9 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 what we learn in this single section of our course. In this chapter, we develop 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 *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. However, proponents of the basic Keynesian model argue that the appropriate measure of the relevance of a theory is its ability to predict or explain actual macroeconomic outcomes, not whether it incorporates every nuance of microeconomic knowledge. Indeed, good theories *must* be abstractions from reality; they are needed precisely because reality is too complex for us to analyze directly. On these grounds, the *IS/LM* model is less easily discredited.

One crucial way in which this section of the course enriches our macroeconomic model is that we are finally introducing *nominal* magnitudes such as money and prices into the *real* economy. We hear almost daily in the financial press about monetary policy and whether the Federal Reserve is likely to raise or lower interest rates. Yet to this point, our models have had no money and no nominal price level, and interest rates have been determined entirely by "real" factors such as saving and investment. Either the press is wrong and the Federal Reserve is engaged in a massive exercise in futility when it attempts to control interest rates or else we have left something important out of our theories.

That something is what Keynes called "effective demand" and that we now call ***aggregate demand***. We studied a simple aggregate-demand and aggregate-supply model in Chapter 2. In the models of the macroeconomy that we have examined (growth models and real-business-cycle models), microeconomic markets are perfectly competitive, which leads to a vertical aggregate-supply curve. When the aggregate-supply curve is vertical, output is wholly determined on the supply side and aggregate demand serves only to set the nominal price level.

The essence of the Keynesian approach to macroeconomics is that there may be situations in which markets do not clear; in particular, situations exist where general excess supply causes firms to produce at less than their capacity because they believe that there is insufficient demand. General excess supply can arise only if prices and wages are not flexible enough to balance the market at every moment. While some aspects of demand have played a role in our models (for example, intertemporal substitution in consumption), the dominant factors in determining the level of production have been those of the supply side: supplies of labor and capital and the level of technological capability.

Macroeconomics changes in fundamental ways when we admit the possibility of a condition of general excess supply. Since firms produce only what they think they can sell, aggregate demand (or expenditure) replaces capacity considerations as the crucial determinant of GDP. Fluctuations in the demand for consumption, investment, government spending, and net exports take on new importance as a source of business-cycle movements. Once we admit the possibility that prices and wages might not move instantaneously to keep markets in balance, changes in nominal variables such as the money supply have effects on the real economy.

The analytics of the Keynesian model are often examined graphically using the *IS/LM* and *AS/AD* frameworks. This chapter presents these models both in terms of formal (mathematical) comparative statics and in terms of the familiar graphs.

B. Comparative-Static Analysis of the Closed-Economy Basic Keynesian Model

What I am calling the "basic Keynesian" model is a framework of macroeconomic analysis in which we divide the economy into an aggregate-demand side and an aggregate-supply side, with the aggregate-demand side usually being further divided into a flow market for expenditures on goods and services and a stock market for the holding of monetary and other financial assets. The *AD/AS* framework represents the interaction of demand-side and supply-side effects in the determination of price. The *IS/LM* or *IS/MP* framework decomposes aggregate demand into flow and stock equilibrium conditions.

The *IS/LM* model is the more traditional model that is the workhorse of most undergraduate macroeconomics courses. It was originally developed by Hicks (1937). The *IS/LM* model 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 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.

Expenditure equilibrium and the **IS** *curve*

The principle behind the *IS* curve is the fundamental idea in Keynes's *General Theory*: the interrelationship between income and expenditures. Keynes's picture of the Great Depression was a situation in which incomes were depressed, which lowered expenditures by income-constrained households and by firms with unused capital. The low level of expenditures (aggregate demand) then assured that incomes stayed low because little was being produced and sold.

The familiar "Keynesian cross" model depicted in Romer's Figure 5.1 demonstrates the equilibrium between desired expenditures (the upward-sloping E line) and income. The Keynesian model assumes that current desired expenditures increase when current income increases, but less than one-for-one:

$$0 < \frac{\partial E}{\partial Y} < 1. \tag{1}$$

At the intersection between the E curve and the 45-degree line, desired expenditures are exactly enough to generate sales consistent with that level of income. At a higher level of income (to the right of the intersection) expenditures would be lower than income; if income were lower, then desired expenditures would exceed income.

The nature of the equilibrium in Romer's Figure 5.1 warrants some discussion. Although two curves are intersecting to determine the level of income and output Y, there is no real consideration of "supply" here. The production function, which relates the amount that can be produced to the available amounts of labor, capital, and knowledge, is conspicuously absent.

