CHAPTER
15

Price Levels and the Exchange Rate in the Long Run

At the end of 1970, you could have bought 358 Japanese yen with a single American dollar; by Christmas 1980 a dollar was worth only 203 yen. Despite a temporary comeback during the 1980s, the dollar's price in yen slumped to around 110 by the start of 2008. Many investors found these price changes difficult to predict, and as a result fortunes were lost—and made—in the foreign exchange market. What economic forces lie behind such dramatic long-term movements in exchange rates?

We have seen that exchange rates are determined by interest rates and expectations about the future, which are, in turn, influenced by conditions in national money markets. To understand fully long-term exchange rate movements, however, we have to extend our model in two directions. First, we must complete our account of the linkages among monetary policies, inflation, interest rates, and exchange rates. Second, we must examine factors other than money supplies and demands—for example, demand shifts in markets for goods and services—that also can have sustained effects on exchange rates.

The model of long-run exchange rate behavior that we develop in this chapter provides the framework that actors in asset markets use to forecast future exchange rates. Because the expectations of these agents influence exchange rates immediately, however, predictions about *long-run* movements in exchange rates are important *even in the short run*. We therefore will draw heavily on this chapter's conclusions when we begin our study of *short-run* interactions between exchange rates and output in Chapter 16.

In the long run, national price levels play a key role in determining both interest rates and the relative prices at which countries' products are traded. A theory of how national price levels interact with exchange rates is thus central to understanding why exchange rates can change dramatically over periods of several years. We begin our analysis by discussing the theory of **purchasing power parity (PPP),** which explains movements in the exchange rate between two countries' currencies by changes in the countries' price levels. Next, we examine reasons why PPP may fail to give accurate long-run predictions and show how the theory must sometimes be modified to account for supply or

demand shifts in countries' output markets. Finally, we look at what our extended PPP theory predicts about how changes in money and output markets affect exchange and interest rates.

Learning Goals

After reading this chapter, you will be able to:

- Explain the purchasing power parity theory of exchange rates and the theory's relationship to international goods-market integration.
- Describe how monetary factors such as ongoing price level inflation affect exchange rates in the long run.
- Discuss the concept of the real exchange rate.
- Understand factors that affect real exchange rates and relative currency prices in the long run.
- Explain the relationship between international real interest rate differences and expected changes in real exchange rates.

The Law of One Price

To understand the market forces that might give rise to the results predicted by the purchasing power parity theory, we discuss first a related but distinct proposition known as the **law of one price.** The law of one price states that in competitive markets free of transportation costs and official barriers to trade (such as tariffs), identical goods sold in different countries must sell for the same price when their prices are expressed in terms of the same currency. For example, if the dollar/pound exchange rate is $1.50 per pound, a sweater that sells for $45 in New York must sell for £30 in London. The dollar price of the sweater when sold in London is then ($1.50 per pound) $\times$ (£30 per sweater) = $45 per sweater, the same as its price in New York.

Let's continue with this example to see why the law of one price must hold when trade is free and there are no transport costs or other trade barriers. If the dollar/pound exchange rate were $1.45 per pound, you could buy a sweater in London by converting $43.50 (= $1.45 per pound $\times$ £30) into £30 in the foreign exchange market. Thus, the dollar price of a sweater in London would be only $43.50. If the same sweater were selling for $45 in New York, U.S. importers and British exporters would have an incentive to buy sweaters in London and ship them to New York, pushing the London price up and the New York price down until prices were equal in the two locations. Similarly, at an exchange rate of $1.55 per pound, the dollar price of sweaters in London would be $46.50 (= $1.55 per pound $\times$ £30), $1.50 more than in New York. Sweaters would be shipped from west to east until a single price prevailed in the two markets.

The law of one price is a restatement, in terms of currencies, of a principle that was important in the trade theory portion of this book: When trade is open and costless, identical goods must trade at the same relative prices regardless of where they are sold. We remind you of that principle here because it provides one link between the domestic prices of goods and exchange rates. We can state the law of one price formally as follows: Let P_{US}^i be the dollar price of good i when sold in the U.S., P_E^i the corresponding euro price in Europe.

Then the law of one price implies that the dollar price of good i is the same wherever it is sold.

$$P^i_{US} = (E_{\$/€}) \times (P^i_E).$$

Equivalently, the dollar/euro exchange rate is the ratio of good i's U.S. and European money prices,

$$E_{\$/€} = P^i_{US}/P^i_E.$$

Purchasing Power Parity

The theory of purchasing power parity states that the exchange rate between two countries' currencies equals the ratio of the countries' price levels. Recall from Chapter 14 that the domestic purchasing power of a country's currency is reflected in the country's price level, the money price of a reference basket of goods and services. The PPP theory therefore predicts that a fall in a currency's domestic purchasing power (as indicated by an increase in the domestic price level) will be associated with a proportional currency depreciation in the foreign exchange market. Symmetrically, PPP predicts that an increase in the currency's domestic purchasing power will be associated with a proportional currency appreciation.

The basic idea of PPP was put forth in the writings of nineteenth-century British economists, among them David Ricardo (the originator of the theory of comparative advantage). Gustav Cassel, a Swedish economist writing in the early twentieth century, popularized PPP by making it the centerpiece of a theory of exchange rates. While there has been much controversy about the general validity of PPP, the theory does highlight important factors behind exchange rate movements.

To express the PPP theory in symbols, let P_{US} be the dollar price of a reference commodity basket sold in the United States and P_E the euro price of the same basket in Europe. (Assume for now that a single basket accurately measures money's purchasing power in both countries.) Then PPP predicts a dollar/euro exchange rate of

$$E_{\$/€} = P_{US}/P_E. \tag{15-1}$$

If, for example, the reference commodity basket costs \$200 in the United States and €160 in Europe, PPP predicts a dollar/euro exchange rate of \$1.25 per euro ($= \$200$ per basket/€160 per basket). If the U.S. price level were to triple (to \$600 per basket), so would the dollar price of a euro. PPP would imply an exchange rate of \$3.75 per euro ($= \$600$ per basket/€160 per basket).

