameter we might introduce to represent technology) and the capital stock are fixed, this implies a direct, one-to-one relationship between output and employment given by $Y = F(L)$.[10] This means that employment and output must move together over the cycle, so any change in output is accompanied by a change in employment. However, this change in employment need not imply a change in the unemployment rate. Changes in the number of workers employed could reflect movements into and out of the labor force rather than movements between employment and unemployment. Only if the labor force is held constant then a change in employment implies a

[10] In Chapter 13 of the coursebook, we consider the issue of varying utilization of labor and capital. In particular, we examine evidence suggesting that firms hold onto, or "hoard," labor when they reduce output during a recession. Such behavior would break the tight, production-function relationship between output and labor input over the business cycle.

one-to-one change in the opposite direction in unemployment. In this case, it is reasonable to think of the aggregate supply curve and the Phillips curve as different ways to telling the same story.

However, we must be careful in carrying this story too far. It treats workers as mere pawns of employers and assumes that they make no real decisions for themselves. When laid off, they just sit around being involuntarily unemployed and waiting to be rehired. There are certainly examples of this kind of unemployment, but it is less common than you might think.

Most unemployed workers, including those who have been laid off, make important decisions that affect their job status. They may drop out of the labor force (early retirement, returning to school, engaging in home production or family activities) or aggressively pursue other employment options. Macroeconomists and labor economists have developed a rich set of theories about the behavior of unemployed workers. These theories, a few of which will occupy our attention in Romer's Chapter 11, suggest that we must be cautious in approaching the relationship between fluctuations in output and those in unemployment.

The original Phillips curve

The Phillips curve was originally proposed as an empirical regularity by A.W. Phillips, an Australian economist. Phillips (1958) plotted nearly a century of data on the unemployment rate and the rate of wage inflation for Britain and found that the data points traced out a downward-sloping curve that appeared to be stable over his very long sample period.

Over the next decade, economists examined the Phillips curve on both theoretical and empirical levels. Empirically, Phillips's curve was found to be robust to a number of changes: a similar curve held for the United States and the same kind of relationship held between *price* inflation and unemployment.

Theoretically, a simple explanation for the Phillips curve was quickly devised. It was assumed to be the result of partial adjustment of wages toward equilibrium in response to excess demand or supply in the labor market. When unemployment was high, there was excess labor supply and wages would fall (or rise less quickly); low unemployment indicated excess demand for labor, which would drive wages upward.

The natural-rate hypothesis

This is an entirely reasonable theory, as long as certain other factors are held constant. Milton Friedman, in his now-famous presidential address to the American Economic Association in December 1967, predicted that the Phillips relationship could not be relied upon to remain stable because it confused nominal and real wages.[11] Low unemployment—lower than what Friedman defined as the "natural" rate—should lead to an increase in *real* wages. If the general level of inflation in the economy is zero, then an increase in real wages is equivalent to an increase in nominal wages. However, in an economy with, say, 10 percent general inflation, a nominal wage rise of more than 10 percent would be required to raise real wages.[12]

Friedman thus argued that unemployment should be related not to the rate of (wage) inflation in nominal terms, but to inflation *relative to people's expectations*. If people expect 10 percent inflation, then low unemployment should lead to inflation greater than 10 percent and high unemployment should lead to inflation below 10 percent.

This theory, which is often called the ***natural-rate hypothesis***, implies that there is no stable relationship between inflation and unemployment in a world where expectations about inflation are not anchored at zero. Rather, there is a relationship, which may be stable, between *unexpected* inflation and unemployment *relative to its natural rate*. The Phillips curve between actual inflation and actual unemployment should shift whenever there is a change either in the expected rate of inflation or in the microeconomic factors that determine the natural rate of unemployment.

Moreover, the natural-rate hypothesis implies no tradeoff between inflation and unemployment at all in the long run. No matter how high the inflation rate, if it persists for a while people in the economy will eventually adjust their expectations in order to anticipate it correctly. At that point, there will be no gap between actual and expected inflation and the unemployment rate should return to the natural rate. Thus, *any* rate of inflation is consistent with the natural rate of unemployment in the long run.

A look at Romer's Figure 6.7 shows that Friedman's prediction about the breakdown of the empirical Phillips curve came true shortly after his writing. The data points between 1961 and 1969 line up with the stable, downward-sloping curve that Phillips found for 1861–1957. However, in 1970 the economy moved directly to the right and it did not return to the same neighborhood of low inflation *and* low unemployment until the late 1990s. From 1970 to 1995, the United States (and most other major economies) suffered through ***stagflation***—the simultaneous occurrence of high unemployment and high inflation.