How is it possible to determine output without taking into consideration the resources available to produce it? There are two answers to this question. The first is that it is not possible: the simple Keynesian-cross model must be considered as part of a larger model in which the supply-side considerations of resource availability also play a role. However, the second answer appeals to the context in which Keynes wrote *The General Theory*. In the midst of the Great Depression, the unemployment rate of labor was near 25 percent and a comparable fraction of the capital stock was shut down. With such vast amounts of unused labor and capital, the constraints of the supply side were indeed irrelevant in many industries. In such situations with massive unemployed resources, it may be reasonable to treat the simple Keynesian model as a stand-alone model of income determination, but during more normal times it is merely one component of a more comprehensive macroeconomic model that includes a supply side as well.

One of the variables that affects the desired-expenditure function is the real interest rate r. The equilibrium level of income in the Keynesian cross depends on the level of r. A higher real interest rate implies lower desired expenditures, shifting the E curve downward as shown in Romer's Figure 5.1. This leads to a lower equilibrium income level. The downward-sloping curve that plots the effect of the real interest rate (on the vertical axis) on the level of equilibrium income (on the horizontal axis) is called the *IS* curve.

The position of the *IS* curve is affected by the fiscal policy variables G and T. An increase in G raises desired expenditures directly, since government spending is one of the components of E.[1] A decrease in T is assumed to raise desired expenditures by increasing the disposable income of households, causing them to consume more.[2] Thus an increase in G or a fall in T will shift the *IS* curve to the right, increasing the level of equilibrium income corresponding to each level of the interest rate. We refer to such a change in the government budget as stimulative ***fiscal policy***. Note that we allow government spending and taxes to move independently with net government borrowing covering any deficit or surplus.

Expenditures and the IS *curve*

No one really doubts that higher incomes lead to higher desired expenditures, as indicated by the upward-sloping E curve. However, the microeconomic basis of this function is far more complex than is suggested by the simple relationship $E = E(Y, r, G, T)$ of Romer's equation (5.1).

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[1] We also must assume, of course, that increases in government spending do not lower desired private spending dollar-for-dollar. While this is surely true for such public goods as defense spending, it may be less obvious for goods such as school lunches or health care that will probably be purchased privately if they are not provided by governments.

[2] It is worth pointing out that rational, consumption-smoothing households who have access to perfect credit markets would not change their spending if the decline in current taxes was accompanied by an increase in future taxes of equal present value, as the government's budget constraint assures us must be the case. For a change in taxes (given government spending) to affect the *IS* curve, this "Ricardian equivalence hypothesis" must fail.

Total desired expenditures in a closed economy comprise households' consumption expenditures, firm's investment in new capital goods, and all non-transfer expenditures of governments. The last of these is typically taken as exogenous in macroeconomic models.[3] However, economists have built detailed models of consumption and investment spending demonstrating that equation (5.1) is a very rough simplification of desired expenditures.

We have already studied the relationship between income and desired consumption in the context of the Ramsey and Diamond models. Wage income—both current and future—is indeed one of the determinants of the desired consumption level in the Ramsey model, but current income enjoys no privileged role in these models. Current income enters alongside accumulated wealth and future income in determining the height of the lifetime budget constraint. For a household that is maximizing lifetime utility and that has access to perfect capital markets in which it can borrow against future earnings, a change in (only) current wage income would have a relatively small effect on lifetime income and thus a small effect on current consumption. In Keynes's terms, the ***marginal propensity to consume*** out of such an income change would be very small.[4]

However, there are two reasons why the apparently simplistic Keynesian specification might be reasonable. First, future wage earnings may be highly correlated with present earnings. If most income changes are regarded as permanent, then changes in current income might proxy for broader changes in expected lifetime income and consumption would respond strongly to changes in current income.[5] Second, if households cannot borrow against future income due to imperfections in capital markets, then they may not be able to smooth consumption. Such "liquidity-constrained" households will typically spend nearly all of their income in low-income periods in an attempt to smooth consumption relative to more prosperous times. A change in income in this setting would lead to a large—perhaps equal—change in consumption: the marginal propensity to consume is close to one.

The real interest rate should affect consumption expenditures through its effect on households' desire for an upward-sloping or downward-sloping lifetime consump-

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[3] However, recent research has developed a class of political-economy models in which the behavior of the economy and the democratic government are analyzed jointly. A selection of these models is discussed in Romer's Chapter 11. Political-economy models are examined in more detail in Economics 341.