By rearranging equation (15-1) to read

$$P_{US} = (E_{\$/€}) \times (P_E),$$

we get an alternative interpretation of PPP. The left side of this equation is the dollar price of the reference commodity basket in the United States; the right side is the dollar price of the reference basket when purchased in Europe (that is, its euro price multiplied by the dollar price of a euro). These two prices are the same if PPP holds. *PPP thus asserts that all countries' price levels are equal when measured in terms of the same currency.*

Equivalently, the right side of the last equation measures the purchasing power of a dollar when exchanged for euros and spent in Europe. PPP therefore holds when, at going exchange rates, every currency's domestic purchasing power is always the same as its foreign purchasing power.

The Relationship Between PPP and the Law of One Price

Superficially, the statement of PPP given by equation (15-1) looks like the law of one price, which says that $E_{\$/€} = P^i_{US}/P^i_E$ for any commodity i. There is a difference between PPP and the law of one price, however: The law of one price applies to individual commodities (such as commodity i), while PPP applies to the general price level, which is a composite of the prices of all the commodities that enter into the reference basket.

If the law of one price holds true for every commodity, of course, PPP must hold automatically as long as the reference baskets used to reckon different countries' price levels are the same. Proponents of the PPP theory argue, however, that its validity (in particular, its validity as a long-run theory) does not require the law of one price to hold exactly.

Even when the law of one price fails to hold for each individual commodity, the argument goes, prices and exchange rates should not stray too far from the relation predicted by PPP. When goods and services become temporarily more expensive in one country than in others, the demands for its currency and its products fall, pushing the exchange rate and domestic prices back in line with PPP. The opposite situation of relatively cheap domestic products leads, analogously, to currency appreciation and price level inflation. PPP thus asserts that even when the law of one price is not literally true, the economic forces behind it will help eventually to equalize a currency's purchasing power in all countries.

Absolute PPP and Relative PPP

The statement that exchange rates equal relative price levels (equation (15-1)) is sometimes referred to as *absolute* PPP. Absolute PPP implies a proposition known as **relative PPP,** which states that the percentage change in the exchange rate between two currencies over any period equals the difference between the percentage changes in national price levels. Relative PPP thus translates absolute PPP from a statement about price and exchange rate *levels* into one about price and exchange rate *changes*. It asserts that prices and exchange rates change in a way that preserves the ratio of each currency's domestic and foreign purchasing powers.

If the U.S. price level rises by 10 percent over a year while Europe's rises by only 5 percent, for example, relative PPP predicts a 5 percent depreciation of the dollar against the euro. The dollar's 5 percent depreciation against the euro just cancels the 5 percent by which U.S. inflation exceeds European, leaving the relative domestic and foreign purchasing powers of both currencies unchanged.

More formally, relative PPP between the United States and Europe would be written as

$$(E_{\$/€,\,t} - E_{\$/€,\,t-1})/E_{\$/€,\,t-1} = \pi_{US,\,t} - \pi_{E,\,t} \tag{15-2}$$

where π_t denotes an inflation rate (that is, $\pi_t = (P_t - P_{t-1})/P_{t-1}$, the percentage change in a price level between dates t and $t-1$).[1] Unlike absolute PPP, relative PPP can be defined only with respect to the time interval over which price levels and the exchange rate change.

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[1] To be precise, equation (15-1) implies a good approximation to equation (15-2) when rates of change are not too large. The *exact* relationship is

$$E_{\$/€,\,t}/E_{\$/€,\,t-1} = (P_{US,\,t}/P_{US,\,t-1})/(P_{E,\,t}/P_{E,\,t-1}).$$

After subtracting 1 from both sides, we write the preceding exact equation as

$$\begin{aligned}(E_{\$/€,\,t} - E_{\$/€,\,t-1})/E_{\$/€,\,t-1} &= (\pi_{US,\,t} + 1)(P_{E,\,t-1}/P_{E,\,t}) - (P_{E,\,t}/P_{E,\,t}) \\ &= (\pi_{US,\,t} - \pi_{E,\,t})/(1 + \pi_{E,\,t}) \\ &= (\pi_{US,\,t} - \pi_{E,\,t}) - \pi_{E,\,t}(\pi_{US,\,t} - \pi_{E,\,t})/(1 + \pi_{E,\,t}).\end{aligned}$$

But if $\pi_{US,\,t}$ and $\pi_{E,\,t}$ are small, the term $-\pi_{E,\,t}(\pi_{US,\,t} - \pi_{E,\,t})/(1 + \pi_{E,\,t})$ in the last equality is negligibly small, implying a very good approximation to (15-2).

In practice, national governments do not take pains to compute the price level indexes they publish using an internationally standardized basket of commodities. Absolute PPP makes no sense, however, unless the two baskets whose prices are compared in equation (15-1) are the same. (There is no reason to expect *different* commodity baskets to sell for the same price!) The notion of relative PPP therefore comes in handy when we have to rely on government price level statistics to evaluate PPP. It makes logical sense to compare percentage exchange rate changes to inflation differences, as above, even when countries base their price *level* estimates on product baskets that differ in coverage and composition.

Relative PPP is important also because it may be valid even when absolute PPP is not. Provided the factors causing deviations from absolute PPP are more or less stable over time, percentage *changes* in relative price levels can still approximate percentage *changes* in exchange rates.

A Long-Run Exchange Rate Model Based on PPP

When combined with the framework of money demand and supply we developed in Chapter 14, the theory of PPP leads to a useful theory of how exchange rates and monetary factors interact in the long run. Because factors that do not influence money supply or money demand play no explicit role in this theory, it is known as the **monetary approach to the exchange rate.** The monetary approach is this chapter's first step in developing a general long-run theory of exchange rates.

