PART VI

The Determination of Exchange Rates in International Asset Markets

CHAPTER 27

Expectations, Money, and the Determination of the Exchange Rate

We now turn our attention explicitly to the determination of exchange rates in international financial markets. In Chapter 23 we adopted the assumption of perfect capital mobility, or perfect international integration of financial markets: There are no transaction costs, capital controls, or other barriers separating international investors from the portfolios they would like to hold. We will maintain this assumption. Large quantities of capital are ready to move back and forth across national boundaries at will. Because investors adjust their portfolios instantaneously in response to changes in rates of return, exchange rates are volatile. The exchange rate is now the relative price of foreign versus domestic *assets,* rather than the relative price of foreign versus domestic *goods.* Thus it is not surprising that exchange rates turn out to be as volatile as the prices of bonds, equities, gold, and other assets, in contrast to the much more stable national price levels. Refer back to Figure 19.4 for an illustration of this volatility.

In Chapters 21 and 22, the international portfolio investor's decision concerning what country's asset to hold depended only on interest rates. This chapter introduces an additional factor that enters investors' decision making: expectations about future changes in exchange rates. It was reasonable to omit this factor when we were studying a fixed exchange rate and assuming the rate had little likelihood of being changed. Under the modern floating rate system, however, investors are forced to wager on exchange rate movements every time they invest internationally. We begin by focusing on a key building block of models of exchange rate determination: international interest rate parity conditions.

27.1 Interest Rate Parity Conditions

If the dollar is expected to lose value in the future against the yen, then Japanese investors will subtract the expected rate of dollar depreciation from the dollar interest rate when contemplating the purchase of U.S. assets. Similarly, U.S. investors will add the expected rate of yen appreciation to the yen interest rate when contemplating the purchase of Japanese assets. If investors do not care about any factors other than the expected rates of return on the two countries' assets, then they will buy the asset with the higher expected return and sell the other, a process that continues until expected returns are equalized across countries. This means that the expected rate of depreciation of the domestic currency, Δs^e, will be equal to the nominal interest differential.

$$i - i^* = \Delta s^e \tag{27.1}$$

This condition is known as *uncovered interest parity.*

Uncovered interest parity is somewhat similar to *covered* interest parity, the arbitrage condition, Equation 21.2, introduced in Chapter 21:

$$i - i^* = fd \tag{27.2}$$

where fd is the forward discount. There is an important difference, however. In the absence of transaction costs, capital controls, and so on, any deviations from Equation 27.2 would mean that investors could risklessly make as much money as they wanted, simply by borrowing in the low-interest-rate country and lending in the other, covering on the forward exchange market. There would be no risk of capital losses (or gains) because the exchange risk is hedged on the forward exchange market. It is very unlikely that such golden profit opportunities exist; indeed, Chapter 21 showed that covered interest parity holds for most industrialized countries.

Uncovered interest parity is another matter. Here investors buying a foreign asset with an apparently high rate of return expose themselves to the risk that whatever is earned in interest will be outweighed by unexpected adverse movements in the exchange rate. Thus uncovered interest parity is a stronger hypothesis than covered interest parity. It will hold only if investors treat domestic currency and foreign currency assets as *perfect substitutes* in their portfolios. In particular, uncovered interest parity will hold only if exchange risk is not important to investors. (This would be the case if investors are relatively certain as to the future exchange rate or, alternatively, if they are risk neutral, i.e., they are unconcerned about risk.)

Expected depreciation and exchange risk are the two factors that can separate domestic and foreign interest rates, even in the absence of barriers to international capital movement. This chapter considers only expected depreciation. We consider exchange risk in Chapter 28.[1]

We will be using Equation 27.1 throughout this chapter. It is important to clarify from the outset that the uncovered interest parity condition is not necessarily a statement about causality; it is not a model specifying the determination of interest rates. Equation 27.1 is an equilibrium condition. It is entirely consistent with the idea that the interest rate is determined to give equilibrium in the money market, as assumed in previous chapters. This chapter simply adds Equation 27.1 as one of the equations that will have to be satisfied simultaneously if investors are to be happy with the portfolios they are holding.

[1]Note that if Equations 27.1 and 27.2 both hold, then we have $fd = \Delta s^e$. This is another way of saying there is no exchange risk premium in the foreign exchange market. (Equation 21.A.3 defined the exchange risk premium. Chapter 28 will discuss it further.)

27.2 The Monetary Model of Exchange Rates with Flexible Prices

Under the assumptions (1) that no transaction costs, government controls, or other barriers are discouraging international trade in bonds, and (2) that investors treat different countries' assets as perfect substitutes in their portfolios, it is as if there is only one type of bond in the world. Different countries' bonds can be aggregated together, as long as they all pay the same expected rate of return; investors will be indifferent to which country's bonds they hold. This is what is meant by assuming uncovered interest parity.

The first half of the chapter will also make some analogous assumptions about goods markets: (1) there are no transportation costs, government controls, or other barriers discouraging international trade in goods, and (2) consumers' tastes are such that they treat different countries' goods as perfect substitutes. Thus it is as if there is only one type of good in the world. Countries' goods can be aggregated together so long as their relative prices are fixed. This is what is meant by purchasing power parity, the condition covered extensively in Chapter 19. That chapter distinguished between the *monetary* approach to the balance of payments, so named because it devotes special attention to international flows of money, and the *monetarist* and *new classical* models, which add the assumption that prices are perfectly flexible so that goods markets always clear. This chapter can be thought of as the monetary approach to the *exchange rate,* the floating rate version of the model studied in Chapter 19 for the case of fixed rates. Only in the first half of this chapter do we add the assumption that goods prices are perfectly flexible, to get what might be called the monetarist or new classical model of the exchange rate.

Why return to the assumption of price flexibility, given all the evidence against it reported earlier? First, the model in which there is only one good as well as one bond in the world is a conveniently simple starting point from which to begin the exploration of the complexities of modern exchange rate theory. Second, purchasing power parity (PPP) is not a bad approximation for considering the very long run (or for considering other cases where there are large changes in money supplies, price levels, and exchange rates, as in hyperinflation). Section 27.3 will reintroduce short-run deviations from PPP: variation in the real exchange rate related to monetary disturbances in the presence of sticky goods prices.

We first brought up the importance of exchange rate expectations at the end of the presentation of the Mundell-Fleming model in Chapter 23, which assumed that prices were fixed in the short run. The discussion there noted that investors might expect the exchange rate in the future to move, from wherever it happened to be at the moment, in the direction of long-run equilibrium. This is how we will model expectations in this chapter. First, however, it will be helpful to have an idea of the long-run equilibrium toward which the exchange rate is expected to move. This is another reason for beginning here by studying the long-run equilibrium in which PPP holds.

We repeat the PPP assumption:

$$\bar{S} = \frac{P}{P^*} \tag{27.3}$$

Here $\overline{S}$ denotes the level of the exchange rate (the "spot" price of foreign exchange), P the domestic price level, and P^* the foreign price level. Placing a bar over the exchange rate indicates that—ultimately—the equation is taken seriously only in long-run equilibrium. $\overline{S}$ is on the left side here because the focus is on how exchange rates are determined. This is in contrast to Chapter 19, which dealt with fixed exchange rates. There the domestic price level was determined by the exchange rate set by the government, so P was on the left side.

Equation 27.3 is incomplete as a theory of what determines the exchange rate because it simply pushes the question back one step. It says that the exchange rate moves in proportion to the price level. What determines the price level?

The Exchange Rate as the Price of Money

The other essential equation in the monetary model of the exchange rate is the one that sets the real supply of money, M/P, equal to the real demand for money, L.

$$M/P = L(i, Y) \tag{27.4}$$

As in the derivation of the LM curve (Equation 22.4), this equation assumes that the demand for money is a decreasing function of the interest rate, i, because people wish to hold less money when other assets pay a higher rate of return compared to money, but an increasing function of income, Y, because people have a greater need for money with which to undertake transactions when income is higher.[2] To treat the relationship as a theory of how the price level is determined, solve for P.

$$P = M/L(i, Y) \tag{27.5}$$

It makes sense to think of the price level as being determined to set money demand equal to money supply because prices are assumed perfectly flexible. Notice that a 10 percent increase in the money supply causes the price level to increase by 10 percent.

The supply and demand for money in the foreign country is modeled in precisely the same way.

$$P^* = M^*/L^*(i^*, Y^*) \tag{27.6}$$

Now take the ratio of the two price level equations, and substitute it into Equation 27.3.

$$\overline{S} = \frac{M/L\,(i,Y)}{M^*/L^*(i^*,Y^*)} = \frac{M/M^*}{L(i,Y)/L^*(i^*,Y^*)} \tag{27.7}$$

Equation 27.7 has a simple intuitive interpretation. The exchange rate is defined as the price of foreign currency in terms of domestic currency. Thus we are now modeling it as the relative price of foreign money rather than the relative price of foreign goods. As such, it should be determined by the relative supply and demand for money. Notice that the foreign money supply, M^*, appears in the denominator. An increase in M^* will

[2]It is possible to derive a money demand function from principles of optimization. Robert Lucas, "Interest Rates and Currency Prices in a Two-Country World," *Journal of Monetary Economics,* 10 (1982): 335–360.

cause a decline in the price of foreign money—the exchange rate, $\overline{S}$—just as an increase in the supply of bananas causes a fall in the price of bananas. An increase in the demand for foreign money, L^*, will have the opposite effect: an increase in the price of foreign money, just as an increase in the demand for bananas causes an increase in the price of bananas. What about the effect of domestic factors? The domestic money supply, M, is in the numerator. An increase in the domestic money supply causes an increase in the exchange rate, a depreciation of the currency. (This is the same result seen in previous chapters.) Finally, an increase in the domestic demand for money causes a decrease in the exchange rate.

The nature of the exchange rate's dependence on the money supplies is very simple: It is directly proportionate to M and inversely proportionate to M^*. When the domestic money supply increases by 10 percent relative to the foreign money supply, the exchange rate goes up by 10 percent because the price level goes up by 10 percent. This is the property of *homogeneity* of nominal variables. See Figure 27.1(a) later in this chapter.

The money demand variables do not necessarily enter in as simply as the money supply variables. For convenience, however, we will adopt a simple functional form for the money demand function, in which the demand for money is proportional to real income in the same way as it is proportional to the price level.[3] Then Y and Y^* will determine the exchange rate in simple ratio form. We also adopt the simplifying assumption that the interest rates enter in simple difference form, represented by the function λ ( ):

$$\overline{S} = \frac{M/M^*}{Y/Y^*} \lambda (i - i^*) \tag{27.8}$$

The simpler functional form chosen for Equation 27.8 clarifies how the exchange rate depends on Y, Y^*, i, and i^*.[4] An increase in domestic real income, Y, has a negative effect on $\overline{S}$—that is, it causes the domestic currency to appreciate—and an increase in foreign income has the opposite effect. An increase in the interest differential, $i - i^*$, has a positive association with $\overline{S}$—that is, it causes the domestic currency to depreciate.[5]

These effects are precisely the reverse of the effects that income and the interest rate appeared to have on the exchange rate in the Mundell-Fleming model in preceding chapters. The apparent contradictions merit some explanation.

