Chapter 5
TRADITIONAL KEYNESIAN THEORIES OF FLUCTUATIONS

This chapter and the next develop models of fluctuations based on the assumption that there are barriers to the instantaneous adjustment of nominal prices and wages. As we will see, sluggish nominal adjustment causes changes in the aggregate demand for goods at a given level of prices to affect the amount that firms produce. As a result, it causes purely monetary disturbances (which affect only demand) to change employment and output. In addition, many real shocks, including changes in government purchases, investment demand, and technology, affect aggregate demand at a given price level. As a result sluggish price adjustment creates a channel other than the intertemporal-substitution and capital-accumulation mechanisms of basic real-business-cycle models through which these shocks affect employment and output.

This chapter takes nominal stickiness as given. It has two main goals. The first is to investigate aggregate demand. We will examine the determinants of aggregate demand and the effects of changes in aggregate demand in both closed and open economies. The second is to consider alternative assumptions about the form of nominal rigidity. We will investigate different assumptions implications for firms' willingness to change output in response to changes in aggregate demand and for the behavior of real wages, markups, and inflation. Chapter 6 then turns to the questions of why nominal prices and wages might not adjust immediately to disturbances.

Because the models we will consider in this chapter are based on traditional Keynesian models, both their substance and their modeling strategy are at the other extreme from the pure real-business-cycle models of Chapter 4. The models in this chapter often directly specify relationships among aggregate variables. The relationships are often static, and the models' implications for the behavior of some variables (such as the capital stock) are sometimes omitted from the analysis. In addition, rather than specifying stochastic processes for the exogenous variables, the analysis focuses on the effects of one-time changes. And the models are so stylized that any effort to see how well they match overall features of the economy is of little value.

The remainder of the chapter consists of six sections. Sections 5.1 and 5.2 develop the aggregate demand side of the standard Keynesian model. These sections take as given that nominal prices and wages are not completely flexible, and that firms change their output in response to changes in demand. Section 5.1 assumes a closed economy, and Section 5.2 considers the open-economy case.

Sections 5.3 and 5.4 consider aggregate supply. Section 5.3 shows how different combinations of wage rigidity, price rigidity, and non-Walrasian features of the labor and goods markets yield different implications about the effect of shifts in aggregate demand on output, unemployment, the real wage, and the markup. Section 5.4 discusses short-run and long-run output-inflation tradeoffs.

Finally, Sections 5.5 and 5.6 discuss some empirical evidence about the real effects of monetary changes and the cyclical behavior of the real wage.

5.1 Aggregate Demand

Since Keynesian models assume that there is some nominal stickiness, it is easiest to start by assuming that the price level is completely fixed. With this assumption, the determination of output and the interest rate for a given price level is described by two equations, one concerning the demand for goods and the other concerning the money market.

The *IS* Curve

The *IS* curve shows the combinations of output and the interest rate such that planned and actual expenditures on output are equal.[1] Planned real expenditure depends positively on real income, negatively on the real interest rate, positively on government purchases of goods and services, and negatively on taxes:

$$E = E(Y, r, G, T), \quad 0 < E_Y < 1, \; E_r < 0, \; E_G > 0, \; E_T < 0. \tag{5.1}$$

Here E is planned real expenditure, Y real output, r the real interest rate, G real government purchases, and T real taxes. E_Y, E_r, and so on denote the partial derivatives of $E(\bullet)$. G and T are taken as given. The negative effect of the real interest rate on planned expenditure operates through firms' investment decisions and through consumers' purchases, particularly of durable goods. Planned expenditure is assumed to increase less than one-for-one with income; that is, $0 < E_Y < 1$.

[1] The *IS* curve is often described as showing equilibrium in the goods market. But since supply is ignored, this is not an accurate description.

In textbook treatments, E is often expressed in terms of its component parts, and strong assumptions are made about how the determinants of planned expenditure enter. A standard formulation is

$$E = C(Y - T) + I(r) + G, \tag{5.2}$$

where $C(\bullet)$ is consumption and $I(\bullet)$ is investment. The restrictions imposed in this specification may be highly unrealistic. For example, there is considerable evidence that the real interest rate affects consumption, and almost overwhelming evidence that income influences investment. To give another example, there is little basis for assuming that income and taxes have equal and opposite effects on planned real expenditures. Since the general formulation in (5.1) is only slightly more difficult, we will use it in what follows.

If one treats goods that a firm produces and then holds as inventories as purchased by the firm, then all output is purchased by someone. Thus actual expenditure equals the economy's output, Y. In equilibrium, planned and actual expenditures must be equal. If planned expenditure falls short of actual expenditure, for example, firms are accumulating unwanted inventories; they will respond by cutting their production. Thus equilibrium requires

$$E = Y. \tag{5.3}$$

Substituting (5.3) into (5.1) yields

$$Y = E(Y, r, G, T). \tag{5.4}$$

Figure 5.1, the *Keynesian cross,* depicts equations (5.1) and (5.3) in (Y, E) space for a given level of the interest rate. Equation (5.3) is just the 45-degree line. Since planned expenditure increases less than one-for-one with Y, the set of points satisfying (5.1) is less steep than the 45-degree line. The point where the planned expenditure curve crosses the 45-degree line (Point A) shows the unique level of income where actual and planned expenditures are equal for the given interest rate.[2]

An increase in the interest rate shifts the planned expenditure line down (since $E(\bullet)$ is decreasing in r), and thus reduces the level of income at which actual and planned expenditures are equal. In terms of the diagram, an increase in the interest rate from r to r' shifts the intersection of the two lines from Point A to Point B. Thus in (Y, r) space, the IS curve slopes down. This is shown in Figure 5.2.

