CHAPTER 15

Money, Interest Rates, and Exchange Rates

Chapter 14 showed how the exchange rate between currencies depends on two factors, the interest that can be earned on deposits of those currencies and the expected future exchange rate. To understand fully the determination of exchange rates, however, we have to learn how interest rates themselves are determined and how expectations of future exchange rates are formed. In this and the next two chapters we examine these topics by building an economic model that links exchange rates, interest rates, and other important macroeconomic variables such as the inflation rate and output.

The first step in building the model is to explain the effects of a country's money supply and of the demand for its money on its interest rate and exchange rate. Because exchange rates are the relative prices of national monies, factors that affect a country's money supply or demand are among the most powerful determinants of its currency's exchange rate against foreign currencies. It is therefore natural to begin a deeper study of exchange rate determination with a discussion of money supply and money demand.

Monetary developments influence the exchange rate by changing *both* interest rates *and* people's expectations about future exchange rates. Expectations about future exchange rates are closely connected with expectations about the future money prices of countries' products; these price movements, in turn, depend on changes in money supply and demand. In examining monetary influences on the exchange rate, we therefore look at how monetary factors influence output prices along with interest rates. Expectations of future exchange rates depend on many factors other than money, however, and these nonmonetary factors are taken up in the next chapter.

Once the theories and determinants of money supply and demand are laid out, we use them to examine how equilibrium interest rates are determined by the equality of money supply and money demand. Then we combine our model of interest rate determination with the interest parity condition to study the effects of monetary shifts on the exchange rate, given the prices of goods and services, the level of output, and market expectations about the future. Finally, we take a first look at the long-term effects of monetary changes on output prices and expected future exchange rates.

LEARNING GOALS

After reading this chapter, you will be able to:

- Describe and discuss the national money markets in which interest rates are determined.
- Show how monetary policy and interest rates feed into the foreign exchange market.
- Distinguish between the economy's long-run position and the short run, in which money prices and wages are sticky.
- Explain how price levels and exchange rates respond to monetary factors in the long run.
- Outline the relationship between the short-run and the long-run effects of monetary policy, and explain the concept of short-run exchange rate overshooting.

Money Defined: A Brief Review

We are so accustomed to using money that we seldom notice the roles it plays in almost all of our everyday transactions. As with many other modern conveniences, we take money for granted until something goes wrong with it! In fact, the easiest way to appreciate the importance of money is to imagine what economic life would be like without it.

In this section we do just that. Our purpose in carrying out this "thought experiment" is to distinguish money from other assets and to describe the characteristics of money that lead people to hold it. These characteristics are central to an analysis of the demand for money.

Money as a Medium of Exchange

The most important function of money is to serve as a *medium of exchange*, a generally accepted means of payment. To see why a medium of exchange is necessary, imagine how time-consuming it would be for people to purchase goods and services in a world where the only type of trade possible is barter trade—the direct trade of goods or services for other goods or services. To have her car repaired, for example, your professor would have to find a mechanic in need of economics lessons!

Money eliminates the enormous search costs connected with a barter system because money is universally acceptable. It eliminates these search costs by enabling an individual to sell the goods and services she produces to people other than the producers of the goods and services she wishes to consume. A complex modern economy would cease functioning without some standardized and convenient means of payment.

Money as a Unit of Account

Money's second important role is as a *unit of account*, that is, as a widely recognized measure of value. It is in this role that we encountered money in Chapter 14: Prices of goods, services, and assets are typically expressed in terms of money. Exchange rates allow us to translate different countries' money prices into comparable terms.

The convention of quoting prices in money terms simplifies economic calculations by making it easy to compare the prices of different commodities. The international price comparisons in Chapter 14, which used exchange rates to compare the prices of different countries' outputs, are similar to the calculations you would have to do many times each day if different commodities' prices were not expressed in terms of a standardized unit of account. If the calculations in Chapter 14 gave you a headache, imagine what it would be like to have to calculate the relative prices of each good and service you consume in terms of several other goods and services—for example, the price of a slice of pizza in terms of bananas. This thought experiment should give you a keener appreciation of using money as a unit of account.

Money as a Store of Value

Because money can be used to transfer purchasing power from the present into the future, it is also an asset, or a *store of value*. This attribute is essential for any medium of exchange because no one would be willing to accept it in payment if its value in terms of goods and services evaporated immediately.

Money's usefulness as a medium of exchange, however, automatically makes it the most *liquid* of all assets. As you will recall from the last chapter, an asset is said to be liquid when it can be transformed into goods and services rapidly and without high transaction costs, such as brokers' fees. Since money is readily acceptable as a means of payment, money sets the standard against which the liquidity of other assets is judged.

What Is Money?

Currency and bank deposits on which checks may be written certainly qualify as money. These are widely accepted means of payment that can be transferred between owners at low cost. Households and firms hold currency and checking deposits as a convenient way of financing routine transactions as they arise. Assets such as real estate do not qualify as money because, unlike currency and checking deposits, they lack the essential property of liquidity.

When we speak in this book of the **money supply,** we are referring to the monetary aggregate the Federal Reserve calls M1, that is, the total amount of currency and checking deposits held by households and firms. In the United States at the end of 2009, the total money supply amounted to $1.722 trillion, equal to roughly 12 percent of that year's GNP.[1]

The large deposits traded by participants in the foreign exchange market are not considered part of the money supply. These deposits are less liquid than money and are not used to finance routine transactions.

How the Money Supply Is Determined

An economy's money supply is controlled by its central bank. The central bank directly regulates the amount of currency in existence and also has indirect control over the amount of checking deposits issued by private banks. The procedures through which the central bank controls the money supply are complex, and we assume for now that the central bank simply sets the size of the money supply at the level it desires. We go into the money supply process in more detail, however, in Chapter 18.

[1] A broader Federal Reserve measure of money supply, M2, includes time deposits, but these are less liquid than the assets included in M1 because the funds in them typically cannot be withdrawn early without penalty. An even broader measure, known as M3, is also tracked by the Fed. A decision on where to draw the line between money and near-money must be somewhat arbitrary and therefore controversial. For further discussion of this question, see Chapter 3 of Frederic S. Mishkin, *The Economics of Money, Banking and Financial Markets*, 9th edition (Boston: Addison Wesley, 2010).

The Demand for Money by Individuals

Having discussed the functions of money and the definition of the money supply, we now examine the factors that determine the amount of money an individual desires to hold. The determinants of individual money demand can be derived from the theory of asset demand discussed in the last chapter.

We saw in the last chapter that individuals base their demand for an asset on three characteristics:

1. The expected return the asset offers compared with the returns offered by other assets.
2. The riskiness of the asset's expected return.
3. The asset's liquidity.

While liquidity plays no important role in determining the relative demands for assets traded in the foreign exchange market, households and firms hold money *only* because of its liquidity. To understand how the economy's households and firms decide the amount of money they wish to hold, we must look more closely at how the three considerations listed above influence money demand.

Expected Return

Currency pays no interest. Checking deposits often do pay some interest, but they offer a rate of return that usually fails to keep pace with the higher returns offered by less liquid forms of wealth. When you hold money, you therefore sacrifice the higher interest rate you could earn by holding your wealth in a government bond, a large time deposit, or some other relatively illiquid asset such as vintage baseball cards or real estate. It is this last rate of interest we have in mind when we refer to "the" interest rate. Since the interest paid on currency is zero while that paid on "checkable" deposits tends to be relatively constant, the difference between the rate of return of money in general and that of less liquid alternative assets is reflected by the market interest rate: The higher the interest rate, the more you sacrifice by holding wealth in the form of money.[2]

Suppose, for example, that the interest rate you could earn from a U.S. Treasury bill is 10 percent per year. If you use $10,000 of your wealth to buy a Treasury bill, you will be paid $11,000 by Uncle Sam at the end of a year, but if you choose instead to keep the $10,000 as cash in a safe-deposit box, you give up the $1,000 interest you could have earned by buying the Treasury bill. You thus sacrifice a 10 percent rate of return by holding your $10,000 as money.

The theory of asset demand developed in the last chapter shows how changes in the rate of interest affect the demand for money. The theory states that, other things equal, people prefer assets offering higher expected returns. Because an increase in the interest rate is a rise in the rate of return on less liquid assets relative to the rate of return on money, individuals will want to hold more of their wealth in nonmoney assets that pay the market interest rate and less of their wealth in the form of money if the interest rate rises. We conclude that, *all else equal, a rise in the interest rate causes the demand for money to fall.*

[2] Many of the illiquid assets that individuals can choose from do not pay their returns in the form of interest. Stocks, for example, pay returns in the form of dividends and capital gains. The family summer house on Cape Cod pays a return in the form of capital gains and the pleasure of vacations at the beach. The assumption behind our analysis of money demand is that once allowance is made for risk, all assets other than money offer an expected rate of return (measured in terms of money) equal to the interest rate. This assumption allows us to use the interest rate to summarize the return an individual forgoes by holding money rather than an illiquid asset.

We can also describe the influence of the interest rate on money demand in terms of the economic concept of *opportunity cost*—the amount you sacrifice by taking one course of action rather than another. The interest rate measures the opportunity cost of holding money rather than interest-bearing bonds. A rise in the interest rate therefore raises the cost of holding money and causes money demand to fall.

Risk

Risk is not an important factor in money demand. It is risky to hold money because an unexpected increase in the prices of goods and services could reduce the value of your money in terms of the commodities you consume. Since interest-paying assets such as government bonds have face values fixed in terms of money, however, the same unexpected increase in prices would reduce the real value of those assets by the same percentage. Because any change in the riskiness of money causes an equal change in the riskiness of bonds, changes in the risk of holding money need not cause individuals to reduce their demand for money and increase their demand for interest-paying assets.

Liquidity

The main benefit of holding money comes from its liquidity. Households and firms hold money because it is the easiest way of financing their everyday purchases. Some large purchases can be financed through the sale of a substantial illiquid asset. An art collector, for example, could sell one of her Picassos to buy a house. To finance a continuing stream of smaller expenditures at various times and for various amounts, however, households and firms have to hold some money.

An individual's need for liquidity rises when the average daily value of his transactions rises. A student who takes the bus every day, for example, does not need to hold as much cash as a business executive who takes taxis during rush hour. We conclude that *a rise in the average value of transactions carried out by a household or firm causes its demand for money to rise.*

Aggregate Money Demand

Our discussion of how individual households and firms determine their demands for money can now be applied to derive the determinants of **aggregate money demand,** the total demand for money by all households and firms in the economy. Aggregate money demand is just the sum of all the economy's individual money demands.

Three main factors determine aggregate money demand:

1. *The interest rate*. A rise in the interest rate causes each individual in the economy to reduce her demand for money. All else equal, aggregate money demand therefore falls when the interest rate rises.

2. *The price level*. The economy's **price level** is the price of a broad reference basket of goods and services in terms of currency. Generally the reference basket includes the standard, everyday consumption items such as food, clothing, and housing, but also less routine purchases such as medical care and legal fees. If the price level rises, individual households and firms must spend more money than before to purchase their usual weekly baskets of goods and services. To maintain the same level of liquidity as before the price level increase, they will therefore have to hold more money.

3. *Real national income*. When real national income (GNP) rises, more goods and services are being sold in the economy. This increase in the real value of transactions raises the demand for money, given the price level.