First consider the effect of income. Recall exchange rate determination in the Mundell-Fleming model. There an increase in income, Y, because it meant higher demand for imports and a deteriorated trade balance, required a depreciation of the

[3] In other words, the demand for nominal money balances is proportional to nominal GDP, which is PY. This assumption holds, for example, in the quantity theory of money, in which velocity, PY/M, is constant. In that model, however, money demand does not depend on the interest rate.

[4] There is a particular functional form for $L(i, Y)$ that allows the interest rates to enter in simple difference form, as in Equation 27.8: the exponential function. The chapter supplement offers a formal presentation of the model in logs.

[5] Equation 27.8 could be applied to a context of fixed exchange rates as easily as to floating rates, or to a context in which the central bank intervenes in the foreign exchange market to some intermediate degree. Lance Girton and Don Roper, "A Monetary Model of Exchange Market Pressure Applied to the Postwar Canadian Experience," *American Economic Review,* 67, no. 4 (1977): 537–548.

currency.[6] Equation 27.8 implies the reverse relationship with Y. The difference is that this section assumes that prices are perfectly flexible and that Y is therefore always at the level of potential output, where all resources in the economy are fully employed. Think of Y as having a bar over it (like $\overline{S}$) to indicate that it refers to potential output. In this context, if income increases, it is not because of expansionary monetary policy or any other kind of increase in demand, but because of supply-side factors such as a higher level of national resources or an improvement in economic efficiency. In other words, when prices are perfectly flexible, all changes in output are changes in potential output. When income increases because of such reasons, it is a sign of strength in the economy and tends to appreciate the currency because it raises the demand for money. For example, appreciation of the yen in the 1970s and 1980s was attributed to rapid growth in the Japanese economy. Appreciation of the dollar in the latter half of the 1990s was attributed to rapid growth in the U.S. economy.

Now consider the effect of interest rates. In the Mundell-Fleming model (with partial capital mobility), an increase in the interest differential, because it improved the capital account, required an appreciation of the currency. In Equation 27.8, in contrast, an increase in the interest differential is associated with a depreciation of the currency. It is important to see the reason for this difference as well.

From the covered interest parity condition, Equation 27.2, the forward discount can be substituted in place of the interest differential. Furthermore, the uncovered interest parity condition, Equation 27.1, shows that the expected depreciation variable can be substituted in place of the interest differential. We can rewrite Equation 27.8 as follows:

$$\overline{S} = \frac{M/M^*}{Y/Y^*}\,\lambda\,(\Delta s^e) \tag{27.9}$$

An increase in the expected rate of depreciation of the currency, Δs^e, has a positive effect on today's exchange rate (it causes the currency to depreciate today). It is clear why: If investors expect the domestic currency to lose value over the coming period, they will choose to shift their portfolios out of that currency and into other assets to protect themselves against the expected future losses. When they seek to shift out of the domestic currency, they drive down its value today ($\overline{S}$ rises). There is an important principle here. If expectations regarding what will happen in the future change, even if no other variables change today, then today's exchange rate will change. In this context, a high interest rate is not a sign of strength for a currency. Rather, it reflects expected future depreciation and is thus a sign of weakness.[7] This is why a high (nomi-

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[6]In Problem 5 at the end of the chapter, you are asked to solve the balance-of-payments equilibrium condition (Equation 22.4) for S.

[7]When investors shift their portfolios out of domestic money in response to expectations of depreciation, what do they shift into? They shift into either domestic or foreign bonds. It makes no difference which, because under the assumption of perfect substitutability, or uncovered interest parity, domestic and foreign bonds are essentially the same thing. In a different version of the model, the *currency substitution* model, people are thought to shift directly from domestic money to foreign money. However, unless they are planning on actually traveling to the foreign country to buy goods, there is in reality little reason for them to hold foreign money. To do so would be to voluntarily give up the interest that could be earned on foreign bonds.

nal) interest rate is not necessarily associated with a strong currency, as it is in the Mundell-Fleming model.

So far, we have represented the rate of return variable (the opportunity cost of holding domestic money) of Equation 27.8 in three ways: as the interest rate differential, the forward discount, and the expected rate of depreciation. There is yet a fourth way to express the rate of return variable, and it will help clarify the first three expressions.

Equation 27.3 expressed purchasing power parity in terms of *levels;* but it can also be expressed in terms of *rates of change:*

$$\Delta\bar{s} = \Delta p - \Delta p^* \tag{27.10}$$

where $\Delta\bar{s}$ is the annualized percentage rate of change of the exchange rate in long-run equilibrium, Δp is the domestic inflation rate, and Δp^* is the foreign inflation rate. Equation 27.10 says that if the domestic inflation rate exceeds the foreign inflation rate, then the domestic currency depreciates at the rate of the inflation differential, to prevent the country's goods from becoming overpriced in world markets.[8]

If the exchange rate acts according to Equation 27.10, investors are presumably aware of this and form their expectations accordingly. Then expected depreciation is equal to the expected inflation differential.

$$\Delta s^e = \Delta p^e - \Delta p^{*e} \tag{27.11}$$

In other words, investors expect the domestic currency to lose value to the extent that they expect its purchasing power over goods to deteriorate at a faster rate than for the foreign currency.

Observe that if the interest differential is equal to the expected rate of depreciation (Equation 27.1, the uncovered interest parity condition) and the expected rate of depreciation is in turn equal to the expected inflation differential (Equation 27.11, PPP in rate of change form), then it follows that the interest differential is equal to the expected inflation differential.

$$i - i^* = \Delta p^e - \Delta p^{*e}$$

This can also be represented as the domestic *real* (that is, expected-inflation adjusted) interest rate equal to the foreign real interest rate.

$$i - \Delta p^e = i^* - \Delta p^{*e}$$

This condition is called *real interest parity*.[9]

[8]Again, the empirical evidence in Chapter 19 showed that PPP is unlikely to hold in the short run. Remember, however, that the model in this section properly applies only to long-run exchange rate determination. The short-run deviations from the equation will be developed soon enough.

[9]Real interest parity could also be obtained through an alternative route—if the real interest rate in each country were tied to a technological constant, the marginal product of capital. In practice, however, real interest rates are observed to be neither constant over time nor equal across countries at a point in time. (Again, only as a description of the long run is the flexible-price view of the world that provides real interest parity meant to be taken literally.)

Using Equation 27.11, we can substitute the expected inflation differential into Equation 27.9.

$$\overline{S} = \frac{M/M^*}{Y/Y^*} \lambda\,(\Delta p^e - \Delta p^{*e}) \qquad (27.12)$$

Now we see that investors will seek to shift out of a currency, thus causing it to depreciate, when it is expected to lose future value in the sense of a high expected rate of inflation.

Venezuela is an example of a country with a high rate of inflation, as compared to the United States. The Venezuelan inflation differential has held consistently enough in the past that by now it is built into expectations and the interest differential. Japan is an example of a country that has long had a low inflation rate, which has become similarly built into its economy. Thus PPP states that the Venezuelan bolivar will depreciate over time while the yen will appreciate over time. The monetary theory also states something stronger, however. It states that when there is a sudden increase in expected future inflation—for example, because a new, more expansionary head of the central bank is appointed—the currency depreciates immediately.

Expectations of Money Growth

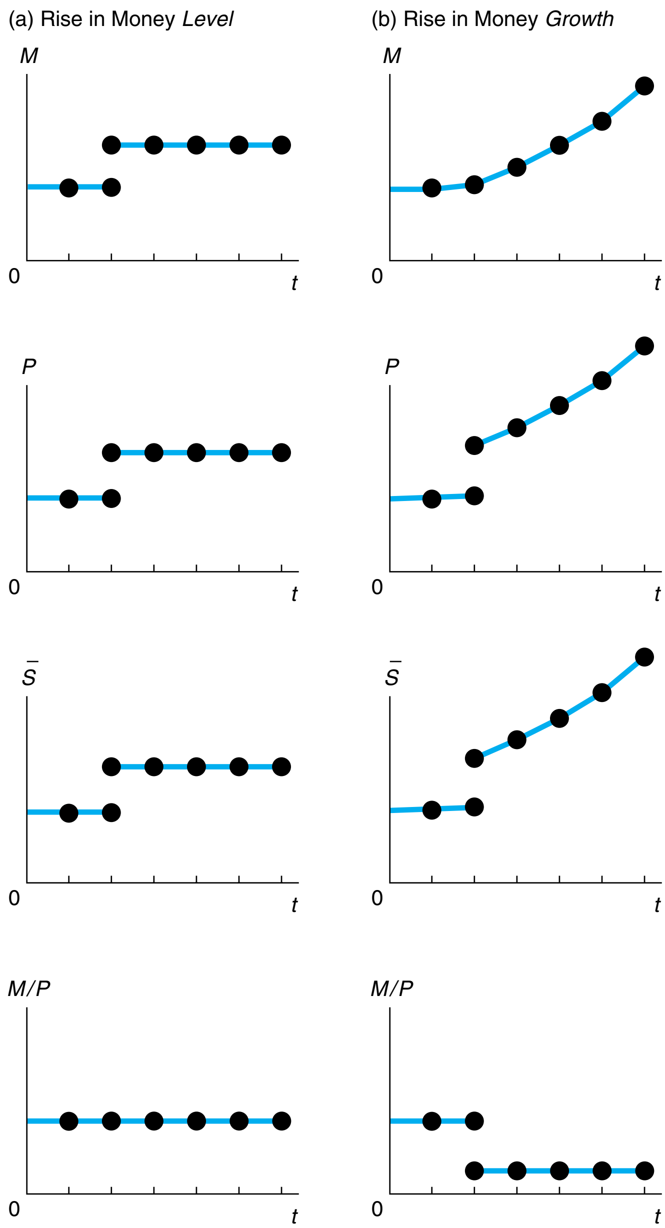
What determines the expected inflation rate? Many factors affect the inflation rate, especially in the short run. In the simple monetary model, however, the rate of money creation, exogenously set by the central bank, drives everything. This can be seen from the money market equilibrium condition, Equation 27.4. Remember that, because prices are perfectly flexible, income in the equation is tied to the exogenous level of potential output. Imagine that the inflation rate, although not zero, is in a steady state, that is, it is constant and has been fully incorporated into expectations and interest rates. It follows from Equation 27.4 that the given rate of increase of the price level presupposes a money growth rate of the same magnitude. If the money growth rate is exogenously set by the central bank, the inflation rate necessarily adjusts accordingly. The point can be made in terms of the *LM* curve used so extensively in the preceding chapters: If the money growth rate were *not* fully reflected in the inflation rate, that is, if the real money supply were increasing, then the *LM* curve would be shifting to the right and real income would be increasing. For there to be a steady state, the ratio of the money supply to the price level must be constant.