Differentiating both sides of (5.4) with respect to r yields

$$\left.\frac{dY}{dr}\right|_{IS} = E_Y\left(\left.\frac{dY}{dr}\right|_{IS}\right) + E_r, \tag{5.5}$$

[2] The Keynesian cross is sometimes described as a theory of income determination. But this is correct only if the interest rate can be treated as fixed, which is usually inappropriate.

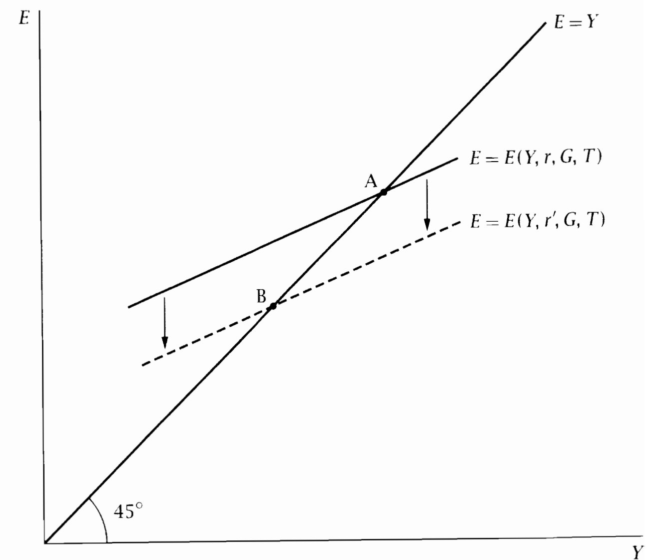

FIGURE 5.1 The Keynesian cross

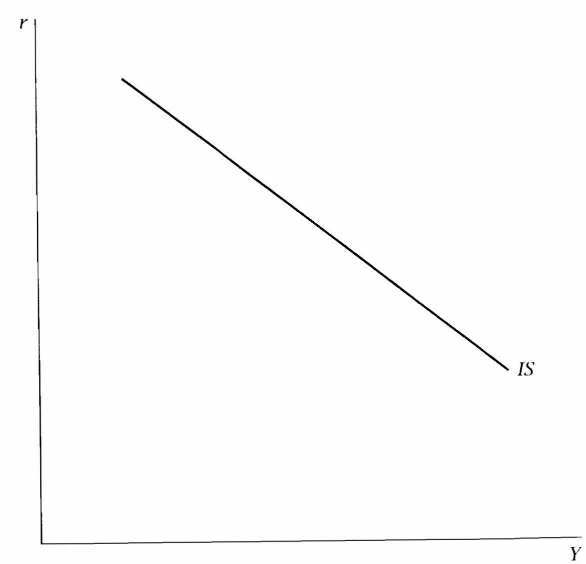

FIGURE 5.2 The *IS* curve

or

$$\left.\frac{dY}{dr}\right|_{IS} = \frac{E_r}{1 - E_Y}, \tag{5.6}$$

where $\left.\frac{dY}{dr}\right|_{IS}$ denotes dY/dr along the *IS* curve. Since this is an expression for dY/dr (rather than dr/dY), it implies that the *IS* curve is flatter when either E_r or E is larger. Intuitively, the larger the effect of the interest rate on planned expenditure, the larger the downward shift of the planned expenditure line, and thus the larger the fall in output. Similarly, the steeper the planned expenditure line, the more output must fall in response to a given downward shift of the planned expenditure line to reach a point where planned and actual expenditures are again in balance, and thus the larger the fall in output. This last effect is the famous *multiplier:* because E depends on Y, the fall in Y needed to restore the equality of E and Y is larger than the amount that E falls at a given Y.

The Money Market

To determine r and Y, we need a second equation. This is provided by the condition for equilibrium in the money market. It is simplest to think of money as high-powered money—currency and reserves—issued by the government. Since high-powered money pays no nominal interest, the opportunity cost of holding it is the nominal interest rate. The demand for real money balances is therefore a decreasing function of the nominal interest rate. In addition, since the volume of transactions is greater when output is higher, the demand for real balances is increasing in output. Thus the condition for the supply and demand of real balances to be equal is

$$\frac{M}{P} = L(r + \pi^e, Y), \qquad L_{r+\pi^e} < 0, \qquad L_Y > 0, \tag{5.7}$$

where M is the quantity of money and P is the price level, and where the nominal interest rate is expressed as the sum of the real interest rate, r, and expected inflation, π^e.

The traditional approach to analyzing (5.7) is to take M as exogenous. In addition, since we are assuming completely fixed prices for the moment, P is fixed and π^e is zero. Thus with these assumptions, the left-hand side of (5.7) is $M/\overline{P}$ and the right-hand side is $L(r, Y)$. Since $L(r, Y)$ is decreasing in r and increasing in Y, the set of combinations of r and Y that satisfy $M/\overline{P} = L(r, Y)$ is upward-sloping in (Y, r) space. This locus is known as the *LM* curve. Under the assumption that the money supply is exogenous, the *IS* and *LM* curves determine output and the real interest rate.