The natural-rate hypothesis interprets the swirling pattern in Figure 6.7 as resulting from shifts in expected inflation and in the natural rate of unemployment. As people

[11] This paper was published as Friedman (1968). Another important set of early papers on the modern theory of the Phillips curve is Phelps (1970).

[12] The natural rate of unemployment is sometimes called the non-accelerating inflation rate of unemployment, or NAIRU.

began to catch on to the presence of inflation, the Phillips curve shifted vertically upward, implying a higher rate of inflation for any level of unemployment. As the baby-boom generation flooded the labor market with young, inexperienced, and often transient workers, the number of workers searching for better jobs "naturally" increased.[13] This increase in the natural rate of unemployment shifted the Phillips curve to the right.

One question that can fairly be posed to advocates of the natural-rate hypothesis is how the Phillips curve could have remained stable for one hundred years. Is it really credible that expected inflation and natural unemployment anchored a stable Phillips curve for a century, only to start wandering all over the map in 1970? The stability of inflationary expectations is actually quite plausible. For most of the century that Phillips studied, England and the major economies of the world were on some form of the gold standard. This maintained a long-run link between the value of the currency and the price of gold, which prevented steady, ongoing inflation from occurring. Indeed, the consumer price index in the United States was at about the same level after World War II as it was in 1800! Ongoing, and therefore expected, inflation did not arise in the United States or Britain until the 1960s, which explains why the Phillips curve did not begin to shift until about 1970.

Modern challenges to the natural-rate hypothesis

By the end of the 1970s, the natural-rate hypothesis had become the new macroeconomic orthodoxy. All of the intermediate macro texts and most of the introductory texts had been rewritten to reflect the new theory. Theoretical development and empirical testing proceeded apace and generally supported the hypothesis. While few, if any, macroeconomists believe in the old Phillips curve, mild challenges to the natural-rate hypothesis have come from several directions.

You may notice that Romer is very careful on page 259 to distinguish between his concept of ***core inflation*** or ***underlying inflation*** and a strict notion of expected inflation. Early theories of the ***expectations-augmented Phillips curve*** based on the natural-rate hypothesis stressed the importance of expectations errors resulting from imperfect information.[14] According to these theories, all deviations of output and unemployment from their natural levels could be eliminated if households and firms could correctly

[13] The baby boom is only one explanation for the increase in natural unemployment in the 1970s and 1980s. We shall study others in due course.

[14] The crucial role of expectations and, in particular, the development of the theory under conditions of ***rational expectations*** follows from the work of Robert Lucas. We shall study a variant of Lucas's imperfect information model in Romer's Chapter 6 Part B and in Chapter 10 of the coursebook.

perceive and forecast the inflation rate. This came to be known as the ***new classical macroeconomics***.

In contrast, ***new Keynesian macroeconomists***, of whom David Romer is one, have developed models with attributes that are similar in many ways to the expectations-based natural-rate hypothesis, but that are based on stickiness of prices or wages rather than on imperfect information. Romer's core inflation reflects the inertia that inflation may acquire when it is embodied in cost of living adjustments in wage contracts and in the institutional process of price setting. Expectations are certainly a major part of core inflation, but there may be elements to core inflation that are more difficult to change than expectations, which can adapt very quickly once people obtain credible new information. Thus, the first challenge takes the form of a broadening of the benchmark inflation rate that moves the Phillips curve from a strict expectation to a more inclusive core inflation rate.

The central premise of the natural-rate hypothesis is that the natural rate itself is independent of inflation. It may shift due to microeconomic factors such as changes in the skill-composition of the job pool and the labor force, changes in policies such as minimum wages or unemployment insurance, or changes in the strength and behavior of labor unions, but it assumes that changes in inflation have no effect on the natural rate. However, two theories have recently suggested ways that inflation could affect the natural rate of unemployment.

The first is the hypothesis of ***hysteresis*** in unemployment. According to the hysteresis theory, periods of high unemployment, such as would result from prolonged disinflations, would cause the natural rate itself to increase. Among the reasons why this might occur are deterioration of relevant job skills by the long-term unemployed and disenfranchisement of unemployed "outsiders" in the process of negotiating wages and employment levels.[15]

Hysteresis is a possible explanation for the experience of continental Europe since 1980, where unemployment has been well above historical levels for more than three decades. While inflation has been quite low, it seems implausible that core inflation would not have adjusted to the lower inflation rate within a few years. Thus, it is unlikely that unemployment has been above the natural rate all this time. Instead, it seems probable that the natural rate itself is higher. The hysteresis theory proposes that high unemployment itself has caused the natural rate to rise.

