

14

Income and Interest Rates under Fixed Exchange Rates

Overview

In this chapter, we learn:

●●● How interest rates determine investment spending

●●● What money is, and how the supply and demand for money are determined

●●● How equilibria on the real and the financial sides of the economy are established

●●● How fiscal and monetary policies affect output and interest rates

●●● How external equilibrium is defined, and what determines it

●●● What fixed exchange rates imply for monetary policy

●●● How fiscal, monetary and exchange rate policy affect output, exchange and interest rates.

14.1 Introduction

In February 2014, in the face of capital outflows and a weakening currency, the Russian central bank buying up rubles with their holdings of U.S. dollars in the foreign exchange market, and raising interest rates, with rates peaking in early 2015(See Figure 14.1.)

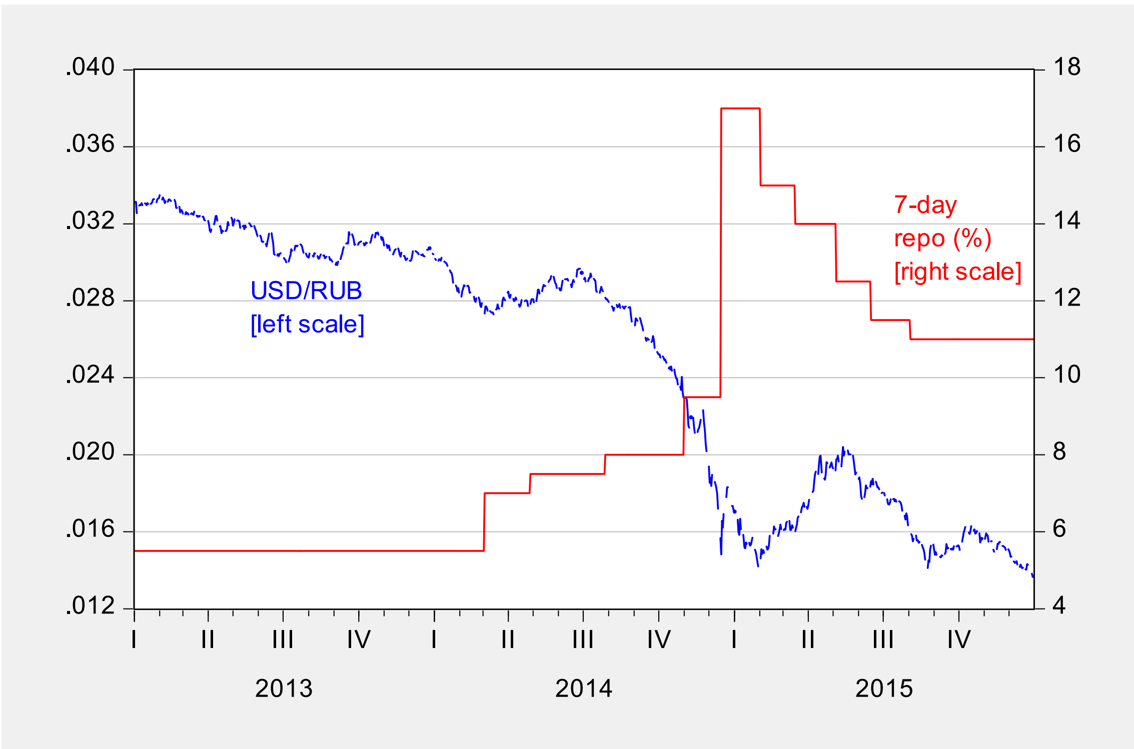

Figure 14.1: The U.S. dollar/Russian ruble exchange rate (1/*S*) (blue, down is a depreciation of the ruble), and the Russian overnight seven day interest rate (red).

Why did Russia's policymakers think these actions would work to stem the flow of capital out of the country? What were the consequences of these measures? We can't answer that question without a model of why and how interest rates are determined, and how higher interest rates affect capital flows.

In this chapter and the next, we develop an integrated model of how the economy interacts with the rest of the world—a model in which savings can move across borders and the value of the currency can change. To begin with, we examine how the economy behaves when the central bank commits to keeping the exchange rate with a foreign currency pegged at a certain value (or close to a certain value).

14.2 An Economy with Money and Interest Rates: the *IS-LM* Model

In order to analyze the role of the financial sector, we modify the model discussed in Chapter 13. This requires that at least one component of aggregate demand depend on a financial sector variable. What we'll do is to let investment in physical capital (factories and equipment) depend on the interest rate. Hence, on the real side of the economy, everything remains the same as in Chapter 13, except for the investment function:

(14.1) $$I = \bar{I} - bi$$

The $\bar{I}$ term is the hypothetical amount firms would invest if the interest rate, i, were zero. This amount $\bar{I}$ is not necessarily constant, but it changes in ways determined by factors outside the model. For instance, a sudden increase in optimism regarding future sales by firm owners might spur greater purchases of plant and equipment, in anticipation of the greater sales.

The variable *i* represents the interest rate on paper assets. In the real world there are many such assets and many available rates of return, but for simplicity we will treat *i* as a single number, the percent interest paid on **bonds**. Bonds represent an alternative way for firmsto devote their resources, besides investing in physical capital: they can buy bonds and thereby lend money to other firms or to the government, with the knowledge that at a future date the resources will come back with a predetermined amount of interest added. We will say more about bonds shortly; for now, the important thing to know is that they are (ideally) completely predictable. (In real life there is always some risk of default, but except with junk bonds it is negligibly small.)

The parameter *b* is the interest sensitivity of investment: it indicates the change in capital investment spending for a one-point change in the interest rate. The minus sign indicates that the higher the interest rate on bonds, the lower the rate of capital investment. Why this relationship between *I* and *i*? Because the higher the interest rate, the higher the *opportunity cost* of investment spending.

To see how this works, imagine a firm, *k*, and consider all the capital investment projects it could conceivably undertake. In Figure 14.2 these projects are ranked from left to right by their rate of return (*RoR*), highest to lowest. The width of each bar corresponds to the cost of the project. The higher the rate of return, the more generously an investment will pay off, and therefore the more attractive the project.

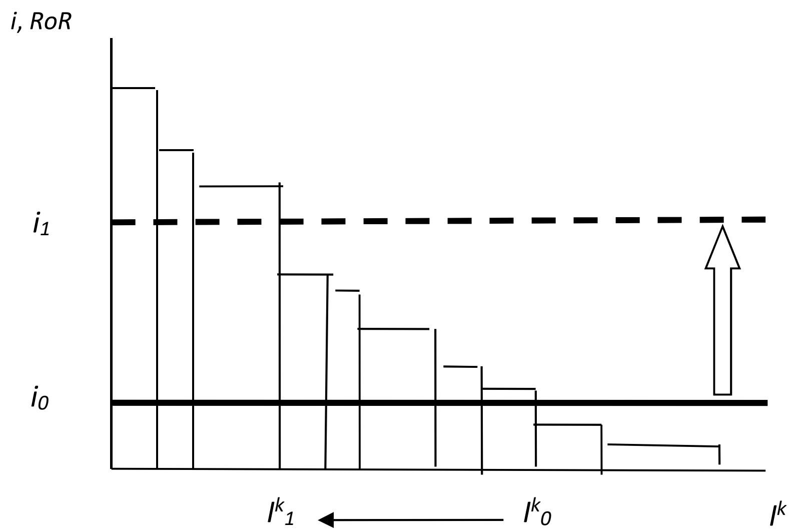

Figure 14.2: Investment projects and rates of return facing firm *k*, and interest rates

When the firm decides which projects to undertake, obviously the most attractive projects are first in line. But how far down the line will the firm go? It depends on the interest rate paid by bonds. When the rate is i_0, then the first eight projects, representing a total investment of I^k_0 , provide a rate of return in excess of the interest rate -- the return the firm would gain from buying bonds instead. The firm will therefore find it to its advantage to invest in projects up to amount I^k_0.

If, now, the interest rate rises to i_1 (the white arrow), then only the top three projects' returns exceed the new rate. The firm will now proceed only on these projects, representing a total cost of I^k_1, which is less than the original amount of I^k_0. Investment spending by the firm declines (the thin arrow).

To summarize, at the firm level there is a negative relationship between the interest rate and investment spending in plant and equipment. The same holds true when one aggregates up to the economy level, since all the firms face a similar decision, and so we have the relationship between *i* and *I* described by Equation (14.1). If we now modify our analysis in Chapter 13 to incorporate our revised model of investment, then by replacing $\bar{I}$ with $\bar{I} - bi$ we obtain the following revised version of Equation (13.7):

(14.2) $$Y = \bar{\alpha}[\bar{A} + \bar{X} - \overline{IM} + (n + v)\bar{q} - bi]$$ <*IS* curve>

Recall that in Chapter 13, component *C* of aggregate demand was a function of *Y*, $C = \bar{C} + c(Y - \bar{T})$. Therefore, Equation (13.7) ended up containing just one endogenous variable, *Y*. Here, by contrast, *I* is a function of a new endogenous variable, *i*, and so Equation (14.2) contains not one endogenous variable but two. If we set up a coordinate system with a horizontal *Y*-axis and a vertical *i*-axis—which we will do very shortly—then Equation (14.2) represents a line, rather than a point with a specific value for *Y*. (That's why there is no longer a 0 subscript on the Y.)

The line is called the ***IS* curve**, because it represents the balance firms strike between *I*nvestment in physical capital and *S*aving, understood as resources that households do not consume but rather save,[1] The downward slope of the line expresses a significant fact about the relationship between interest rates and national productivity: as the interest rate goes up, firms are more inclined to save and less inclined to invest, which causes productivity to decline.

Modeling the Financial Sector

Equation (14.2) describes the relationship between Y and i in the real sector of the economy, where goods and services are produced. That was the focus of Chapter 13 and has been the focus of this chapter so far. Now we turn to the financial sector, and to the role of **money**.

We often use the term money as interchangeably with income. In our model, money is an asset that is used to facilitate transactions and store wealth. . More concretely, we can picture money as pieces of paper (green, in the U.S.), but its distinguishing *functional* characteristic is that it is a means of conducting transactions, and secondarily as a store of wealth. Bonds earn returns but cannot easily be used in transactions. Money yields no returns,[2] but since firms households must conduct transactions they will want to hold a certain portion of their total wealth in the form of money.

In the economy's real sector, firms' choices lead to equilibrium between investment and saving. We will now model the financial sector as a market where bonds and money change hands.