Taylor (1995) proposes a slightly different approach. Modern central banks do not target the money supply. Instead, they adjust it to achieve a target for the interest rate, and they adjust their interest-rate target in

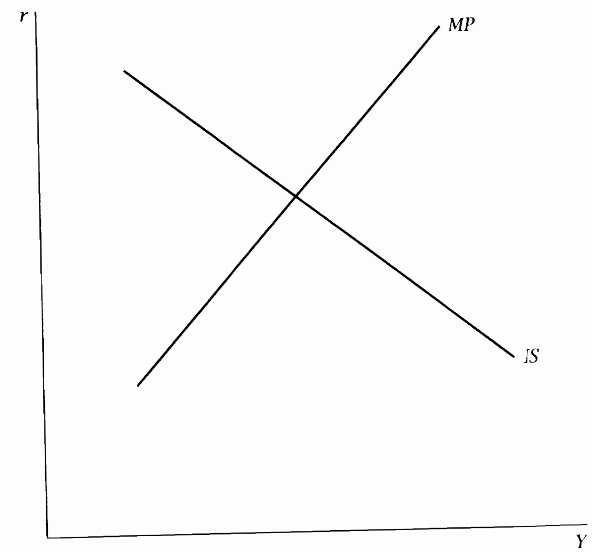

FIGURE 5.3 The *IS-MP* diagram

response to movements in output and inflation. Thus rather than assuming that M is exogenous, we will assume that the central bank follows an interest-rate rule. Writing the rule as one for the real interest rate, we can express it as

$$r = r(Y, \pi), \qquad r_Y > 0, \qquad r_\pi > 0. \tag{5.8}$$

This assumption leads directly to an upward-sloping locus in (Y, r) space. This locus is known as the *MP* curve. It is shown together with the *IS* curve in Figure 5.3.[3]

When the central bank follows an interest-rate rule, it adjusts the money supply so that the interest rate follows the rule. That is, M is an endogenous variable given by

$$M = PL(r(Y, \pi) + \pi^e, Y). \tag{5.9}$$

For most purposes, however, we can simply ignore the money supply and focus on the *IS* equation and the interest-rate rule.

Because it is both simpler and more realistic, we will employ the *MP* approach in what follows. For most purposes, however, the *LM* approach has similar implications.

[3] Sections 10.6 and 10.7 provide a more detailed discussion of interest-rate rules.

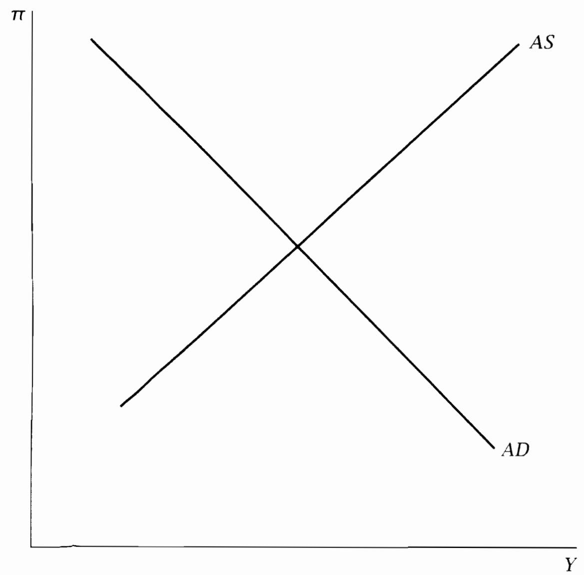

FIGURE 5.4 The *AS-AD* diagram

The *AS-AD* Diagram

When prices are not completely fixed, the determination of output and inflation can be described by two curves in output-inflation space, an upward-sloping aggregate supply (*AS*) curve and a downward-sloping aggregate demand (*AD*) curve. They are shown in Figure 5.4. The *AS* curve is the subject of Sections 5.3 and 5.4 and of most of Chapter 6. For now, however, we just assume some positive relationship between output and inflation:

$$\pi = \pi(Y), \qquad \pi'(\bullet) \geq 0. \tag{5.10}$$

Thus, we are relaxing our assumption that prices are completely fixed in favor of the assumption that inflation has some response to output.

The *AD* curve comes from the *IS* and *MP* curves. To see this, consider a rise in inflation. Since π does not enter the planned expenditure function, $E(\bullet)$, the *IS* curve is unaffected. But since the monetary-policy rule, $r = r(Y, \pi)$, is increasing in π, the rise in inflation increases the real interest rate the central bank sets at a given level of output. That is, the *MP* curve shifts up. As a result, as Figure 5.5 shows, r rises and Y falls. Thus the level of output at the intersection of the *IS* and *MP* curves is a decreasing

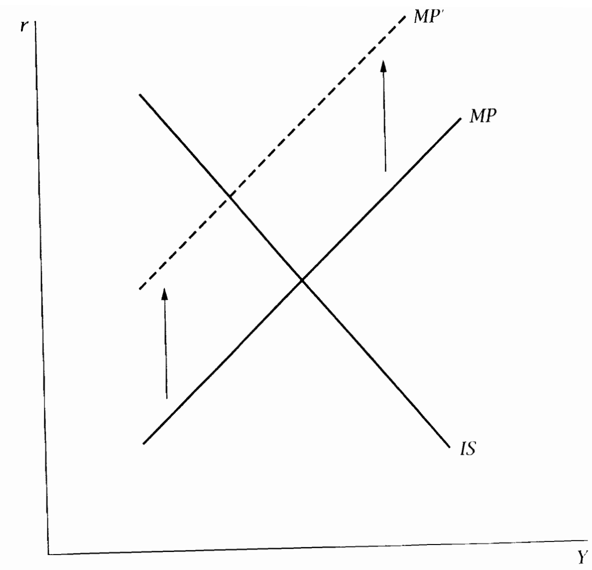

FIGURE 5.5 The effects of an increase in inflation

function of the inflation rate. This is what is shown by the aggregate demand curve.[4]

To find how much Y changes in response to a change in π, differentiate (5.4) and (5.8) with respect to π. This yields two equations in two unknowns:

$$\left.\frac{dY}{d\pi}\right|_{AD} = E_Y \left.\frac{dY}{d\pi}\right|_{AD} + E_r \left.\frac{dr}{d\pi}\right|_{AD}, \tag{5.11}$$

$$\left.\frac{dr}{d\pi}\right|_{AD} = r_\pi + r_Y \left.\frac{dY}{d\pi}\right|_{AD}. \tag{5.12}$$

These can be solved to obtain

$$\left.\frac{dY}{d\pi}\right|_{AD} = \frac{r_\pi}{[(1 - E_Y)/E_r] - r_Y}. \tag{5.13}$$

This expression is unambiguously negative, and it shows the determinants of the slope of the aggregate demand curve.