If P is the price level, R is the interest rate, and Y is real GNP, the aggregate demand for money, M^d, can be expressed as

$$M^d = P \times L(R, Y), \tag{15-1}$$

where the value of $L(R, Y)$ falls when R rises, and rises when Y rises.[3] To see why we have specified that aggregate money demand is *proportional* to the price level, imagine that all prices doubled but the interest rate and everyone's *real* incomes remained unchanged. The money value of each individual's average daily transactions would then simply double, as would the amount of money each wished to hold.

We usually write the aggregate money demand relation (15-1) in the equivalent form

$$M^d/P = L(R, Y), \tag{15-2}$$

and call $L(R, Y)$ aggregate *real* money demand. This way of expressing money demand shows that the aggregate demand for liquidity, $L(R, Y)$, is not a demand for a certain number of currency units but is instead a demand to hold a certain amount of real purchasing power in liquid form. The ratio M^d/P—that is, desired money holdings measured in terms of a typical reference basket of commodities—equals the amount of real purchasing power people would like to hold in liquid form. For example, if people wished to hold \$1,000 in cash at a price level of \$100 per commodity basket, their real money holdings would be equivalent to \$1,000/(\$100 per basket) = 10 baskets. If the price level doubled (to \$200 per basket), the purchasing power of their \$1,000 in cash would be halved, since it would now be worth only 5 baskets.

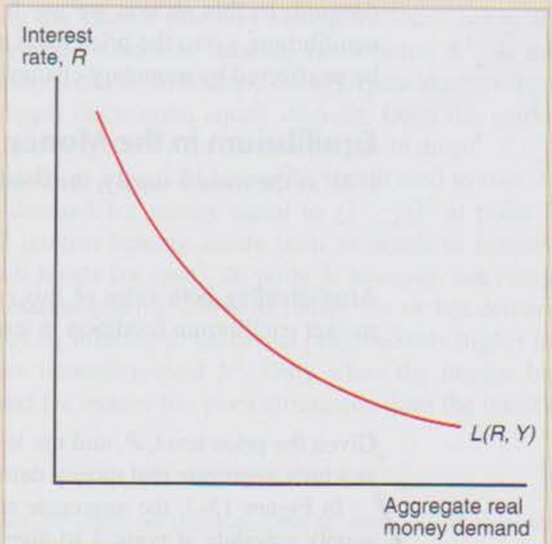
Figure 15-1 shows how aggregate real money demand is affected by the interest rate for a fixed level of real income, Y. The aggregate real money demand schedule $L(R, Y)$ slopes downward because a fall in the interest rate raises the desired real money holdings of each household and firm in the economy.

For a given level of real GNP, changes in the interest rate cause movements *along* the $L(R, Y)$ schedule. Changes in real GNP, however, cause the schedule itself to shift.

Figure 15-1

Aggregate Real Money Demand and the Interest Rate

The downward-sloping real money demand schedule shows that for a given real income level Y, real money demand rises as the interest rate falls.



[3] Naturally, $L(R, Y)$ rises when R falls, and falls when Y falls.

Figure 15-2

Effect on the Aggregate Real Money Demand Schedule of a Rise in Real Income

An increase in real income from Y^1 to Y^2 raises the demand for real money balances at every level of the interest rate and causes the whole demand schedule to shift upward.

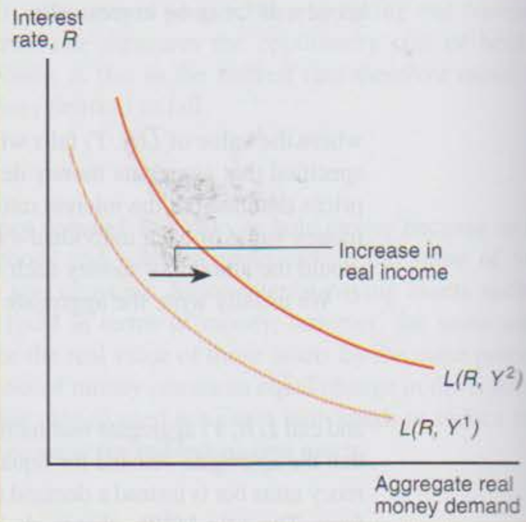


Figure 15-2 shows how a rise in real GNP from Y^1 to Y^2 affects the position of the aggregate real money demand schedule. Because a rise in real GNP raises aggregate real money demand for a given interest rate, the schedule $L(R, Y^2)$ lies to the right of $L(R, Y^1)$ when Y^2 is greater than Y^1.

The Equilibrium Interest Rate: The Interaction of Money Supply and Demand

As you might expect from other economics courses you've taken, the money market is in equilibrium when the money supply set by the central bank equals aggregate money demand. In this section we see how the interest rate is determined by money market equilibrium, given the price level and output, both of which are temporarily assumed to be unaffected by monetary changes.

Equilibrium in the Money Market

If M^s is the money supply, the condition for equilibrium in the money market is

$$M^s = M^d. \tag{15-3}$$

After dividing both sides of this equality by the price level, we can express the money market equilibrium condition in terms of aggregate real money demand as

$$M^s/P = L(R, Y). \tag{15-4}$$

Given the price level, P, and the level of output, Y, the equilibrium interest rate is the one at which aggregate real money demand equals the real money supply.

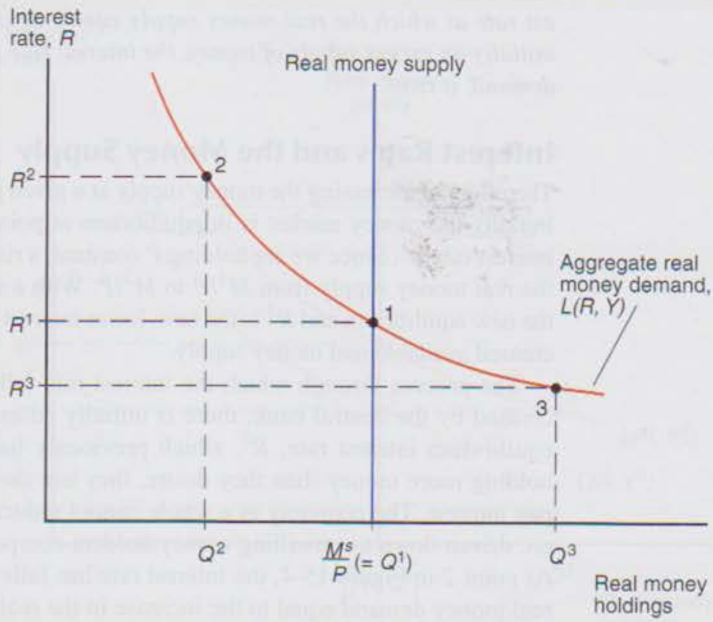
In Figure 15-3, the aggregate real money demand schedule intersects the real money supply schedule at point 1 to give an equilibrium interest rate of R^1. The money supply schedule is vertical at M^s/P because M^s is set by the central bank while P is taken as given.

Let's see why the interest rate tends to settle at its equilibrium level by considering what happens if the market is initially at point 2, with an interest rate, R^2, that is above R^1.

Figure 15-3

Determination of the Equilibrium Interest Rate

With P and Y given and a real money supply of M^S/P, money market equilibrium is at point 1. At this point, aggregate real money demand and the real money supply are equal and the equilibrium interest rate is R^1.



At point 2 the demand for real money holdings falls short of the supply by $Q^1 - Q^2$, so there is an excess supply of money. If individuals are holding more money than they desire given the interest rate of R^2, they will attempt to reduce their liquidity by using some money to purchase interest-bearing assets. In other words, individuals will attempt to get rid of their excess money by lending it to others. Since there is an aggregate excess supply of money at R^2, however, not everyone can succeed in doing this: There are more people who would like to lend money to reduce their liquidity than there are people who would like to borrow money to increase theirs. Those who cannot unload their extra money try to tempt potential borrowers by lowering the interest rate they charge for loans below R^2. The downward pressure on the interest rate continues until the rate reaches R^1. At this interest rate, anyone wishing to lend money can do so because the aggregate excess supply of money has disappeared; that is, supply once again equals demand. Once the market reaches point 1, there is therefore no further tendency for the interest rate to drop.[4]

Similarly, if the interest rate is initially at a level R^3 below R^1, it will tend to rise. As Figure 15-3 shows, there is excess demand for money equal to $Q^3 - Q^1$ at point 3. Individuals therefore attempt to sell interest-bearing assets such as bonds to increase their money holdings (that is, they sell bonds for cash). At point 3, however, not everyone can succeed in selling enough interest-bearing assets to satisfy his or her demand for money. Thus, people bid for money by offering to borrow at progressively higher interest rates and push the interest rate upward toward R^1. Only when the market has reached point 1 and the excess demand for money has been eliminated does the interest rate stop rising.

[4] Another way to view this process is as follows: We saw in the last chapter that an asset's rate of return falls when its current price rises relative to its future value. When there is an excess supply of money, the current money prices of illiquid assets that pay interest will be bid up as individuals attempt to reduce their money holdings. This rise in current asset prices lowers the rate of return on nonmoney assets, and since this rate of return is equal to the interest rate (after adjustment for risk), the interest rate also must fall.

We can summarize our findings as follows: *The market always moves toward an interest rate at which the real money supply equals aggregate real money demand. If there is initially an excess supply of money, the interest rate falls, and if there is initially an excess demand, it rises.*

Interest Rates and the Money Supply

The effect of increasing the money supply at a given price level is illustrated in Figure 15-4. Initially the money market is in equilibrium at point 1, with a money supply M^1 and an interest rate R^1. Since we are holding P constant, a rise in the money supply to M^2 increases the real money supply from M^1/P to M^2/P. With a real money supply of M^2/P, point 2 is the new equilibrium and R^2 is the new, lower interest rate that induces people to hold the increased available real money supply.

The process through which the interest rate falls is by now familiar. After M^s is increased by the central bank, there is initially an excess real supply of money at the old equilibrium interest rate, R^1, which previously balanced the market. Since people are holding more money than they desire, they use their surplus funds to bid for assets that pay interest. The economy as a whole cannot reduce its money holdings, so interest rates are driven down as unwilling money holders compete to lend their excess cash balances. At point 2 in Figure 15-4, the interest rate has fallen sufficiently to induce an increase in real money demand equal to the increase in the real money supply.

By running the above policy experiment in reverse, we can see how a reduction of the money supply forces interest rates upward. A fall in M^s causes an excess demand for money at the interest rate that previously balanced supply and demand. People attempt to sell interest-bearing assets—that is, to borrow—to rebuild their depleted real money holdings. Since they cannot all be successful when there is excess money demand, the interest rate is pushed upward until everyone is content to hold the smaller real money stock.

We conclude that *an increase in the money supply lowers the interest rate, while a fall in the money supply raises the interest rate, given the price level and output.*

Figure 15-4

Effect of an Increase in the Money Supply on the Interest Rate

For a given price level, P, and real income level, Y, an increase in the money supply from M^1 to M^2 reduces the interest rate from R^1 (point 1) to R^2 (point 2).