It would be reasonable to represent the financial sector as a market in bonds, graphically depicted with the bonds on the horizontal axis and their price on the vertical axis. However, for our purposes it will instead be convenient to represent the financial sector as a market in *money*, which is the flip side of the same coin.[3]

Equilibrium in the money market is described by the standard condition that quantity demanded equals quantity supplied. Dividing by the price level, P, gives the condition in real (inflation-adjusted) terms:

$$\frac{M^d}{P} = \frac{M^s}{P} \tag{14.3}$$

Money supply is assumed to be given exogenously, set by the central bank. That means that the number of pieces of paper called money circulating through the economy is a number the central bank decides on and has the ability to change at will. That's why we put an overbar over the M.[4]

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[2] That, at least, is our simplifying assumption. In reality, the differences between money and bonds are not quite so sharp. After all, money in a savings account earns interest.

[4] We hold the price level constant and therefore place an overbar over the P, as well.

(14.4) $$\frac{M^S}{P} = \frac{\bar{M}}{\bar{P}}$$

Money demand is a positive function of income and a negative function of the interest rate.

(14.5) $$\frac{M^d}{P} = kY - hi$$

Money demand rises with income, because it is assumed that greater income goes hand in hand with a greater number of transactions and therefore a greater need for money to conduct them. The parameter k is the **income sensitivity of money demand**, the change in dollars of money demanded for a one-unit change in real income.

The parameter h is the **interest sensitivity of money demand**, the change in dollars demanded when the interest rate rises by one percentage point. Why does money demand depend negatively on the interest rate? Since the interest rate is the return on the alternative asset (bonds), and it can be interpreted as the opportunity cost of holding money. Alternatively, the interest rate can be understood as the cost of borrowing. Someone who wants more money on hand must pay interest *i* to obtain it. Either way, the interest rate is the cost of holding money. The higher the cost, the less money actors will hold.

Notice, we assume that in the money market, the central bank is the supplier and all other actors—firms, households, the government—make up the demand side. We do not care about money market interactions internal to the demand side, because what we are interested in is the central bank's role in determining the total amount of money in circulation. Money transferred from firm *k* to firm *j* was in circulation before and remains in circulation afterward, only now held by firm *j* instead of firm *k*. By contrast, money in the central bank's vaults is officially out of circulation; it enters circulation when the central bank uses it to pay for assets in the domestic market or the foreign exchange market.[5]

Returning, now, to our mathematical analysis, we substitute Equations (14.4) and (14.5) into Equation (14.3) and solve for the interest rate:

(14.6) $$i = -\left(\frac{1}{h}\right)\left(\frac{\bar{M}}{\bar{P}}\right) + \left(\frac{k}{h}\right)Y$$ <*LM* curve>

Again we have a linear relationship between *Y* and *i*, this time representing the equilibrium between money and bonds in the financial market. This line is called ***LM* curve**, because it represents the value actors in the economy attach to the **Liquidity** of *M*oney, meaning its ready availability for transactions. The higher the level of economic activity, as indicated by income *Y*, the greater the need for liquidity, and the more actors must expect to pay (given a fixed amount of money circulating), in the form of interest *i*, to hold money. Thus for the *LM* curve, *i* is

[5] On the domestic side, we model those assets as bonds; see Section 14.5.

positively dependent on *Y*.[6]

We have two equations, (14.2) and (14.6), with the same two unknowns. We can substitute the latter into the former and then solve for *Y* to obtain an updated version of Equation (13.20) giving the equilibrium income:

(14.7) $$Y_0 = \underbrace{\left(\frac{1}{1-c+m+\frac{bk}{h}}\right)}_{\equiv\hat{\alpha}}[\bar{A} + \bar{X} - \overline{IM} + (n+v)\bar{q} + \left(\frac{b}{h}\right)\left(\frac{\bar{M}}{\bar{P}}\right)]$$

Notice that equilibrium income now depends on the level of autonomous spending, the real exchange rate, and the money stock (in real terms). The equilibrium interest rate, i_0, can be found by using Equation (14.7) to substitute into Equation (14.6). Notice also that the new multiplier, $\hat{\alpha}$, is made smaller than the old one, $\bar{\alpha}$, by the addition of the *bk*/*h* term in the denominator. This will be discussed further in the next section.

Graphically, Y_0 is the income at the point of intersection in a Keynesian Cross where the aggregate demand function has been modified by replacing Ī with $I = \bar{I} + \left(\frac{b}{h}\right)\left(\frac{\bar{M}}{\bar{P}}\right) - \left(\frac{bk}{h}\right)Y$ on the basis of Equations (14.1) and (14.6). But the Keynesian Cross doesn't display the interest rate. If we plot Equations (14.2) and (14.6) with *Y* on the horizontal axis and *i* on the vertical, we obtain a visual depiction of the *IS-LM* model, as it's called; see Figure 14.3. This model is

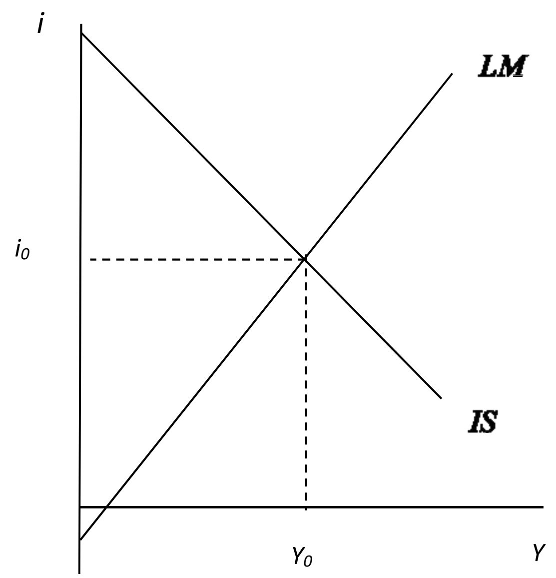


Figure 14.3: *IS-LM* equilibrium

Equilibrium income and interest rates are determined by the intersection of the two curves. Note

[6] The name "LM curve" is an abbreviation for "liquidity preference equals money supply", where liquidity preference is an older term for money demand.

the following characteristics of these curves:

- The position of the *IS* curve depends on $\bar{A}, \bar{X}, \overline{IM}$, and $\bar{q}$, which together determine the intercept on the *Y*-axis. Increases in $\bar{A}, \bar{X},$ and $\bar{q}$ shift the *IS* curve to the right (outward), while an increase in $\overline{IM}$ shifts in the curve to the left (inward).

- The position of the *LM* curve depends on the real money stock, $\bar{M}/\bar{P}$, which determines the intercept on the *i*-axis. An increase in $\bar{M}$ shifts the *LM* curve downward—or, what amounts to the same thing, rightward.

The intersection point (Y_0, i_0) is where the economy and all its submarkets are in equilibrium.

14.3 Policy Options for Affecting Output

It's easiest to explain the intuition for the IS-LM model by showing how policy works in model. First we'll consider fiscal policy (as discussed in Chapter 13), second, monetary policy and finally, exchange rate policy.

Fiscal Policy

An increase in government spending increases autonomous spending (remember that $\bar{G}$ is part of $\bar{A}$); initially aggregate demand rises by $\Delta G = \Delta A$. To meet the aggregate demand, more goods have to be produced, and production requires that the factors of production have to be paid. With the resulting income, households have higher disposable income, a portion of which they consume. In the absence of effects due to investment and the demand for money, the multiplier effect described in Chapter 13 will kick in: each real dollar's worth of increase in government spending yields a series of spending increases $\Delta G + (c - m)\Delta G + (c - m)^2\Delta G \ldots$. In Figure 14.4, the government spending increase shows up as a rightward shift of the *IS* curve (gray arrow) by a distance $\bar{\alpha}\Delta G$, so that if interest rates were to stay constant, income would rise to Y'_0.

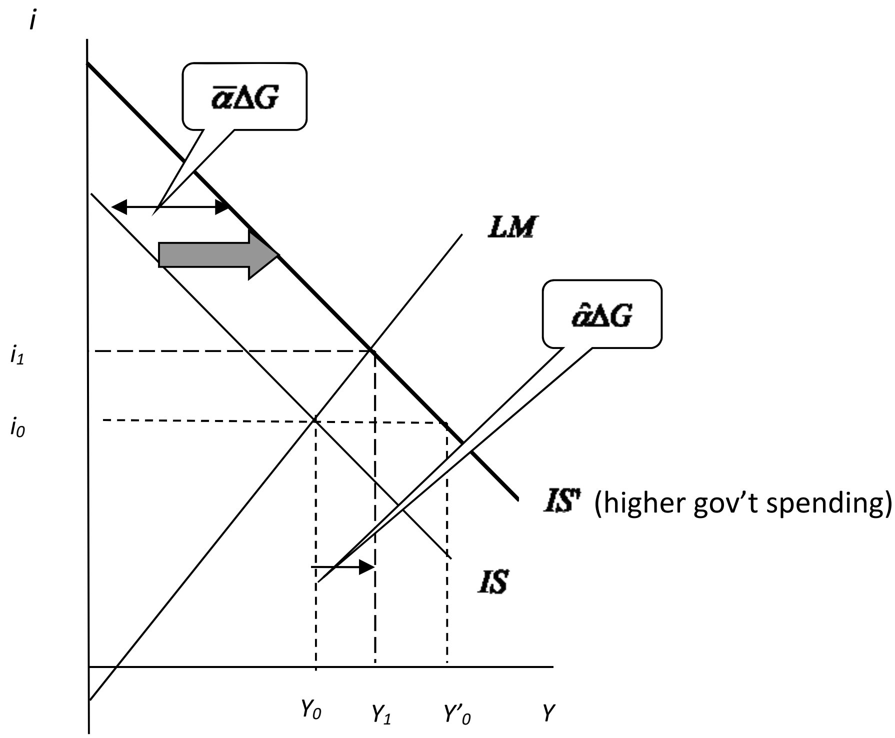


Figure 14.4: Expansionary fiscal policy in the IS-LM model

What happens, now, if we incorporate the effects from investment and the demand for money, as reflected in the interest rate? Recall that money demand depends on income. As GDP and income rise (due to the above mechanism), the quantity of money demanded rises. However, the central bank is assumed to hold the money supply constant. If, initially, the quantity of money demanded equaled the quantity of money supplied (i.e., the economy was on the LM curve), then without a change in the interest rate, the quantity of money demanded will exceed the quantity of money supplied. The interest rate must rise to keep the quantity of money demanded in equilibrium with the (fixed) quantity of money supplied.