[4] When prices are not completely flexible, P and π^e, as well as π, can vary. However, these two variables only enter the model in equation (5.9), which describes how the central bank must adjust the money supply to follow its interest-rate rule. Thus for the most part they can be neglected. See Problem 5.2.

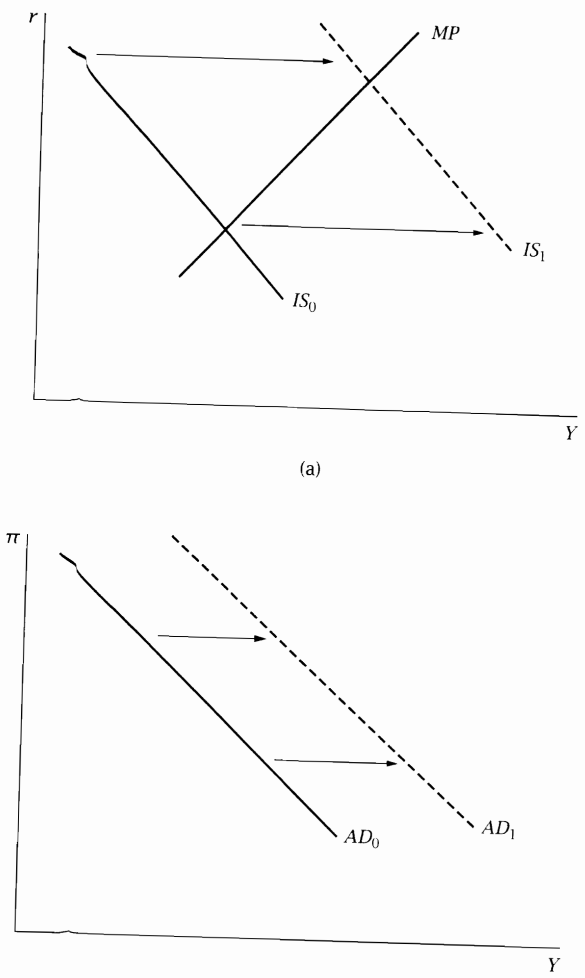

FIGURE 5.6 The effects of an increase in government purchases

Example: The Effects of an Increase in Government Purchases

The *IS* and *MP* curves provide a simple model of aggregate demand that can be used to analyze many issues. Suppose, for example, that government purchases rise. The increase in *G* raises planned expenditure for a given level of output and the interest rate. The planned expenditure line in Figure 5.1 therefore shifts up, and so the level of *Y* such that actual and planned expenditures are equal is higher for a given level of the interest rate. Thus the *IS* curve shifts to the right; this is shown in Panel (a) of Figure 5.6. The shift in the *IS* curve raises *Y* (and *r*) for a given inflation rate, and thus moves the *AD* curve outward; this is shown in Panel (b) of the figure.[5]

The impact of this change in aggregate demand on output and inflation depends on the aggregate supply curve. If it is vertical, only inflation increases. If it is horizontal, only output increases. And if it is upward-sloping but not vertical, both output and inflation increase.

Thus, incomplete adjustment of nominal prices introduces a new channel through which shocks affect output. For some reason, which we have not yet specified, nominal prices do not adjust fully in the short run. As a result, any change in the demand for goods at a given price level affects output. In contrast, the intertemporal-substitution and wealth effects that drive employment fluctuations in real-business-cycle models would correspond to effects of government purchases on the aggregate supply curve—that is, they would affect not the quantity of output that households and firms want to buy at a given price level, but the quantity that firms want to produce at a given price level.

5.2 The Open Economy

In most practical applications, the exchange rate and international trade are important to short-run fluctuations. This section therefore extends the *IS-MP* model to the case of an open economy.

The Real Exchange Rate and Planned Expenditure

It is simplest to think of the rest of the world as consisting of a single country. Let e denote the nominal exchange rate—specifically, the price of a unit of foreign currency in terms of domestic currency. With this definition, a rise in the exchange rate means that foreign currency has become more expensive, and therefore corresponds to a weakening, or depreciation, of the domestic currency. Similarly, a fall in e corresponds to an appreciation of the domestic currency. Let P^* denote the price level abroad (that is, the price of foreign goods in units of foreign currency). These definitions imply that the real exchange rate—the price of foreign goods in units of domestic goods, denoted ε—is eP^*/P.

[5] The *IS-MP* diagram is drawn for a given value of π. Thus the amount that output increases in the *IS-MP* diagram is the same as the amount that the aggregate demand curve shifts to the right at the value of π assumed in the *IS-MP* diagram.

A higher real exchange rate implies that foreign goods have become more expensive relative to domestic goods. Both domestic residents and foreigners are therefore likely to increase their purchases of domestic goods relative to foreign ones. Thus planned expenditure rises. Mathematically, equation (5.4) becomes

$$Y = E(Y, r, G, T, \varepsilon), \tag{5.14}$$

with $E(\bullet)$ increasing in ε.[6] The central bank's choice of the real interest rate continues to be increasing in output and inflation. Thus the *MP* curve is unaffected.[7]

At this point one can make different assumptions about the exchange-rate regime (floating or fixed), capital mobility (perfect or imperfect), and exchange-rate expectations (static or rational). What set of assumptions is appropriate depends on the economy being studied and the questions being asked. Here we discuss some of the most important possibilities.

Floating Exchange Rates and Perfect Capital Mobility

The simplest assumptions about capital movements are that there are no barriers to capital mobility and that investors are risk-neutral; we will refer to this case as *perfect capital mobility*. Barriers to foreign investment in most industrialized countries are small, and many investors appear willing to make large changes in their portfolios in response to small rate-of-return differences. As a result, perfect capital mobility is likely to be a good approximation for many purposes.