We think of the monetary approach as a *long-run* and not a short-run theory because it does not allow for the price rigidities that seem important in explaining short-run macro-economic developments, in particular departures from full employment. Instead, the mone-tary approach proceeds as if prices can adjust right away to maintain full employment as well as PPP. Here, as in the previous chapter, when we refer to a variable's "long-run" value we mean the variable's equilibrium value in a hypothetical world of perfectly flexible output and factor market prices.

There is actually considerable controversy among macroeconomists about the sources of apparent price level stickiness, with some maintaining that prices and wages only appear rigid and in reality adjust immediately to clear markets. To an economist of the aforemen-tioned school, this chapter's models would describe the short-run behavior of an economy in which the speed of price level adjustment is so high that no significant unemployment ever occurs.

The Fundamental Equation of the Monetary Approach

To develop the monetary approach's predictions for the dollar/euro exchange rate, we will assume that in the long run the foreign exchange market sets that rate so that PPP holds (see equation (15-1)):

$$E_{\$/€} = P_{US}/P_E.$$

In other words, we assume the above equation would hold in a world where there were no market rigidities to prevent the exchange rate and other prices from adjusting immediately to levels consistent with full employment.

In the previous chapter, equation (14-5) showed how we can explain domestic price levels in terms of domestic money demands and supplies. In the United States,

$$P_{US} = M_{US}^s/L(R_\$, Y_{US}), \tag{15-3}$$

while in Europe,

$$P_{\mathrm{E}} = M_{\mathrm{E}}^{s}/L(R_{\unicode{x20AC}}, Y_{\mathrm{E}}). \tag{15-4}$$

As before, we have used the symbol M^{s} to stand for a country's money supply and $L(R, Y)$ to stand for its aggregate real money demand, which decreases when the interest rate rises and increases when real output rises.[2]

Equations (15-3) and (15-4) show how the monetary approach to the exchange rate comes by its name. According to the statement of PPP in equation (15-1), the dollar price of a euro is simply the dollar price of U.S. output divided by the euro price of European output. These two price levels, in turn, are determined completely by the supply and demand for each currency area's money: The United States' price level is the U.S. money supply divided by U.S. real money demand, as shown in (15-3), and Europe's price level similarly is the European money supply divided by European real money demand, as shown in (15-4). The monetary approach therefore makes the general prediction that *the exchange rate, which is the relative price of American and European money, is fully determined in the long run by the relative supplies of those monies and the relative real demands for them.* Shifts in interest rates and output levels affect the exchange rate only through their influences on money demand.

In addition, the monetary approach makes a number of specific predictions about the long-run effects on the exchange rate of changes in money supplies, interest rates, and output levels:

1. *Money supplies.* Other things equal, a permanent rise in the U.S. money supply M_{US}^{s} causes a proportional increase in the long-run U.S. price level P_{US}, as equation (15-3) shows. Because under PPP, $E_{\$/\unicode{x20AC}} = P_{\mathrm{US}}/P_{\mathrm{E}}$, however, $E_{\$/\unicode{x20AC}}$ also rises in the long run in proportion to the increase in the U.S. money supply. (For example, if M_{US}^{s} rises by 10 percent, P_{US} and $E_{\$/\unicode{x20AC}}$ both eventually rise by 10 percent as well.) Thus, an increase in the U.S. money supply causes a proportional long-run *depreciation* of the dollar against the euro. Conversely, equation (15-4) shows that a permanent increase in the European money supply causes a proportional increase in the long-run European price level. Under PPP, this price level rise implies a proportional long-run *appreciation* of the dollar against the euro (which is the same as a proportional depreciation of the euro against the dollar).

2. *Interest rates.* A rise in the interest rate $R_{\$}$ on dollar-denominated assets lowers real U.S. money demand $L(R_{\$}, Y_{\mathrm{US}})$. By (15-3) the long-run U.S. price level rises, and under PPP the dollar must depreciate against the euro in proportion to this U.S. price level increase. A rise in the interest rate $R_{\unicode{x20AC}}$ on euro-denominated assets has the reverse long-run exchange rate effect. Because real European money demand $L(R_{\unicode{x20AC}}, Y_{\mathrm{E}})$ falls, Europe's price level rises, by (15-4). Under PPP, the dollar must appreciate against the euro in proportion to Europe's price level increase.

3. *Output levels.* A rise in U.S. output raises real U.S. money demand $L(R_{\$}, Y_{\mathrm{US}})$, leading by (15-3) to a fall in the long-run U.S. price level. According to PPP, there is an appreciation of the dollar against the euro. Symmetrically, a rise in European output raises $L(R_{\unicode{x20AC}}, Y_{\mathrm{E}})$ and, by (15-4), causes a fall in Europe's long-run price level. PPP predicts that this development will make the dollar depreciate against the euro.

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[2]To simplify the notation, we assume identical money demand functions for the United States and Europe.

To understand these predictions, remember that the monetary approach, like any long-run theory, essentially assumes that price levels adjust as quickly as exchange rates do—that is, right away. For example, a rise in real U.S. output raises the transactions demand for real U.S. money balances. According to the monetary approach, the U.S. price level drops *immediately* to bring about a market-clearing increase in the supply of real balances. PPP implies that this instantaneous American price deflation is accompanied by an instantaneous dollar appreciation on the foreign exchanges.

The monetary approach leads to a result familiar from Chapter 14, that the long-run foreign exchange value of a country's currency moves in proportion to its money supply (prediction 1 above). The theory also raises what seems to be a paradox (prediction 2). In our previous examples, we always found that a currency *appreciates* when the interest rate it offers rises relative to foreign interest rates. How is it that we have now arrived at precisely the opposite conclusion—that a rise in a country's interest rate *depreciates* its currency by lowering the real demand for its money?

At the end of Chapter 13, we warned that no account of how a change in interest rates affects the exchange rate is complete until we specify *exactly why interest rates have changed*. This point explains the apparent contradiction in our findings about interest and exchange rates. To resolve the puzzle, however, we must first examine more closely how monetary policies and interest rates are connected in the long run.