What is the effect on the exchange rate of a permanent increase in the money growth rate of, say, 1 percent per annum? The inflation rate goes up permanently by 1 percent per annum. As soon as the change is recognized by the public, expected depreciation and the interest rate go up by the same 1 percent. As a result, the demand for the currency falls. If the change is recognized at the same moment that it actually takes effect, as it will be if the central bank announces the change in policy, then the price of the currency falls instantaneously. Figure 27.1(a) shows this as a discrete upward jump in the exchange rate (and in the price level). This jump occurs even though the level of the money supply does not jump discretely, only its rate of growth does. Thus the per-

FIGURE 27.1

The Effect of Changes in the Money Supply on the Equilibrium Exchange Rate

When the money supply, *M*, jumps to a higher level, the equilibrium price level, *P*, and spot rate, $\bar{S}$, jump in proportion, as in (a). When the money supply grows at a faster rate, the equilibrium price level and spot rate grow at the same faster rate. In addition, there is a sudden drop in demand for the currency when investors discover the change, as in (b).



centage change in the exchange rate in any given interval of time can be greater than the percentage change in the money supply observed during that interval (particularly if the interval is short). This will happen if the change in the money supply is thought to signal a permanent change in the per annum money growth rate.

Hyperinflation

An example where this framework, the monetary approach to the exchange rate, is thought to apply well is the case of hyperinflation. As we noted in Section 19.3, hyperinflations occurred in a number of central European countries in the aftermath of World War I. The German experience, from February 1920 to November 1923, has been extensively studied. In October 1923 the rate of money growth reached 1,300 percent *per month.* The inflation rate reached 29,586 percent per month. That is just over 20 percent per day; at that rate, the price level doubles in less than four days! Fascinating stories abound of what life was like under such conditions. Wages were paid twice a day so workers could shop at lunchtime before prices rose again. So much paper currency was needed to make simple purchases that a wheelbarrow might be needed to carry it to the store. It is said that one shopper left a wheelbarrow full of cash briefly, and found on returning that the wheelbarrow had been stolen, but the currency had been left.

In October 1923 the rate of depreciation of the mark reached 29,957 percent per month. The price level and exchange rate were going up at roughly the same rate—that is, the real exchange rate had reached a steady state. However, in the transition to this steady state, the price level (and exchange rate) had gone up more than the money supply: *Real* money balances fell to a fraction (0.15) of their original level, as in the bottom panel of Figure 27.1(b).

Figure 27.2 illustrates the change in real money balances for thirteen hyperinflations of the past century. The worse the hyperinflation, the more extreme the fall in real money holdings. This reflects the fact that the real demand for the currency depends negatively on the rate at which it is expected to lose value. Thus it is not quite true in the new classical model that no change in a monetary variable can have an effect on any real variable. (We are classifying the level of real money balances as a real variable.) A change in the money growth *rate* has an effect on the level of real money balances.[10] Nevertheless, whether the change occurs in the level of the money supply or in its rate of change, there is still no effect on the real interest rate or real exchange rate.[11]

When the Money Supply Follows a Random Walk

The case already considered, where people expect a constant growth rate of domestic money indefinitely into the future, is relatively easy to understand. In this case, the various versions of the rate of return on alternative assets—the expected inflation differential, nominal interest differential, forward discount, and expected rate of depre-

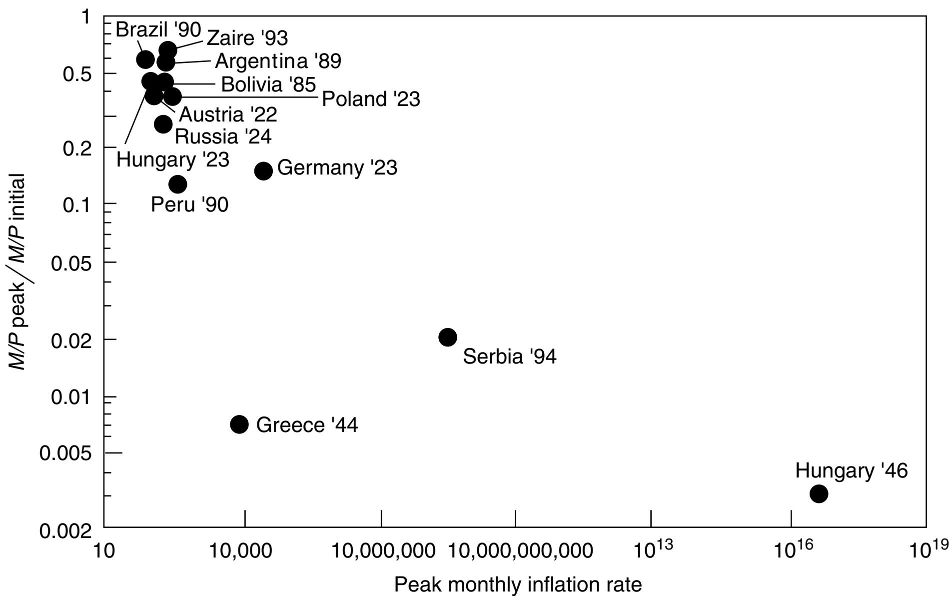
[10]This property is called a lack of "superneutrality."

[11]See Rudiger Dornbusch, "Lessons from the German Inflation Experience of the 1920s," in R. Dornbusch, S. Fischer, and J. Bossons, eds., *Macroeconomics and Finance: Essays in Honor of Franco Modigliani* (Cambridge, MA: MIT Press, 1987), pp. 337–366. The seminal statement of the flexible-price version of the monetary approach to the exchange rate was made in the context of the German hyperinflation: Jacob Frenkel, "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence," *Scandinavian Journal of Economics* (1976): 200–224. The classic study of money demand in interwar hyperinflation is Philip Cagan, "The Monetary Dynamics of Hyperinflation," in Milton Friedman, ed., *Studies in the Quantity Theory of Money* (Chicago: University of Chicago Press, 1956).

FIGURE 27.2

Real Money Holdings in Great Hyperinflations of the Twentieth Century

Real money holdings fall in hyperinflations because the demand for money depends on expected rates of return. The larger the increase in the inflation rate, the bigger the fall in real money.



ciation—are all equal to the expected money growth rate differential. The public's expectations as to the future path of the money supply in the long run, however, may not be accurately described by a single constant growth rate. Consider two alternatives.

First, what happens if the money supply is thought to follow a random walk? That is, although people know the money supply will probably change, they think it could as easily go down as up. At any point in time, the best forecast of the change in money supply is zero. As a matter of fact, there is indeed a great deal of "noise" in the monthly money supply numbers that are reported, for example, by the Federal Reserve. This means that when the central bank reports an increase in the money growth rate in a given month, the chances are good that the increase is purely transitory and does not signal a new, permanently higher money growth rate.

If the expected values of the future money supply changes are zero, then the expected inflation differential, expected depreciation rate, and interest rate differential are also zero.[12] The middle term disappears from the equations for $\overline{S}$ derived earlier. A

[12]Any increase in money demand coming from growth in potential output is omitted here. If money demand increases, the currency can appreciate even without a change in the money supply. There also has long been a gradual downward trend in real money demand arising from innovation in banking. For example, since the invention of automatic teller machines, there has been less need to carry cash around.

1 percent increase in the money supply, although it has a 1 percent effect on the price level and exchange rate, has no further effects. This case is illustrated in Figure 27.1(a) for a single change in the money supply. The exchange rate simply follows a random walk in lockstep with the domestic money supply (relative to the foreign money supply). Note that these are the only circumstances—random-walk money supplies in a flexible-price monetary model—under which the exchange rate should theoretically be expected to follow a random walk. Most of the time there will be some reason to expect future depreciation (or appreciation) over a long horizon, as in a high- (or low-) inflation country.

When the Money Supply Is Expected to Jump in the Future

What happens if the public suddenly raises its estimate of the probability that the money supply will be increased in four years because the more expansionary of two political parties will come to power in the next presidential election? Four years from now, assuming the anticipated increase in the money supply indeed materializes, the exchange rate will increase proportionately. It might seem that an event so far off in the future would have no effect on *today's* exchange rate. This supposition turns out to be incorrect, however, assuming that investors' expectations are *forward looking,* or rational. Under rational expectations, investors know the true model that determines the exchange rate. They form their expectations of the future exchange rate by taking the mathematical expectation, using all available information including their knowledge of the true model. In other words, *expectations,* meaning what investors anticipate, are now the same as *mathematical expectation,* meaning the average realized value given all available information.[13]

Rational investors, in estimating how much the currency will be worth next period, will think further ahead in the future than just one period. They will make the following calculation. They will realize that if it is known that the money supply and the exchange rate will increase in year 4, then in year 3 investors will shift their portfolios out of the domestic currency to protect themselves from the capital loss expected over the subsequent period. They will realize that, as a result, some of the depreciation will take place in year 3. However, if it can be foreseen that the currency will depreciate in year 3, then it can be foreseen that investors in year 2 will shift out of the domestic currency to protect themselves from the expected loss; some of the depreciation thus takes place in year 2. If the currency is expected to depreciate in year 2, by the same logic it will depreciate in year 1. Finally, if the domestic currency is expected to depreciate in year 1, then rational investors living in the present will shift their portfolios out of it immediately. If *all* today's investors make this calculation, they will cause the currency to depreciate today, even if the money supply is not expected to increase for four years.

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[13]Chapter 26 explained that workers who have rational expectations forecast the price level optimally and determine their wage demands accordingly. Here investors who have rational expectations forecast the exchange rate optimally and determine their asset demands accordingly. In both cases, the individuals are assumed to have as much knowledge of the correct model of the economy, and as much up-to-date information on the economic variables, as the economists building the model.

In theory, if investors suddenly decided for some reason that the money supply was going to increase in the year 2100, by the same logic there would be an effect on today's exchange rate. The effect on today's exchange rate is smaller, the further into the future is the expected increase in the money supply. Future changes in the money supply are *discounted* back to the present. So, reassuringly, the anticipation of an increase in the money supply in the year 2100 would have a negligibly small effect on the exchange rate today.

27.3 Two Examples of the Importance of Expectations

The expectation regarding future changes in the exchange rate plays a key role, as we have seen. We further offer two specific illustrations of this point, while staying within the framework of the same model.

Speculative Bubbles

Exchange rates are often alleged to fluctuate excessively, in the sense that "unnecessary" movement in the exchange rate takes place even in the absence of any movement in fundamental macroeconomic variables such as the money supply. We have just seen in the preceding section that today's exchange rate can move in a given period without any movement in the money supply taking place in that period. This is not a valid example of excess variability, however, because such movements are caused by expectations of actual movements in the money supply, even if the latter do not take place in the same period. The question arises whether changes in expectations that shift demand for the currency and thus cause the exchange rate to move can occur with no basis in fundamentals at all.

Financial commentators have discussed the possibility of *speculative bubbles* ever since such classic historical episodes as the Dutch tulip bulb mania of the seventeenth century and the South Seas Company stock market bubble of the early eighteenth century, which even took in Sir Isaac Newton. In recent years, large puzzling movements in exchange rates have been identified as speculative bubbles by some. The final 20 percent appreciation of the dollar in the eight months preceding its peak in 1985, for example, seems difficult to explain otherwise. (Refer ahead to Figure 27.4(b).) The same is true of the appreciation of the yen up to 1995.