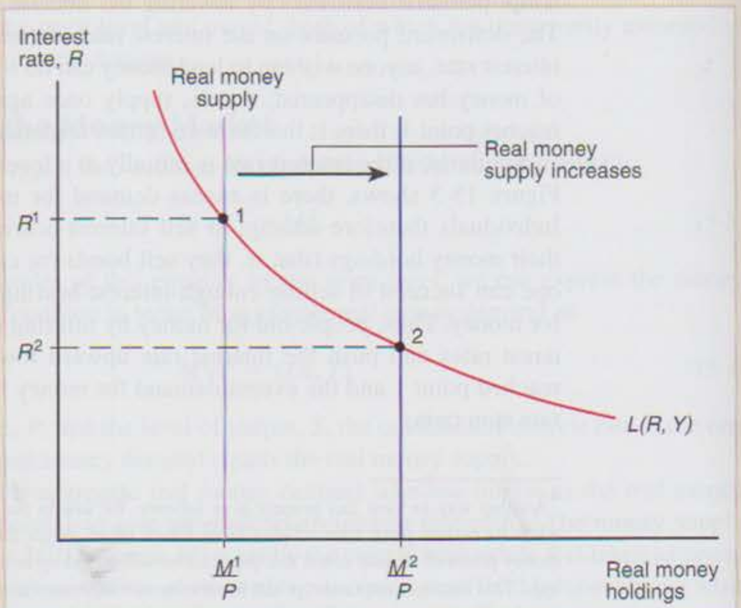
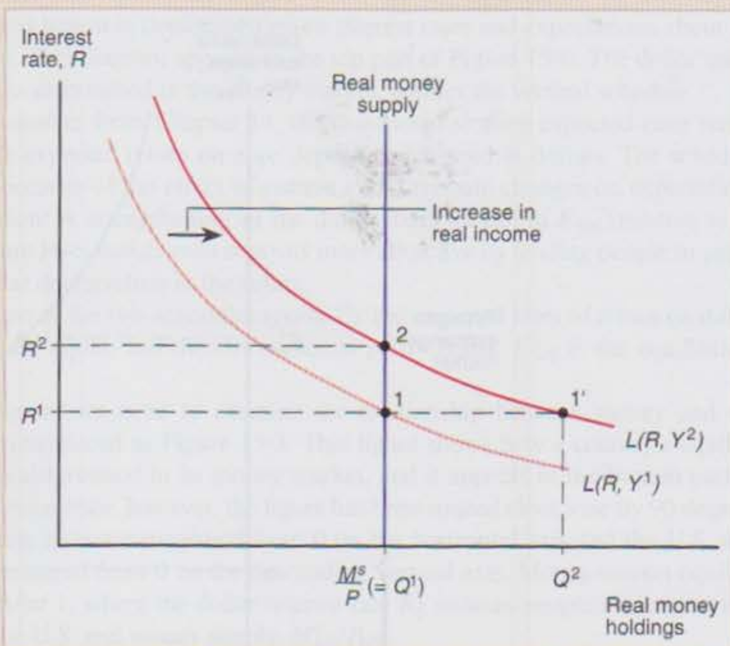


Figure 15-5

Effect on the Interest Rate of a Rise in Real Income

Given the real money supply, M^S/P (= Q^1), a rise in real income from Y^1 to Y^2 raises the interest rate from R^1 (point 1) to R^2 (point 2).



Output and the Interest Rate

Figure 15-5 shows the effect on the interest rate of a rise in the level of output from Y^1 to Y^2, given the money supply and the price level. As we saw earlier, an increase in output causes the entire aggregate real money demand schedule to shift to the right, moving the equilibrium away from point 1. At the old equilibrium interest rate, R^1, there is an excess demand for money equal to $Q^2 - Q^1$ (point 1′). Since the real money supply is given, the interest rate is bid up until it reaches the higher, new equilibrium level R^2 (point 2). A fall in output has opposite effects, causing the aggregate real money demand schedule to shift to the left and therefore causing the equilibrium interest rate to fall.

We conclude that *an increase in real output raises the interest rate, while a fall in real output lowers the interest rate, given the price level and the money supply.*

The Money Supply and the Exchange Rate in the Short Run

In Chapter 14 we learned about the interest parity condition, which predicts how interest rate movements influence the exchange rate, given expectations about the exchange rate's future level. Now that we know how shifts in a country's money supply affect the interest rate on nonmoney assets denominated in its currency, we can see how monetary changes affect the exchange rate. We will discover that *an increase in a country's money supply causes its currency to depreciate in the foreign exchange market, while a reduction in the money supply causes its currency to appreciate.*

In this section we continue to take the price level (along with real output) as given, and for that reason we label the analysis of this section **short run**. The **long-run** analysis of an economic event allows for the complete adjustment of the price level (which may take a long time) and for full employment of all factors of production. Later in this chapter we examine the long-run effects of money supply changes on the price level, the exchange rate,

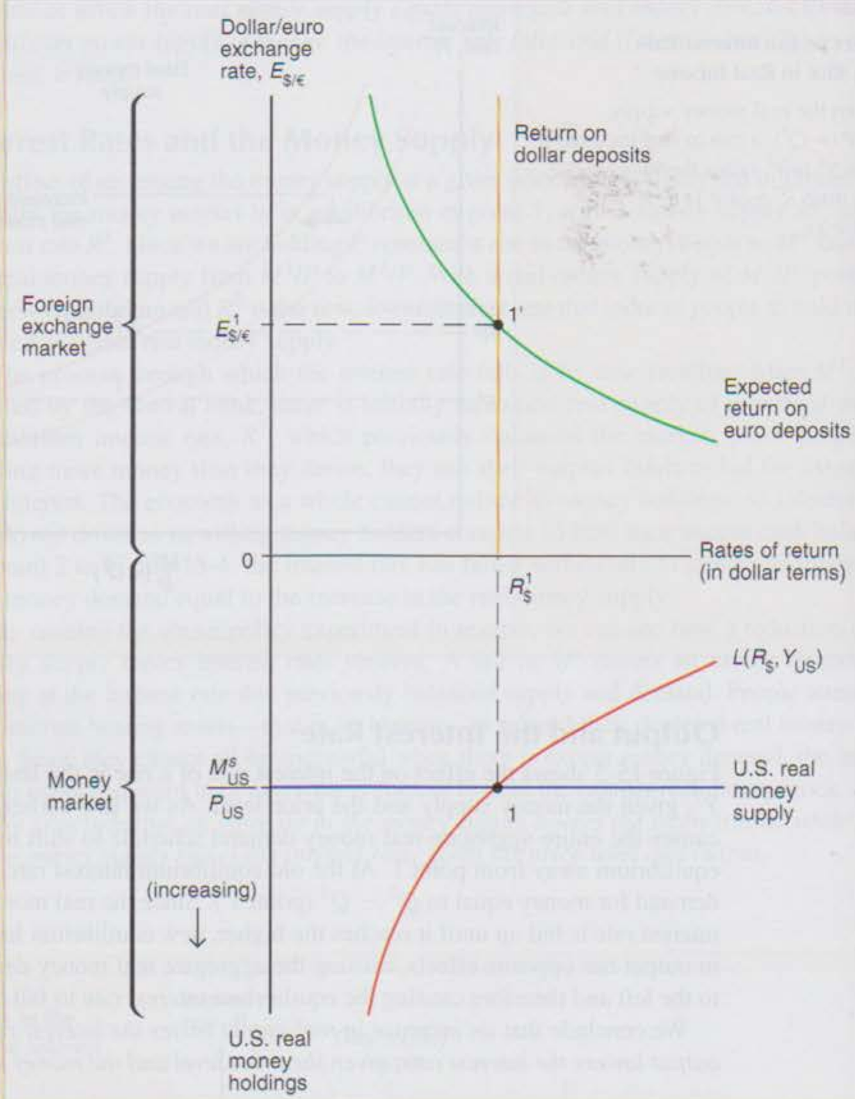


Figure 15-6

Simultaneous Equilibrium in the U.S. Money Market and the Foreign Exchange Market

Both asset markets are in equilibrium at the interest rate $R^1_\$$ and exchange rate $E^1_{\$/€}$; at these values, money supply equals money demand (point 1) and the interest parity condition holds (point 1′).

and other macroeconomic variables. Our long-run analysis will show how the money supply influences exchange rate expectations, which we also continue to take as given for now.

Linking Money, the Interest Rate, and the Exchange Rate

To analyze the relationship between money and the exchange rate in the short run in Figure 15-6, we combine two diagrams that we have already studied separately. Let's assume once again that we are looking at the dollar/euro exchange rate, that is, the price of euros in terms of dollars.

The first diagram (introduced as Figure 14-4) shows equilibrium in the foreign exchange market and how it is determined given interest rates and expectations about future exchange rates. This diagram appears as the top part of Figure 15-6. The dollar interest rate, $R^1_\$$, which is determined in the money market, defines the vertical schedule.

As you will remember from Chapter 14, the downward-sloping expected euro return schedule shows the expected return on euro deposits, measured in dollars. The schedule slopes downward because of the effect of current exchange rate changes on expectations of future depreciation: A strengthening of the dollar today (a fall in $E_{\$/€}$) relative to its *given* expected future level makes euro deposits more attractive by leading people to anticipate a sharper dollar depreciation in the future.

At the intersection of the two schedules (point 1′), the expected rates of return on dollar and euro deposits are equal, and therefore interest parity holds. $E^1_{\$/€}$ is the equilibrium exchange rate.

The second diagram we need to examine the relationship between money and the exchange rate was introduced as Figure 15-3. This figure shows how a country's equilibrium interest rate is determined in its money market, and it appears as the bottom part of Figure 15-6. For convenience, however, the figure has been rotated clockwise by 90 degrees so that dollar interest rates are measured from 0 on the horizontal axis and the U.S. real money supply is measured from 0 on the descending vertical axis. Money market equilibrium is shown at point 1, where the dollar interest rate $R^1_\$$ induces people to demand real balances equal to the U.S. real money supply, M^s_{US}/P_{US}.

Figure 15-6 emphasizes the link between the U.S. money market (bottom) and the foreign exchange market (top)—the U.S. money market determines the dollar interest rate, which in turn affects the exchange rate that maintains interest parity. (Of course, there is a similar link between the European money market and the foreign exchange market that operates through changes in the euro interest rate.)

Figure 15-7 illustrates these linkages. The U.S. and European central banks, the Federal Reserve System and the European System of Central Banks (ESCB), respectively, determine the U.S. and European money supplies, M^s_{US} and M^s_E. Given the price levels and national incomes of the two countries, equilibrium in national money markets leads to the dollar and euro interest rates $R_\$$ and $R_€$. These interest rates feed into the foreign exchange market, where, given expectations about the future dollar/euro exchange rate, the current rate $E_{\$/€}$ is determined by the interest parity condition.

U.S. Money Supply and the Dollar/Euro Exchange Rate

We now use our model of asset market linkages (the links between the money and foreign exchange markets) to ask how the dollar/euro exchange rate changes when the Federal Reserve changes the U.S. money supply M^s_{US}. The effects of this change are summarized in Figure 15-8.

At the initial money supply M^1_{US}, the money market is in equilibrium at point 1 with an interest rate $R^1_\$$. Given the euro interest rate and the expected future exchange rate, a dollar interest rate of $R^1_\$$ implies that foreign exchange market equilibrium occurs at point 1′, with an exchange rate equal to $E^1_{\$/€}$.