Ongoing Inflation, Interest Parity, and PPP

In the last chapter we saw that a permanent increase in the *level* of a country's money supply ultimately results in a proportional rise in its price level but has no effect on the long-run values of the interest rate or real output. While the conceptual experiment of a one-time, stepwise money supply change is useful for thinking about the long-run effects of money, it is not too realistic as a description of actual monetary policies. More often, the monetary authorities choose a *growth rate* for the money supply, say, 5 or 10 or 50 percent per year, and then allow money to grow gradually, through incremental but frequent increases. What are the long-run effects of a policy that allows the money supply to grow smoothly forever at a positive rate?

The reasoning in Chapter 14 suggests that continuing money supply growth will require a continuing rise in the price level—a situation of *ongoing* inflation. As firms and workers catch on to the fact that the money supply is growing steadily at, say, a 10 percent annual rate, they will adjust by raising prices and wages by the same 10 percent every year, thus keeping their real incomes constant. Full-employment output depends on supplies of productive factors, but it is safe to assume that factor supplies, and thus output, are unaffected over the long run by different choices of a constant growth rate for the money supply. *Other things equal, money supply growth at a constant rate eventually results in ongoing price level inflation at the same rate, but changes in this long-run inflation rate do not affect the full-employment output level or the long-run relative prices of goods and services.*

The interest rate, however, is definitely not independent of the money supply growth rate in the long run. While the long-run interest rate does not depend on the absolute *level* of the money supply, continuing *growth* in the money supply eventually will affect the interest rate. The easiest way to see how a permanent increase in inflation affects the long-run interest rate is by combining PPP with the interest rate parity condition on which our previous analysis of exchange rate determination was built.

As in the preceding two chapters, the condition of interest parity between dollar and euro assets is

$$R_\$ = R_\text{€} + (E^e_{\$/\text{€}} - E_{\$/\text{€}})/E_{\$/\text{€}}$$

(recall equation (13-2), page 324). Now let's ask how this parity condition, which must hold in the long run as well as in the short run, fits with the other parity condition we are assuming in our long-run model, purchasing power parity. According to relative PPP, the percentage change in the dollar/euro exchange rate over the next year, say, will equal the difference between the inflation rates of the United States and Europe over that year (see equation (15-2)). Since people understand this relationship, however, it must also be true that they *expect* the percentage exchange rate change to equal the U.S.–Europe inflation difference. The interest parity condition written above now tells us the following: *If people expect relative PPP to hold, the difference between the interest rates offered by dollar and euro deposits will equal the difference between the inflation rates expected, over the relevant horizon, in the United States and in Europe.*

Some additional notation is helpful in deriving this result more formally. If P^e is the price level expected in a country for a year from today, the expected inflation rate in that country, π^e, is the expected percentage increase in the price level over the coming year,

$$\pi^e = (P^e - P)/P.$$

If relative PPP holds, however, market participants will also expect it to hold, which means that we can replace the actual depreciation and inflation rates in equation (15-2) with the values the market expects to materialize:

$$(E^e_{\$/€} - E_{\$/€})/E_{\$/€} = \pi^e_{US} - \pi^e_{E}.$$

By combining this "expected" version of relative PPP with the interest parity condition

$$R_\$ = R_€ + (E^e_{\$/€} - E_{\$/€})/E_{\$/€}$$

and rearranging, we arrive at a formula that expresses the international interest rate difference as the difference between expected national inflation rates:

$$R_\$ - R_€ = \pi^e_{US} - \pi^e_{E}. \tag{15-5}$$

If, as PPP predicts, currency depreciation is expected to offset the international inflation difference (so that the expected dollar depreciation rate is $\pi^e_{US} - \pi^e_{E}$), the interest rate difference must equal the expected inflation difference.

The Fisher Effect

Equation (15-5) gives us the long-run relationship between ongoing inflation and interest rates that we need to explain the monetary approach's predictions about how interest rates affect exchange rates. The equation tells us that *all else equal, a rise in a country's expected inflation rate will eventually cause an equal rise in the interest rate that deposits of its currency offer. Similarly, a fall in the expected inflation rate will eventually cause a fall in the interest rate.*

This long-run relationship between inflation and interest rates is called the **Fisher effect.** The Fisher effect implies, for example, that if U.S. inflation were to rise permanently from a constant level of 5 percent per year to a constant level of 10 percent per year, dollar interest rates would eventually catch up with the higher inflation, rising by 5 percentage points per year from their initial level. These changes would leave the *real rate of return* on dollar assets, measured in terms of U.S. goods and services, unchanged. The Fisher effect is

therefore another example of the general idea that in the long run, purely monetary developments should have no effect on an economy's relative prices.[3]

The Fisher effect is behind the seemingly paradoxical monetary approach prediction that a currency depreciates in the foreign exchange market when its interest rate rises relative to foreign currency interest rates. In the long-run equilibrium assumed by the monetary approach, a rise in the difference between home and foreign interest rates occurs only when expected home inflation rises relative to expected foreign inflation. This is certainly not the case in the short run, when the domestic price level is sticky. In the short run, as we saw in Chapter 14, the interest rate can rise when the domestic money supply *falls* because the sticky domestic price level leads to an excess demand for real money balances at the initial interest rate. Under the flexible-price monetary approach, however, the price level would fall right away, leaving the *real* money supply unchanged and thus making the interest rate change unnecessary.

We can better understand how interest rates and exchange rates interact under the monetary approach by thinking through an example. Our example illustrates why the monetary approach associates sustained interest rate hikes with current as well as future currency depreciation, and sustained interest rate slumps with appreciation.

Imagine that at time t_0 the Federal Reserve unexpectedly increases the growth rate of the U.S. money supply from π to the higher level $\pi + \Delta\pi$. Figure 15-1 illustrates how this change affects the dollar/euro exchange rate $E_{\$/€}$, as well as other U.S. variables, under the assumptions of the monetary approach. To simplify the graphs, we assume that in Europe the inflation rate remains constant at zero.