When the exchange rate is on a speculative bubble path, it wanders away from the equilibrium value dictated by macroeconomic fundamentals because of self-confirming expectations. Such a bubble would arise as follows. In period 0, speculators suddenly decide for some reason that the currency is going to depreciate in period 1. (For example, even without any good reason to expect a future change in fundamentals, speculators may form their expectations by simplistically extrapolating a recent blip in the exchange rate.) To protect themselves against the feared depreciation, they sell the currency and drive down its price in period 0. Is such behavior irrational? Not necessarily. The currency might actually depreciate in period 1, justifying their fears; it will do so if there is a fall in demand for it in period 1, which will happen if there is an expectation of further depreciation in period 2. Is it irrational to expect a depreciation in period 2? Not if there is a fall in demand for it in period 2 because of an expectation of depreciation in period 3. Similarly, it will be rational to expect depreciation in period 3 if depreciation is also expected in period 4, and so forth. If there is an ultimate day of reckoning on which the value of the currency is known to be tied down to some specific value, this will prevent the speculative bubble from getting started. But without such a day of reckoning, there is nothing in the expectations logic that prevents the exchange rate from soaring indefinitely high, regardless of the economic fundamentals. Although society in the aggregate will probably be harmed by such unnecessary movements, each individual speculator will feel constrained to follow the herd because, given that everyone else is pushing the exchange rate up, the individual would lose money by trying to buck the trend alone.

In practice, the exchange rate does not shoot off to infinity, that is, diverge indefinitely far from the long-run value implied by fundamentals. At most, it wanders away from fundamentals equilibrium for a short time before the bubble bursts. It is possible, however, that such bubbles regularly form and subsequently burst, thus adding to the variability of floating exchange rates. Some of those who believe this phenomenon is important argue that a more interventionist policy on the part of the government might be able to reduce unnecessary volatility in the economy even without a change in monetary policy.

Target Zones and the Honeymoon Effect

Some economists who dislike the high variability of floating exchange rates, but who recognize that fixed exchange rates are not a practical alternative for large industrialized countries, propose the adoption of a system of *target zones* for the dollar, yen, and European currencies. Under this system the countries involved would (1) agree on the fundamental equilibrium value of each exchange rate (subject to periodic review), (2) agree on fairly wide bands within which exchange rates would be free to fluctuate, and (3) commit to altering monetary policies when exchange rates threaten to violate those bands.[14] Critics of such schemes object on the basis that governments are not very good at choosing the correct fundamental equilibrium rates.

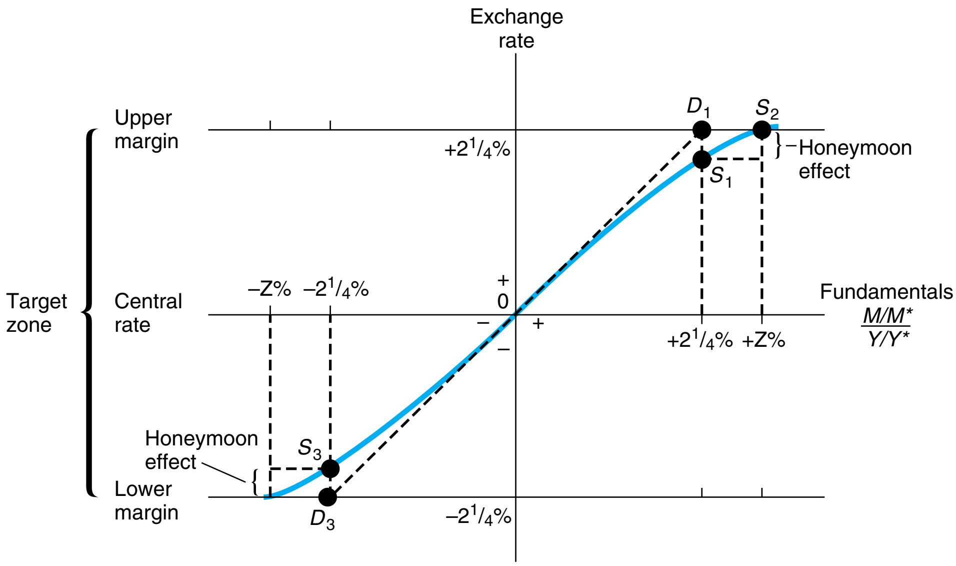
The theory of target zones shows—when the authorities are credibly committed to using monetary policy to stabilize the exchange rate within the announced bands—that speculation can help in this effort. The theory was developed in the 1980s to describe the Exchange Rate Mechanism of the EMS.[15] Let us assume that France and Germany announce that the franc/mark rate will be subject to specified margins around the central rate, say plus or minus 2¼ percent. (This was the actual width of the band from 1979 to 1993. Denmark still maintains such a band.) What happens if, subsequently, French

[14]John Williamson, "Target Zones and the Management of the Dollar," *Brookings Papers on Economic Activity,* 1 (Washington, DC: Brookings Institution, 1986): 165–174.
[15]Paul Krugman, "Target Zones and Exchange Rate Dynamics," *Quarterly Journal of Economics,* 106 (1991): 669–682.

FIGURE 27.3

The Target Zone

If expectations played no role, then the monetary authorities would have to intervene as soon as fundamentals had drifted as far as $\pm 2\frac{1}{4}$ percent, at D_1. But speculation helps reduce the range of variation of S.



or German economic fundamentals drift in a particular direction and the exchange rate draws near to one of the proclaimed margins of the target zone?

The horizontal axis of Figure 27.3 measures economic fundamentals. Assume the franc/mark rate is determined by the monetary model, as represented by Equation 27.9, so that fundamentals are represented simply by $(M/M^*)/(Y/Y^*)$. The vertical axis measures the franc/mark exchange rate, S. Let us say that the exchange rate nears the upper margin because real growth in Germany exceeds real growth in France. If the monetary authorities do not have a genuine commitment to the target zone arrangement, then there is nothing to stop the exchange rate from going right through the boundary. But let us assume the authorities are in fact prepared to adjust monetary policy to keep the exchange rate inside the band. This means that the Bank of France is prepared to reduce French money growth to offset the decrease in the relative demand for francs.

It might appear that as soon as the macroeconomic fundamentals, $(M/M^*)/(Y/Y^*)$, reach the level of 2¼ percent above the central rate, where the diagonal line crosses the upper margin for S at point D_1, the Bank of France must step in to prevent the rate from breaching the limit. But we must remember that the exchange rate is determined not just by the current fundamentals but also by investor expectations, Δs^e. When the exchange rate nears the upper margin, speculators are aware that it is much more likely in the future to move down rather than up because the central bank will intervene against an upward movement. In other words, Δs^e is negative. Investors respond with a reduced demand for marks. The result is that when fundamentals are at D_1, the equilibrium value of the exchange rate is at S_1. Thus speculation works to narrow the range of variation of the exchange rate, even before the authorities roll up their sleeves. The difference between the two points has been called the *honeymoon effect.* Not until the fundamentals reach some more extreme limiting point, indicated in Figure 27.3 by $+Z\%$, will the exchange rate draw so close to the boundary of the target zone that the Bank of France is forced to intervene by taking francs out of circulation. This is point S_2.

The same honeymoon effect holds at the lower margin. If the fundamentals drift to 2¼ percent below the central rate, speculators know that a future increase is more likely than a future decrease. They respond by increasing their demand for marks. They push the exchange rate up from point D_3 to point S_3. The honeymoon effect pushes other points off the diagonal line as well, into a curve with a flattened S shape. The key point is that speculation helps narrow the range of variation. The catch, once again, is that the authorities' commitment to intervene when necessary must be credible.

27.4 Overshooting and the Real Exchange Rate

The equation developed in Section 27.2 has a number of problems if it is intended as a complete theory. Chief among them is that it at best explains only movement in the *nominal* exchange rate. As a consequence of the flexible-price, or PPP, assumption, it cannot account for movement in the *real* exchange rate. Chapter 19 showed that the evidence is strongly against PPP—in other words, against a constant real exchange rate—in the short run. It appears that goods prices are in fact sticky, whether as a result of imperfect information, contracts, costs incurred in changing prices, or inertia in consumer habits. As a result, disturbances in the nominal exchange rate are reflected as disturbances in the real exchange rate, which die out only very slowly over time. This was the justification for the constant-price assumption made in the Keynesian and Mundell-Fleming models (Chapters 17–18 and 22–23, respectively). Assuming that goods prices are literally constant is too extreme, however. In the presence of excess demand for goods, prices do eventually adjust upward. The flexible-price monetary model went to the opposite extreme and assumed there are no barriers to prevent goods prices from adjusting instantaneously. This section develops the sticky price version of the monetary model. It is a realistic synthesis of the two extremes. It turns out to be equivalent to the Mundell-Fleming model in the short run and the monetarist model in the long run. The model is from a classic article by Rudiger Dornbusch.[16]

The effort to derive the long-run equilibrium exchange rate, $\bar{S}$, in the first half of the chapter has not been wasted. This section merely adds in $S - \bar{S}$, short-run deviations of the exchange rate from that equilibrium.

[16] "Expectations and Exchange Rate Dynamics," *Journal of Political Economy* (1976): 1161–1174.

International Differences in Real Interest Rates

Related to the problem that real exchange rates are not constant is the problem that real interest rates also are not constant. National differences in nominal interest rates do not fully reflect differences in expected inflation rates. In the 1970s there was a rough correspondence between interest rates in the major industrialized countries and their inflation rates. Those countries that experienced substantial increases in inflation also experienced substantial increases in nominal interest rates. Thus the pattern of the 1970s was loosely consistent with the idea that nominal interest rate differentials reflect expected inflation differentials. In other words, the pattern was consistent with the real interest parity condition used to derive Equation 27.12.

This pattern broke down after 1980. Nominal interest rates rose in all countries and came down only slowly after 1984, even though inflation began declining steadily in 1981. The U.S. interest rate rose the furthest, even though inflation in the United States fell more rapidly than in Japan and Germany. In the early 1990s the situation reversed: The real interest rate in Germany rose above the U.S. real interest rate. In short, real interest differentials became large and highly variable in the 1980s and 1990s.[17] For this reason, the models cannot remain in the simple form that assumes real interest parity. Variation in the real interest rate differential must be included as an additional factor in the model of variation in the real exchange rate.

We retain the assumption that expected returns are equalized across countries when expressed in common currency units: Not only are there no barriers that slow down portfolio adjustment, but investors treat domestic and foreign bonds as perfect substitutes in their portfolios.[18] Thus uncovered interest parity holds as before.

$$i - i^* = \Delta s^e$$

Subtracting the expected inflation differential, $\Delta p^e - \Delta p^{*e}$, from both sides yields an analogous parity condition in real terms:

$$(i - \Delta p^e) - (i^* - \Delta p^{*e}) = \Delta s^e - \Delta p^e + \Delta p^{*e}$$

or

$$r - r^* = (\Delta s_{\text{real}})^e \tag{27.13}$$

[17]One can sometimes come to different conclusions regarding real interest rates, depending on the precise measure one uses for expected inflation. The apparent variation in real interest rates in the 1970s was small enough that some economists attributed it entirely to the problem of measurement, believing that, ex ante, real interest rates were, in truth, constant. But movements in the 1980s were so large, regardless of what measure one uses for expected inflation, that it was no longer possible to argue that real interest rates were constant. Real interest rates for the United States and an average of ten trading partners are shown in Figure 27.4(a).