What happens when the Federal Reserve, perhaps fearing the onset of a recession, raises the U.S. money supply to M^2_{US}? This increase sets in motion the following sequence of events: (1) At the initial interest rate $R^1_\$$, there is an excess supply of money in the U.S. money market, so the dollar interest rate falls to $R^2_\$$ as the money market reaches its new equilibrium position (point 2). (2) Given the initial exchange rate $E^1_{\$/€}$ and the new, lower interest rate on dollars, $R^2_\$$, the expected return on euro deposits is greater than that on dollar deposits. Holders of dollar deposits therefore try to sell them for euro deposits,

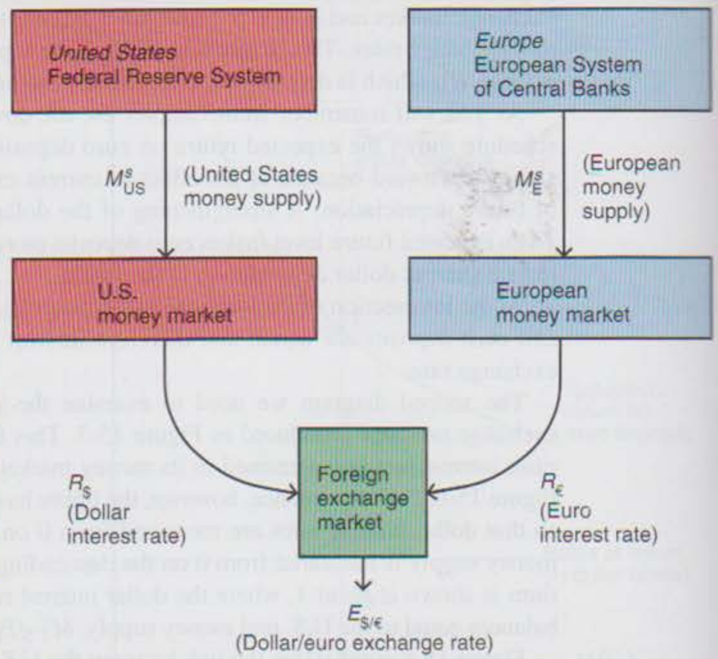


Figure 15-7

Money Market/Exchange Rate Linkages

Monetary policy actions by the Fed affect the U.S. interest rate, changing the dollar/euro exchange rate that clears the foreign exchange market. The ESCB can affect the exchange rate by changing the European money supply and interest rate.

which are momentarily more attractive. (3) The dollar depreciates to $E^2_{\$/€}$ as holders of dollar deposits bid for euro deposits. The foreign exchange market is once again in equilibrium at point 2′ because the exchange rate's move to $E^2_{\$/€}$ causes a fall in the dollar's expected future depreciation rate sufficient to offset the fall in the dollar interest rate.

We conclude that *an increase in a country's money supply causes its currency to depreciate in the foreign exchange market. By running Figure 15-8 in reverse, you can see that a reduction in a country's money supply causes its currency to appreciate in the foreign exchange market.*

Europe's Money Supply and the Dollar/Euro Exchange Rate

The conclusions we have reached also apply when the ESCB changes Europe's money supply. Suppose that the ESCB fears a recession in Europe and hopes to head it off through a looser monetary policy. An increase in M^s_E causes a depreciation of the euro (that is, an appreciation of the dollar, or a fall in $E_{\$/€}$), while a reduction in M^s_E causes an appreciation of the euro (that is, a depreciation of the dollar, or a rise in $E_{\$/€}$).

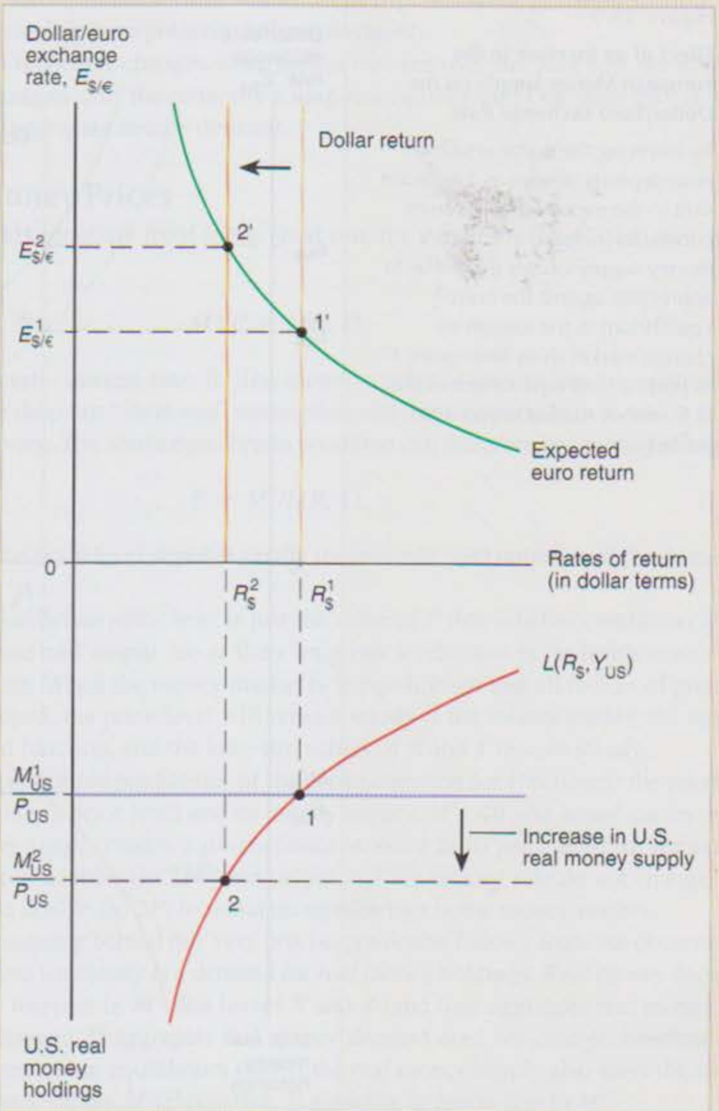
The mechanism at work, which runs from the European interest rate to the exchange rate, is the same as the one we just analyzed. It is good exercise to verify these assertions by drawing figures similar to Figures 15-6 and 15-8 that illustrate the linkage between the European money market and the foreign exchange market.

Here we use a different approach to show how changes in Europe's money supply affect the dollar/euro exchange rate. In Chapter 14 we learned that a fall in the euro interest rate, $R_€$, shifts the downward-sloping schedule in the upper part of Figure 15-6 to the left. The reason is that for any level of the exchange rate, a fall in $R_€$, lowers the expected rate of return on euro deposits. Since a rise in the European money supply M^s_E lowers $R_€$, we can see the effect on the exchange rate by shifting the expected euro return schedule in the top part of Figure 15-6 to the left.

Figure 15-8

Effect on the Dollar/Euro Exchange Rate and Dollar Interest Rate of an Increase in the U.S. Money Supply

Given P_{US} and Y_{US} when the money supply rises from M^1_{US} to M^2_{US} the dollar interest rate declines (as money market equilibrium is reestablished at point 2) and the dollar depreciates against the euro (as foreign exchange market equilibrium is reestablished at point 2′).



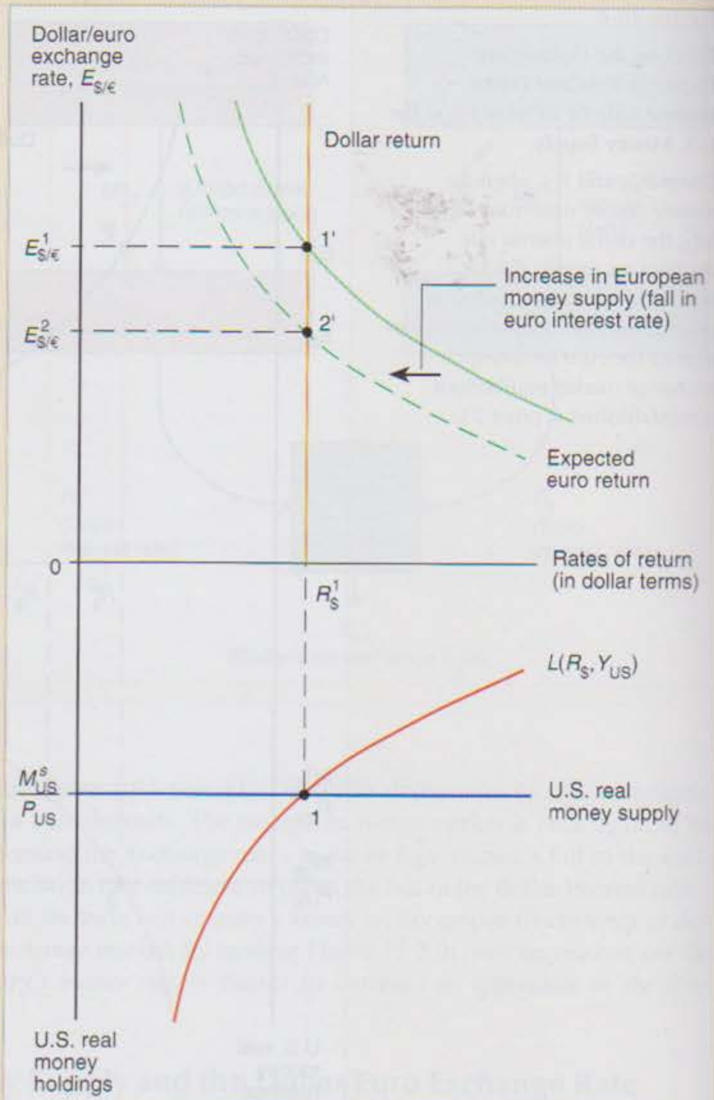
The result of an increase in the European money supply is shown in Figure 15-9. Initially the U.S. money market is in equilibrium at point 1 and the foreign exchange market is in equilibrium at point 1′, with an exchange rate $E^1_{\$/€}$. An increase in Europe's money supply lowers $R_€$ and therefore shifts to the left the schedule linking the expected return on euro deposits to the exchange rate. Foreign exchange market equilibrium is restored at point 2′, with an exchange rate of $E^2_{\$/€}$. We see that the increase in European money causes the euro to depreciate against the dollar (that is, causes a fall in the dollar price of euros). Similarly, a fall in Europe's money supply would cause the euro to appreciate against the dollar (that is, $E_{\$/€}$ would rise). The change in the European money supply does not disturb the U.S. money market equilibrium, which remains at point 1.[5]

[5] The U.S. money market equilibrium remains at point 1 because the price adjustments that equilibrate the European money market and the foreign exchange market after the increase in Europe's money supply do not change either the money supply or the money demand in the United States, given Y_{US} and P_{US}.

Figure 15-9

Effect of an Increase in the European Money Supply on the Dollar/Euro Exchange Rate

By lowering the dollar return on euro deposits (shown as a leftward shift in the expected euro return curve), an increase in Europe's money supply causes the dollar to appreciate against the euro. Equilibrium in the foreign exchange market shifts from point 1′ to point 2′, but equilibrium in the U.S. money market remains at point 1.



Money, the Price Level, and the Exchange Rate in the Long Run

Our short-run analysis of the link between countries' money markets and the foreign exchange market rested on the simplifying assumption that price levels and exchange rate expectations were given. To extend our understanding of how money supply and money demand affect exchange rates, we must examine how monetary factors affect a country's price level in the long run.

An economy's **long-run equilibrium** is the position it would eventually reach if no new economic shocks occurred during the adjustment to full employment. You can think of long-run equilibrium as the equilibrium that would be maintained after all wages and prices had had enough time to adjust to their market-clearing levels. An equivalent way of thinking of it is as the equilibrium that would occur if prices were perfectly flexible and always adjusted immediately to preserve full employment.

In studying how monetary changes work themselves out over the long run, we will examine how such changes shift the economy's long-run equilibrium. Our main tool is once again the theory of aggregate money demand.

