The *IS-LM* Model and the *DD-AA* Model

In this appendix we examine the relationship between the *DD-AA* model of the chapter and another model frequently used to answer questions in international macroeconomics, the *IS-LM* model. The *IS-LM* model generalizes the *DD-AA* model by allowing the real domestic interest rate to affect aggregate demand.

The diagram usually used to analyze the *IS-LM* model has the nominal interest rate and output, rather than the nominal exchange rate and output, on its axes. Like the *DD-AA* diagram, the *IS-LM* diagram determines the short-run equilibrium of the economy as the intersection of two individual market equilibrium curves, called *IS* and *LM*. The *IS* curve is the schedule of nominal interest rates and output levels at which the output and foreign exchange markets are in equilibrium, while the *LM* curve shows points at which the money market is in equilibrium.[1]

The *IS-LM* model assumes that investment, and some forms of consumer purchases (such as purchases of autos and other durable goods), are negatively related to the expected real interest rate. When the expected real interest rate is low, firms find it profitable to borrow and undertake investment plans. (The appendix to Chapter 7 presented a model of this link between investment and the real interest rate.) A low expected real interest rate also makes it more profitable to carry inventories rather than alternative assets. For both these reasons, we would expect investment to rise when the expected real interest rate falls. Similarly, because consumers find borrowing cheap and saving unattractive when the real interest rate is low, interest-responsive consumer purchases also rise when the real interest rate falls. As Appendix 1 to Chapter 16 shows, however, theoretical arguments as well as the evidence suggest the consumption response to the interest rate is weaker than the investment response.

In the *IS-LM* model, aggregate demand is therefore written as a function of the real exchange rate, disposable income, *and* the real interest rate,

$$D(EP^*/P, Y - T, R - \pi^e) =$$
$$C(Y - T, R - \pi^e) + I(R - \pi^e) + G + CA(EP^*/P, Y - T, R - \pi^e),$$

where π^e is the expected inflation rate and $R - \pi^e$ therefore is the expected real interest rate. The model assumes that P, P^*, G, T, R^*, and E^e are all given. (To simplify the notation, we've left G out of the aggregate demand function D.)

To find the *IS* curve of R and Y combinations such that aggregate demand equals output,

$$Y = D(EP^*/P, Y - T, R - \pi^e),$$

we must first write this output market equilibrium condition so that it does not depend on E.

---

[1] In a closed-economy context, the original exposition of the *IS-LM* model is in J. R. Hicks, "Mr. Keynes and the 'Classics': A Suggested Interpretation," *Econometrica* 5 (April 1937), pp. 147–159. Hicks's article still makes enjoyable and instructive reading today. The name *IS* comes from the fact that in a closed economy (but not necessarily in an open economy!) the output market is in equilibrium when investment (*I*) and saving (*S*) are equal. Along the *LM* schedule, real money demand (*L*) equals the real money supply (M^s/P in our notation). The open-economy version of the model, with the expectations assumption $E = E^e$ made for simplicity, is called the *Mundell-Fleming model*. Columbia University economist Robert Mundell won a Nobel Prize in 1999 for his work on the model.

We solve for E using the interest parity condition, $R = R^* + (E^e - E)/E$. If we solve this equation for E, the result is

$$E = E^e/(1 + R - R^*).$$

Substitution of this expression into the aggregate demand function shows that we can express the condition for output market equilibrium as

$$Y = D[E^e P^*/P(1 + R - R^*), Y - T, R - \pi^e].$$

To get a complete picture of how output changes affect goods market equilibrium, we must remember that the inflation rate in the economy depends positively on the gap between actual output, Y, and full employment output, Y^f. We therefore write π^e as an increasing function of that gap:

$$\pi^e = \pi^e(Y - Y^f).$$

Under this assumption on expectations, the goods market is in equilibrium when

$$Y = D[E^e P^*/P(1 + R - R^*), Y - T, R - \pi^e(Y - Y^f)].$$

This condition shows that a fall in the nominal interest rate R raises aggregate demand through two channels: (1) Given the expected future exchange rate, a fall in R causes a domestic currency depreciation that improves the current account. (2) Given expected inflation, a fall in R directly encourages consumption and investment spending that falls only partly on imports. Only the second of these channels—the effect of the interest rate on spending—would be present in a closed-economy *IS-LM* model.