[18]Saying that expected rates of returns are equalized across countries when expressed in common units is not the same as saying that real interest rates are equalized across countries. A country's real interest rate is the return on its bonds, expressed in terms of purchasing power *over that country's goods.* An international investor has an incentive to arbitrage away any differentials in interest rates when expressed in a common currency, but there is no incentive to arbitrage away a differential between the U.S. rate of return expressed in terms of U.S. goods and the German rate of return expressed in terms of German goods. If PPP held, then the two calculations would be the same. However, this section allows for the fact that PPP does not hold.

where r and r^* are the domestic and foreign real interest rates, and $(\Delta s_{real})^e$ is the expected rate of change of the real exchange rate, SP^*/P, algebraically equal to the expected rate of change of the nominal exchange rate minus the expected inflation differential. Equation 27.13 shows that the differential in real interest rates is equal to the expected rate of real depreciation of the currency. Intuitively, if investors expect a country's currency to be depreciating in real terms, they will not be willing to hold its assets unless they are compensated by a higher real interest rate.

To take an example, we have noted that in 1984–1985 the U.S. real interest rate was above its major trading partners' real interest rates. We now see that this differential was signaling that investors expected the dollar to depreciate in real terms in the future. (They turned out to be right.) To take a different example, Chile had very high real interest rates in the late 1970s, signaling in part that investors considered the government's attempt to peg the value of the currency at a high level to be unsustainable. (They too turned out to be right.)

Regressive Expectations

The next question is what determines expectations. It is always difficult to model expectations because it is difficult to know what goes on inside people's minds. Yet it is natural to suppose that, when the exchange rate is observed to deviate from the long-run equilibrium level, investors will expect it to move back in the direction of that equilibrium over time. For this purpose we need to know what we mean by the long-run equilibrium. PPP is a good candidate for the long-run equilibrium. In fact, we used the assumption of PPP in the monetary model at the beginning of the chapter to represent the long-run equilibrium level of the exchange rate, $\bar{S}$.

Section 19.2 showed that after a disturbance there is a slow but positive tendency for the real exchange rate to return toward PPP until the next disturbance comes along. The tendency to return to equilibrium is so slow—and new disturbances come along so often—that it is difficult to detect. When a large enough data sample is examined, however, it is possible to detect a tendency for the exchange rate to eliminate 15 percent or more of the existing gap per year. If this tendency to *regress* toward equilibrium exists in the real exchange rate, then investors are presumably aware of it. (This is another application of the idea that investors are rational.) Thus investors are said to have *regressive expectations:*

$$\Delta s^e_{real} = -\theta(S - \bar{S})/\bar{S} \tag{27.14}$$

The equation says that when the currency is thought to be overvalued, that is, to have a higher current value than is given by long-run equilibrium, $\bar{S}$, investors will expect it to depreciate in the future. When the currency is thought to be undervalued, that is, to have a lower current value than in long-run equilibrium, investors expect it to appreciate in the future. The parameter θ is the rate at which the real exchange rate is expected to regress toward equilibrium.

Before proceeding with Equation 27.14, it would be reassuring to have some evidence that this is, in fact, how expectations are formed. A number of surveys periodically ask bankers, foreign exchange traders, economists, and other market participants their expectations regarding the exchange rate. Although different survey respondents form their expectations in different ways, some systematic patterns are evident. After the dollar appreciated sharply above its PPP level in the early 1980s, for example, the survey respondents reported an expectation that it would depreciate in the future. According to two surveys, the median investor in 1984 expected the dollar to depreciate at a rate of 8.5 percent to 10.0 percent over the following year, against an average of the mark, yen, pound, French franc, and Swiss franc.[19] Equation 27.14 turns out to fit these data well; the parameter θ is estimated at 0.2. It is often dangerous to put too much faith in responses to surveys. In this case, however, it is reassuring that the speed at which people seem to expect the exchange rate to regress to PPP is in the general range of estimates of the speed at which it does in fact regress to PPP.

The Effect of Monetary Policy on the Real Interest Rate and Real Exchange Rate

We now combine Equations 27.13 and 27.14

$$r - r^* = -\theta(S - \bar{S})/\bar{S}$$

and solve for the exchange rate as a function of the real interest differential.

$$(S - \bar{S})/\bar{S} = -(1/\theta)(r - r^*) \qquad (27.15)$$

Equation 27.15 says that when the domestic real interest rate exceeds the foreign rate, the value of the domestic currency exceeds its long-run equilibrium value. Why?

Consider an increase in the Canadian real interest rate, as for example occurred in the 1988–1990 monetary contraction. It quickly leads to an increase in international investors' demand for Canadian assets, causing the Canadian dollar to appreciate. When the currency appreciates above its long-run equilibrium value, investors expect that in the future it will have to come back down because it is overvalued. How much does the currency appreciate? Until it has gone far enough that the expectation of future depreciation back toward equilibrium is large enough to offset the interest differential. Only then will investors be willing to hold other assets despite the fact that they do not pay as high an interest rate as Canadian assets. In other words, the overvaluation must be sufficiently large to offset the interest differential in the minds of investors. Loosely speaking, capital comes into the country and the currency appreciates until this condition is met. More precisely, the appreciation should be simultaneous with the increase in the interest rate and the resulting increase in demand for domestic assets. No measurable net capital inflow need actually take place. Recall that the exchange rate adjusts instantaneously so as to equate supply and demand.

Notice in Equation 27.15 that if θ is large, the coefficient $(1/\theta)$ is small. A given increase in the real interest differential will be associated with only a small appreciation of the currency because this is sufficient to generate the necessary expectation of future depreciation. If the expected speed of adjustment is low, however, then the effect on the

[19]This is as contrasted with the average for the period 1976 to 1979, before the dollar appreciation had begun, when expected depreciation was −0.2 percent. Jeffrey Frankel and Kenneth Froot, "Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations," *American Economic Review,* 77, no. 1 (1987): 133–153.

exchange rate can be large. For example, if θ is 0.2, then a .01 increase in the real interest rate causes a 5 percent (.01/0.2) appreciation of the currency.

Let us return to the example of the shift in U.S. monetary policy that took place in 1979. In the late 1970s monetary policy had been loose in the United States and the inflation rate was high. As a result, real interest rates became low, even below zero. (Although nominal interest rates were relatively high by historic standards, the inflation rate was just as high.) Figure 27.4(a) shows how low U.S. real interest rates were in the late 1970s. In this period the dollar depreciated to what was then its lowest level of the floating rate era. Then, in October 1979 the Federal Reserve Board under Chairman Paul Volcker dramatically shifted monetary policy to a tighter stance to fight inflation. Interest rates rose sharply in early 1980, and the dollar appreciated in response to the increased attractiveness of U.S. assets. The nominal interest rate differential between the United States and its trading partners, approximately zero in the period 1976 to 1979, rose to about .03 in the period 1981 to 1982.

The real interest rate differential continued to rise through mid-1984, mostly in the form of declining expectations of U.S. inflation. The rise was clear for long-term interest rates, shown in Figure 27.4(a). The increase in real rates of return made U.S. assets more attractive and caused the dollar to appreciate. Figure 27.4(b) shows how the real value of the dollar increased with the real interest rate differential. As of mid-1984, a real interest rate differential as large as 3 or 4 percent on ten-year bonds implied that investors expected the dollar to depreciate in real terms at a rate of at least 3 percent per year on average over the next ten years, or 30 percent altogether. If ten years is considered the appropriate length of time needed for the real exchange rate to return virtually all the way to its long-term equilibrium level, then this simple calculation suggests that investors considered the dollar to be about 30 percent above its long-run equilibrium.[20]

In terms of the Mundell-Fleming graph, the U.S. economy in the mid-1980s could be represented as an *IS-LM* intersection at a real interest rate in excess of that prevailing in the rest of the world. The reason has been discussed before: an imbalanced mix of monetary and fiscal policy. Chapter 23 raised the question of how a positive real interest differential like this could be consistent with perfect capital mobility. Now we know the answer: Because the dollar had appreciated so far above its long-run equilibrium, there was an expectation of future dollar depreciation that was sufficient to offset the interest differential in investors' minds.

Long-Run Equilibrium

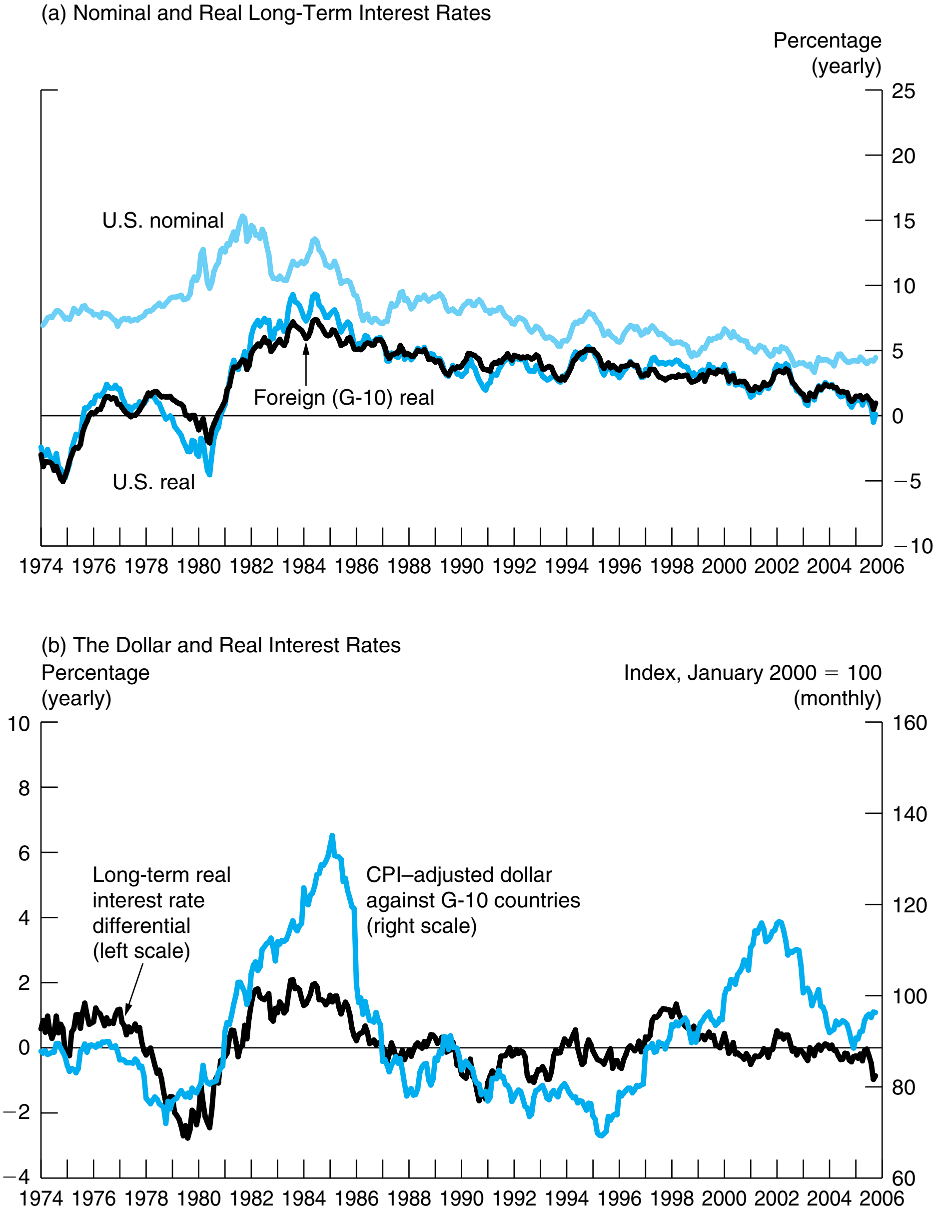
We have shown that the level of the exchange rate, S, relative to its long-run equilibrium, $\bar{S}$, is determined by the real interest rate differential, itself determined by such factors as monetary policy. If $\bar{S}$ is constant, for example, movement in S is entirely