Money and Money Prices

If the price level and output are fixed in the short run, the condition (15-4) of money market equilibrium,

$$M^s/P = L(R, Y),$$

determines the domestic interest rate, R. The money market always moves to equilibrium, however, even if we drop our "short-run" assumption and think of periods over which P and Y, as well as R, can vary. The above equilibrium condition can therefore be rearranged to give

$$P = M^s/L(R, Y), \tag{15-5}$$

which shows how the price level depends on the interest rate, real output, and the domestic money supply.

The *long-run equilibrium price level* is just the value of P that satisfies condition (15-5) when the interest rate and output are at their long-run levels, that is, at levels consistent with full employment. When the money market is in equilibrium and all factors of production are fully employed, the price level will remain steady if the money supply, the aggregate money demand function, and the long-run values of R and Y remain steady.

One of the most important predictions of the above equation for P concerns the relationship between a country's price level and its money supply, M^s: *All else equal, an increase in a country's money supply causes a proportional increase in its price level.* If, for example, the money supply doubles (to $2M^s$) but output and the interest rate do not change, the price level must also double (to $2P$) to maintain equilibrium in the money market.

The economic reasoning behind this very precise prediction follows from our observation above that the demand for money is a demand for *real* money holdings: Real money demand is not altered by an increase in M^s that leaves R and Y (and thus aggregate real money demand $L(R, Y)$) unchanged. If aggregate real money demand does not change, however, the money market will remain in equilibrium only if the real money supply also stays the same. To keep the real money supply M^s/P constant, P must rise in proportion to M^s.

The Long-Run Effects of Money Supply Changes

Our theory of how the money supply affects the price level *given* the interest rate and output is not yet a theory of how money supply changes affect the price level in the long run. To develop such a theory, we still have to determine the long-run effects of a money supply change on the interest rate and output. This is easier than you might think. As we now argue, *a change in the supply of money has no effect on the long-run values of the interest rate or real output.*[6]

[6] The preceding statement refers only to changes in the *level* of the nominal money supply and not, for example, to changes in the *rate* at which the money supply is growing over time. The proposition that a one-time change in the level of the money supply has no effects on the long-run values of real economic variables is often called the *long-run neutrality of money*. In contrast, changes in the money supply growth rate need not be neutral in the long run. At the very least, a sustained change in the monetary growth rate will eventually affect equilibrium real money balances by raising the money interest rate (as discussed in the next chapter).

The best way to understand the long-run effects of money supply on the interest rate and output is to think first about a *currency reform*, in which a country's government redefines the national currency unit. For example, the government of Turkey reformed its currency on January 1, 2005, simply by issuing "new" Turkish lira, each equal to 1 million "old" Turkish lira. The effect of this reform was to lower the number of currency units in circulation, and all lira prices, to $\frac{1}{1,000,000}$ of their old lira values. But the redefinition of the monetary unit had no effect on real output, the interest rate, or the relative prices of goods: All that occurred was a one-time change in all values measured in lira. A decision to measure distance in half-miles rather than miles would have as little effect on real economic variables as the Turkish government's decision to chop six zeros off the end of every magnitude measured in terms of money.

An increase in the supply of a country's currency has the same effect in the long run as a currency reform. A doubling of the money supply, for example, has the same long-run effect as a currency reform in which each unit of currency is replaced by two units of "new" currency. If the economy is initially fully employed, every money price in the economy eventually doubles, but real GNP, the interest rate, and all relative prices return to their long-run or full-employment levels.

Why is a money supply change just like a currency reform in its effects on the economy's long-run equilibrium? The full-employment output level is determined by the economy's endowments of labor and capital, so in the long run, real output does not depend on the money supply. Similarly, the interest rate is independent of the money supply in the long run. If the money supply and all prices double permanently, there is no reason why people previously willing to exchange \$1 today for \$1.10 a year from now should not be willing afterward to exchange \$2 today for \$2.20 a year from now, so the interest rate will remain at 10 percent per annum. Relative prices also remain the same if all money prices double, since relative prices are just ratios of money prices. Thus, money supply changes do not change the long-run allocation of resources. Only the absolute level of money prices changes.[7]

When studying the effect of an increase in the money supply over long time periods, we are therefore justified in assuming that the long-run values of R and Y will not be changed by a change in the supply of money. Thus, we can draw the following conclusion from equation (15-5): *A permanent increase in the money supply causes a proportional increase in the price level's long-run value. In particular, if the economy is initially at full employment, a permanent increase in the money supply eventually will be followed by a proportional increase in the price level.*

Empirical Evidence on Money Supplies and Price Levels

In looking at actual data on money and prices, we should not expect to see an exactly proportional relationship over long periods, partly because output, the interest rate, and the aggregate real money demand function can shift for reasons that have nothing to do with the supply of money. Output changes as a result of capital accumulation and technological advance (for example, more powerful computers), and money demand behavior may change as a result of demographic trends or financial innovations such as electronic cash-transfer facilities. In addition, actual economies are rarely in positions of long-run equilibrium. Nonetheless, we should expect the data to show a clear-cut positive association between money supplies and price levels. If real-world data did not provide strong evidence

[7] To understand more fully why a one-time change in the money supply does not change the long-run level of the interest rate, it may be useful to think of interest rates measured in terms of money as defining relative prices of currency units available on different dates. If the dollar interest rate is R percent per annum, giving up \$1 today buys you \$$(1 + R)$ next year. Thus, $1/(1 + R)$ is the relative price of future dollars in terms of current dollars, and this relative price would not change if the real value of the monetary units were scaled up or down by the same factor on all dates.

that money supplies and price levels move together in the long run, the usefulness of the theory of money demand we have developed would be in severe doubt.

The wide swings in Latin American rates of price level increase in recent decades make the region an ideal case study of the relationship between money supplies and price levels. Price level inflation had been high and variable in Latin America for more than a decade, when efforts at macroeconomic reform began to bring inflation lower by the mid-1990s.

On the basis of our theories, we would expect to find such sharp swings in inflation rates accompanied by swings in growth rates of money supplies. This expectation is confirmed by Figure 15-10, which plots annual average growth rates of the money supply against annual inflation rates. On average, years with higher money growth also tend to be years with higher inflation. In addition, the data points cluster around the 45-degree line, along which money supplies and price levels increase in proportion.

The main lesson to be drawn from Figure 15-10 is that the data confirm the strong long-run link between national money supplies and national price levels predicted by economic theory.

Money and the Exchange Rate in the Long Run

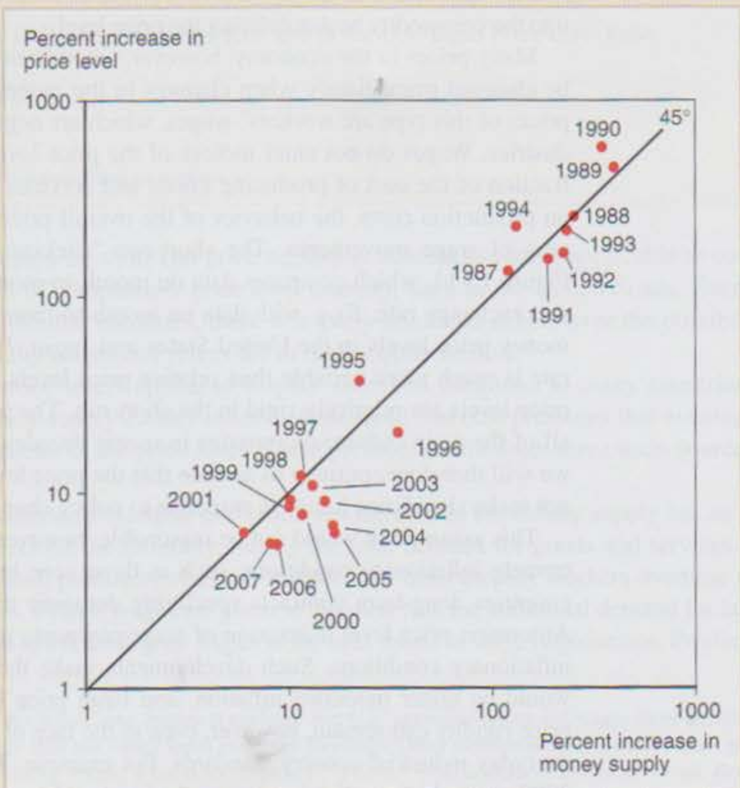
The domestic currency price of foreign currency is one of the many prices in the economy that rise in the long run after a permanent increase in the money supply. If you think again about the effects of a currency reform, you will see how the exchange rate moves in the long run. Suppose, for example, that the U.S. government replaced every pair of "old" dollars with one "new" dollar. Then if the dollar/euro exchange rate had been 1.20 *old* dollars per euro before the reform, it would change to 0.60 *new* dollars

Figure 15-10

Average Money Growth and Inflation in Western Hemisphere Developing Countries, by Year, 1987–2007

Even year by year, there is a strong positive relation between average Latin American money supply growth and inflation. (Both axes have logarithmic scales.)

Source: IMF, *World Economic Outlook*, various issues. Regional aggregates are weighted by shares of dollar GDP in total regional dollar GDP.



per euro immediately after the reform. In much the same way, a halving of the U.S. money supply would eventually lead the dollar to appreciate from an exchange rate of 1.20 dollars/euro to one of 0.60 dollars/euro. Since the dollar prices of all U.S. goods and services would also decrease by half, this 50 percent appreciation of the dollar leaves the *relative* prices of all U.S. and foreign goods and services unchanged.

We conclude that, all else equal, *a permanent increase in a country's money supply causes a proportional long-run depreciation of its currency against foreign currencies. Similarly, a permanent decrease in a country's money supply causes a proportional long-run appreciation of its currency against foreign currencies.*

Inflation and Exchange Rate Dynamics

In this section we tie together our short-run and long-run findings about the effects of monetary changes by examining the process through which the price level adjusts to its long-run position. An economy experiences **inflation** when its price level is rising and **deflation** when its price level is falling. Our examination of inflation will give us a deeper understanding of how the exchange rate adjusts to monetary disturbances in the economy.

Short-Run Price Rigidity versus Long-Run Price Flexibility

Our analysis of the short-run effects of monetary changes assumed that a country's price level, unlike its exchange rate, does not jump immediately. This assumption cannot be exactly correct, because many commodities, such as agricultural products, are traded in markets where prices adjust sharply every day as supply or demand conditions shift. In addition, exchange rate changes themselves may affect the prices of some tradable goods and services that enter into the commodity basket defining the price level.

Many prices in the economy, however, are written into long-term contracts and cannot be changed immediately when changes in the money supply occur. The most important prices of this type are workers' wages, which are negotiated only periodically in many industries. Wages do not enter indices of the price level directly, but they make up a large fraction of the cost of producing goods and services. Since output prices depend heavily on production costs, the behavior of the overall price level is influenced by the sluggishness of wage movements. The short-run "stickiness" of price levels is illustrated by Figure 15-11, which compares data on month-to-month percentage changes in the dollar/yen exchange rate, $E_{\$/¥}$, with data on month-to-month percentage changes in the ratio of money price levels in the United States and Japan, P_{US}/P_J. As you can see, the exchange rate is much more variable than relative price levels, a fact consistent with the view that price levels are relatively rigid in the short run. The pattern shown in the figure applies to all of the main industrial countries in recent decades. In light of this and other evidence, we will therefore continue to assume that the price level is given in the short run and does not make significant jumps in response to policy changes.