A more recent challenge to the natural-rate hypothesis proposes that there may be a leftward bulge at low inflation rates in the otherwise vertical long-run Phillips curve. The rationale behind the bulge theory is that when inflation is low, people may ignore

---

[15] The hysteresis hypothesis is discussed briefly in Romer's Chapter 10 and in the unemployment chapter of the coursebook. A readable exposition from the research literature is Blanchard and Summers (1986).

it altogether and behave as though core or expected inflation is zero.[16] If inflationary expectations do not adjust to permanent changes in inflation that stay near zero, then the downward-sloping original Phillips may be valid in that range. Inflation of, say, 2 percent might lead to permanently lower unemployment than zero inflation if people ignore the inflation. This theory could explain how the United States was able to achieve and sustain remarkably low unemployment rates in the late 1990s with steady but low inflation.

F. Suggestions for Further Reading

The **IS/LM** *and Mundell-Fleming models*

Most intermediate macroeconomics texts have basic descriptions of the IS/LM model. Some of the better ones are listed below. No edition numbers or publication dates are given because they change very frequently and almost any edition will be suitable.

Blanchard, Olivier, *Macroeconomics* , (Upper Saddle River, New Jersey: Prentice-Hall).

Abel, Andrew, and Ben Bernanke, *Macroeconomics*, (Reading, Mass: Addison Wesley Longman).

Hall, Robert E., and John B. Taylor, *Macroeconomics*, (New York, W.W. Norton).

Dornbusch, Rudiger, and Stanley Fischer, *Macroeconomics*, (New York, McGraw-Hill).

Burda, Michael, and Charles Wyplosz, *Macroeconomics: A European Text*, (Oxford: Oxford University Press). (A less Ameri-centric presentation with good mathematical appendices.)

Sachs, Jeffrey, and Felipe Larrain, M*acroeconomics in the Global Economy*, (Upper Saddle River, New Jersey: Prentice-Hall). (A more open-economy presentation.)

The original presentations of these models are:

Hicks, John R., "Mr. Keynes and the 'Classics': A Suggested Interpretation," *Econometrica* 5(2), April 1937, 147–59. (The original exposition of the *IS/LM* model.)

Hansen, Alvin H., *A Guide to Keynes* (New York: McGraw-Hill, 1953). (An early full exposition of the *IS/LM* framework as an interpretation of Keynes.)

Mundell, Robert A., *International Economics* (New York: Macmillan, 1968). (A seminal exposition of the Mundell-Fleming model.)

[16] See Akerlof, Dickens, and Perry (2000).

Fleming, J. Marcus, "Domestic Financial Policies under Fixed and under Floating Exchange Rates," *IMF Staff Papers* 9, November 1962, 369–379. (Lays out the basic foundations of the Mundell-Fleming model.)

The Phillips curve

Phillips, A.W., "The Relationship between Unemployment and the Rate of Change of Money Wages in the United Kingdom, 1861–1957," *Economica* 25, November 1958, 283–299. (The original exposition.)

Friedman, Milton, "The Role of Monetary Policy," *American Economic Review* 58:1, March 1968, 1–17. Reprinted in Snowdon and Vane, *A Macroeconomics Reader*, pp. 164–79. (Friedman's famous Presidential Address to the American Economic Association in which he laid the foundation for the modern Phillips curve.)

Phelps, Edmund S., ed., *Microeconomic Foundations of Employment and Inflation Theory*, (New York: W.W. Norton, 1970). (A collection of early papers on the microfoundations of the Phillips curve.)

G. Works Cited in Text

Akerlof, George A., William T. Dickens, and George L. Perry. 2000. Why a Little Inflation is Good. *Milken Institute Review* 2 (4):12-18.

Blanchard, Olivier J., and Lawrence H. Summers. 1986. Hysteresis and the European Unemployment Problem. In *NBER Macroeconomics Annual 1986*, edited by S. Fischer. Cambridge, Mass.: MIT Press.

Clarida, Richard, Jordi Galí, and Mark Gertler. 2000. Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory. *Quarterly Journal of Economics* 115 (1):147-80.

Fischer, Stanley. 1977. Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule. *Journal of Political Economy* 85 (1):191-205.

Friedman, Milton. 1968. The Role of Monetary Policy. *American Economic Review* 58 (1):1-17.

Phelps, Edmund S. 1970. *Microeconomic Foundations of Employment and Inflation Theory*. New York: W.W. Norton.

Phillips, A.W. 1958. The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1962-1957. *Economica* 25 (100):283-299.

Taylor, John B. 1979. Staggered Wage Setting in a Macro Model. *American Economic Review* 69 (2):108-13.

———. 1993. Discretion versus Policy Rules in Practice. *Carnegie Rochester Conference Series on Public Policy* 39:195-214.