Due to the higher interest rate, income does not rise to Y'_0 (which would have been the case using the model in Chapter 13) but only to Y_1. Equivalently, the increase in output $\hat{\alpha}\Delta G$ is smaller than what would have been implied by the simple Keynesian multiplier, $\overline{\alpha}\Delta G$.

The increase in output is less in this model because of **crowding out**. Higher government spending leads to higher output, which leads to more transactions, which leads to higher demand for money. That, given a constant money supply, results in a higher interest rate. The higher interest rate depresses investment spending, thereby offsetting in part the increase in output. What has happened is that economy-boosting government spending has partly crowded out spending by firms. Output still increases, but not as much as it does without the crowding out effect.

Monetary Policy

Now we turn to monetary policy, which in this model means changes in the money supply.[7] If $\overline{M}$ is increased while $\overline{P}$ remains constant, then $\overline{M}/\overline{P}$ rises, and the LM curve shifts rightward, as shown by the gray arrow in Figure 14.5.

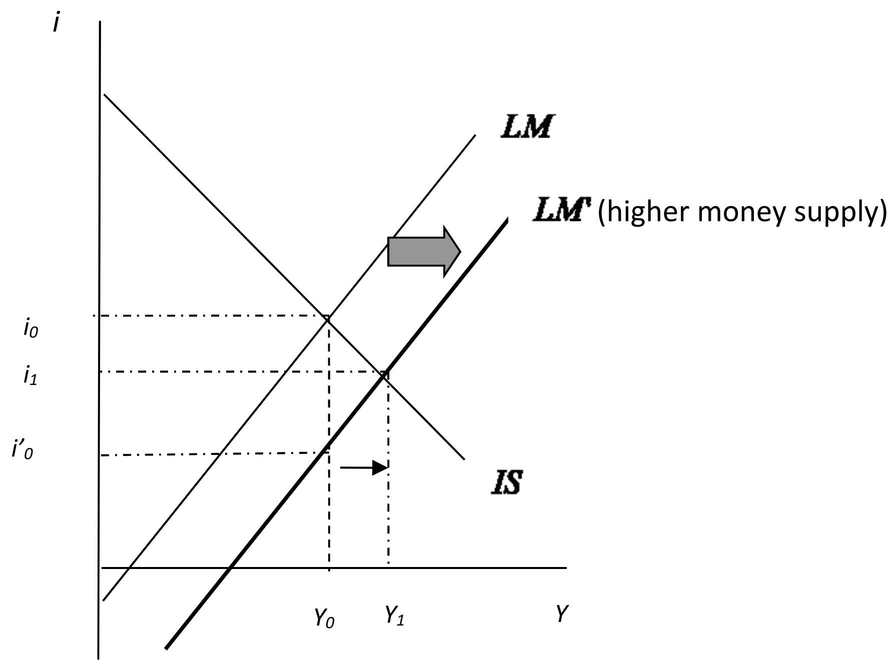


Figure 14.5: Expansionary monetary policy in the *IS-LM* model

When the money supply increases, at the original income levels and interest rates there is an excess quantity of money. This excess quantity of money implies an excess demand for bonds; the resulting rise in the price of bonds is the same as a decline in the interest rate, i.e., a decline in the return on bonds.[8] . Holding income constant, the interest rate would fall to i'_0. That, however, is not the end of the story. The lower interest rate results in a higher level of investment spending (recall Figure 14.2), which means a higher level of aggregate demand and hence output (which in turn induces some additional money demand). Interest rates end up at i_1, and income at Y_1.

To sum up, expanding the money supply drives down interest rates and hence spurs investment, which increases income. This makes expansionary monetary policy part of the toolkit for any central bank seeking to keep GDP from slipping downward. The U.S. Federal Reserve, which is formally charged with keeping the unemployment under control, is a case in point.

[7] In the real world, many central banks (including the United States') target a particular interest rate and make whatever adjustments to the money supply will drive the interest rate to that point. Then monetary policy is often described as focusing on the interest rate the central bank controls. An increase in the money supply, holding everything else constant, is the same as a decrease in that interest rate.
[8] To see this, consider a coupon bond which pays $10 per year, with a market price of $100; the current yield, or interest rate, is 10%. If the price were to rise to $110, then the current yield would be 9.1$.

Exchange Rate Policy

Finally, consider the impact of exchange rate policy. An increase in the real exchange rate that makes the domestically produced goods more affordable than their foreign counterparts increases net exports (more exports, fewer imports), which results in an increase in aggregate demand. This has the same overall effect as government spending, namely to shift the IS curve in Figure 14.6 rightward (gray arrow), resulting in an increase in output. Once again, however, the effect is partly undercut by diminished investment due to the higher interest rate.

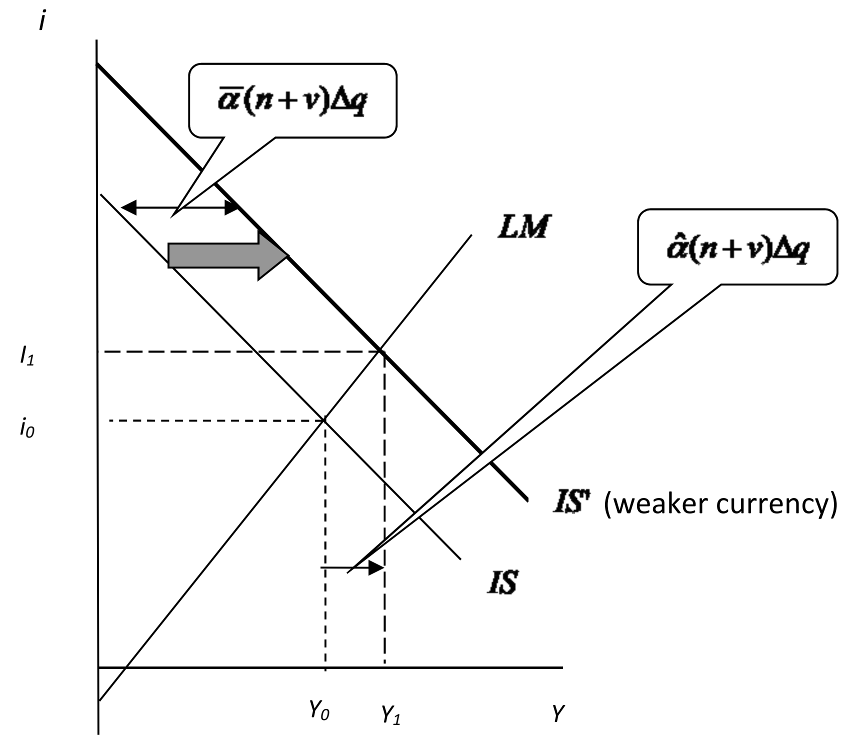


Figure 14.6: Exchange rate devaluation in the IS-LM model

The Relative Magnitudes of Policy Effects

We can relate the magnitude of the change in the economy's output, *Y*, to changes in the policy variables. Take equation (14.7), and break it up into the constituent changes (i.e., take a total differential):

(14.8) $$\Delta Y = \hat{\alpha}[\Delta A + \Delta X - \Delta IM + (n+v)\Delta q + \left(\frac{b}{h}\right)\Delta\left(\frac{M}{P}\right)]$$

Then the change in income, or GDP, can be attributed to a combination of changes in the amount of autonomous spending, changes in the money supply, or changes in the real exchange rate.

To determine the impact of changes from just one of those factors, one sets all the other changes to zero. For government spending *only*, after re-arranging, one obtains the following:

$$\frac{\Delta Y}{\Delta G} = \hat{\alpha} \geq 0$$

For a change in the real money supply *only*, the impact on income is:

$$\frac{\Delta Y}{\Delta (M/P)} = \hat{\alpha}\left(\frac{b}{h}\right) \geq 0$$

The final policy tool in our model is **devaluation**/**revaluation** of the real exchange rate. For a change in this rate *only*, the impact on income is:

$$\frac{\Delta Y}{\Delta q} = \hat{\alpha}(n + v) \geq 0$$

If the exchange rate rises (devalues or depreciates), then exports increase and imports decrease, leading to a boost in income, which is magnified by way of the usual multiplier process.

14.4 Introducing an External Balance Condition

Thus far, we haven't incorporated any restrictions on how exchange rates or financial flows might be affected by the country's interaction with the rest of the world. In order to account for that interaction, we need to include some sort of equilibrium condition that reflects the addition of the rest of the world as, in effect, another sector in our model of the economy.

This new condition is based on the balance of payments identity, which was described in Chapter 11. Recall that by this identity, the current account, the financial account, and official reserves transactions must sum to zero:

(14.9) $$CA + FA + ORT \equiv 0$$

This means that if there is a deficit on the current account, one of two things must be true. Either the financial account is in surplus, $FA > 0$, meaning that foreigners are lending domestic actors enough to finance the deficit, or else foreign exchange reserves are declining, $ORT > 0$, because the central bank is exchanging domestic currency for foreign currency to facilitate foreign imports.

Our equilibrium condition related to the balance of payments is that official reserves transactions are zero. On the assumption that the current account can be approximated by the trade balance, we use $TB + FA$ to represent the balance of payments and require that this equal zero:

(14.10) $$TB + FA = 0$$

That is, our definition of external equilibrium is a condition where foreign exchange reserves are neither increasing nor decreasing. This is a reasonable condition, since it's sustainable. In concrete terms, this means that if the country is running a trade deficit, importing more that it exports, then the rest of the world must be willing to lend enough to finance that deficit. If exports are purchased by foreigners with foreign currency, and imports are purchased with foreign currency held by the home country, then foreigners must be willing to lend enough foreign currency to make up the difference.

We have already described the behavior of the trade balance in Chapter 13. However, we have yet to say anything about what the financial account depends on. As usual, we use a linear function with an autonomous constant term and a linear term:

(14.11) $$FA = \overline{FA} + \kappa(i - \bar{\imath}^{*})$$

The parameter κ is the sensitivity of financial flows to the interest differential. That is, κ describes the extent to which a higher domestic interest rate, i, compared to the interest rate in the foreign country, $\bar{\imath}^{*}$, promotes foreign purchases of domestic debt instruments—in our model, domestic bonds.

The higher the interest rate differential, $i - \bar{\imath}^{*}$, the more financial capital flows into the home country, holding all else constant. This is simply a reflection of the fact a higher return on domestic financial assets makes those assets attractive those assets to foreign purchasers. So, for instance, a foreign firm that could earn interest $\bar{\imath}^{*}$ on bonds issued by its own government or higher interest i by purchasing a U.S. government bond will tend to prefer the latter. The bond purchase constitutes a loan to United States and thus an inflow of resources.