This assumption would not be reasonable, however, for all countries at all times. In extremely inflationary conditions, such as those seen in the 1980s in some Latin American countries, long-term contracts specifying domestic money payments may go out of use. Automatic price level indexation of wage payments may also be widespread under highly inflationary conditions. Such developments make the price level much less rigid than it would be under moderate inflation, and large price level jumps become possible. Some price rigidity can remain, however, even in the face of inflation rates that would be high by everyday industrial-country standards. For example, Turkey's 30 percent inflation rate for 2002 seems high until it is compared with the 114 percent depreciation of the Turkish lira against the U.S. dollar over the same year.

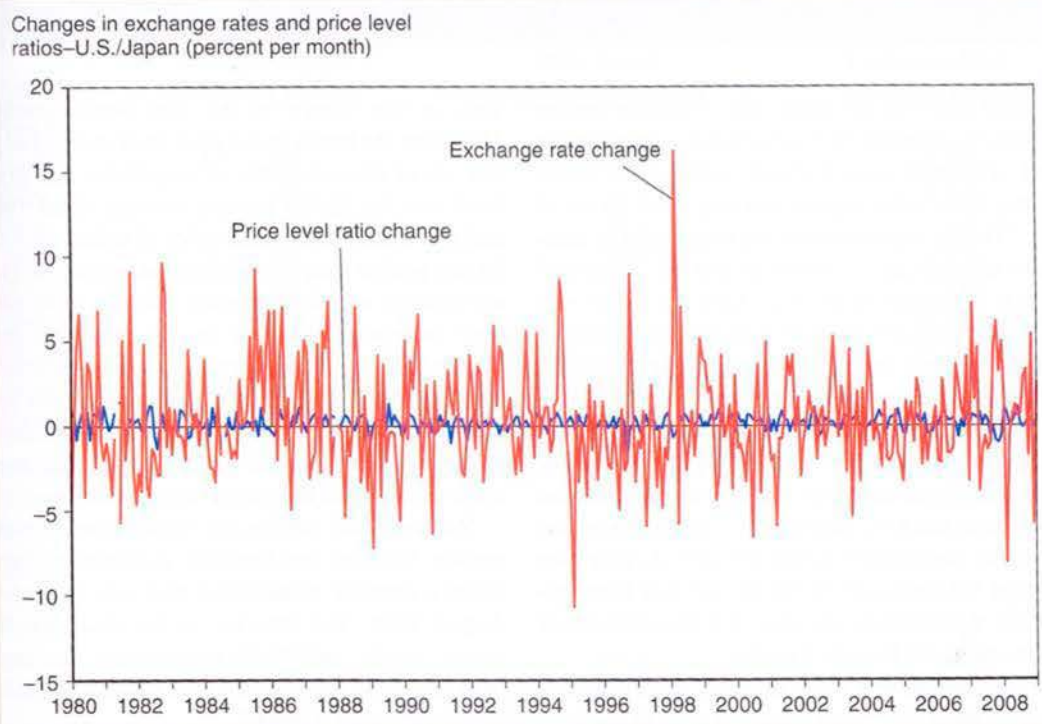


Figure 15-11

Month-to-Month Variability of the Dollar/Yen Exchange Rate and of the U.S./Japan Price Level Ratio, 1980–2009

The much greater month-to-month variability of the exchange rate suggests that price levels are relatively sticky in the short run.

Source: International Monetary Fund, *International Financial Statistics.*

Our analysis assuming short-run price rigidity is nonetheless most applicable to countries with histories of comparative price level stability, such as the United States. Even in the cases of low-inflation countries, there is a lively academic debate over the possibility that seemingly sticky wages and prices are in reality quite flexible.[8]

Although the price levels appear to display short-run stickiness in many countries, a change in the money supply creates immediate demand and cost pressures that eventually lead to *future* increases in the price level. These pressures come from three main sources:

1. *Excess demand for output and labor.* An increase in the money supply has an expansionary effect on the economy, raising the total demand for goods and services. To meet this demand, producers of goods and services must employ workers overtime and make new hires. Even if wages are given in the short run, the additional demand for labor allows workers to ask for higher wages in the next round of wage negotiations. Producers

[8] For a discussion of this debate, and empirical evidence that U.S. aggregate prices and wages show significant rigidity, see the book by Hall and Papell listed in Further Readings. Other summaries of U.S. evidence are given by Mark A. Wynne, "Sticky Prices: What Is the Evidence?" *Federal Reserve Bank of Dallas Economic Review* (First Quarter 1995), pp. 1–12; and by Mark J. Bils and Peter J. Klenow, "Some Evidence of the Importance of Sticky Prices," *Journal of Political Economy* 112 (October 2004), pp. 947–985.

Money Supply Growth and Hyperinflation in Bolivia

In 1984 and 1985 the small Latin American country of Bolivia experienced *hyperinflation*—an explosive and seemingly uncontrollable inflation in which money loses value rapidly and may even go out of use.* During hyperinflations the magnitudes of monetary changes are so enormous that the "long-run" effects of money on the price level can occur very quickly. These episodes therefore provide laboratory conditions well suited for testing long-run theories about the effects of money supplies on prices.

On the next page we show data on Bolivia's money supply and price level during the hyperinflation. An official exchange rate between the Bolivian peso and the U.S. dollar was controlled by the Bolivian government during this period, so we list instead values for an exchange rate that better reflected market forces, the price of dollars in terms of pesos on the La Paz black market.

The data show a clear tendency for the money supply, price level, and exchange rate to move in step, as the theory in the text would predict. Moreover, the trends in the price level and exchange rate are of the same order of magnitude: The price level rose by 22,908 percent between April 1984 and July 1985 and the peso price of dollars rose by 24,662 percent over the same period. These percentage changes actually are greater than the corresponding percentage increase in the money supply (which is "only" 17,433 percent), but the difference is to be expected. Exploding inflation causes real money demand to fall over time, and this additional monetary change makes money prices rise even more quickly than the money supply itself rises.

We chose July 1985 as the endpoint for the comparison because the Bolivian government introduced a dramatic stabilization plan near the end of August 1985. You can see in the data how the money supply and, more dramatically, the price level and exchange rate all began to level out in the two months after August.

*In a classic paper, Columbia University economist Phillip Cagan drew the line between inflation and hyperinflation at an inflation rate of 50 percent per month (which, through the power of compounding, comes out to 12,875 percent per year). See "The Monetary Dynamics of Hyperinflation," in Milton Friedman, ed., *Studies in the Quantity Theory of Money*. Chicago: University of Chicago Press, 1956, pp. 25–117.

are willing to pay these higher wages, for they know that in a booming economy, it will not be hard to pass higher wage costs on to consumers through higher product prices.

2. *Inflationary expectations.* If everyone expects the price level to rise in the future, their expectation will increase the pace of inflation today. Workers bargaining over wage contracts will insist on higher money wages to counteract the effect on their real wages of the anticipated general increase in prices. Producers, once again, will give in to these wage demands if they expect product prices to rise and cover the additional wage costs.

3. *Raw materials prices.* Many raw materials used in the production of final goods, for example, petroleum products and metals, are sold in markets where prices adjust sharply even in the short run. By causing the prices of such materials to jump upward, a money supply increase raises production costs in materials-using industries. Eventually, producers in those industries will raise product prices to cover their higher costs.

Permanent Money Supply Changes and the Exchange Rate

We now apply our analysis of inflation to study the adjustment of the dollar/euro exchange rate following a *permanent* increase in the U.S. money supply. Figure 15-12 shows both the short-run (Figure 15-12a) and the long-run (Figure 15-12b) effects of this disturbance. We suppose that the economy starts with all variables at their long-run levels and that output remains constant as the economy adjusts to the money supply change.

Macroeconomic Data for Bolivia, April 1984–October 1985

Month	Money Supply (Billions of Pesos)	Price Level (Relative to 1982 Average = 1	Exchange Rate (Pesos per Dollar)
1984			
April	270	21.1	3,576
May	330	31.1	3,512
June	440	32.3	3,342
July	599	34.0	3,570
August	718	39.1	7,038
September	889	53.7	13,685
October	1,194	85.5	15,205
November	1,495	112.4	18,469
December	3,296	180.9	24,515
1985			
January	4,630	305.3	73,016
February	6,455	863.3	141,101
March	9,089	1,078.6	128,137
April	12,885	1,205.7	167,428
May	21,309	1,635.7	272,375
June	27,778	2,919.1	481,756
July	47,341	4,854.6	885,476
August	74,306	8,081.0	1,182,300
September	103,272	12,647.6	1,087,440
October	132,550	12,411.8	1,120,210

Source: Juan-Antonio Morales, "Inflation Stabilization in Bolivia," in Michael Bruno et al., eds., *Inflation Stabilization: The Experience of Israel, Argentina, Brazil, Bolivia, and Mexico*. Cambridge: MIT Press, 1988, table 7A-1. Money supply is M1.

Figure 15-12a assumes the U.S. price level is initially given at P^1_{US}. An increase in the nominal money supply from M^1_{US} to M^2_{US} therefore raises the real money supply from M^1_{US}/P^1_{US} to M^2_{US}/P^1_{US} in the short run, lowering the interest rate from $R^1_\$$ (point 1) to $R^2_\$$ (point 2). So far, our analysis proceeds exactly as it did earlier in this chapter.

The first change in our analysis comes when we ask how the American money supply change (shown in the bottom part of panel (a)) affects the foreign exchange market (shown in the top part of panel (a)). As before, the fall in the U.S. interest rate is shown as a leftward shift in the vertical schedule giving the dollar return on dollar deposits. This is no longer the whole story, however, for the money supply increase now affects *exchange rate expectations*. Because the U.S. money supply change is permanent, people expect a long-run increase in all dollar prices, including the exchange rate, which is the dollar price of euros. As you will recall from Chapter 14, a rise in the expected future dollar/euro exchange rate (a future dollar depreciation) raises the expected dollar return on euro deposits; it thus shifts the downward-sloping schedule in the top part of Figure 15-12a to the right. The dollar depreciates against the euro, moving from an exchange rate of $E^1_{\$/€}$ (point 1′) to $E^2_{\$/€}$ (point 2′). Notice that the dollar depreciation is *greater* than it would be if the expected future dollar/euro exchange rate stayed fixed (as it might if the money supply increase were temporary rather than permanent). If the expectation $E^e_{\$/€}$ did not change, the new short-run equilibrium would be at point 3′ rather than at point 2′.