[4] The marginal propensity to consume is $\partial C / \partial Y$ and is usually argued to be between zero and one.

[5] The distinction between permanent and transitory changes in income is at the heart of Milton Friedman's permanent-income hypothesis. It implies, for example, that changes in income that are known to be temporary such as one-time tax rebates or bonuses should lead to smaller changes in consumption than permanent income changes. See Friedman (1957).

tion path, as discussed in the Ramsey and Diamond growth models. It also should influence firms' desired expenditures on new capital goods. A higher real interest rate increases the opportunity cost of owning and using capital, so it should lower desired investment spending.

Models of consumption and investment spending are the subject of Romer's Chapters 7 and 8, and are discussed in Chapters 15 and 16 of the Coursebook.

Money demand and monetary policy

The *IS* curve gives us one relationship between r and Y based on equilibrium between the *flows* of income and desired expenditures. If we knew the level of r we could determine what Y must be, or *vice versa*. In order to determine the levels of both variables, we need a second equilibrium relationship. We seek a second relationship in the equilibrium between the *stocks* of monetary and non-monetary assets and the demand for these assets.

The more traditional way to characterize the asset-equilibrium relationship is the *LM* curve, describing the conditions leading the quantity of money demanded by households and firms to equal the quantity supplied by the central bank and the financial system. Since the demand for money depends on the interest rate (negatively) and income (positively), there are many alternative combinations of r and Y for which the demand will equal any given level of money supply. This upward-sloping collection of (Y, r) pairs is the *LM* curve.

The *LM* analysis was developed to describe a financial system in which the central bank follows a policy of choosing a target level (or growth rate) for the money supply. Under such a regime, the short-term interest rate adjusts in order to balance money demand with the quantity that the central bank has chosen to supply. We describe the *IS/LM* analysis below and it is discussed in detail in Mankiw's intermediate text.

However, most modern central banks no longer set monetary policy according to money-supply or money-growth targets. Instead, most now follow policies that target a specific short-term interest rate and allow the money supply to adjust to whatever level achieves balances asset markets at the desired interest-rate target.[6] While one can analyze this kind of monetary-policy rule with the *IS/LM* model, it is more naturally represented in the *IS/MP* model that Romer depicts in Figure 5.3.

Households and firms demand money because it is useful in performing transactions. Since the amount of money needed for a transaction is exactly proportional to the price of the goods and services being purchased, it follows immediately that the nominal demand for money should increase proportionally with any increase in the

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[6] The Federal Reserve Board in the United States last followed a strict monetary rule between 1979 and 1982. Since then, interest-rate targets have been more important.

general price level. Thus, we usually write the money-demand equation in terms of ***real money balances*** M/P. We also model money demand as being an increasing (sometimes, though not necessarily, proportional) function of the volume of transactions being carried out in the economy, which is represented by aggregate income Y.

Households and firms have asset budget constraints: their total stock of wealth must be divided among alternative assets such as capital, bonds, and money. Holding an extra dollar of money balances implies forgoing the holding of one of the other assets. Since the other assets bear interest (in the case of bonds) or capital earnings (in the case of capital), the opportunity cost of holding money is the forgone return on these assets. We assume for simplicity that capital and bonds bear the same rate of return (which they would under perfect foresight and risk neutrality), so we can measure the real return on non-money assets by the interest rate.

The opportunity cost of holding money *vis-à-vis* alternative assets is the difference in the real rates of return between them. The real rate of return on holding money is its nominal return (zero) minus the rate at which money loses value over time (the inflation rate). Thus, money's expected real return is $-\pi^e$ and the difference between the real return on bonds/capital (r) and money ($-\pi$) is $i = r + \pi^e$, which is the nominal rate of interest.

The **LM** *curve*

Putting all of this together gives us a money demand function like Romer's equation (5.7), in which the real demand for money depends negatively on the nominal interest rate and positively on real income. If M is taken as the central bank's exogenous policy instrument, then this equation gives us the *LM* curve, which can be the second relationship that we need between r and Y, at least for given values of the price level.

Intermediate texts such as Mankiw's analyze the basic structure of the *IS*/*LM* model in great detail. The *LM* curve represented by Romer's equation (5.7) slopes upward in (Y, r) space, so it has a unique intersection with the *IS* curve. This *IS*/*LM* equilibrium determines the values of Y and r that are consistent with equilibrium expenditures and money holding, given the levels of P, G, T, and M.