Substituting the expression for the trade balance (exports $\bar{X}$ minus imports $\overline{IM}$) and the just-developed expression for the financial account into Equation (14.10), we can then re-arrange to solve for the interest rate and thereby obtain the ***BP* = 0 curve**:

(14.12) $$i = -\left(\frac{1}{\kappa}\right)[(\bar{X} - \overline{IM} + \overline{FA}) + (n+v)q] + \bar{\imath}^{*} + \left(\frac{m}{\kappa}\right)Y \qquad \text{<}BP = 0\text{ curve>}$$

The overbar over $i*$ indicates that the foreign interest rate is treated as given (or exogenous). Notice that the slope of this curve is positive (m/κ), and that anything that changes the autonomous components of exports, imports, and financial flows ($\bar{X}, \overline{IM},$ and $\overline{FA}$) will shift the curve. So, too, will changes in q.

The *BP* = 0 curve is the combination of all points for which the trade balance and financial flows are such that the balance of payments equals zero, so that official foreign exchange reserves do not change. The slope of the *BP* = 0 curve is positive because higher income is associated with higher imports and a lower trade balance; to maintain *TB* + *FA* at zero, then, financial inflows must be higher. This occurs when the interest rate is higher, holding foreign interest rates constant.

The *IS* and *LM* and *BP* = 0 curves are all shown in Figure 14.7. The figure pictures an economy in equilibrium both internally and externally, at interest rate i_0 and income level Y_0. This model combining the *IS-LM* model and an external condition related to the balance of payments is called the IS-LM-BP model. It is also called the **Mundell-Fleming model**.[9]

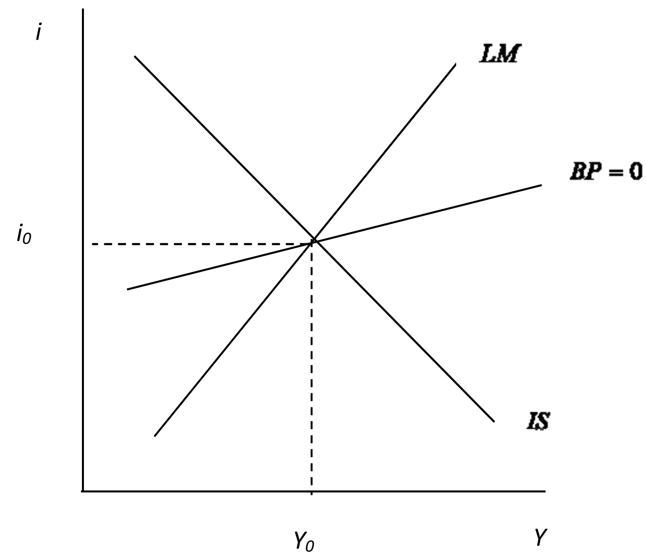


Figure 14.7: Equilibrium in the IS-LM-BP model

14.5 Policy Options under Fixed Exchange Rates

Fiscal Policy

We now examine the implications of the model when policymakers fix the exchange rate. In the fixed exchange rate situation, q does not change unless the government devalues or revalues the currency.[10] To denote the fact that the real exchange rate is controlled by the central bank, and is changed exogenously, we will put a bar over q, hence $\bar{q}$.

Shifts in the *IS* and *LM* curves occur for the same reasons as before. Consider what happens if government spending increases, as shown in Figure 14.8. The *IS* curve shifts outward (denoted by the gray arrow).

[9] The original references are Fleming (1962) and Mundell (1963).
[10] In reality the central bank sets the *nominal* exchange rate, S. If the price level is fixed at home and abroad, then the real exchange rate is also fixed.

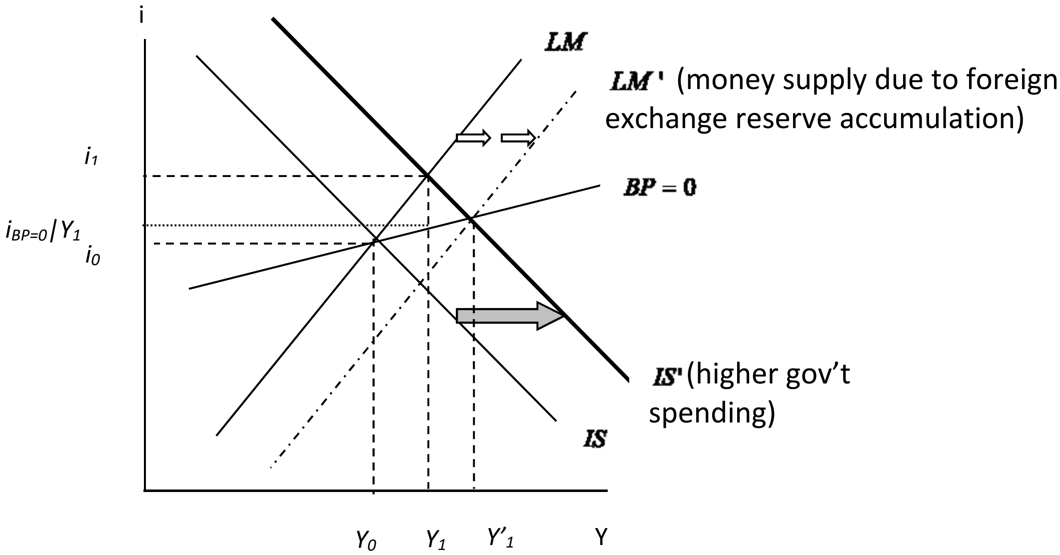


Figure 14.8: Expansionary fiscal policy with fixed exchange rates and high capital mobility

In this case, the equilibrium income and interest rate rise. Notice that the new equilibrium interest rate, i_1, is higher than that consistent with external equilibrium (i.e., $BP = 0$). As a consequence, the balance of payments is in surplus, so $ORT < 0$, and foreign exchange reserves are increasing.

What happens next depends critically on the actions of the central bank. The increase in foreign exchange reserves implies an increase in currency or bank reserves (i.e., money), unless some offsetting action is undertaken. Any such offsetting action is termed **sterilization**. In the absence of sterilizing intervention, the *LM* curve will shift rightward to the new *LM* (white arrows), setting income at level Y'_1. However, if the central bank sterilizes the inflow, then the *LM* curve remains at Y_1.

To show why a net financial inflow causes an *LM* shift in the absence of sterilization, we have to digress in order to examine the workings of the central bank. A central bank purchases domestic assets (such as government bonds) and foreign exchange, and pays by issuing currency and crediting private banks with bank reserves. The central bank balance sheet, in Table 14.1, reflects the cumulative effect of these operations:

Central Bank
Balance Sheet

Assets	Liabilities
Domestic Assets (DA)	Currency (CU)

Foreign exchange reserves (FXRes)	Bank reserves (Res)

Table 14.1: Central Bank Balance Sheet

The sum of central bank liabilities (**currency** and **bank reserves**) is termed the **money *base***. This is technically different from the money supply, which determines the position of the LM curve, but for our purposes, we will just assume that when the money base increases, the money supply increases.[11]

The central bank typically increases or decreases the money supply by conducting **open market operations**. For instance, in Section 14.2, the central bank would increase the money supply by buying **domestic assets**, such as government bonds (*DA* in Table 14.1) from the private banks, paying for them with currency.

Suppose, now, that there is a financial inflow that more than offsets a trade deficit. This will cause foreign exchange reserves (*FXRes*) to rise. Notice that when *FXRes* rises on the asset side of the balance sheet, then the money base also rises. For instance, if the *FXRes* rises by the equivalent of 1 billion Chinese yuan, then the effect on the central bank balance sheet will be as shown in Table 14.2. The resulting increase in the money supply leads to the outward shift in the LM curve shown in Figure 14.6.

Central Bank Balance Sheet

Assets	Liabilities
	+1 CNY (CU)
+1 CNY (FXRes)	

Table 14.2: Change in Balance Sheet due to Unsterilized Balance of Payments Surplus

What happens in the case of sterilization, by contrast, is that the central bank keeps the money supply constant by selling *DA* in exchange for currency. The process of exactly offsetting the

[11] The money supply consists of currency and checking deposits; the former is a liability of the central bank, while the latter is a liability of the private banking system. If banks are forced to hold a minimum amount of bank reserves as a share of total checking deposits (say 10%, so \$100 deposits requires \$10 bank reserves), then there will be a fixed relationship between money supply and money base. (This assumes that the private banks do not hold any reserves above the required minimum.)

increase in *FXRes* with a decrease in *DA* is termed a "sterilization of reserve accumulation." This is illustrated in Table 14.3. The net change in the money base is zero. So then, if the inflow is sterilized, then the *LM* curve does not shift outward in Figure 14.8.

Central Bank
Balance Sheet

Assets	Liabilities
	+1 CNY
-1 CNY (DA)	-1 CNY (CU)
+1 CNY (FXRes)	

Table 14.3: Change in Balance Sheet due to Sterilized Balance of Payments Surplus

In Figure 14.8, the $BP = 0$ curve is drawn flatter than the *LM* curve; this flat $BP = 0$ curve arises because κ is large relative to m. This situation is often characterized as a case of high **capital mobility**: financial flows respond strongly to small interest rate changes in interest rate differentials—and therefore to small changes in the domestic interest rate, given that the foreign interest rate is assumed to be fixed.

Nothing, however, guarantees that the $BP = 0$ line, with slope m/κ, will be flatter than the *LM* curve, with slope k/h. One can imagine that international investors might be reluctant to place their financial capital in, say, a small, developing country unless the capital will earn a very high rate of return. Under those conditions, financial flows will not be very sensitive to interest differentials, making κ small. Then the slope of the $BP = 0$ curve will be steep, perhaps steeper than that of the LM curve.

Under those conditions, the effect of a fiscal expansion will be as depicted in Figure 14.9. The IS curve shifts outward (the gray arrow), and output and the interest rate rise as before. Now, however, the equilibrium interest rate is *lower* than that required for external equilibrium. Hence, $BP < 0$, $ORT > 0$, and foreign exchange reserves decline. If the central bank does not sterilize the foreign reserves' decline, then the *LM* curve will shift inward until external equilibrium is restored at income Y_0 If the central bank does sterilize, then the *LM* remains where it was, with income at Y_1. Of course, this must come to an end when foreign exchange reserves are depleted.