For exchange-rate expectations, the simplest assumption is that investors do not expect the real exchange rate to change. This assumption can be justified both on the grounds of ease and on the grounds that it is difficult to find evidence of predictable exchange-rate movements (Meese and Rogoff, 1983).

Perfect capital mobility implies that if there were any difference in the expected rate of return between domestic and foreign assets, investors would put all their wealth into the asset with the higher yield. Since both types of assets must be held by someone, it follows that the expected rates of return on the two assets cannot be different. With static expectations about the real exchange rate, this condition is simply

$$r = r^*, \tag{5.15}$$

where r^* is the foreign interest rate. r^* is taken as given.

[6] The function is sometimes assumed to take the specific form $C(Y - T) + I(r) + G + NX(\varepsilon)$, where NX denotes net exports.

[7] As described in Section 10.6, the real exchange rate may affect the central bank's interest-rate target. For simplicity we neglect this possibility here.

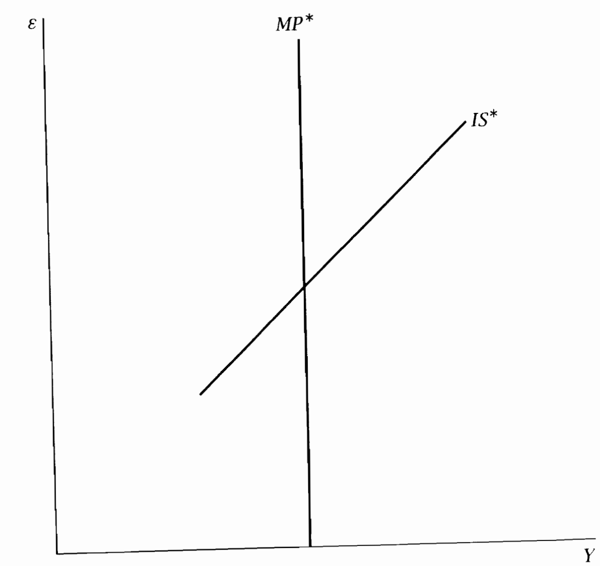

FIGURE 5.7 Perfect capital mobility and a floating exchange rate

With a floating exchange rate, aggregate demand at a given inflation rate is described by the three equations (5.8), (5.14), and (5.15) in the three unknowns r, Y, and ε. Since r is determined trivially by the requirement that it equals r^*, the system immediately reduces to two equations in Y and ε:

$$r^* = r(Y, \pi), \tag{5.16}$$

$$Y = E(Y, r^*, G, T, \varepsilon). \tag{5.17}$$

Figure 5.7 plots the sets of points satisfying (5.16) and (5.17) in output-exchange rate space. Since an increase in ε raises planned expenditure, the set of solutions to (5.17) is upward-sloping; this is shown as the IS^* curve in the figure. And since the exchange rate does not enter the central bank's interest-rate rule, the set of solutions to (5.16) is vertical; this is shown as the MP^* curve.

The fact that the MP^* curve is vertical means that output for a given inflation rate—that is, the position of the *AD* curve—is determined entirely by monetary policy. To take the same example as in the previous section, suppose that government purchases rise. This change shifts the IS^* curve to the right. But since the MP^* curve is vertical, at a given inflation rate this leads only to appreciation of the exchange rate and has no effect on output. Thus the aggregate demand curve is unaffected.[8]

Rational Exchange-Rate Expectations and Overshooting

This analysis assumes that real-exchange-rate expectations are static. But with a floating exchange rate, it turns out that when plausible assumptions about the dynamics of prices and output are added to the model, there are predictable changes in the exchange rate. Thus static expectations are not rational: an investor with static expectations is making systematic errors in his or her exchange-rate forecasts. Such an investor can therefore earn a higher average rate of return by using information that helps to forecast exchange-rate movements. Thus it is natural to ask what happens if investors form their expectations concerning movements in the exchange rate using all the available information—that is, if they have rational expectations.

When expectations are not static, perfect capital mobility no longer necessarily implies that domestic and foreign interest rates are equal. Consider an investor at some time t deciding where to hold his or her wealth. If the investor buys one unit of a domestic asset that earns a continuously compounded real rate of return of r, at time $t+\Delta t$ the real value of the asset is $e^{r\Delta t}$. Suppose the investor instead invests in foreign assets. At t, the funds the investor used to buy the domestic asset can be used instead to purchase $1/\varepsilon(t)$ units of foreign assets; after Δt, these assets have a real value abroad of $e^{r^*\Delta t}/\varepsilon(t)$; and their real value domestically is $\varepsilon(t+\Delta t)e^{r^*\Delta t}/\varepsilon(t)$.

Under perfect capital mobility, these two ways of investing must have the same expected payoff. $\varepsilon(t)$, r, and r^* are known, but $\varepsilon(t+\Delta t)$ may be uncertain. Thus we have

$$e^{r\Delta t} = \frac{E[\varepsilon(t+\Delta t)]}{\varepsilon(t)} e^{r^*\Delta t}. \tag{5.18}$$

Equation (5.18) holds for all values of Δt. The derivatives of both sides with respect to Δt are therefore equal:

$$e^{r\Delta t} r = \frac{E[\varepsilon(t+\Delta t)]}{\varepsilon(t)} e^{r^*\Delta t} r^* + e^{r^*\Delta t} \frac{E[\dot{\varepsilon}(t+\Delta t)]}{\varepsilon(t)}. \tag{5.19}$$