[20]The argument for looking at long-term real interest rate differentials to see how overvalued the market considers the currency to be was developed by Peter Isard, "An Accounting Framework and Some Issues for Modeling How Exchange Rates Respond to the News," in Jacob Frenkel, ed., *Exchange Rates and International Macroeconomics* (Chicago: University of Chicago Press, 1983).

FIGURE 27.4

U.S. and Foreign Real Interest Rates and the Exchange Rate

(a) The U.S. real interest rate was low in the late 1970s and high in the early 1980s, both absolutely and relative to Group of 10 trading partners. (b) The big swings in the real interest differential usually coincide with swings in the value of the dollar.



explained by movement in the real interest rate differential. In general, however, it is unlikely that the long-run equilibrium rate is constant. Even assuming that the long-run equilibrium *real* exchange rate is constant,[21] it cannot be assumed that the equilibrium *nominal* exchange rate, $\bar{S}$, is constant. Because it is a nominal magnitude, like the price levels, it will follow a rising path over time in an economy with a high rate of money growth and inflation.

Section 27.2 used PPP to derive a model of the exchange rate. At that point we were operating under the assumption that prices were perfectly flexible, whereas we have recognized since then that they are in fact sticky. In the long run, prices *are* flexible, however. Thus PPP can be used to characterize long-run equilibrium. So, although Equation 27.12 no longer serves as a model of the moment-to-moment exchange rate, S, it now serves nicely as a model of the long-run equilibrium exchange rate, $\bar{S}$.

The next task is to see how the exchange rate moves from the short-run equilibrium to the long run. The transition from short run to long run is illustrated in Figure 27.5, which shows the exchange rate on the horizontal axis and the price level on the vertical axis. The proportionality between $\bar{S}$ and P that holds in PPP equilibrium is graphed as an upward-sloping 45º line. It is necessary to be on the PPP line only in the long run. This means that when the money supply goes up permanently by 10 percent and the price level eventually rises proportionately, the exchange rate too will eventually rise by the same 10 percent. This is a movement up along the PPP line, from point A to point B.

Equation 27.15 indicates that in the long run, with the exchange rate at its equilibrium level ($S = \bar{S}$), the real interest rate differential is zero ($r = r^*$). The explanation is that if there is no reason for investors to expect future depreciation of the currency (in real terms), then they have no reason to require a (real) interest rate differential to be willing to hold the currency. This international equalization of real interest rates is similar to the real interest parity condition that followed from Equation 27.11 in Section 27.2, but now we see that it holds only in long-run equilibrium.

The Path from Short-Run Overshooting to Long-Run Equilibrium

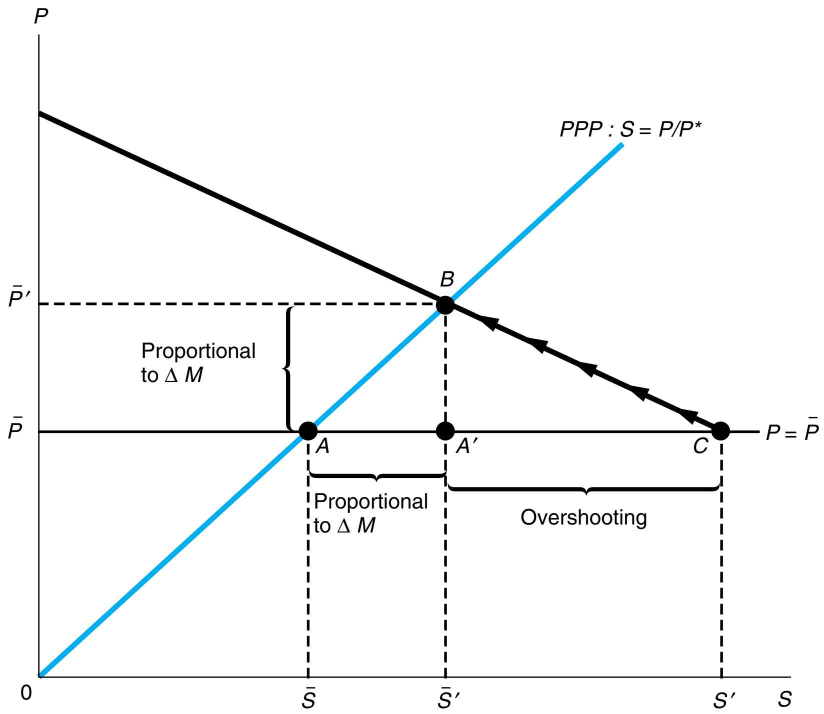
The central question addressed by the overshooting model is: What happens in the immediate aftermath of an increase in the money supply? It would clearly be wrong to assume that the economy will stay on the PPP line; goods markets do not adjust fast enough to guarantee this in the short run. The assumption that goods prices are sticky means that when the nominal money supply, M, increases by 10 percent, the real money supply, M/P, on impact, also increases by 10 percent, because prices do not move at all in the short run. Money market equilibrium then requires that the monetary expansion will drive down the interest rate. (In terms of the Mundell-Fleming

[21]The possibility that the long-run equilibrium real exchange rate might itself change cannot be ruled out. Japan long had an upward trend in the long-run equilibrium real value of its currency. To take another example, it has been suggested that the long-run equilibrium real value of the dollar is lower than it was in the 1980s because the United States has run up $3 trillion in international debt, which requires a permanent improvement in the trade balance to earn the foreign exchange to service the debt.

FIGURE 27.5

The Dornbusch Overshooting Diagram

An increase in the money supply, *M*, raises the price level, *P*, and spot rate, *S*, proportionately in the long run by PPP (at *B*). In the short run, however, *P* is tied down. As a result, *S* increases more than proportionately in the short run at *C*; that is, it overshoots its long-run equilibrium.



model, the LM curve shifts to the right.) The lower interest rate in the home country, in turn, causes international investors to head for the exits. The decline in demand for domestic assets causes the currency to depreciate.

We can figure the size of the depreciation. $\bar{S}$ alone increases by the same 10 percent as the money supply. But the total change in S is greater: Equation 27.15 says that $S/\bar{S}$ increases by $(1/\theta)$ times the fall in the interest rate.[22] Only when the currency has depreciated that far do investors have the necessary expectation of appreciation back toward long-run equilibrium that they must have if they are to hold domestic assets willingly, despite the fact that these assets pay a lower rate of interest than foreign assets. We have just derived the now-classic *overshooting* result of Rudiger Dornbusch: Even though the long-run equilibrium exchange rate increases by the same proportion as the money supply, the short-term equilibrium exchange rate increases more than proportionately.

[22]The fall in the nominal rate is in turn $1/\mu$ times the increase in the money supply, where μ is the semielasticity of money demand with respect to the interest rate. (See the chapter supplement.)

If the monetary expansion raises the level of output, then the interest rate will not fall by as much as it would if the level of output were constant. As a result, the currency will not overshoot its long-run equilibrium by as much. Conversely, if the monetary expansion raises the expected inflation rate, then the real interest rate will fall by more than the nominal interest rate, and as a result the currency will overshoot its long-run equilibrium by more. But this does not qualitatively change the results described in the text. The algebra for these cases, and indeed for this entire section, can be found in Rudiger Dornbusch, "Expectations and Exchange Rate Dynamics," *Journal of Political Economy,* 84, no. 6 (1976), 1161–1176.

Where is the economy now in Figure 27.5? In the short run it cannot leave the horizontal latitude of the starting point, A, because P is tied down. S increases, which means a move to the right in the graph. How far? The economy moves further than point A' because if it stopped there, S would have increased only by the same percentage as $\overline{S}$. S must increase by more than $\overline{S}$. Thus the economy moves, on impact, to a point like C.[23]

Establishing the short-run equilibrium, C, and the long-run equilibrium, B, prompts the next question: How do we get from here to there? At point C several factors are stimulating the demand for goods. First, the real interest rate has fallen, which should stimulate the domestic demand for capital goods, construction, and consumer durables. Second, the real value of the currency has fallen. Indeed, any point below or to the right of the PPP line is a point where domestic goods are cheaper than foreign goods. This should stimulate the demand for domestically produced tradable goods, such as the foreign demand for exports. The increased demand for goods will put upward pressure on prices. The price level will be somewhat higher after a little time has passed.

As the price level, P, slowly rises to higher levels, the real money supply, M/P, slowly declines to lower levels, although it is still higher than it was before the increase in M. (The LM curve slowly shifts back to the left.) As a result, the interest rate slowly rises, although it is still lower than the foreign interest rate. Equation 27.15 shows that as the interest rate rises, the currency appreciates back toward its long-run equilibrium; international investors no longer find domestic assets quite so unattractive. Thus, as we move up in Figure 27.5 (higher P), we also move back to the left (lower S).[24]

The process continues as long as the real money supply is greater than it was before the monetary expansion—that is, as long as the real interest rate and real currency values are low—because the excess demand for goods continues to cause prices to rise. When the price level has risen by the same proportion as the money supply, then the real money supply, real interest rate, and real exchange rate are all back to their original levels. Only then is there no excess demand for goods and no need for prices to continue rising. This long-run equilibrium is none other than point B, the PPP point at which all nominal magnitudes have increased by the same percentage. This illustrates a general principle that has recurred over several previous chapters: In the long run in which all real magnitudes have had time to return to their equilibrium values, all nominal magnitudes must change proportionately. Figure 27.6(a) shows how, after the initial overshooting caused by the increase in the level of the money supply, the real money supply and real interest rate return over time to their original levels, and as a consequence the exchange rate gradually approaches its new equilibrium level.