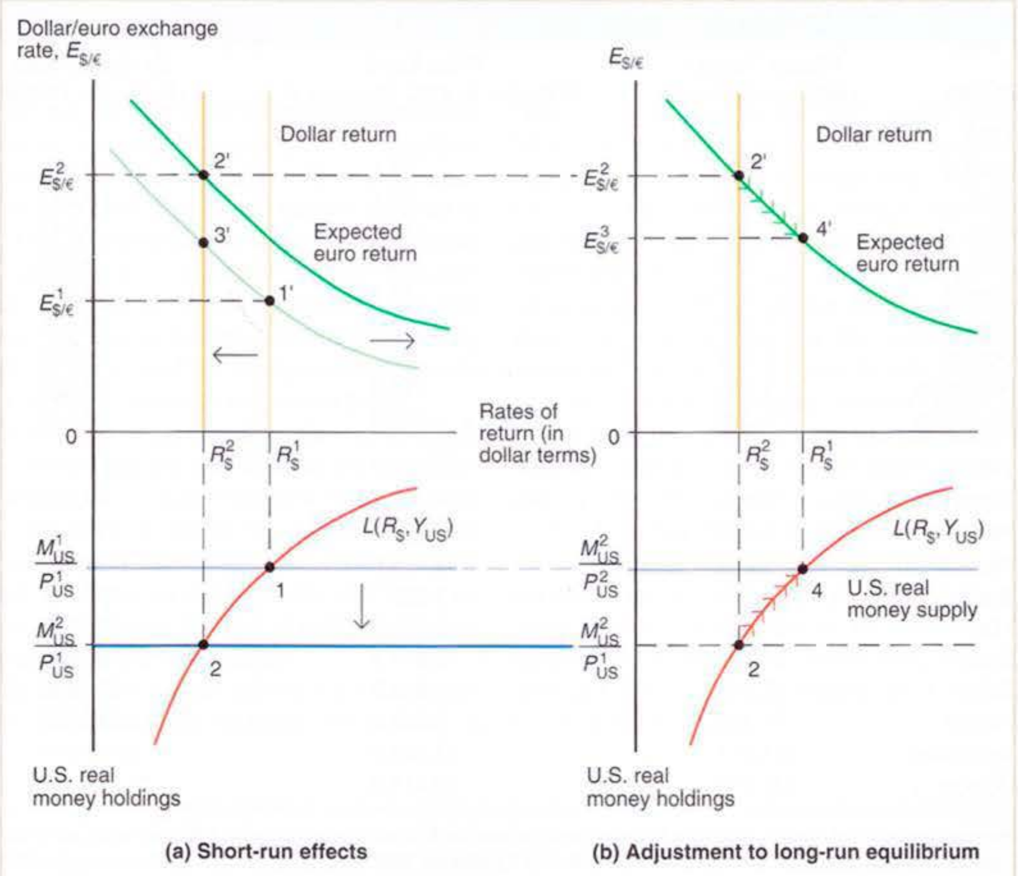


Figure 15-12

Short-Run and Long-Run Effects of an Increase in the U.S. Money Supply (Given Real Output, *Y*)

(a) Short-run adjustment of the asset markets. (b) How the interest rate, price level, and exchange rate move over time as the economy approaches its long-run equilibrium.

Figure 15-12b shows how the interest rate and exchange rate behave as the price level rises during the economy's adjustment to its long-run equilibrium. The price level begins to rise from the initially given level P^1_{US}, eventually reaching P^2_{US}. Because the long-run increase in the price level must be proportional to the increase in the money supply, the final *real* money supply, M^2_{US}/P^2_{US}, is shown equal to the initial real money supply, M^1_{US}/P^1_{US}. Since output is given and the real money supply has returned to its original level, the equilibrium interest rate must again equal $R^1_\$$ in the long run (point 4). The interest rate therefore rises from $R^2_\$$ (point 2) to $R^1_\$$ (point 4) as the price level rises from P^1_{US} to P^2_{US}.

The rising U.S. interest rate has exchange rate effects that can also be seen in Figure 15-12b: The dollar *appreciates* against the euro in the process of adjustment. If exchange rate expectations do not change further during the adjustment process, the foreign exchange market moves to its long-run position along the downward-sloping schedule defining the dollar return on euro deposits. The market's path is just the path traced out by the vertical dollar interest rate schedule as it moves rightward because of

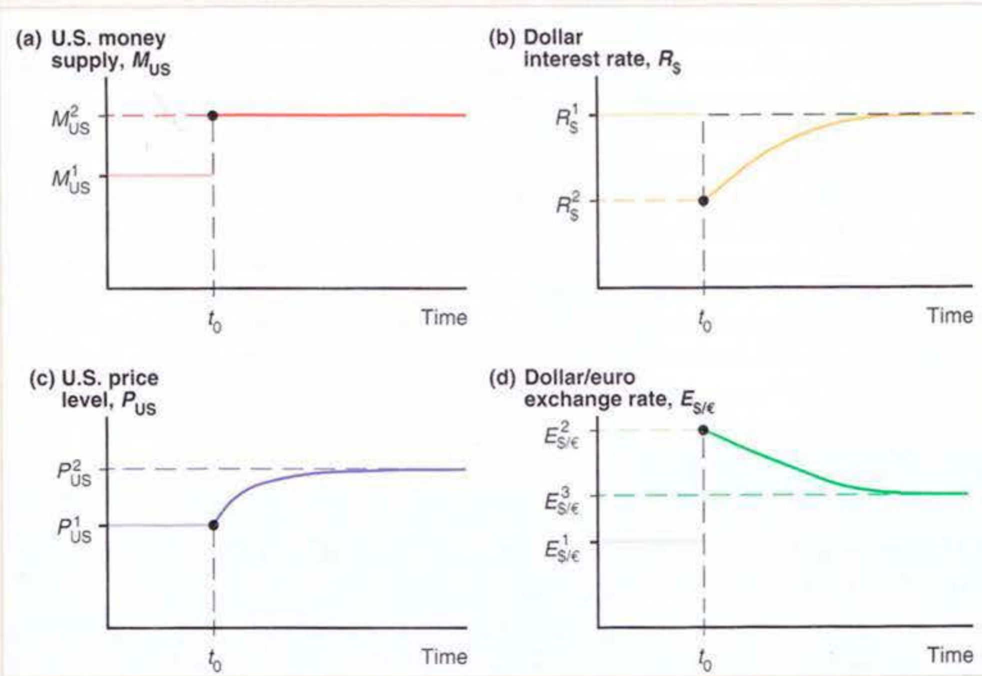


Figure 15-13

Time Paths of U.S. Economic Variables After a Permanent Increase in the U.S. Money Supply

After the money supply increases at t_0 in panel (a), the interest rate (in panel (b)), price level (in panel (c)), and exchange rate (in panel (d)) move as shown toward their long-run levels. As indicated in panel (d) by the initial jump from $E^1_{\$/€}$ to $E^2_{\$/€}$, the exchange rate overshoots in the short run before settling down to its long-run level, $E^3_{\$/€}$.

the price level's gradual rise. In the long run (point 4′), the equilibrium exchange rate, $E^3_{\$/€}$, is higher than at the original equilibrium, point 1′. Like the price level, the dollar/euro exchange rate has risen in proportion to the increase in the money supply.

Figure 15-13 shows time paths like the ones just described for the U.S. money supply, the dollar interest rate, the U.S. price level, and the dollar/euro exchange rate. The figure is drawn so that the long-run increases in the price level (Figure 15-13c) and exchange rate (Figure 15-13d) are proportional to the increase in the money supply (Figure 15-13a).

Exchange Rate Overshooting

In its initial depreciation after a money supply rise, the exchange rate jumps from $E^1_{\$/€}$ up to $E^2_{\$/€}$, a depreciation greater than its *long-run* depreciation from $E^1_{\$/€}$ to $E^3_{\$/€}$ (see Figure 15-13d). The exchange rate is said to overshoot when its immediate response to a disturbance is greater than its long-run response. **Exchange rate overshooting** is an important phenomenon because it helps explain why exchange rates move so sharply from day to day.

The economic explanation of overshooting comes from the interest parity condition. The explanation is easiest to grasp if we assume that before the money supply increase first occurs, no change in the dollar/euro exchange rate is expected, so that $R^1_\$$ equals $R_€$, the given interest rate on euro deposits. A permanent increase in the U.S. money supply doesn't affect $R_€$, so it causes $R^1_\$$ to fall below $R_€$ and remain below that interest rate

(Figure 15-13b) until the U.S. price level has completed the long-run adjustment to P^2_{US} shown in Figure 15-13c. For the foreign exchange market to be in equilibrium during this adjustment process, however, the interest difference in favor of euro deposits must be offset by an expected *appreciation* of the dollar against the euro, that is, by an expected fall in $E_{\$/€}$. Only if the dollar/euro exchange rate overshoots $E^3_{\$/€}$ initially will market participants expect a subsequent appreciation of the dollar against the euro.

Overshooting is a direct consequence of the short-run rigidity of the price level. In a hypothetical world where the price level could adjust immediately to its new, long-run level after a money supply increase, the dollar interest rate would not fall because prices *would* adjust immediately and prevent the real money supply from rising. Thus, there would be no need for overshooting to maintain equilibrium in the foreign exchange market. The exchange rate would maintain equilibrium simply by jumping to its new, long-run level right away.

Case Study

Can Higher Inflation Lead to Currency *Appreciation?* The Implications of Inflation Targeting

In the overshooting model that we have just examined, an increase in the money supply leads to higher inflation and currency depreciation, as shown in Figure 15–13. It may seem puzzling, then, that readers of the financial press often see headlines such as the following one from the *Financial Times* of May 24, 2007: "Inflation Drives Canadian Dollar Higher." In light of the seemingly reasonable model set out in this chapter, can such statements possibly make sense?

A clue comes from reading further in the *Financial Times* news story on Canadian inflation. According to the *FT*:

> [A]nalysts said that the main driver of the recent bout of Canadian dollar appreciation was higher-than-expected April inflation data, which saw the bond market fully price in a 25 basis point rise in Canadian interest rates by the end of the year.

If central banks act to raise interest rates when inflation rises, then because higher interest rates cause currency appreciation, it might be possible to resolve the apparent contradiction to our model. To do so fully, however, we must consider two aspects of the way in which modern central banks actually formulate and implement monetary policy.

1. *The interest rate, not the money supply, is the prime instrument of monetary policy.* Nowadays, most central banks do not actually target the money supply in order to control inflation. They instead target a benchmark short-term rate of interest (such as the overnight "federal funds" rate in the United States). How does our discussion of money market equilibrium help us to understand this process? Consider Figure 15-3, and assume that the central bank wishes to set an interest rate of R^1. It can do so simply by agreeing to provide or take up all of the cash that the market wishes to trade at that rate of interest. If the money supply is initially Q^2, for example, there will be an excess demand for money at the interest rate R^1, so people will sell bonds to the central bank for money (in effect, borrowing) until the money supply has expanded to Q^1 and the excess demand is gone. Central banks tend to set an interest rate, rather than the money supply, because the money demand schedule $L(R, Y)$ shifts around frequently in practice. If the central bank were to fix the money supply, the result would be high and possibly damaging interest rate volatility; it is thus more practical to fix the interest rate and let the money supply adjust automatically when necessary.[9]

Our discussion above of the positive relationship between the money supply and price level will tip you off, however, to one potential problem of an interest rate instrument. If the money supply is free to grow or shrink as markets collectively desire, how can the price level and inflation be kept under control? For example, if market actors doubt the central bank's resolve to control inflation, and suddenly push the price level up because they expect higher prices in the future, they could simply borrow more money from the central bank, thereby bringing about the money supply increase needed to maintain higher prices in the long run. This worrisome possibility brings us to the second pillar of modern monetary policy.