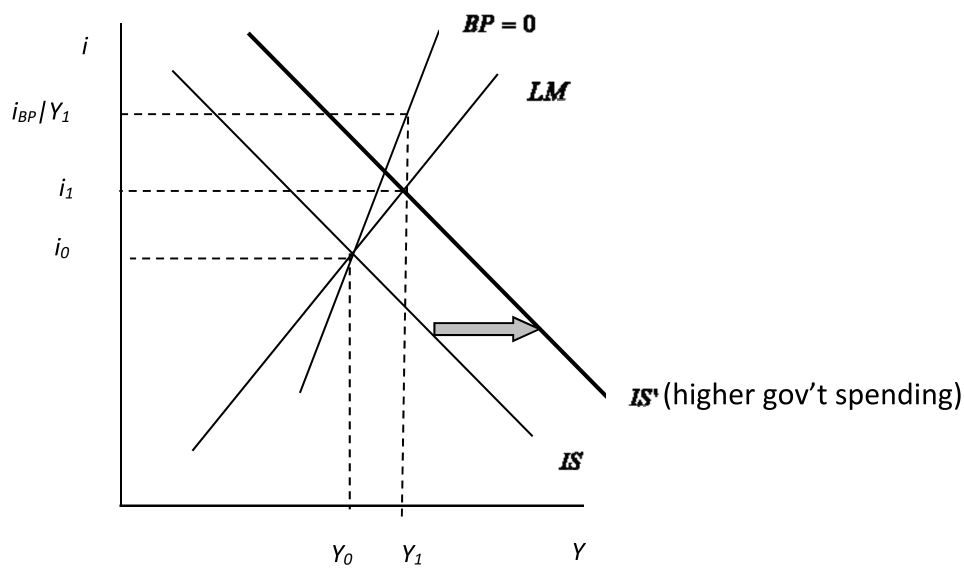


Figure 14.9: Expansionary fiscal policy with fixed exchange rates and low capital mobility

Monetary Policy under Fixed Exchange Rates

Now we consider monetary policy, by examining the case of high capital mobility in Figure 14.10 (The low mobility scenario yields the same result.) An expansion of the money supply shifts the *LM* curve shifts outward, driving the interest rate down to i_1.

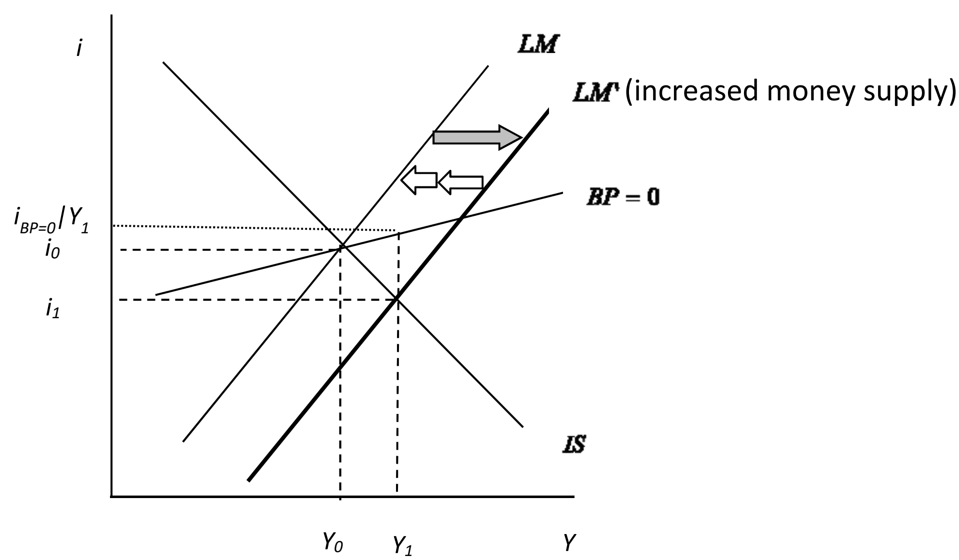


Figure 14.10: Expansionary monetary policy with fixed exchange rates and high capital mobility

In this case, the resulting equilibrium interest rate i_1 is less than what is required for external equilibrium. ($i_{BP=0}|Y_1$) As a consequence, there is a balance of payments deficit, $ORT > 0$, and foreign exchange reserves are run down. In the absence of offsetting sterilization by the central bank, the money supply shrinks, and the *LM* curve shifts back (white arrows). This process stops only when the interest rate is back at i_0—in other words, when the monetary policy is undone.

This happens because monetary policy is subordinated to the pegging of the exchange rate.

If the central bank were instead to shrink the money supply, shifting the *LM* curve inward, then the reverse process would occur. The resulting higher interest rate would draw in financial flows in amounts exceeding what is needed to maintain foreign exchange reserve levels. The increase in foreign exchange reserves would result in a corresponding increase in the amount of domestic currency circulating, thereby increasing the money supply. That process undoes the initial monetary policy.

The fact that monetary policy is undone by the response of capital flows is a demonstration of the loss of a country's **monetary autonomy** when it enters into a fixed exchange rate system. Since the loss of foreign exchange reserves is faster when capital mobility is high, then the higher the degree of capital mobility, the greater the loss in autonomy. (This applies when countries use market forces to set the equilibrium exchange rate at the official pegged rate. Sometimes countries also use **capital controls** and other exchange restrictions to set the rate at the official rate, as in the case of China.)

As noted above, this process can be delayed by sterilization. Again, however, sterilization of can continue only as long as the central bank possesses foreign exchange reserves. When reserves are exhausted, sterilization is no longer feasible, and the money supply will once again be out of the central bank's control. Sterilization of capital inflows does not face the constraint of foreign exchange reserves; in principle reserves could increase without bounds. However, in order to maintain the money base so as to keep the money supply constant, the central bank has to sell domestic assets as the stock of foreign exchange increases. Here it is the exhaustion of the stock of domestic assets the central bank holds that puts an end to sterilization. At that point, the money supply increases.

The greater the degree of capital mobility, the less the scope for monetary autonomy. At the limit, when capital mobility is infinite ($\kappa = \infty$), under fixed exchange rates there is no monetary autonomy whatsoever. Under this condition, policymakers must choose either a fixed exchange rate with no monetary autonomy or monetary autonomy and a freely floating exchange rate. This choice is part of the International Trilemma discussed at further length in Section 15.8.

Responding to Balance of Payments Deficits: Devaluation vs. the Interest Rate Defense

In our model, the government exerts control over the economy through three levers: fiscal policy, monetary policy, and the value of the currency. By changing the value of the currency—which the central bank does by exchanging home currency for foreign in large quantity—the government can affect the level of economic activity. This comes about mainly by changes in the relative prices of home and foreign goods.

Suppose a country faces a balance of payments deficit, as shown in Figure 14.11. Notice that initially, the equilibrium interest rate is below that consistent with equilibrium. Under these conditions, a devaluation could be a particularly useful policy. Notice that q enters into both the $BP = 0$ equation and the *IS* equation; hence a devaluation would shift both curves (gray arrows).

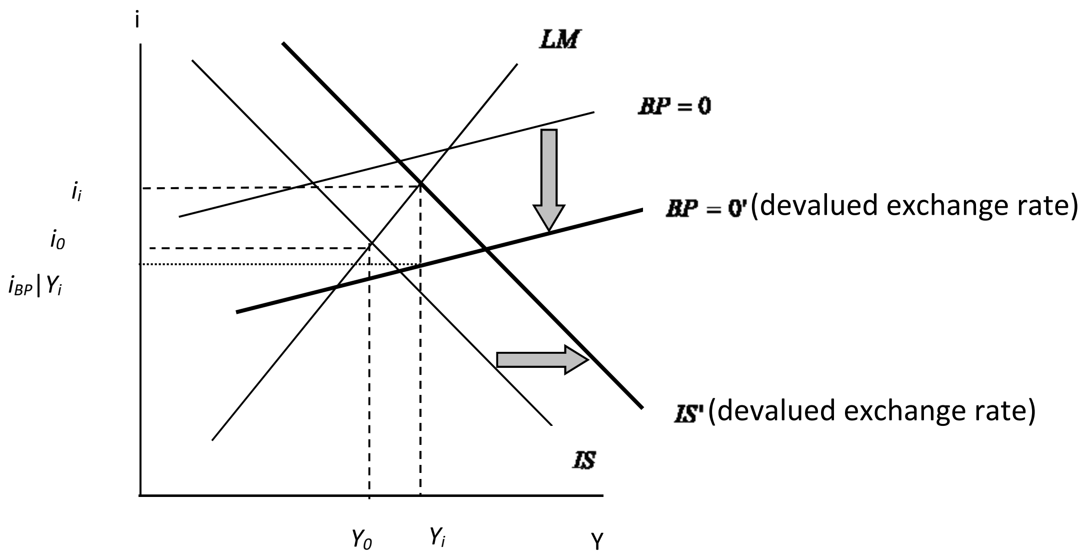


Figure 14.11: Devaluation from an initial balance of payments deficit

At the new equilibrium, the balance of payments is in surplus, since interest rate i_1 is greater than rate $i_{BP|Y1}$. The balance of payments problem has been remedied, and in fact foreign exchange reserves will now accumulate.

The balance of payments surplus will be undone over time, however, if the central bank does not sterilize the reserve accumulation. As foreign exchange reserves rise, the money base increases, shifting the LM curve outward. Eventually, the interest rate will fall to the level consistent with external balance, and reserve accumulation ceases.

Now, let's return to the question raised at the beginning of the chapter. Why would raising the interest rate – what is called an **interest rate defense** -- remedy a balance of payments deficit? We start with the same conditions as in Figure 14.11, but now the central bank raises the interest rate by tightening monetary policy so that the LM curve shifts inward (gray arrow), as in Figure 14.12.