Notice the correspondence between what investors at point C thought would happen in the future and what actually did happen. In the short-run overshooting equilibrium at C (when the price level had not yet had time to adjust to the increase in the

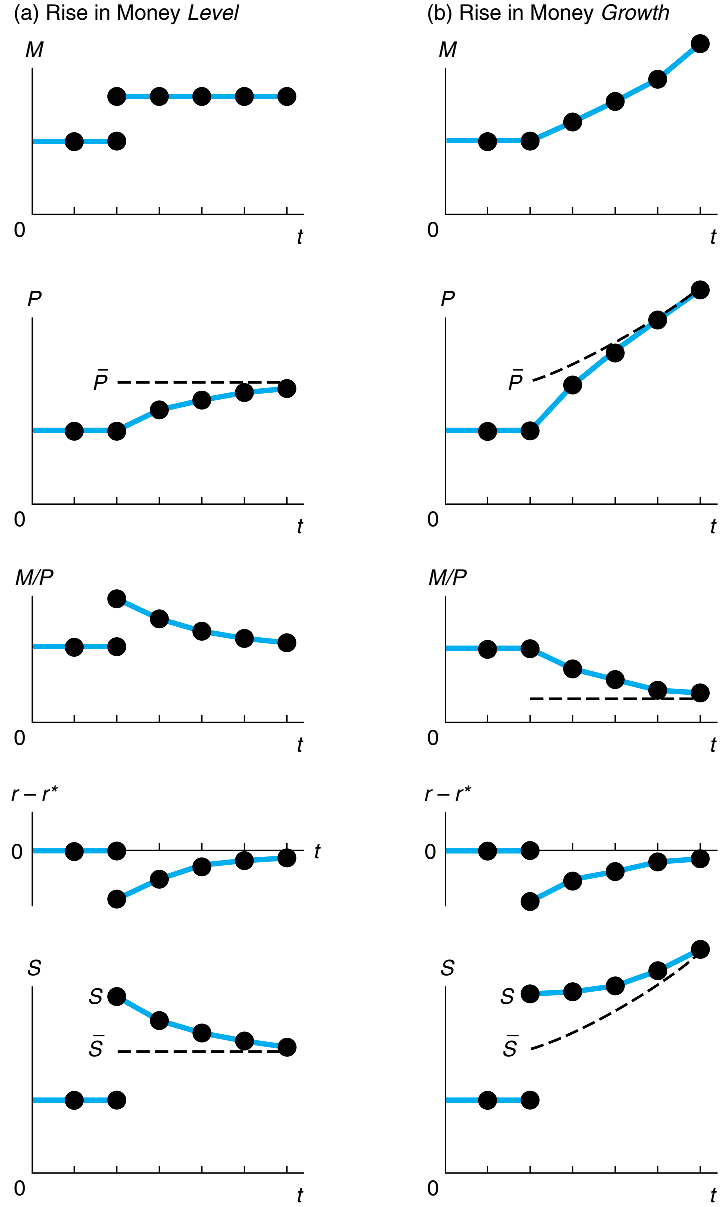
[23]Point C corresponds to point B in the Mundell-Fleming diagram, Figure 23.3. The interest differential is now attributed to the expectation of future appreciation (rather than to imperfect capital mobility).

[24]The downward-sloping line connecting points B and C represents equilibrium in the asset markets, the relationship that must hold between P and S (via the interest rate, i) for the given money supply, M, to be willingly held.

FIGURE 27.6

Overshooting Effects of Changes in the Money Supply

(a) After a jump in the *level* of the money supply, *P* can only increase slowly. As a result, the real money supply *M*/*P*, real interest differential, $r - r^*$, and spot rate, *S*, temporarily deviate from their long-run equilibriums. (b) An increase in the *rate of change* of the money supply causes similar deviations from long-run equilibrium, but now equilibrium is itself a moving target.



money supply), investors thought the currency would appreciate in the future because they had regressive expectations. We have just established that this is, in fact, what happens as the price level adjusts: S does indeed move in the direction of $\bar{S}$. If investors have rational expectations, then they know the complete model, and the rate at which they expect S to move toward $\bar{S}$ is precisely the rate at which it does so.

The model studied at the beginning of this chapter, where goods prices were perfectly flexible, can be viewed as a special case of the complete model. It is the case where adjustment in the goods markets is instantaneous. If the rate of change of prices is highly responsive to the excess demand for goods, then the system will move to point *B* very quickly. In the limit, the system will jump from *A* to *B* instantaneously. In that case, PPP always holds, $S = \overline{S}$, and Equation 27.12 constitutes a complete analysis of exchange rate determination. The Mundell-Fleming model can be viewed as the opposite extreme, where the speed of adjustment in goods markets is very slow.[25]

Exchange Rate Volatility

We have seen what happens in the aftermath of a single monetary disturbance. However, in practice, if one looks for the nominal exchange rate to follow the path of Figure 27.5 in the aftermath of an overshooting episode—a smooth return to long-run equilibrium—one is likely to be disappointed. In the real world, new disturbances come along all the time, so that before the exchange rate has had time to return much of the way toward its equilibrium, a new policy change in one direction or the other is likely to occur.[26] The effect on the exchange rate of any given monetary disturbance is as we have just seen it to be, notwithstanding the possibility of future disturbances. When each new change in the money supply hits, the exchange rate changes more than proportionately; it then begins to move gradually back toward its long-run equilibrium, until the next monetary disturbance comes along.

Empirically, changes in the exchange rate are more variable than changes in the money supply or the price level. It is an attractive property of the overshooting model that it can explain this variability in exchange rates without having to appeal to speculative bubbles or irrationality on the part of investors. The volatility of exchange rates in the model is a consequence of the fact that asset markets adjust instantaneously while good markets adjust slowly. If goods prices adjusted instantaneously, there would be no overshooting of the exchange rate. Exchange rate changes would be no more variable than changes in the money supply.

There is an analogy with a law of chemistry called Le Châtelier's principle. When one variable in a physical system (such as the pressure or temperature of a gas) is constrained from changing in response to a disturbance (such as a change in its volume), one or more of the other variables in the system must change by more than it otherwise would, to compensate. Paul Samuelson first pointed out the possible application to economics: When one price is constrained from changing in response to a change in supply of a commodity, some other price must change by more to compensate. William Branson has pointed out the relevance for overshooting of the exchange rate: When the general price level is constrained from changing in response to a change in the money supply, the exchange rate changes more than proportionately to compensate.

[25]This discussion of overshooting has considered only changes in the level of the money supply. Changes in the expected growth rate of the money supply also cause overshooting, as illustrated in Figure 27.6(b).

[26]Refer back to Figure 19.3 for an idea of the frequency of disturbances to the real exchange rate in 200 years of U.S.–U.K. history.

Furthermore, the slower is the speed of adjustment (expected by investors), θ in Equation 27.14, the greater is the degree of overshooting.[27] This happens because if the speed of exchange rate adjustment, θ, is low, then for any given fall in the interest differential, it takes a large undervaluation of the exchange rate to generate the necessary expectation of future appreciation equal to the interest differential. In terms of Figure 27.5, if θ is low, the asset market equilibrium line is flat and the exchange rate has to increase even further than C before investors are willing to hold domestic assets. If the expected speed of adjustment is very high, however, then a movement just slightly beyond A', an increase in S just a little more than proportionate to the increase in the money supply, will be sufficient to satisfy investors.

Without knowing precisely the size of θ (or the other parameters in the monetary model), we cannot say the observation that exchange rates are much more variable than money supplies necessarily means that exchange rates are excessively variable. The variability may simply be the overshooting phenomenon in operation.

27.5 Two More Examples of the Importance of Expectations

We have emphasized throughout this chapter the important role that expectations play in determining exchange rates in modern asset markets. We illustrate the point with two more examples.

The Example of Official Announcements of Economic Statistics

Government announcements illustrate the importance of changes in expectations. Consider the case of the weekly money announcements. Every week, the Federal Reserve Board announces what the money stock was in the preceding week. In the early 1980s the announcements were made at 4:10 p.m. on Friday afternoons and referred to the money stock nine days earlier. The financial markets looked forward to each week's announcement with both eagerness and trepidation. When the time drew near, trading slowed down and even stopped as traders gathered around the newswire or computer terminal. When the announcement came out, prices in the various financial markets would jump in reaction, and trading would take off again. The most widely remarked reaction took place in the credit markets. When the Fed announced a money supply that was greater than observers had previously been expecting, interest rates would immediately jump up in reaction (or bond prices would jump down, which is another way of saying the same thing).[28] When the Fed announced a money supply that was smaller than had been expected, interest rates would fall in reaction.

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[27] The expected speed of the rate of exchange rate adjustment, θ, in turn depends on the actual speed of adjustment of goods prices, assuming that expectations are rational.

[28] Bond prices move inversely with the interest rate. If the interest rate is 5 percent, then a one-year Treasury bill with a face value of \$10,000 will have a price of about \$9,500, so that investors who buy the Treasury bill have the same rate of return as if they put their money into the bank and earned the interest. If the interest rate goes up, then the price investors will be willing to pay for the \$10,000 Treasury bill necessarily goes down.

What was the reason for these reactions? They might seem puzzling, considering the theory that an increase in the money supply works to lower the interest rate rather than to raise it. The first thing to realize is that the interest rate movements on Friday afternoons were not directly caused by the changes in the money supply itself—which had taken place a week earlier—but rather by the effect of the new information on *expectations* as to future monetary policy.

According to the theory of efficient markets, it is only the *unanticipated* component of the announced change in the money supply that matters. If the announcement reports an increase no larger than had been previously expected, then there should be no effect on prices in the bond market, foreign exchange market, or any other financial markets. Economists often refer to the importance of "news," to signify that it is only new information that matters.

There are two possible different explanations for a rise in the nominal interest rate in response to a money announcement: a rise in the expected inflation rate or a rise in the real interest rate. The rise in the nominal interest rate could be related to a rise in the expected inflation rate, if investors concluded from the announcement of an increase in the money supply that the Fed planned a faster rate of money growth in the future than had previously been expected. This is the case where investors do not put much credence in the money growth target that the Fed has announced for the year and interpret deviations of the money supply from the previously expected path as evidence that the Fed has changed its target. Conversely, the rise in the nominal interest rate would be related to a rise in the real interest rate if investors interpret the announcement as a sign that the Fed will tighten monetary policy in the near future. This is a reasonable thing to expect the Fed to do if the increase in the money stock occurred for reasons beyond its control (e.g., banks can expand credit to a certain degree, without there necessarily having been a change in Fed policy), and if it is seriously committed to keeping the money supply within its previously set target range. In other words, this is the case where the Fed's commitment to the preannounced target is credible to the financial markets.

How is it possible to tell, at any particular time, which is the real cause of an increase in the nominal interest rate? The foreign exchange market provides the answer to this question. If there is an expectation of looser monetary policy and higher expected inflation, the exchange rate models predict that the dollar will fall on the news. Conversely, if there is an expectation of tighter monetary policy and a higher real interest rate, the dollar should rise on the news.