Figure 15-1a shows the sudden acceleration of U.S. money supply growth at time t_0. (We have scaled the vertical axes of the graphs so that constant slopes represent constant proportional growth rates of variables.) The policy change generates expectations of more rapid currency depreciation in the future: Under PPP the dollar will now depreciate at the rate $\pi + \Delta\pi$ rather than at the lower rate π. Interest parity therefore requires the dollar interest rate to rise, as shown in Figure 15-1b, from its initial level $R_\$^1$ to a new level that reflects the extra expected dollar depreciation, $R_\$^2 = R_\$^1 + \Delta\pi$ (see equation (15-5)). Notice that this adjustment leaves the euro interest rate unchanged; but since Europe's money supply and output haven't changed, the original euro interest rate will still maintain equilibrium in Europe's money market.

You can see from Figure 15-1a that the *level* of the money supply does not actually jump upward at t_0—only the *future growth rate* changes. Since there is no immediate increase in the money supply, but there is an interest rate rise that reduces money demand, there would be an excess supply of real U.S. money balances at the price level prevailing just prior to t_0. In the face of this potential excess supply the U.S. price level does jump upward at t_0 (see Figure 15-1c), reducing the real money supply so that it again equals real money demand (see equation (15-3)). Consistently with the upward jump in P_{US} at t_0, Figure 15-1d shows the simultaneous proportional upward jump in $E_{\$/€}$ implied by PPP.

How can we visualize the reaction of the foreign exchange market at time t_0? The dollar interest rate rises not because of a change in current levels of money supply or demand, but solely because people expect more rapid future money supply growth and dollar depreciation. As investors respond by moving into foreign deposits, which momentarily offer higher expected returns, the dollar depreciates sharply in the foreign exchange

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[3]The effect is named after Irving Fisher of Yale University, one of the great American economists of the early 20th century. The effect is discussed at length in his book, *The Theory of Interest* (New York: Macmillan, 1930). Fisher, incidentally, gave an early account of the interest parity condition on which our theory of foreign exchange market equilibrium is based.
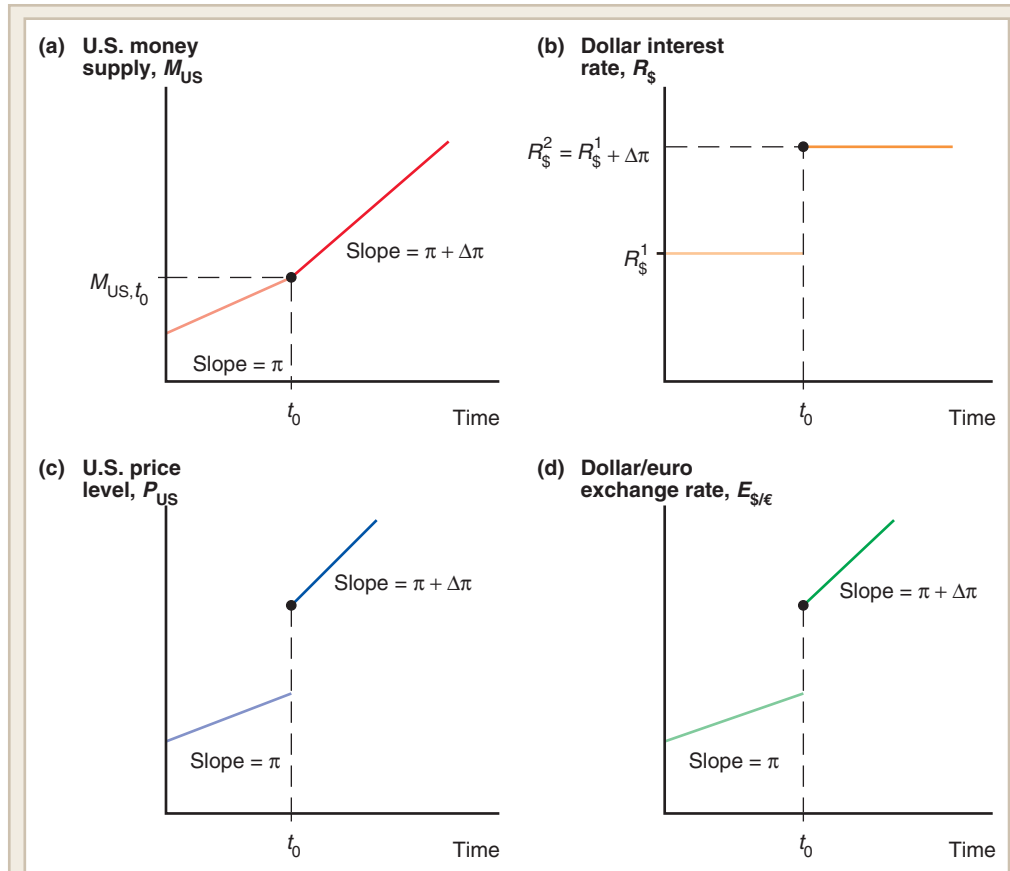
Figure 15-1

Long-Run Time Paths of U.S. Economic Variables After a Permanent Increase in the Growth Rate of the U.S. Money Supply

After the money supply growth rate increases at time t_0 in panel (a), the interest rate (in panel (b)), price level (in panel (c)), and exchange rate (in panel (d)) move to new long-run equilibrium paths. (The money supply, price level, and exchange rate are all measured on a *natural logarithmic* scale, which makes variables that change at constant proportional rates appear as straight lines when they are graphed against time. The slope of the line equals the variable's proportional growth rate.)

market, moving to a new trend line along which depreciation is more rapid than it was up to time t_0.[4]

Notice how different assumptions about the speed of price level adjustment lead to contrasting predictions about how exchange and interest rates interact. In the example of a fall in the money supply under sticky prices, an interest rate rise is needed to preserve money