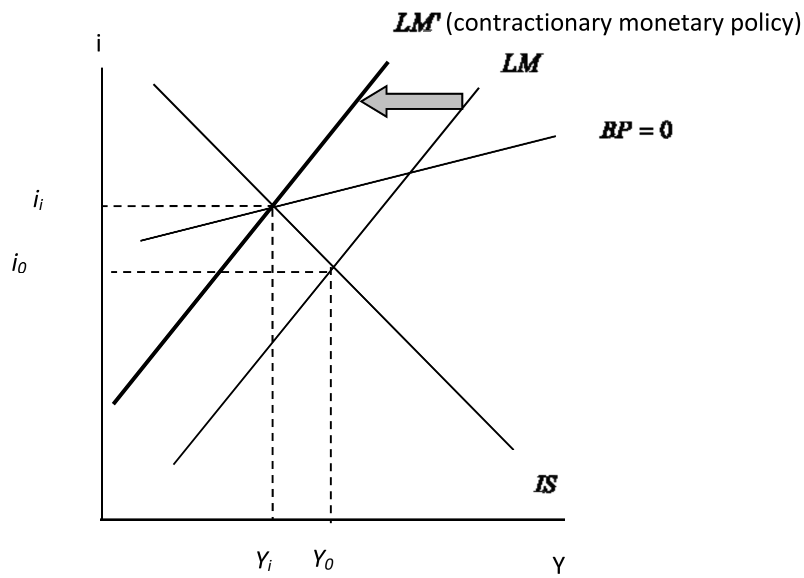


Figure 14.12: Interest rate defense in a balance of payments deficit

The resulting equilibrium is sustainable in terms of the balance of payments, but, as depicted in Figure 14.12, would result in a lower level of income. Hence, the interest rate defense brings with it serious costs.

Rarely do central banks use just one of the tools available to them. In 2014, Russia used the interest rate defense and subsequently allowed the currency to weaken. The interest rate defense worked at the cost of weakening the economy. As financial capital outflows increased, the currency weakened despite the interest rate defense, and eventually, by mid-2015, the central bank relented, allowing the currency to weaken in value.

14.6 Application: China's Surpluses and Reserve Accumulation

One of the best illustrations of the impact of a fixed exchange rate is China. Beginning in 2002, China began running significant current account surpluses (Figure 14.13). These surpluses arose from a variety of factors, including China's joining the World Trade Organization, which could be interpreted as an exogenous increase in net exports.

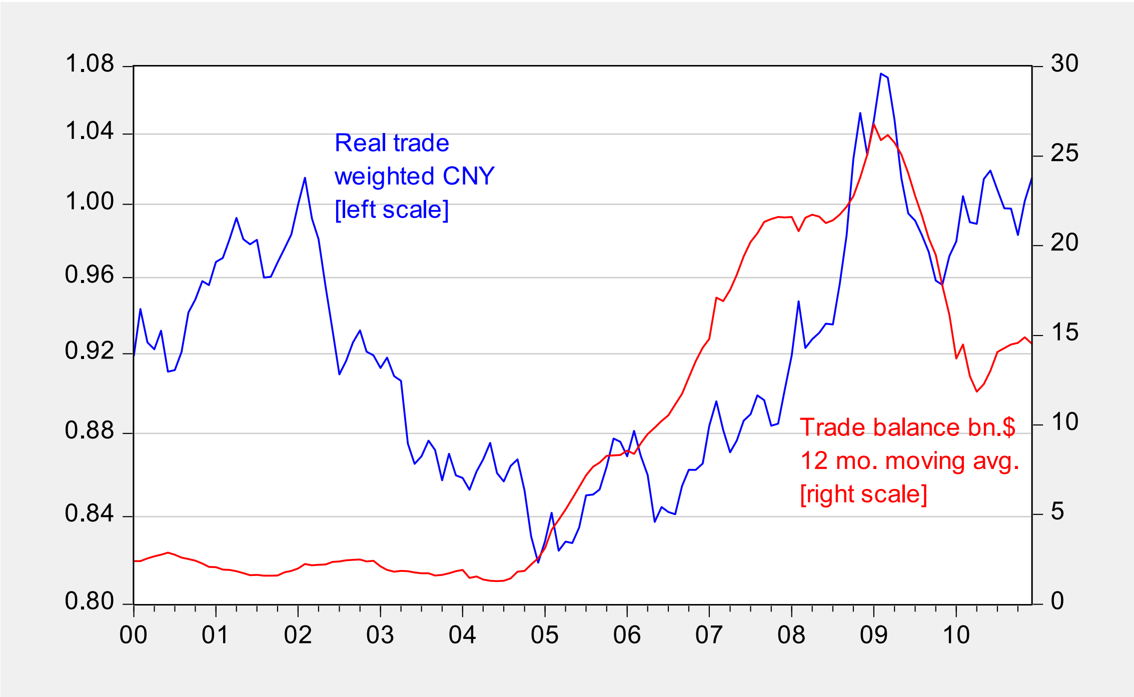


Figure 14.13: Log trade weighted value of the Chinese yuan (blue, left scale), and 12-month moving average of Chinese trade balance, in billions of USD.

In addition, rapid productivity growth can be interpreted as a depreciation in the real exchange rate. In the IS-LM=BP=0 model, each of these effects result in an outward shift in the IS curve and a downward shift in the $BP = 0$ curve. The resulting equilibrium is illustrated in Figure 14.14. Notice that the equilibrium interest rate i_0 exceeds that necessary for external equilibrium, $i_{BP|Y0}$.

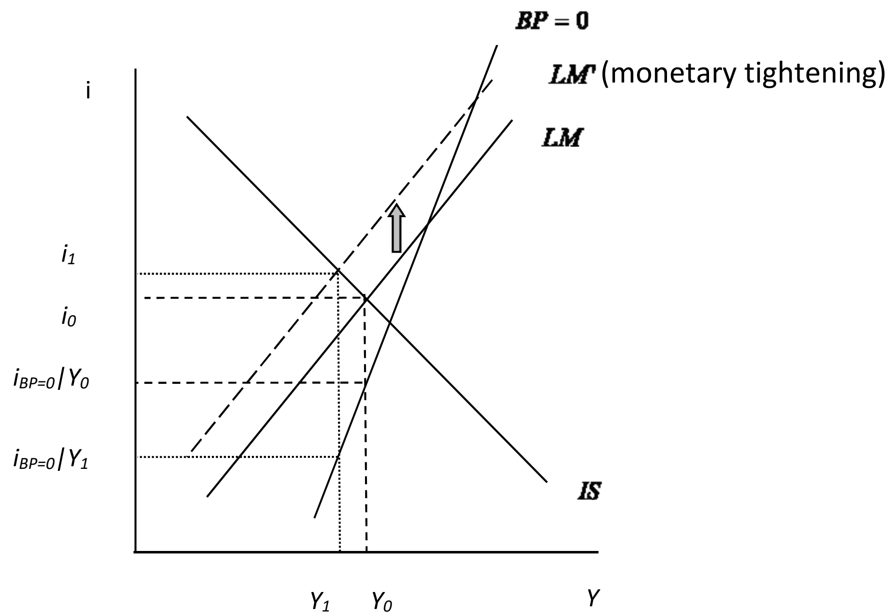


Figure 14.14: China 2004–2005.

Over the next two years, China's current account surplus increased, resulting in accelerating reserve accumulation. Notice that in order to prevent the LM shifting outward (which would have increased GDP and reduced the current account), the central bank had to sterilize the reserve accumulation. Instead of selling Chinese government bonds (reducing *DA* on the central bank balance sheet), the People's Bank of China (PBoC) relied mostly on forcing the banking sector to hold more bank reserves. This served to reduce the money supply relative to what it otherwise would have been.

In 2004 the PBoC tried to offset the expansionary effect of a weak currency by tightening money policy (gray arrow). This shifted the LM curve upward, raising the interest rate, and widening the gap between the equilibrium interest rate i_1 and the interest rate consistent with external balance, $i_{BP|Y1}$. In other words, government policy exacerbated reserve accumulation. Chinese foreign exchange reserves surged starting in 2004, as shown in Figure 14.15.

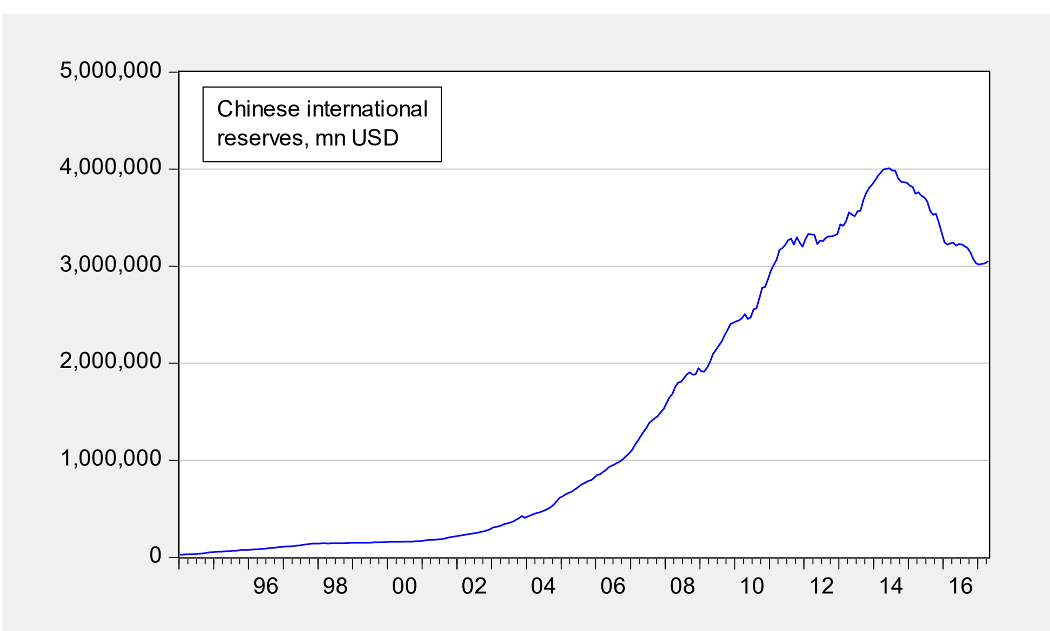


Figure 14.15: International reserves, in millions of USD. Source: IMF, *International Financial Statistics.*

A much more reasonable approach would have been to revalue the Chinese yuan. This would have shifted the *IS* curve inward (achieving the goal of reducing GDP) and shifted the *BP* = 0 curve upward (see the gray arrows). These effects are on display in Figure 14.16.