We can derive an ***aggregate-demand curve*** by exploring the effects of a change in the price level on the *IS* and *LM* curves. 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.

The **MP** *curve*

If, instead of fixing the money supply, central banks follow the now-common policy of targeting interest rates, then we it is more natural to express the asset-market equilibrium condition by the *MP* curve, which makes the interest rate exogenous and the money supply endogenous. 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.

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 inevitably 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 fall when real output falls and rise when output rises. This leads to a positive relationship between the interest rate and real output. Romer represents this relationship by the monetary-policy, or *MP*, function of equation (5.8), where $r = r(Y, \pi)$, with $r_Y > 0$ and $r_\pi > 0$.[7]

If we plot the resulting equilibria in (Y, r) space, we get an upward-sloping curve that depends on the rate of inflation. An increase in π would shift the *MP* curve upward.

Aggregate demand and aggregate supply

Substituting the real interest rate from the monetary-policy rule (5.8) into the *IS* curve (5.4) gives us

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[7] 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 (5.8). Suppose that the nominal-interest-rate rule is $i = i(Y, \pi)$, then the corresponding real-interest-rate rule is $r = i(Y, \pi) - \pi \equiv r(Y, \pi)$.

$$Y = E\left[Y, r(Y, \pi), G, T\right], \tag{2}$$

which is the (implicit) equation for the aggregate-demand (*AD*) curve. This curve gives the value of demand-side equilibrium income Y as a function of the inflation rate π, given the fiscal-policy variables G and T.[8]

We can find the effect of π on Y on the *AD* curve by differentiating equation (2) with respect to π:

$$\frac{\partial Y}{\partial \pi} = E_Y \frac{\partial Y}{\partial \pi} + E_r r_Y \frac{\partial Y}{\partial \pi} + E_r r_\pi,$$

where we have used the assumption that G and T are exogenous to impose

$$\frac{\partial G}{\partial \pi} = \frac{\partial T}{\partial \pi} = 0.$$

Solving for $\partial Y / \partial \pi$ yields

$$\left.\frac{\partial Y}{\partial \pi}\right|_{AD} = \frac{E_r r_\pi}{1 - E_Y - E_r r_Y} < 0. \tag{3}$$

The slope of the *AD* curve in (Y, π) space is the reciprocal of the expression in (3) because Y is on the horizontal axis and π on the vertical.

We can now add an aggregate-supply curve to the *AD* curve to examine *AD/AS* equilibrium as Romer does in equation (5.10) and Figure 5.4.

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 5.3, 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'll call Case 0. This is the case where, as in the real-business-cycle model and our growth models, there

[8] Note a subtle difference here. In the *IS/LM* representation the aggregate-demand curve was a function of the price level P, while in the *IS/MP* framework quantity demanded depends on the inflation rate π.

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 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 affect 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 5.3 and more rigorously in Chapter 6.

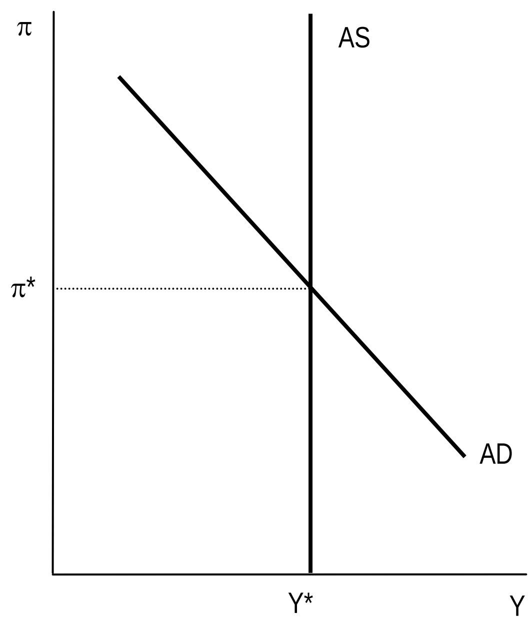

Figure 1. Aggregate supply with no market imperfections.

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.[9] Modern Keynesians bring this kind of wage stickiness into the model through nominal-wage contracts.[10]

[9] 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 rela-

As Romer discusses on page 242, 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.

Case 2: Inflation stickiness with 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 inflation rate π would be predetermined and unresponsive to changes in current output Y.