The *IS* curve is found by asking how output must respond to such a fall in the interest rate to maintain output market equilibrium. Since a fall in R raises aggregate demand, the output market will remain in equilibrium after R falls only if Y rises. The *IS* curve therefore slopes downward, as shown in Figure 1. Even though the *IS* and *DD* curves both reflect output market equilibrium, *IS* slopes downward while *DD* slopes upward. The reason for

Figure 1

Short-Run Equilibrium in the *IS-LM* Model

Equilibrium is at point 1, where the output and asset markets simultaneously clear.
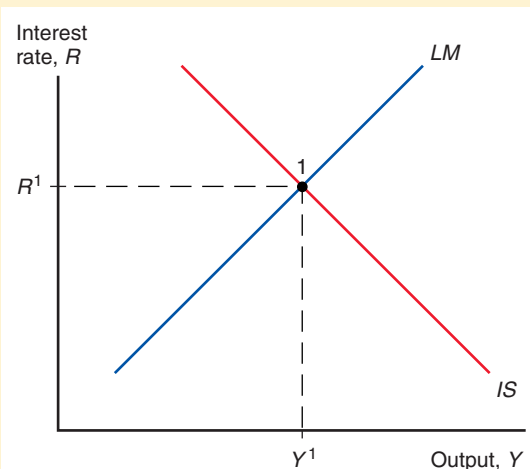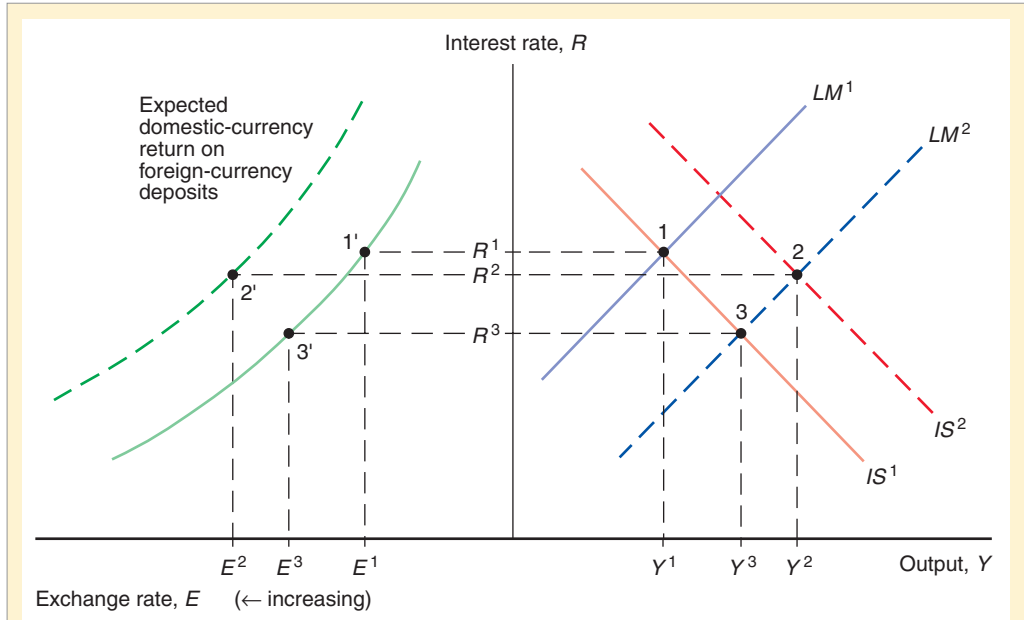
Figure 2

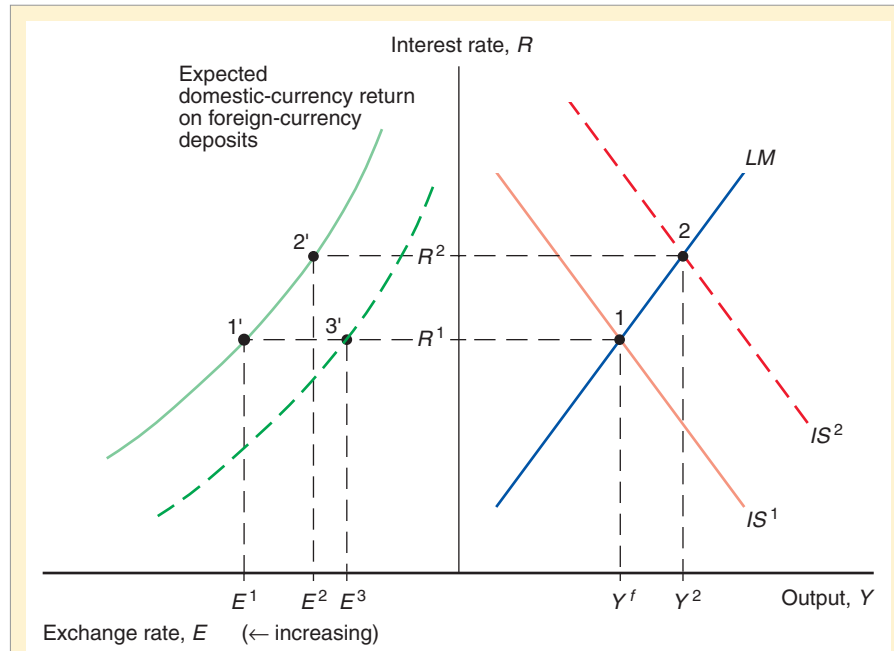**Effects of Permanent and Temporary Increases in the Money Supply in the *IS-LM* Model**