When this expression is evaluated at $\Delta t = 0$, it simplifies to

$$r = r^* + \frac{E[\dot{\varepsilon}(t)]}{\varepsilon(t)}. \tag{5.20}$$

Since $r = i - \pi^e$, $r^* = i^* - \pi^{e*}$, and $E[\dot{\varepsilon}]/\varepsilon = (E[\dot{e}]/e) + \pi^{e*} - \pi^e$, equation (5.20) implies a similar relationship concerning nominal interest rates and expected movements of the nominal exchange rate:

$$i = i^* + \frac{E[\dot{e}(t)]}{e(t)}. \tag{5.21}$$

Equations (5.20) and (5.21) state that under perfect capital mobility, interest-rate differences must be offset by expectations of exchange-rate movements. For example, (5.20) implies that the domestic real interest rate can exceed the foreign real interest rate only if the domestic currency is expected to depreciate in real terms at a rate equal to the real-interest-rate differential. Equation (5.20) (or [5.21]) is known as *uncovered interest-rate parity*.[9]

The possibility of expected exchange-rate movements associated with interest-rate differences gives rise to the possibility of *exchange-rate overshooting* (Dornbusch, 1976). "Overshooting" refers to a situation where the initial reaction of a variable to a shock is greater than its long-run response. The interest-rate-parity condition, (5.20) or (5.21), implies that the nominal exchange rate is likely to overshoot in response to a monetary change. To see this, suppose that initially $i = i^*$ and the nominal exchange rate is not expected to change, and that the central bank shifts to a more expansionary policy. That is, the central bank targets a lower real interest rate for a given level of output and inflation. From (5.7), we know that this requires increasing the money supply. As stressed later in the chapter, Keynesian models generally imply that monetary changes have no real effects in the long run. Thus the long-run effect of the expansion will be to cause both the price level and the exchange rate to rise.

Now consider the short-run effect of the change. If it reduces the nominal interest rate, then (5.21) implies that $E[\dot{e}]$ must be negative: if i is less than i^*, investors will hold domestic assets only if they expect the domestic currency to appreciate. But this means that the domestic currency is worth less now than it will be in the long run; that is, it must have depreciated by so much at the time of the shock that it has overshot its expected long-run value.

This leaves the question of whether the monetary expansion reduces the domestic interest rate. A particularly simple case occurs in a variant of the

[8] Recall that the condition for equilibrium in the money market is $M/P = L(r + \pi^e, Y)$ (equation [5.9]). When P and π^e are fixed and r equals r^*, this simplifies to $M/\overline{P} = L(r^* + \overline{\pi}^e, Y)$. It follows that in this case, if M does not change in response to the increase in G, Y does not change. Thus, the LM and MP approaches have the same implications. Equivalently, here the central bank does not need to change M to follow its interest-rate rule.

[9] The parity is "uncovered" because although positive expected profits can be made by purchasing one country's assets and selling the other's when (5.20) and (5.21) fail, these profits are not riskless. The alternative is *covered interest-rate parity*, which refers to the relationship in (5.20) and (5.21) with the expected future exchange rate replaced by the price in futures markets of commitments to buy or sell foreign currency at a later date. Failure of covered interest-rate parity would imply a riskless profit opportunity.

model where not only are there completely fixed prices in the short run, but where producers cannot change output in the very short run, so that the *IS* equation, (5.14), need not be satisfied at every moment. With both prices and output fixed, the only variable that can adjust to ensure that the money-market equilibrium condition, (5.7), is satisfied is the interest rate. Thus i must fall in response to the monetary expansion, and so there must be exchange-rate overshooting.

The intuition for this result is straightforward. If at the time of the shock the exchange rate merely depreciates to its new long-run equilibrium level, the interest-rate differential causes all investors to want to purchase foreign currency to obtain the higher-yielding foreign assets. This cannot be an equilibrium. Instead, the price of domestic currency is bid down until it is sufficiently below its expected long-run level that the expected appreciation just balances the lower interest rate on domestic assets.[10]

Imperfect Capital Mobility

The assumptions that there are no barriers to capital movements between countries and that investors are risk-neutral are surely too strong. Transaction costs and the desire to diversify, for example, cause investors not to put all their wealth into a single country's assets in response to a small difference in expected returns. It is therefore natural to consider the effects of imperfect capital mobility. For simplicity we revert to the assumption of static expectations concerning the real exchange rate.

A simple way to model imperfect capital mobility is to assume that capital flows depend on the difference between domestic and foreign interest rates. Specifically, define the capital and financial flow, *CF*, as foreigners' purchases of domestic assets minus domestic residents' purchases of foreign assets. Our assumption is

$$CF = CF(r - r^*), \qquad CF'(\bullet) > 0. \tag{5.22}$$

Equilibrium in the foreign-exchange market requires that the capital and financial flow, *CF*, and net exports, *NX*, sum to zero. If their sum is positive, for example, this means that foreign demand for domestic goods and assets exceeds domestic demand for foreign goods and assets. But this means that foreigners want to trade for more of the domestic currency than domestic residents want to trade for foreign currency, and thus that the foreign-exchange market is not in equilibrium. Thus equilibrium requires[11]

$$CF(r - r^*) + NX(Y, r, G, T, \varepsilon) = 0. \tag{5.23}$$

The aggregate demand side of the model now consists of the open-economy *IS* equation, (5.14); the *MP* equation, (5.8); and the balance-of-payments equation, (5.23). If net exports are the only component of planned expenditure that is affected by the exchange rate, the model can be analyzed graphically. With this assumption, we can write planned expenditure as the sum of domestic residents' planned expenditure (on both domestic and foreign goods) and net exports:

$$Y = E^D(Y, r, G, T) + NX(Y, r, G, T, \varepsilon), \tag{5.24}$$

where $E^D(\bullet)$ is domestic residents' planned expenditure. $E^D(\bullet)$ is assumed to satisfy $0 < E^D_Y < 1$, $E^D_r < 0$, $E^D_G > 0$, and $E^D_T < 0$. We can then use (5.23) to substitute for net exports, and thereby eliminate the exchange rate from the model:

$$Y = E^D(Y, r, G, T) - CF(r - r^*). \tag{5.25}$$

Since $CF(r - r^*)$ is increasing in r, the set of points satisfying (5.25) is downward-sloping in (Y, r) space. Since it shows the points where planned and actual expenditures are equal, we continue to call it the *IS* curve. It is shown in Figure 5.8. Note, however, that the exchange rate is implicitly changing as we move along the curve. Since the interest rate affects Y in (5.25) both through its direct effect on domestic demand and through its effect on the exchange rate and net exports, the open-economy *IS* curve is flatter than the closed-economy one. The *MP* curve is the same as before.[12]

The results for this case typically fall between those for a closed economy and those for perfect capital mobility. Consider again the effects of an increase in government purchases. Since this increase raises expenditure for a given interest rate, the *IS* curve shifts to the right. Thus, in contrast to what happens with perfect capital mobility, r and Y rise for a given price level. Since the open-economy *IS* curve is flatter than the closed-economy one, however, the effects are weaker than they are in a closed economy. The effects of other shocks can be analyzed in similar ways.

[10] When the *IS* equation is assumed to hold continuously, a monetary expansion no longer necessarily reduces i. Thus in this case there can be either undershooting or overshooting (Dornbusch, 1976).

[11] With perfect capital mobility, *CF* is minus infinity if r is less than r^*, is plus infinity if r is greater than r^*, and can take on any value—since investors are indifferent about which country's assets to hold—if r equals r^*. Thus (5.23) can hold in this case only if $r = r^*$.

[12] The model can easily be generalized to allow $CF(\bullet)$ to depend on more than $r - r^*$ and $E^D(\bullet)$ to depend on ε. Under plausible assumptions, the set of points in (Y, r) space satisfying the extended versions of (5.14) and (5.23) continues to be downward-sloping. As a result, the model's main messages are unchanged.

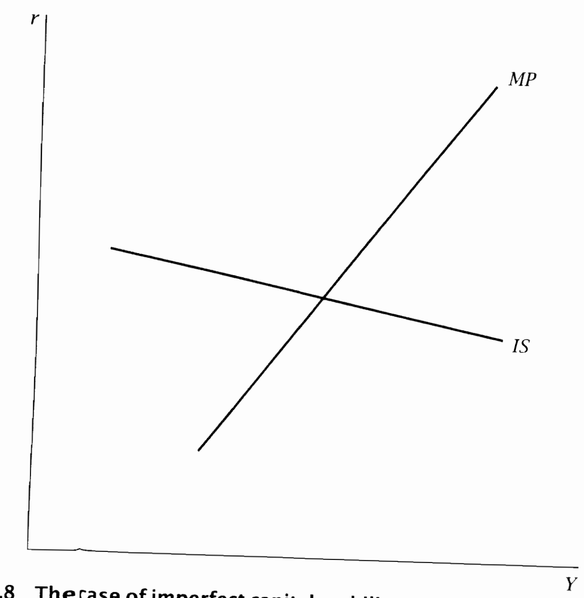

FIGURE 5.8 **The case of imperfect capital mobility and a floating exchange rate**

Fixed Exchange Rates

Many countries have fixed rather than floating exchange rates. In this section we briefly discuss what happens when exchange rates are fixed.

To keep matters manageable, we make two simplifications. The first is to assume that net exports depend only on the real exchange rate:

$$NX = NX(\varepsilon). \tag{5.26}$$

And, of course, with a fixed exchange rate, ε is given by

$$\varepsilon = \bar{\varepsilon}, \tag{5.27}$$

where $\bar{\varepsilon}$ is the level of the fixed exchange rate.[13]

The second simplification is to assume imperfect capital mobility. To fix the exchange rate, the central bank must be willing to purchase and sell foreign currency for domestic currency at the desired exchange rate. The determinants of these purchases and sales clearly differ from the determinants of other purchases and sales of foreign assets. It is therefore helpful to redefine CF as all of capital and financial flows other than the central bank's purchases and sales of foreign currency, and to define the *reserve gain* as the difference between the central bank's purchases and sales of foreign currency. With these definitions and our assumption about net exports, the condition for equilibrium in the foreign-exchange market, (5.23), becomes

$$CF(r - r^*) + NX(\bar{\varepsilon}) = RG, \tag{5.28}$$

where RG is the reserve gain. If, for example, $CF = 0$ and $NX > 0$, the value of sales of domestic goods and assets to foreigners exceeds the value of sales of foreign goods and assets to domestic residents. In this case, the foreign-exchange market can be in equilibrium only if the central bank is acquiring foreign currency.

Central banks do not have unlimited reserves of foreign currency. Thus there is some limit to the reserve losses a central bank can sustain. It simplifies the analysis to assume that the central bank starts with no reserves at all, and thus that its reserve gain cannot be negative. That is, it faces the constraint

$$RG \geq 0. \tag{5.29}$$

When the central bank's desired interest rate would cause it to lose reserves, it must set an interest rate above its desired rate in order to preserve the fixed exchange rate. Thus the real interest rate is given by the MP equation, (5.8), if that is consistent with $RG > 0$, but by the level that leads to $RG = 0$ otherwise. If we let r_o denote the interest rate that yields $RG = 0$, we have

$$r = \begin{cases} r(Y, \pi) & \text{if } CF(r(Y,\pi) - r^*) + NX(\bar{\varepsilon}) > 0 \\ r_o & \text{otherwise.} \end{cases} \tag{5.30}$$

Equation (5.30) shows how fixing the exchange rate constrains monetary policy. The central bank is free to set a high interest rate, since this only leads foreigners to want to purchase domestic currency to obtain high-yielding domestic assets, and it can meet this demand simply by printing money. But it faces a limit to its ability to lower interest rates. When domestic interest rates are low, people want to convert domestic to foreign currency. And since the central bank cannot print foreign currency, it has a limited ability to meet this demand.