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[4]In the general case in which Europe's inflation rate π_E is not zero, the dollar, rather than depreciating against the euro at rate π before t_0 and at rate $\pi + \Delta\pi$ afterward, depreciates at rate $\pi - \pi_E$ until t_0 and at rate $\pi + \Delta\pi - \pi_E$ thereafter.

market equilibrium, given that the price level cannot do so by dropping immediately in response to the money supply reduction. In that sticky-price case, an interest rate rise is associated with lower expected inflation and a long-run currency appreciation, so the currency appreciates immediately. In our monetary-approach example of a rise in money supply growth, however, an interest rate increase is associated with higher expected inflation and a currency that will be weaker on all future dates. An immediate currency *depreciation* is the result.[5]

These contrasting results of interest rate changes underlie our earlier warning that an explanation of exchange rates based on interest rates must carefully account for the factors that cause interest rates to move. These factors can simultaneously affect expected future exchange rates and can therefore have a decisive impact on the foreign exchange market's response to the interest rate change. The appendix to this chapter shows in detail how expectations change in the case we analyzed.

Empirical Evidence on PPP and the Law of One Price

How well does the PPP theory explain actual data on exchange rates and national price levels? A brief answer is that *all versions of the PPP theory do badly* in explaining the facts. In particular, changes in national price levels often tell us relatively little about exchange rate movements.

Do not conclude from this evidence, however, that the effort you've put into learning about PPP has been wasted. As we'll see later in this chapter, PPP is a key building block of exchange rate models more realistic than the monetary approach. Indeed, the empirical failures of PPP give us important clues about how more realistic models should be set up.

To test *absolute* PPP, economic researchers compare the international prices of a broad reference basket of commodities, making careful adjustments for intercountry quality differences among supposedly identical goods. These comparisons typically conclude that absolute PPP is way off the mark: The prices of identical commodity baskets, when converted to a single currency, differ substantially across countries. Even the law of one price does not fare well in some recent studies of price data broken down by commodity type. Manufactured goods that seem to be very similar to each other have sold at widely different prices in various markets since the early 1970s. Because the argument leading to absolute PPP builds on the law of one price, it is not surprising that PPP does not stand up well to the data.[6]

Relative PPP is sometimes a reasonable approximation to the data, but it, too, usually performs poorly. Figure 15-2 illustrates relative PPP's weakness by plotting both the yen/dollar exchange rate, $E_{¥/\$}$, and the ratio of the Japanese and U.S. price levels, P_J/P_{US},

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[5]National money supplies typically trend upward over time, as in Figure 15-1a. Such trends lead to corresponding upward trends in price levels; if two countries' price level trends differ, PPP implies a trend in their exchange rate as well. From now on, when we refer to a change in the money supply, price level, or exchange rate, we will mean by this a change in the level of the variable *relative to its previously expected trend path*—that is, a parallel shift in the trend path. When instead we want to consider changes in the slopes of trend paths themselves, we will say so explicitly.

[6]Some of the negative evidence on absolute PPP is discussed in the Case Study to follow. Regarding the law of one price, see, for example, Peter Isard, "How Far Can We Push the Law of One Price?" *American Economic Review* 67 (December 1977), pp. 942–948; Irving B. Kravis and Robert E. Lipsey, "Price Behavior in the Light of Balance of Payments Theories," *Journal of International Economics* 8 (May 1978), pp. 193–246; and the paper by Goldberg and Knetter in Further Reading.
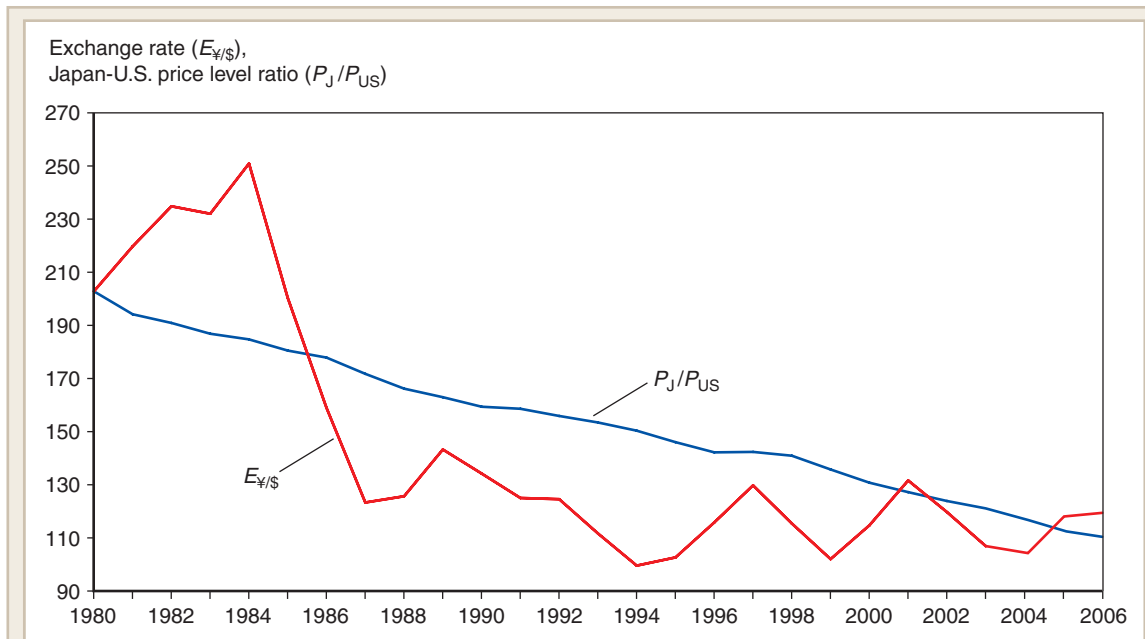
Figure 15-2

The Yen/Dollar Exchange Rate and Relative Japan-U.S. Price Levels, 1980–2006

The graph shows that relative PPP did not explain the yen/dollar exchange rate after 1980.