The evidence suggests that in the late 1970s, the Fed's money growth targets were not very credible. The dollar often fell in value immediately following announcements of money supplies that were greater than had been expected. Investors worried about excessive money growth and the inflationary consequences.

After October 1979, however, the Fed switched to a new set of operating procedures designed to set a firm course for the money supply, with the aim of fighting inflation. The pattern of reaction to the weekly money announcements switched as well. In the early 1980s there was a clear pattern in which both the interest rate and the dollar rose immediately in response to announced money figures that were greater than expected. This suggests (1) that investors during this period expected the Fed to correct deviations from the target, (2) that investors believe that monetary contraction raises real interest rates, and (3) that higher real interest rates make U.S. assets more attractive and cause the dollar to appreciate, as in the overshooting model.[29]

The importance of the weekly money announcements diminished after 1982, when the Federal Reserve started paying less attention to the money supply because innovations in the banking sector and other shifts in the demand for money had taken much of the meaning from M1 and the other traditional measures of monetary policy. The Federal Reserve Board then stopped all pretense of setting M1 targets. As a result, interest rates and exchange rates no longer respond strongly to the money announcements. However, there are still macroeconomic variables that provoke major reactions when announced. After news suggesting strong economic growth, such as a decline in the unemployment rate or an increase in retail sales or durable goods orders, the dollar tends to appreciate. Investors figure, as in the monetary models, that higher domestic output raises the demand for domestic money.[30] Similarly, when there is an announcement of a better trade balance than had been expected, the dollar tends to appreciate.[31]

Is Speculation Stabilizing?

It might seem that overshooting is an example of what is called *destabilizing speculation*—that investors, by freely buying and selling foreign exchange based on their expectations of changes in the exchange rate, make the exchange rate more variable than it would otherwise be. This is not the case, however. The overshooting model just developed illustrates the general principle that expectations are stabilizing rather than destabilizing, as long as an increase in the level of the current exchange rate causes investors to reduce their expectations as to its future rate of change. (This is the case in regressive expectations, represented by Equation 27.14: S enters with a negative sign.) The reason is that if investors act on the basis of such expectations, they will buy the currency when its value is low and sell when its value is high. This will raise the currency's price when it would otherwise be low and lower the price when it would otherwise be high. This type of speculation works to moderate the fluctuations that would otherwise occur in the exchange rate.

Investors, or speculators, who buy low and sell high will also make a profit. This is why Milton Friedman argued that stabilizing speculators would prosper. Any speculators who were destabilizing would be buying high and selling low. They would lose money and thus soon be driven out of business.

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[29]Charles Engel and Jeffrey Frankel, "Why Interest Rates React to Money Announcements: An Explanation from the Foreign Exchange Market," *Journal of Monetary Economics,* 13 (1984): 31–39.

[30]Gikas Hardouvelis, "Economic News, Exchange Rates and Interest Rates," *Journal of International Money and Finance,* 7 (1988): 23–25.

[31]The trade balance has no effect on the exchange rate in the model developed in this chapter (beyond the effect of any of the other components of GDP $\equiv C + I + G + X - M$). This is a consequence of the assumption that when a country runs a trade deficit, the rest of the world is willing to lend it however much money it needs to finance its deficits—regardless of how much debt it has already incurred in the past—so long as it pays the world rate of interest. The next chapter introduces a role for the debt, so that the trade balance again matters for exchange rate determination.

It has sometimes been suggested that the government should try to discourage speculation—for example, by enacting capital controls or a tax on foreign exchange transactions, thereby returning the economy to a lower degree of international capital mobility. James Tobin wrote that "we need to throw some sand in the well-greased wheels" of international financial markets through a small tax on all foreign exchange transactions.[32] If investors act on the basis of the type of stabilizing expectations studied here, Tobin's proposal to discourage speculation would increase overshooting rather than reduce it, assuming the new barrier to international capital flows was effective. If investors had to overcome a significant transaction cost to buy a foreign currency, then the exchange rate would have to drift even further from its long-run equilibrium before the expectation of future appreciation was sufficiently great to inspire investors to buy it.

What, then, do proponents of such antispeculator taxes have in mind? They have in mind that speculators do not form expectations in a stabilizing manner, such as is given by Equation 27.14. Rather, they believe that speculators form their expectations by simply extrapolating past trends. Such forecasting rules are called *bandwagon expectations:* If investors actually act on the basis of them, they jump on the bandwagon whenever the currency starts to move in one direction or the other. In such case, they can create the sort of speculative bubbles described in Section 27.3. Investors buy when the currency is already high, thereby pushing it higher (until the bubble bursts); they sell the currency when it is already low, thereby pushing it lower. In such an environment, speculation would indeed increase exchange rate volatility.

Which expectations, stabilizing or destabilizing, prevail in practice? Under normal circumstances, when markets are functioning properly, economists believe that expectations are formed predominantly in a stabilizing manner. For example, during the period 1982 to 1984, because the dollar had risen above its PPP equilibrium, many forecasters expected it to depreciate in the future. Any investors who acted on the basis of such expectations, far from being the cause of the appreciation of the dollar, were selling dollars and thus dampening the price below what it would be otherwise.

There are times, however, when most market participants seem to lose sight of economic fundamentals and to extrapolate trends instead. As noted earlier, some observers have argued that July 1984 to February 1985 was such a period, with the final appreciation of the dollar up to its peak attributable to a speculative bubble rather than to fundamentals. Figure 27.4 does make it appear this way: The 1985 spike in the dollar is a major movement in the exchange rate that does not correspond to a movement in the real interest rate differential. In this view, the dollar did more than overshoot its long-run equilibrium; it overshot its short-run equilibrium as well.[33] A similar overvaluation appeared in the years 2001 to 2002, particularly against the euro.

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[32]James Tobin, "A Proposal for International Monetary Reform," *Eastern Economic Journal,* 4, nos. 3–4 (1978): 153–159.

[33]Paul Krugman, "Is the Strong Dollar Sustainable?" *The U.S. Dollar—Recent Developments, Outlook, and Policy Options* (Kansas City: Federal Reserve Bank of Kansas City, 1985), pp. 103–133.

The view that the dollar was following a speculative bubble path by the end of 1984 would be sympathetic to the switch at the U.S. Treasury from a noninterventionist policy of benign neglect of the dollar under Secretary Donald Regan from 1981 to 1984, to a more activist policy under Secretary James Baker beginning in 1985. The switch was symbolized in September 1985 by the Plaza Accord, in which the finance ministers of the G-5 countries agreed to try to bring the dollar down. The Plaza is widely regarded as a case of successful management of the exchange rate by policy makers. Unfortunately, government officials are not always more skilled at identifying when the exchange rate has departed from fundamentals than are private investors.

Keep in mind that the existence of a speculative bubble does not mean it is easy for an investor to profit from it. The knowledge that the bubble must eventually burst does not mean investors can confidently expect to make money by moving into another currency (or "selling short") because there is no telling how long the bubble will continue, and the investor who does not go along with the trend will lose money as long as it continues.

27.6 Summary

This chapter examined how monetary forces determine the exchange rate under a floating rate system. This required introducing exchange rate expectations, in addition to interest rates, as a factor in determining investors' decisions regarding what assets to hold. Modern models of exchange rate determination share the property of perfect international capital mobility. If there is also perfect substitutability between domestic and foreign bonds, then uncovered interest parity holds: The interest differential must be just large enough to offset investors' expected depreciation of the domestic currency.

The chapter introduced a flexible-price version of the monetary model, in which purchasing power parity holds, which is relevant for long-run equilibrium. The resulting equation shows how the exchange rate, as the relative price of two currencies, is determined by the supply and demand for two currencies. It is useful for seeing how (1) an exogenous increase in real income raises the demand for money and thus causes the currency to appreciate, (2) an increase in the current level of the money supply causes an immediate proportionate depreciation of the currency in equilibrium, and (3) an increase in the expected future rate of growth of money and inflation causes an immediate fall in the equilibrium value of the currency.

These results pertain to long-run equilibrium. The rest of the chapter explained that the short-run equilibrium is characterized by overshooting. When the money supply increases, the currency immediately depreciates *more* than proportionately; that is, it depreciates by more than it will in the long run. This is a consequence of goods prices being sticky in the short run. The increase in the nominal money supply is an increase in the real money supply. It reduces the interest rate, causing investors to shift their demand to foreign assets and causing the domestic currency to depreciate. This much is similar to the effects of monetary expansion in the Mundell-Fleming model of Chapters 22 and 23. The new effect is that today's depreciation generates the expectation among investors that the currency will in the future have to appreciate back toward long-run equilibrium. This expectation of appreciation must be just sufficient to offset the interest differential, for investors to be willing to hold domestic assets. Thus when a loose monetary policy pushes the domestic real interest rate below the foreign real interest rate, it will also push the real value of the currency below its usual level.

Modern models of exchange rate determination share another property: They are designed to fit the empirically observed high variability of floating exchange rates. These models explain such variability in three respects. First, because the exchange rate is seen to be determined in financial markets, it can be as volatile as the prices of stocks, bonds, precious metals, and other assets. The expectation of a future loss in the value of the currency is enough to cause a large shift in demand and thus a large fall in the equilibrium value of the currency today. Second, when goods prices adjust slowly but asset markets adjust instantly, the exchange rate in the short run overshoots its long-run equilibrium. Third, when a speculative bubble gets started, the exchange rate can deviate even from the short-run equilibrium that is determined by the monetary fundamentals.

CHAPTER PROBLEMS

1. If there is a downward shift in the demand for dollars because of increased use of credit cards, what is the effect on the exchange rate?
2. Assume in the monetary model with flexible prices that the public decides today the money supply is expected to jump in the future. Draw the versions of the graphs of the four variables that correspond to Figure 27.1.
3. **a.** If an investor were able to predict that a country's currency will appreciate in the future because of a slower inflation rate in that country than in others, does this mean that the investor can necessarily earn a higher return by holding that currency?

   b. What if the investor were able to predict that a currency will appreciate in the future because it has already overshot (downward) its long-run equilibrium?
4. Are the following three statements true or false?
   - i. If a country has a high interest rate, then its assets will be attractive to hold, and so the value of the currency will be high.
   - ii. If a country has a high interest rate, investors must expect that its currency will lose value in the future.
   - iii. If investors expect that a currency will lose value in the future, then they will have a low demand for it and it will have a low value today.

   How do statements ii and iii together appear to contradict statement i? Can you reconcile the three statements with each other? (*Hint:* It might help to distinguish *why* the interest rate is high.)
5. The following is the balance-of-payments equilibrium condition from the Mundell-Fleming model, Equation 23.4, with exports depending on the exchange rate, S, and

foreign income, Y^*, and imports depending on Y. (All relationships here are assumed to be linear, and m and m^* are the marginal propensities to import.)

$$\chi S + m^*Y^* - mY + \overline{KA} + k(i - i^*) = 0$$

a. Turn this equation into a model of exchange rate determination by solving for S.
b. What policies determine i?
c. Explain why the signs on Y, Y^*, i, and i^* here differ from those in Equation 27.8.

SUGGESTIONS FOR FURTHER READING

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