With a fixed exchange rate, the condition for planned and actual expenditures to be equal is

$$Y = E(Y, r, G, T, \bar{\varepsilon}). \tag{5.31}$$

[13] Note that (5.27) assumes that it is the real exchange rate that is fixed. Most countries with a fixed exchange rate fix the nominal rate. But assuming that they fix the real exchange rate simplifies the analysis greatly and captures the essence of the difference between fixed and floating regimes: both nominal and real exchange rates are dramatically less volatile under fixed exchange rates.

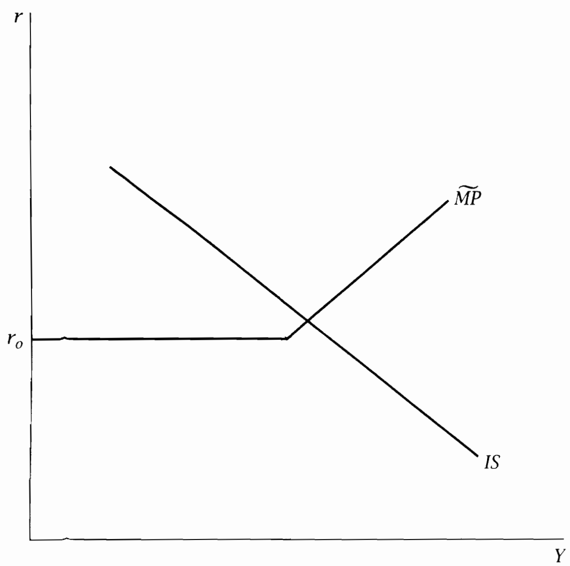

FIGURE 5.9 Fixed exchange rates

As in the closed-economy and floating-exchange-rate cases, the set of solutions to this equation is downward-sloping in (Y, r) space. It is shown as the *IS* curve in Figure 5.9, together with the modified monetary-policy equation, (5.30), labeled $\widetilde{MP}$. In the case shown, the two curves intersect at a point where the reserve gain is positive, and so the central bank is able to follow its usual interest-rate rule.

This model can be used to analyze a variety of developments. An increase in government purchases, for example, shifts the *IS* curve to the right. Y rises, and r either rises or remains the same (depending on where the *IS* and $\widetilde{MP}$ curves intersect). A more interesting case is provided by a downward shift in the demand for a country's exports. With a fixed exchange rate, net exports fall, and so the *IS* curve shifts to the left. In addition, however, the fall in net exports lowers the reserve gain at a given r (see [5.28]). As a result, r_0—the r needed to maintain the fixed exchange rate—rises. All of this is shown in Figure 5.10. In the case shown, the desire to fix the exchange rate does not merely prevent the central bank from lowering the interest rate as much as it wishes in response to the fall in output; it forces it to raise the interest rate, which magnifies the fall in output.

Finally, with a fixed exchange rate, the exchange rate itself is a policy instrument. For example, a devaluation—an increase in the fixed exchange rate, $\bar{\varepsilon}$—has the opposite effects of a decline in export demand: the *IS* curve shifts to the right, and the interest rate needed to maintain the exchange rate declines. For this reason, devaluation is often an attractive alternative to defending the exchange rate when export demand falls.[14]

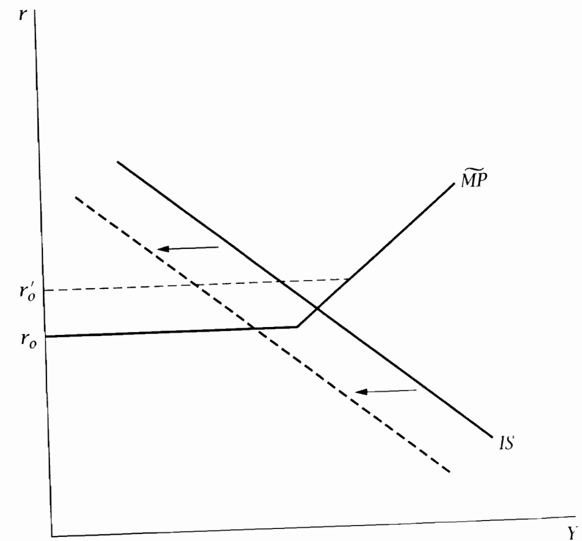

FIGURE 5.10 A fall in export demand with fixed exchange rates

[14] This analysis can be generalized in various ways. For example, suppose we replace the assumption about net exports in (5.26) with the more general equation $NX = NX(Y, r, G, T, \bar{\varepsilon})$, with $NX_Y < 0$ and $CF'(r - r^*) + NX_r > 0$. Since the reserve gain is now decreasing in Y, the horizontal portion of the $\widetilde{MP}$ curve becomes upward-sloping. Under the realistic assumption that $CF(\bullet)$ is quite responsive to $r - r^*$, however, this portion of the curve remains close to flat.

A more interesting extension is to assume that for practical or political reasons, there is an upper limit as well as a lower limit to the reserve gain. With this assumption, the $\widetilde{MP}$ curve is first flat (at the level of r that yields the minimum reserve gain), then upward-sloping, and then flat again (at the level of r that yields the maximum reserve gain). As capital mobility increases, the upward-sloping piece becomes smaller, and it disappears completely if capital is perfectly mobile. One implication is what has been called the "impossible trinity": one cannot simultaneously have a fixed exchange rate, highly mobile capital, and independent monetary policy.