Source: IMF, *International Financial Statistics*. Exchange rates and price levels are end-of-year data.

through 2006. Price levels are measured by indexes reported by the Japanese and U.S. governments.[7]

Relative PPP predicts that $E_{¥/\$}$ and P_J/P_{US} should move in proportion, but clearly they do not. In the early 1980s there was a steep appreciation of the dollar against the yen, even though, with Japan's price level consistently falling relative to that in the United States, relative PPP suggests that the dollar should have *de*preciated instead. The same inflation trends continued after the mid-1980s, but the yen then appreciated by far more than the amount that PPP would have predicted. Only over fairly long periods is relative PPP approximately satisfied. In view of the lengthy departures from PPP in between, however, that theory appears to be of limited use even as a long-run explanation.

Studies of other currencies largely confirm the results in Figure 15-2. Relative PPP has not held up well.[8] As you will learn later in this book, between the end of World War II in 1945 and the early 1970s, exchange rates were fixed within narrow internationally agreed

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[7]The price level measures in Figure 15-2 are index numbers, not dollar amounts. For example, the U.S. consumer price index (CPI) was 100 in the base year 2000 and only about 50 in 1980, so the dollar price of a reference commodity basket of typical U.S. consumption purchases doubled between 1980 and 2000. Base years for the U.S. and Japanese price indexes were chosen so that their 1980 ratio would equal the 1980 exchange rate, but this imposed equality does *not* mean that absolute PPP held in 1980. Although Figure 15-2 uses CPIs, other price indexes lead to similar pictures.

[8]See, for example, the paper by Taylor and Taylor in this chapter's Further Reading.

margins through the intervention of central banks in the foreign exchange market. During that period of fixed exchange rates, PPP did not do too badly. During the first half of the 1920s, however, when many exchange rates were market-determined as in the 1970s and after, important deviations from relative PPP occurred, just as in recent decades.[9]

Explaining the Problems with PPP

What explains the negative empirical results described in the previous section? There are several immediate problems with our rationale for the PPP theory of exchange rates, which was based on the law of one price:

1. Contrary to the assumption of the law of one price, transport costs and restrictions on trade certainly do exist. These trade barriers may be high enough to prevent some goods and services from being traded between countries.

2. Monopolistic or oligopolistic practices in goods markets may interact with transport costs and other trade barriers to weaken further the link between the prices of similar goods sold in different countries.

3. Because the inflation data reported in different countries are based on different commodity baskets, there is no reason for exchange rate changes to offset official measures of inflation differences, even when there are no barriers to trade and all products are tradable.

Trade Barriers and Nontradables

Transport costs and governmental trade restrictions make it expensive to move goods between markets located in different countries and therefore weaken the law of one price mechanism underlying PPP. Suppose once again that the same sweater sells for $45 in New York and for £30 in London, but that it costs $2 to ship a sweater between the two cities. At an exchange rate of $1.45 per pound, the dollar price of a London sweater is ($1.45 per pound) $\times$ (£30) = $43.50, but an American importer would have to pay $43.50 + $2 = $45.50 to purchase the sweater in London and get it to New York. At an exchange rate of $1.45 per pound, it therefore would not pay to ship sweaters from London to New York, even though their dollar price would be higher in the latter location. Similarly, at an exchange rate of $1.55 per pound, an American exporter would lose money by shipping sweaters from New York to London even though the New York price of $45 would then be below the dollar price of the sweater in London, $46.50.

The lesson of this example is that transport costs sever the close link between exchange rates and goods prices implied by the law of one price. The greater the transport costs, the greater the range over which the exchange rate can move, given goods prices in different countries. Official trade restrictions such as tariffs have a similar effect, because a fee paid to the customs inspector affects the importer's profit in the same way as an equivalent shipping fee. Either type of trade impediment weakens the basis of PPP by allowing the purchasing power of a given currency to differ more widely from country to country. For example, in the presence of trade impediments, a dollar need not go as far in London as in Chicago—and it doesn't, as anyone who has been to London has found out.

[9]See Paul R. Krugman, "Purchasing Power Parity and Exchange Rates: Another Look at the Evidence," *Journal of International Economics* 8 (August 1978), pp. 397–407; Paul De Grauwe, Marc Janssens, and Hilde Leliaert, *Real-Exchange-Rate Variability from 1920 to 1926 and 1973 to 1982,* Princeton Studies in International Finance 56 (International Finance Section, Department of Economics, Princeton University, September 1985); and Hans Genberg, "Purchasing Power Parity Under Fixed and Flexible Exchange Rates," *Journal of International Economics* 8 (May 1978), pp. 247–276.

As you will recall from Chapter 3, transport costs may be so large relative to the cost of producing some goods and services that they can never be traded internationally at a profit. Such goods and services are called *nontradables*. The time-honored classroom example of a nontradable is the haircut. A Frenchman desiring an American haircut would have to transport himself to the United States or transport an American barber to France; in either case, the cost of transport is so large relative to the price of the service being purchased that (tourists excepted) French haircuts are consumed only by residents of France while American haircuts are consumed only by residents of the United States.

The existence in all countries of nontraded goods and services whose prices are not linked internationally allows systematic deviations even from relative PPP. Because the price of a nontradable is determined entirely by its *domestic* supply and demand curves, shifts in those curves may cause the domestic price of a broad commodity basket to change relative to the foreign price of the same basket. Other things equal, a rise in the price of a country's nontradables will raise its price level relative to foreign price levels (measuring all countries' price levels in terms of a single currency). Looked at another way, the purchasing power of any given currency will fall in countries where the prices of nontradables rise.

Each country's price level includes a wide variety of nontradables, including (along with haircuts) routine medical treatment, dance instruction, and housing, among others. Broadly speaking, we can identify traded goods with manufactured products, raw materials, and agricultural products. Nontradables are primarily services and the output of the construction industry. There are naturally exceptions to this rule. For example, financial services provided by banks and brokerage houses often can be traded internationally. (The rise of the Internet, in particular, has expanded the range of tradable services.) In addition, trade restrictions, if sufficiently severe, can cause goods that would normally be traded to become nontraded. Thus, in most countries some manufactures are nontraded.