Firms in this model are assumed to supply however much output customers want to buy at the predetermined price/inflation rate. Thus the aggregate-supply curve is horizontal as in Romer's Figure 5.12 up to the point where the real wage rises so high that firms cannot produce additional output without making losses.

The behavior of the labor market in this model is shown in Romer's Figure 5.13. 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.[11] A decrease in aggregate demand

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tive 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.

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

[11] For a given position of the labor-supply curve, the level Y^{MAX} is the level of output where the labor-supply curve intersects the labor-demand curve at its kink. In Figure 5.13, this would be a level of output slightly higher than the one shown by the original labor-demand curve.

shifts the labor-demand curve as shown in Figure 5.13, leading to a strongly procyclical real wage and a countercyclical markup on 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 imperfect 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 section 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.[12] 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

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.

[12] 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[13] 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.

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).

[13] 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.

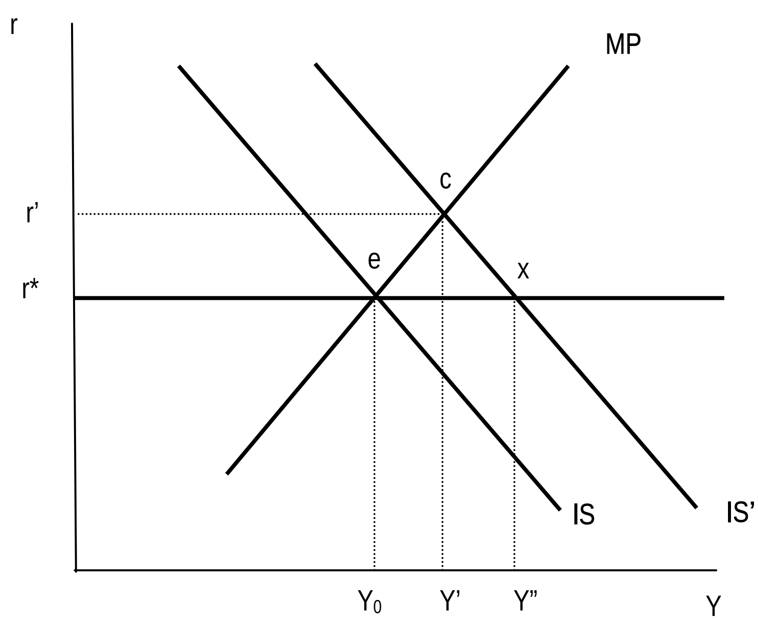

Figure 2. Expansionary fiscal policy in an open economy

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.[14] If wealth-holders have some degree of preference for one currency over another, then domestic and foreign bonds are less-than-perfect substitutes.

[14] 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 $CF' \rightarrow \infty$ 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[15]

$$Y = F\left(\bar{K}, L\right).$$

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

[15] 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.

number of workers employed could reflect movements into and out of the labor force rather than movements between employment and unemployment.

However, if the labor force is held constant then a change in employment implies a one-to-one change in the opposite direction in unemployment. This is the rationale for thinking 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 who 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 9, 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 in 1958 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.[16] 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 implies 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.[17]

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. 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 5.16 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 5.16 as resulting from shifts in expected inflation and in the natural rate of unemployment. As

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

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

people 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.[18] 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 adjust until 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 255 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.[19] According to these theories, all deviations of output and unemployment from their natural levels could be eliminated if households and firms could correctly perceive and forecast the inflation rate. This came to be known as the ***new classical macroeconomics***.

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[18] 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.

[19] 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 and in Chapter 9 of the coursebook.

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 changes in inflation are assumed to 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.[20]

Hysteresis is a possible explanation for the experience of continental Europe since 1980, where unemployment has been well above historical levels for two decades. While inflation has been quite low, it seems implausible that core inflation would not have adjusted to the lower inflation rate by now. 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 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 it altogether and behave as though core or expected inflation is zero.[21] If

[20] The hysteresis hypothesis is discussed briefly in Romer's Chapter 9 and in the unemployment chapter of the coursebook. A readable exposition from the research literature is Blanchard and Summers (1986).

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

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 has been 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.)

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 micro-foundations 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.

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

Friedman, Milton. 1957. *A Theory of the Consumption Function*. Princeton, N.J.: Princeton University Press.

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

Hicks, John R. 1937. Mr. Keynes and the 'Classics'. *Econometrica* 5 (2):147-159.

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 (4):283-299.

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