2. *Most central banks adjust their policy interest rates expressly so as to keep inflation in check.* A central bank can keep inflation from getting too high or too low by raising the interest rate when it learns that inflation is running higher than expected, and lowering it when inflation is running lower. As we will see more fully in Chapter 17, a rise in the interest rate, which causes the currency to appreciate, puts a damper on demand for a country's products by making them more expensive compared to foreign goods. This fall in demand, in turn, promotes lower domestic prices. A fall in the interest rate, symmetrically, supports domestic prices. Indeed, many central banks now follow formal strategies of *inflation targeting*, under which they announce a target (or target range) for the inflation rate and adjust the interest rate to keep inflation on target. Central banks generally target so-called *core* inflation, which is inflation in the price level excluding volatile components such as energy prices, rather than *headline* inflation, which is inflation in the total consumer price index. The formal practice of inflation targeting was initiated by New Zealand's central bank in 1989, and the central banks of many other developed and developing areas, including Canada, Chile, Mexico, South Africa, Sweden, Thailand, the United Kingdom, and the euro zone, have followed suit. The central banks of the United States and Japan, while strongly averse to inflation, have so far been reluctant to announce definite inflation targets.[10]

We can now understand the "paradox" of higher-than-expected inflation causing currency appreciation rather than depreciation. Suppose market participants unexpectedly push up prices and borrow to enlarge the money supply. Thus, when the Canadian government releases new price data, the data show a price level higher than

[9] For a nontechnical account of modern central bank policy implementation, see Michael Woodford, "Monetary Policy in a World Without Money," *International Finance* 3 (July 2000), pp. 229–260. Woodford's provocative title points to another advantage of the interest rate instrument for central banks: It is possible to conduct monetary policy even if checking deposits pay interest at competitive rates. For many purposes, however, it is reasonable to ignore the variability of the $L(R, Y)$ schedule and simply assume that the central bank directly sets the money supply. In the rest of the book we shall, for the most part, make that simplifying assumption. The major exception will be when we introduce fixed exchange rates in Chapter 18.

[10] The International Monetary Fund (IMF), which we will discuss in Chapter 19, maintains a useful classification of its member countries with regard to their monetary policy frameworks as well as their exchange rate systems; see the documentation and data at http://www.imf.org/external/np/mfd/er/2008/eng/0408.htm. The IMF does not consider Switzerland to be an inflation targeter, but the difference between its actual procedures and inflation targeting is small, and this Case Study therefore includes it among the inflation-targeting countries. On inflation-targeting practices and the theory behind them, see the books by Bernanke et al. and by Truman in Further Readings. For a critique of the idea of targeting core rather than headline inflation, see Stephen Cecchetti, "Core Inflation Is an Unreliable Guide," *Financial Times*, September 12, 2006.

what market participants had previously predicted. If the Bank of Canada is expected to raise interest rates quickly so as to push the price level and money supply back on course, there is no reason for the future expected exchange rate to change. But with higher Canadian interest rates, interest parity requires an expected future *depreciation* of the Canadian dollar, which is consistent with an unchanged future exchange rate only if the Canadian dollar *appreciates* immediately. The picture of the economy's adjustment after the unexpected increase in money and prices would look like Figure 15–13 in reverse (that is, constructed to reflect a monetary contraction rather than an expansion)—with the added assumption that the Bank of Canada gradually moves interest rates back to their initial level as the price level returns to its targeted path.[11]

Economists Richard Clarida of Columbia University and Daniel Waldman of Barclays Capital offer striking statistical evidence consistent with this explanation.[12] These writers measure unexpected inflation as the inflation rate estimate initially announced by a government, prior to any data revisions, less the median of inflation forecasts for that period previously published by a set of banking industry analysts. For a sample of ten countries—Australia, Britain, Canada, the euro area, Japan, New Zealand, Norway, Sweden, Switzerland, and the United States—Clarida and Waldman examine the exchange rate changes that occur in the period lasting from five minutes prior to an inflation announcement to five minutes afterward. Their key findings are these:

1. On average for the ten currencies that they study, news that inflation is unexpectedly high does indeed lead a currency to appreciate, not depreciate.
2. The effect is stronger for core than for headline inflation.
3. The effect is much stronger for the inflation-targeting countries than for the United States and Japan, the two countries that do not announce inflation targets. In the case of Canada, for example, the announcement of an annual core inflation rate that is 1 percent per year above the market expectation leads the Canadian dollar to appreciate immediately by about 3 percent against the U.S. dollar. The corresponding effect for the U.S. dollar/euro exchange rate, while in the same direction, is only about one-quarter as big.
4. For countries where sufficiently long data series are available, the strengthening effect of unexpected inflation on the currency is present after the introduction of inflation targeting, but not before.

Scientific theories can be conclusively disproved, of course, but never conclusively proved. So far, however, the theory that strict inflation targeting makes bad news on inflation good news for the currency looks quite persuasive.

[11] Strictly speaking, the narrative in the text describes a setting with price level rather than inflation rate targeting. (Can you see the difference?) The reasoning in the case of inflation targeting is nearly identical, however, provided that the central bank's interest rate response to unexpectedly high inflation is sufficiently strong.

[12] See Clarida and Waldman, "Is Bad News About Inflation Good News for the Exchange Rate? And If So, Can That Tell Us Anything about the Conduct of Monetary Policy?" in John Y. Campbell, ed., *Asset Prices and Monetary Policy* (Chicago: University of Chicago Press, 2008). Michael W. Klein of Tufts University and Linda S. Goldberg of the Federal Reserve Bank of New York used a related approach to investigate changing market perceptions of the European Central Bank's inflation aversion after its founding in 1999; see "Establishing Credibility: Evolving Perceptions of the European Central Bank," Institute for International Integration Studies Discussion Paper 194, Trinity College, Dublin, December 2006.

SUMMARY

1. Money is held because of its liquidity. When considered in real terms, *aggregate money demand* is not a demand for a certain number of currency units but is instead a demand for a certain amount of purchasing power. Aggregate real money demand depends negatively on the opportunity cost of holding money (measured by the domestic interest rate) and positively on the volume of transactions in the economy (measured by real GNP).
2. The money market is in equilibrium when the real *money supply* equals aggregate real money demand. With the *price level* and real output given, a rise in the money supply lowers the interest rate and a fall in the money supply raises the interest rate. A rise in real output raises the interest rate, given the price level, while a fall in real output has the opposite effect.
3. By lowering the domestic interest rate, an increase in the money supply causes the domestic currency to depreciate in the foreign exchange market (even when expectations of future exchange rates do not change). Similarly, a fall in the domestic money supply causes the domestic currency to appreciate against foreign currencies.
4. The assumption that the price level is given in the *short run* is a good approximation to reality in countries with moderate *inflation*, but it is a misleading assumption over the *long run*. Permanent changes in the money supply push the *long-run equilibrium* price level proportionally in the same direction but do not influence the long-run values of output, the interest rate, or any relative prices. One important money price whose long-run equilibrium level rises in proportion to a permanent money supply increase is the exchange rate, the domestic currency price of foreign currency.
5. An increase in the money supply can cause the exchange rate to overshoot its long-run level in the short run. If output is given, a permanent money supply increase, for example, causes a more-than-proportional short-run depreciation of the currency, followed by an appreciation of the currency to its long-run exchange rate. *Exchange rate overshooting*, which heightens the volatility of exchange rates, is a direct result of sluggish short-run price level adjustment and the interest parity condition.

KEY TERMS

aggregate money demand, p. 358
deflation, p. 372
exchange rate overshooting, p. 377
inflation, p. 372
long run, p. 363
long-run equilibrium, p. 368
money supply, p. 356
price level, p. 358
short run, p. 363

PROBLEMS

1. Suppose there is a reduction in aggregate real money demand, that is, a negative shift in the aggregate real money demand function. Trace the short-run and long-run effects on the exchange rate, interest rate, and price level.
2. How would you expect a fall in a country's population to alter its aggregate money demand function? Would it matter if the fall in population were due to a fall in the number of households or to a fall in the size of the average household?
3. The velocity of money, V, is defined as the ratio of real GNP to real money holdings, $V = Y/(M/P)$ in this chapter's notation. Use equation (15-4) to derive an expression for velocity and explain how velocity varies with changes in R and in Y. (Hint: The

effect of output changes on V depends on the elasticity of aggregate money demand with respect to real output, which economists believe to be less than unity.) What is the relationship between velocity and the exchange rate?

4. What is the short-run effect on the exchange rate of an increase in domestic real GNP, given expectations about future exchange rates?
5. Does our discussion of money's usefulness as a medium of exchange and unit of account suggest reasons why some currencies become vehicle currencies for foreign exchange transactions? (The concept of a vehicle currency was discussed in Chapter 14.)
6. If a currency reform has no effects on the economy's real variables, why do governments typically institute currency reforms in connection with broader programs aimed at halting runaway inflation? (There are many instances in addition to the Turkish case mentioned in the text. Other examples include Israel's switch from the pound to the shekel, Argentina's switches from the peso to the austral and back to the peso, and Brazil's switches from the cruzeiro to the cruzado, from the cruzado to the cruzeiro, from the cruzeiro to the cruzeiro real, and from the cruzeiro real to the real, the current currency, which was introduced in 1994.)
7. Imagine that the central bank of an economy with unemployment doubles its money supply. In the long run, full employment is restored and output returns to its full-employment level. On the (admittedly unlikely) assumption that the interest rate before the money supply increase equals the long-run interest rate, is the long-run increase in the price level more than proportional or less than proportional to the money supply change? What if (as is more likely) the interest rate is initially below its long-run level?
8. Between 1984 and 1985, the money supply in the United States increased to \$641.0 billion from \$570.3 billion, while that of Brazil increased to 106.1 billion cruzados from 24.4 billion. Over the same period, the U.S. consumer price index rose to 100 from a level of 96.6, while the corresponding index for Brazil rose to 100 from a level of only 31. Calculate the 1984–1985 rates of money supply growth and inflation for the United States and Brazil, respectively. Assuming that other factors affecting the money markets did not change too dramatically, how do these numbers match up with the predictions of this chapter's model? How would you explain the apparently different responses of U.S. compared with Brazilian prices?
9. Continuing with the preceding question, note that the monetary value of output in 1985 was \$4,010 billion in the United States and 1,418 billion cruzados in Brazil. Refer back to question 3 and calculate velocity for the two countries in 1985. Why do you think velocity was so much higher in Brazil?
10. In our discussion of short-run exchange rate overshooting, we assumed that real output was given. Assume instead that an increase in the money supply raises real output in the short run (an assumption that will be justified in Chapter 17). How does this affect the extent to which the exchange rate overshoots when the money supply first increases? Is it likely that the exchange rate undershoots? (Hint: In Figure 15-12a, allow the aggregate real money demand schedule to shift in response to the increase in output.)
11. Figure 14-2 shows that Japan's short-term interest rates have had periods during which they are near or equal to zero. Is the fact that the yen interest rates shown never drop below zero a coincidence, or can you think of some reason why interest rates might be bounded below by zero?
12. How might a zero interest rate complicate the task of monetary policy? (Hint: At a zero rate of interest, there is no advantage in switching from money to bonds.)
13. As we observed in this chapter, central banks, rather than purposefully setting the level of the money supply, usually set a target level for a short-term interest rate by standing ready to lend or borrow whatever money people wish to hold at that interest rate. (When people need more money for a reason other than a change in

the interest rate, the money supply therefore expands, and it contracts when they wish to hold less.)

a. Describe the problems that might arise if a central bank sets monetary policy by holding the market interest rate constant. (First, consider the flexible-price case, and ask yourself if you can find a unique equilibrium price level when the central bank simply gives people all the money they wish to hold at the pegged interest rate. Then consider the sticky-price case.)

b. Does the situation change if the central bank raises the interest rate when prices are high, according to a formula such as $R - R_0 = a(P - P_0)$, where a is a positive constant and P_0 a target price level?

c. Suppose the central bank's policy rule is $R - R_0 = a(P - P_0) + u$, where u is a random movement in the policy interest rate. In the overshooting model shown in Figure 15-12, describe how the economy would adjust to a permanent one-time unexpected fall in the random factor u, and say why. You can interpret the fall in u as an interest rate cut by the central bank, and therefore as an expansionary monetary action. Compare your story with the one depicted in Figure 15-13.

FURTHER READINGS

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