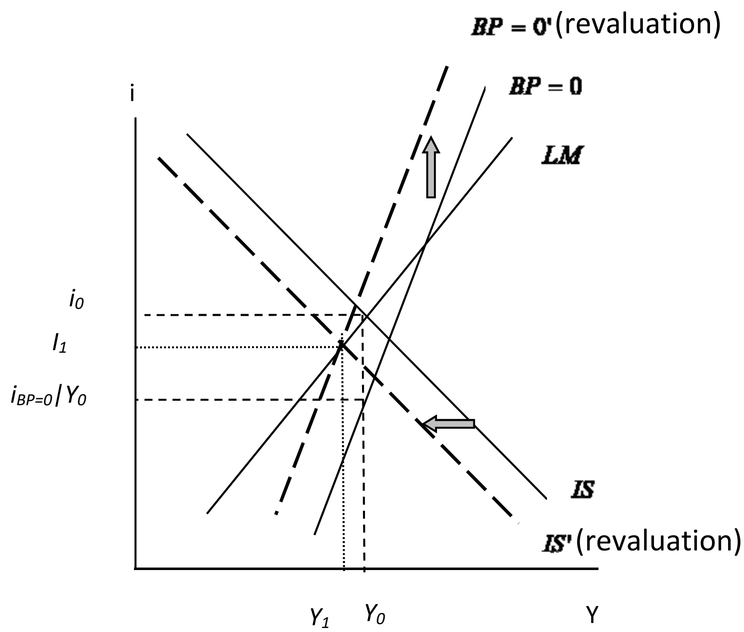


Figure 14.16: China, 2005-2008.

A currency revaluation could have accomplished the dual aims of cooling off the economy and reducing the current account surplus and pace of reserve accumulation. This is essentially the policy China finally undertook, under pressure from the international community, since China went off its de facto peg against the U.S. dollar in July 2005. By June 2015, after years of yuan appreciation, Chinese foreign exchange reserves peaked, at *over $4 trillion*.

Since that time, China's financial outflows have increased, so that, when combined with foreign exchange intervention, China's reserves had declined by nearly a trillion dollars by early 2017.

14.7 Conclusion

This chapter develops a model of the economy that incorporates a role for money and interest rates. Monetary policy affects output by changing interest rates, thereby affecting any interest-sensitive components of aggregate demand. In the model developed, the interest-sensitive component is investment. Fiscal policy retains influence, albeit diminished, by virtue of the crowding out effect: when output rises with an increase in government spending, the rising demand for money induces an elevated interest rate that reduces investment and output somewhat. This framework is called the *IS-LM* model.

External equilibrium is defined as stability of foreign exchange reserves. This occurs when a trade deficit is financed by financial capital inflows, or a trade surplus finances financial capital outflows. Combining this external balance condition with the *IS-LM* model results in the Mundell-Fleming model.

When the real exchange rate is fixed by the central bank, then monetary policy is not autonomous in the long term. Monetary policy has to accommodate fiscal policy and is therefore unable to undertake independent measures. If changes in foreign exchange reserves are offset, or sterilized, monetary policy can independently affect output over a limited time frame. That ability ends when the central bank's relevant reserves, of either foreign currency or bonds, run out.

In the next chapter, we examine the alternate scenario, where the exchange rate is allowed to move freely. Then the balance of payments is always in equilibrium, so that official reserves transactions are essentially held at zero. In that case, monetary policy will have greater scope for independent action, and fiscal policy correspondingly less.

Summary Points

1. A model that distinguishes between the economy's real and financial sides are developed. The real side is linked to the financial side by way of investment sensitivity to interest rates.

2. Fiscal policy is less powerful in the new model than in the simple Keynesian one, because higher income induces higher interest rates, which depress investment.

3. Monetary policy works by changing interest rates, thereby affecting investment and total aggregate demand.

4. In an economy on a fixed exchange rate, the central bank is committed to buying and selling foreign exchange to peg the currency at a certain value.

5. Both monetary and fiscal policy are effective in affecting output, but they are only remain effective so long as foreign exchange changes are sterilized.

6. The degree of capital mobility is important to determining the effectiveness of either fiscal or monetary policy, when foreign exchange changes are sterilized.

Key Concepts

Bank reserves

Bonds

BP = 0 curve
Capital controls
Capital mobility
Currency
Current account
Crowding out
Devaluation
Domestic assets
Financial account
Interest rate defense
IS curve
Liquidity
LM curve
Monetary autonomy
Money
Money base
Money demand
Money supply
Mundell-Fleming model
Official reserves transactions
Open market operations
Revaluation
Sterilization

Review Questions

1. XXXX

Exercises

1. In the *IS-LM* model, is it true that the interest rate is determined solely in the financial sector?

2. Assume one doesn't have to consider the external balance condition. What is the size of the government spending multiplier, compared to that in Chapter 13, if investment spending does not depend on the interest rate? Is it larger or smaller than in Chapter 13?

3. Monetary policy works by changing the money supply so as to affect the interest rate. How can the central bank can change the money supply?

4. Consider fiscal policy in an economy described by the following equations:

(1) $Y = AD$
(2) $AD = C + I + G + X - IM$
(3) $C = \bar{C} + c(Y - T)$
(4) $T = \bar{T}$
(5) $I = \bar{I} - bi$

(6) $G = \bar{G}$

(7) $X = \bar{X} + vq$

(8) $IM = \overline{IM} + mY - nq$

(9) $\frac{M^d}{P} = \frac{M^s}{P}$

(10) $\frac{M^S}{P} = \frac{\bar{M}}{\bar{P}}$

(11) $\frac{M^d}{P} = kY - hi$

For now, ignore the external balance condition.
(a) Solve for the *IS* curve, with Y on the left hand side.
(b) Solve for the *LM* curve, with i on the left hand side.
(c) Graph the *IS* and *LM* curves on a single graph. Show the vertical intercepts, the slopes, and the intersection.
(d) Solve for equilibrium income. Show your work.
(e) Calculate the change in income resulting from a given increase in government spending, ΔG.
(f) Show graphically what happens when government spending is increased. Clearly indicate the distance of the curve shifts, and the amount of the income change.
(g) Is the effect of government spending on income greater or less in this model, as compared to the simple Keynesian model? Explain why the difference occurs, in words.
(h) Answer Part (g) again, assuming the interest sensitivity of money demand to be infinite.
(i) Answer Part (g) again, if the interest sensitivity of investment were infinite.

5. Consider the same economy described in Problem 4.
(a) Calculate the change in income for a given change in money supply, $\Delta(M/P)$. Assume that the price level P is fixed at 1.
(b) Show graphically what happens when the real money stock is increased. Clearly indicate the distance of the curve shifts and the amount of the income change.
(c) Suppose that the interest sensitivity of investment is extremely high. Show graphically the effect upon output and interest rates that result from an increase of the real money stock. Clearly indicate the size of the change in income.
(d) Suppose that the interest sensitivity of money demand is extremely high. Show graphically the effect upon output and interest rates that result from an increase of the real money stock. Clearly indicate the size of the change in income.

6. Suppose the economy is described by the following set of equations, as in the Mundell-Fleming model.

(1) $Y = \bar{\alpha}[\bar{A} + \bar{X} - \overline{IM} + (n+v)\bar{q} - bi]$ <IS curve>

(1') $i = \frac{\bar{A} + \bar{X} - \overline{IM} + (n+v)\bar{q}}{b} - \left(\frac{1-c(1-t)+m}{b}\right)Y$ <IS curve>

(2) $i = -\left(\frac{1}{h}\right)\left(\frac{\bar{M}}{\bar{P}}\right) + \left(\frac{k}{h}\right)Y$ <LM curve>

(3) $i = -\left(\frac{1}{\kappa}\right)[(\bar{X} - \overline{IM} + \overline{FA}) + (n+v)\bar{q}] + \bar{i}^* + \left(\frac{m}{\kappa}\right)Y$ <BP=0 curve>

(a) Draw a graph of initial equilibrium, where the goods and money markets are in equilibrium, as is the balance of payments. Assume that $m/\kappa < k/h$.
(b) Show what happens if government spending is increased, both immediately, and over time, assuming no sterilization.
(c) At the new equilibrium, what is true about (i) the level of output; (ii) the level of investment; (iii) the real exchange rate; and (iv) the trade balance?
(d) 4 Redraw the graph in Part (a), and show the impact of a monetary contraction, both immediately and over time. Assume that over time, financial flows are sterilized.
(e) Explain why the process you lay out in Part (d) occurs.
(f) Answer Part (d) if financial flows are not sterilized.
(g) Does your answer to Part (d) change if $m/\kappa > k/h$?

7. Consider the same economy described in Problem 6, with $m/\kappa < k/h$.
   (a) Assume the economy begins in equilibrium. Show what happens in the short term if the foreign interest rate rises exogenously.
   (b) Assume the central bank sterilizes inflows/outflows. Is the balance of payments in surplus, deficit or equal to zero?
   (c) Suppose the central bank wishes to re-establish balance of payments equilibrium. What policies can it implement in order to achieve that goal?

8. In the same economy examined in Problem 7, show the impact in the short term of a revaluation of the currency. What happens to output, the interest rate and the balance of payments?

9. Suppose a country is running a balance of payments deficit. What are the policy options for remedying the deficit?

Worked Exercise

4.1 Solve for the IS curve, with Y on the left hand side.

Substitute equations (2) through (8) into equation (1):

$$Y = AD = \underbrace{\bar{C} + c(Y - \bar{T})}_{C} + \underbrace{\bar{I} - bi}_{I} + \underbrace{\bar{G}}_{G} + \underbrace{(\bar{X} + v\bar{q})}_{X} - \underbrace{(\overline{IM} + mY - n\bar{q})}_{IM}$$

Collecting terms:

$$Y = \underbrace{\bar{C} - c\bar{T} + \bar{I} + \bar{G}}_{\bar{A}} + (\bar{X} - \overline{IM}) + (n+v)\bar{q} - bi + (c - m)Y$$

Rearranging:

$$Y - (c - m)Y = Y(1 - c + m) = \bar{A} + (\bar{X} - \overline{IM}) + (n + v)\bar{q} - bi$$

$$Y = \left(\frac{1}{1 - c + m}\right)[\bar{A} + (\bar{X} - \overline{IM}) + (n + v)\bar{q} - bi]$$

4.2 Solve for the LM curve, with i on the left hand side.

Substitute equations (10) and (11) into equation (9):