A temporary increase in the money supply shifts the *LM* curve alone to the right, but a permanent increase shifts both the *IS* and *LM* curves in that direction.

this difference is that the interest rate and the exchange rate are inversely related by the interest parity condition, given the expected future exchange rate.[2]

The slope of the *LM* (or money market equilibrium) curve is much easier to derive. Money market equilibrium holds when $M^s/P = L(R, Y)$. Because a rise in the interest rate reduces money demand, it results in an excess supply of money for a given output level. To maintain equilibrium in the money market after R rises, Y must therefore rise also (because a rise in output stimulates the transactions demand for money). The *LM* curve thus has a positive slope, as shown in Figure 1. The intersection of the *IS* and *LM* curves at point 1 determines the short-run equilibrium values of output, Y^1, and the nominal interest rate, R^1. The equilibrium interest rate, in turn, determines a short-run equilibrium exchange rate through the interest parity condition.

The *IS-LM* model can be used to analyze the effects of monetary and fiscal policies. A temporary increase in the money supply, for example, shifts *LM* to the right, lowering the interest rate and expanding output. A *permanent* increase in the money supply, however, shifts *LM* to the right but also shifts *IS* to the right, since in an open economy that schedule depends on E^e, which now rises. The right-hand side of Figure 2 shows these shifts. At the

---

[2]In concluding that *IS* has a negative slope, we have argued that a rise in output reduces the excess demand for output caused by a fall in R. This reduction in excess demand occurs because while consumption demand rises with a rise in output, it rises by less. Notice, however, that a rise in output also raises expected inflation and thus stimulates demand. So it is conceivable that a fall in output, not a rise, eliminates excess demand in the output market. We assume that this perverse possibility (which would give an upward-sloping *IS* curve) does not arise.

Figure 3

Effects of Permanent and Temporary Fiscal Expansions in the *IS-LM* Model

Temporary fiscal expansion has a positive effect on output while permanent fiscal expansion has none.

new short-run equilibrium following a permanent increase in the money supply (point 2), output and the interest rate are higher than at the short-run equilibrium (point 3) following an equal temporary increase. The nominal interest rate can even be higher at point 2 than at point 1. This possibility provides another example of how the Fisher expected inflation effect of Chapter 15 can push the nominal interest rate upward after a monetary expansion.

The left-hand side of Figure 2 shows how the monetary changes affect the exchange rate. This is our usual picture of equilibrium in the foreign exchange market, but it has been reflected through the vertical axis so that a movement to the left along the horizontal axis is an increase in E (a depreciation of the home currency). The interest rate R^2 following a permanent increase in the money supply implies foreign exchange market equilibrium at point $2'$, since the accompanying rise in E^e shifts the curve that measures the expected domestic currency return on foreign deposits. That curve does not shift if the money supply increase is temporary, so the equilibrium interest rate R^3 that results in this case leads to foreign exchange equilibrium at point $3'$.

Fiscal policy is analyzed in Figure 3, which assumes a long-run equilibrium starting point. A temporary increase in government spending, for example, shifts IS^1 to the right but has no effect on *LM*. The new short-run equilibrium at point 2 shows a rise in output and a rise in the nominal interest rate, while the foreign exchange market equilibrium at point $2'$ indicates a temporary currency appreciation. A permanent increase in government spending causes a fall in the long-run equilibrium exchange rate and thus a fall in E^e. The *IS* curve therefore does not shift out as much as in the case of a temporary policy. In fact, it does not shift at all: As in the *DD-AA* model, *a permanent fiscal expansion has no effect on output or*

the home interest rate. The reason why permanent fiscal policy moves are weaker than transitory ones can be seen in the figure's left-hand side (point 3′). The accompanying change in exchange rate expectations generates a sharper currency appreciation and thus, through the response of net exports, a complete "crowding out" effect on aggregate demand.[3]

---

[3]One way the *IS-LM* model differs from the *DD-AA* model is that in the former, monetary expansion can cause a deterioration of the current account (even when there are no J-curve effects) by lowering the real interest rate and thus encouraging domestic spending. We leave it to the interested student to derive the *IS-LM* version of Chapter 16's *XX* curve.