$kY - hi = \frac{M^d}{P} = \frac{M^s}{P} = \frac{\bar{M}}{\bar{P}}$

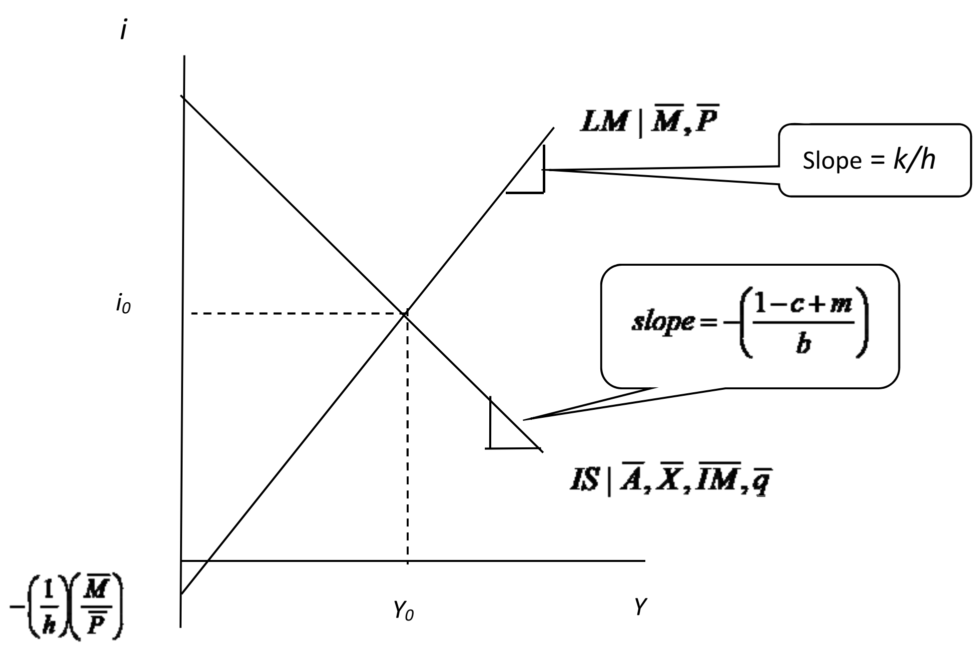
Rearrange:

$-hi = \frac{\bar{M}}{\bar{P}} - kY$

Divide both sides by $-h$:

$i = -\left(\frac{1}{h}\right)\left(\frac{\bar{M}}{\bar{P}}\right) + \left(\frac{k}{h}\right)Y$

4.3 Graph the IS and LM curves on a single graph. Show the vertical intercepts, the slopes, and the intersection.



4.4 Solve for equilibrium income. Show your work.

Substitute the LM curve into the IS curve:

$$Y = \left(\frac{1}{1-c+m}\right)\left[\bar{A} + (\bar{X} - \overline{IM}) + (n+v)\bar{q} - b\left\langle -\left(\frac{1}{h}\right)\left(\frac{\bar{M}}{\bar{P}}\right) + \left(\frac{k}{h}\right)Y\right\rangle\right]$$

Rearrange:

$$Y(1-c+m) = \left[\bar{A} + (\bar{X} - \overline{IM}) + (n+v)\bar{q} + \left(\frac{b}{h}\right)\left(\frac{\bar{M}}{\bar{P}}\right) - \left(\frac{bk}{h}\right)Y\right]$$

$$Y(1-c+m+bk/h) = \left[\bar{A} + (\bar{X} - \overline{IM}) + (n+v)\bar{q} + \left(\frac{b}{h}\right)\left(\frac{\bar{M}}{\bar{P}}\right)\right]$$

$$Y_0 = \underbrace{\left(\frac{1}{1-c+m+\frac{bk}{h}}\right)}_{\hat{\alpha}}\left[\bar{A} + (\bar{X} - \overline{IM}) + (n+v)\bar{q} + \left(\frac{b}{h}\right)\left(\frac{\bar{M}}{\bar{P}}\right)\right]$$

4.5 Calculate the change in income resulting from a given increase in government spending, ΔG.

Take the total differential of the answer to 4.4:

$$\Delta Y = \hat{\alpha}\left[\Delta A + \Delta X - \Delta IM + (n+v)\Delta q + \left(\frac{b}{h}\right)\Delta\left(\frac{M}{P}\right)\right]$$

Since

$$\bar{A} \equiv \bar{C} - c\bar{T} + \bar{I} + \bar{G}$$
$$\Delta A = \Delta C - c\Delta T + \Delta I + \Delta G$$

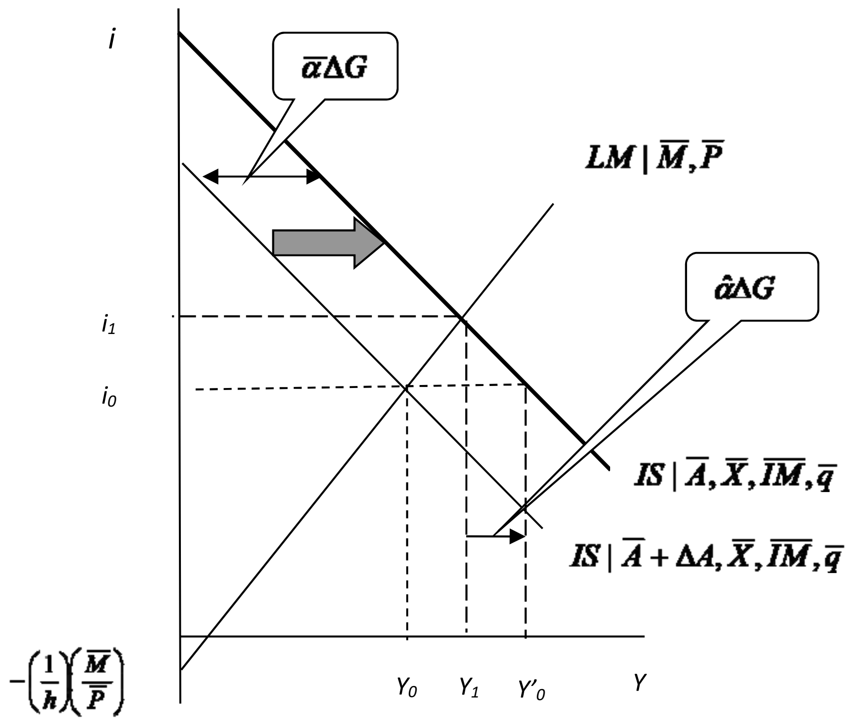
Assuming only government spending changes, then:

$$\Delta Y = \hat{\alpha}\Delta A = \hat{\alpha}\Delta G$$

Or:

$$\frac{\Delta Y}{\Delta G} = \hat{\alpha}$$

4.6 Show graphically what happens when government spending is increased. Clearly indicate the distance of the curve shifts, and the amount of the income change.

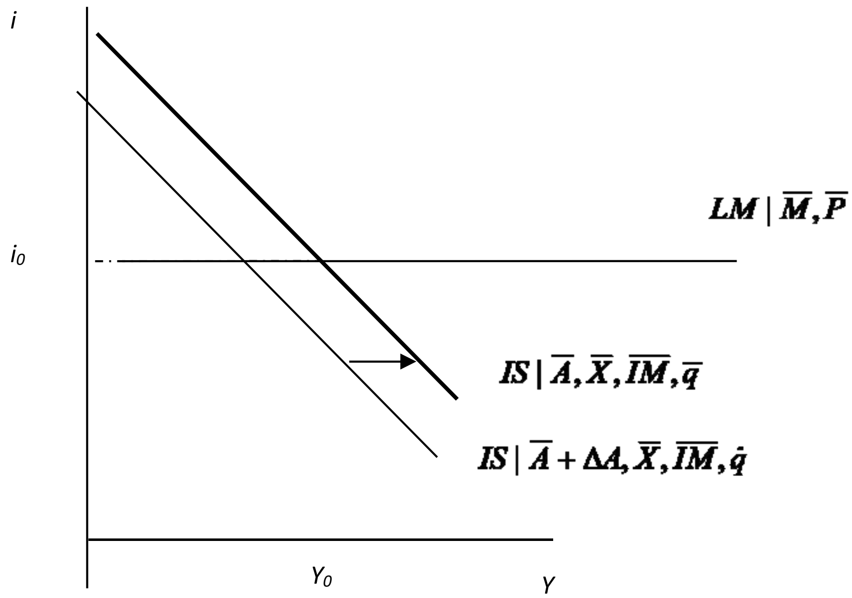


4.7 Is the effect of government spending on income greater or less in this model, as compared to the simple Keynesian model? Explain why the difference occurs, in words.

The effect is less in absolute value, because of crowding out of investment. As income rises, demand for money rises. Since the money supply is fixed, the equilibrating interest rate in the money market must rise. As a consequence, investment falls, and this decreases aggregate demand and output relative to what it would have been if interest rates remain unchanged. As a consequence, output rises by only, $\Delta Y = \hat{\alpha}\Delta G$ rather than $\Delta Y = \overline{\alpha}\Delta G$.

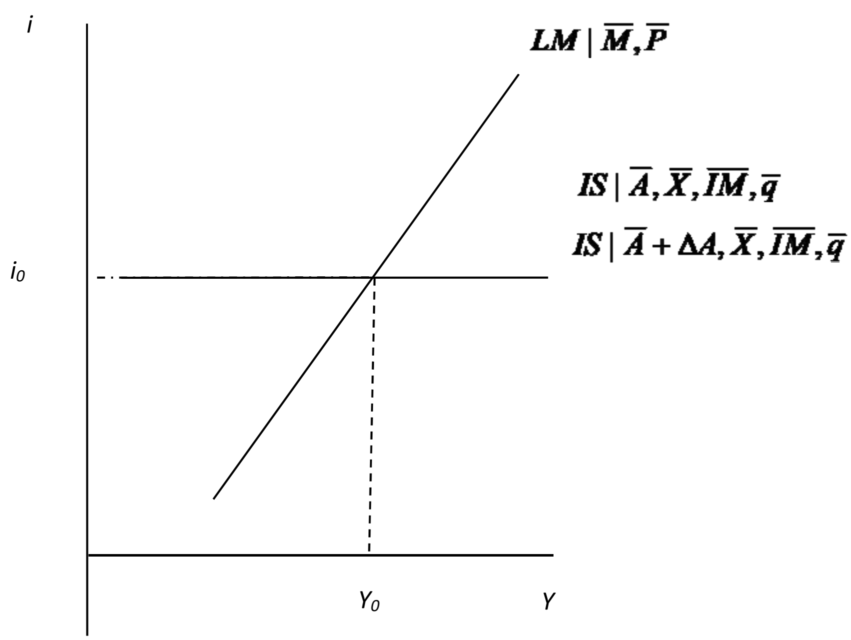
4.8 Answer 4.7 again, if the interest sensitivity of money demand were infinite. Explain why this is true.

If the interest sensitivity of money demand were infinite, then the LM curve would be perfectly flat. Then the shift inward is the same as the reduction in income. Notice that when h=∞, $\hat{\alpha} = \overline{\alpha}$.



4.9 Answer 4.7 again, if the interest sensitivity of investment were infinite. Explain why this is true.

If the interest sensitivity of investment were infinite, then the IS curve is horizontal, and does not shift down as lump sum taxes are reduced.



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