We can get a very rough idea of the importance of nontradables in the American economy by looking at the contribution of the service and construction industries to U.S. GNP. In 2006, the output of these industries accounted for about 46 percent of U.S. GNP.

Numbers like these are likely to understate the importance of nontradables in determining national price levels. Even the prices of tradable products usually include costs of nontraded distribution and marketing services that bring goods from producers to consumers. (See "Some Meaty Evidence on the Law of One Price," pages 396–397.) Nontradables help explain the wide departures from relative PPP illustrated by Figure 15-2.

Departures from Free Competition

When trade barriers and imperfectly competitive market structures occur together, linkages between national price levels are weakened further. An extreme case occurs when a single firm sells a commodity for different prices in different markets. (Recall the analysis of dumping in Chapter 6.)

When a firm sells the same product for different prices in different markets, we say that it is practicing **pricing to market.** Pricing to market may reflect different demand conditions in different countries. For example, countries where demand is more price-inelastic will tend to be charged higher markups over a monopolistic seller's production cost. Empirical studies of firm-level export data have yielded strong evidence of pervasive pricing to market in manufacturing trade.[10]

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[10] For a detailed review of the evidence, see the paper by Goldberg and Knetter in this chapter's Further Reading. Theoretical contributions on pricing to market include Rudiger Dornbusch, "Exchange Rates and Prices," *American Economic Review* 77 (March 1987), pp. 93–106; and Paul R. Krugman, "Pricing to Market When the Exchange Rate Changes," in Sven W. Arndt and J. David Richardson, eds., *Real-Financial Linkages among Open Economies* (Cambridge, MA: MIT Press, 1987).

Some Meaty Evidence on the Law of One Price

In the summer of 1986 the *Economist* magazine conducted an extensive survey on the prices of Big Mac hamburgers at McDonald's restaurants throughout the world. This apparently whimsical undertaking was not the result of an outbreak of editorial giddiness. The magazine wanted to poke fun at economists who confidently declare exchange rates to be "overvalued" or "undervalued" on the basis of PPP comparisons. Since Big Macs are "sold in 41 countries, with only the most trivial changes of recipe," the magazine argued, a comparison of hamburger prices should serve as a "medium-rare guide to whether currencies are trading at the right exchange rates."[*] Since 1986 the *Economist* has periodically updated its calculations.

One way of interpreting the *Economist* survey is as a test of the law of one price. Viewed in this way, the results of the initial test were quite startling. The dollar prices of Big Macs turned out to be wildly different in different countries. The price of a Big Mac in New York was 50 percent higher than in Australia and 64 percent higher than in Hong Kong. In contrast, a Parisian Big Mac cost 54 percent more than its New York counterpart; a Tokyo Big Mac cost 50 percent more. Only in Britain and Ireland were the dollar prices of the burgers close to New York levels.

How can this dramatic violation of the law of one price be explained? As the *Economist* noted, transport costs and government regulations are part of the explanation. Product differentiation is probably an important additional factor. Because relatively few close substitutes for Big Macs are available in some countries, product differentiation may give McDonald's some power to tailor prices to the local market. Finally, remember that the price of a Big Mac must cover not only the cost of ground meat and buns, but also the wages of serving people, rent, electricity, and so on. The prices of these nonfood inputs can differ sharply in different countries.

We have reproduced the results of the *Economist*'s January 2007 survey report. The table on the following page shows various countries' prices of Big Macs, measured in U.S. dollar terms. These range from a high of $7.44 in Iceland (more than twice the U.S. price) to only $1.41 in China (less than half the U.S. price).

For each country, we can figure out a "Big Mac PPP," which is the hypothetical level of the exchange rate that would equate the dollar price of a locally sold Big Mac to its $3.22 U.S. price. For example, in January 2007, an Icelandic krona cost about $0.0146 in the foreign exchange market. The exchange rate that would have equalized U.S. and Icelandic burger prices, however, was

(0.0146 dollars per krone)
$\times$ (3.22 dollars per burger/7.44 dollars per burger)
= 0.632 cents per krona.

It is often said that a currency is overvalued when its exchange rate makes domestic goods expensive relative to similar goods sold abroad and undervalued in the opposite case. For the Icelandic krona, for example, the degree of overvaluation is the percentage by which the market dollar price of a krona exceeds the hypothetical Big Mac PPP rate, or

$100 \times (0.0146 - 0.00632)/0.00632 = 131$ percent.

Likewise, in January 2007 the dollar price of the Chinese renminbi was 56 percent *below* the level needed to bring about burger price parity: That country's currency was *under*valued by 56 percent, according to the Big Mac measure. China's currency would have had to appreciate substantially against the dollar to bring the Chinese and U.S. prices of Big Macs into line. Iceland's currency, in contrast, would have had to depreciate substantially.

In general, a "PPP exchange rate" is defined as one that equates the international prices of some broad basket of goods and services, not just hamburgers. As we shall see, there are several reasons why we might expect PPP not to hold exactly, even over long periods. Thus, despite the widespread use of terms like *overvaluation*, policy makers have to be very cautious in judging whether any particular level of the exchange rate may signal the need for economic policy changes.

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[*]"On the Hamburger Standard," *Economist,* September 6–12, 1986.

	Big Mac prices		Implied PPP* of the dollar	Actual dollar exchange rate Jan. 31, 2007	Under (−)/over (+) valuation against the dollar, %
	In local currency	In dollars			
United States[†]	$3.22	3.22			
Argentina	Peso 8.25	2.65	2.56	3.11	−18
Australia	A$3.45	2.67	1.07	1.29	−17
Brazil	Real 6.4	3.01	1.99	2.13	−6
Britain	£1.99	3.90	1.62[‡]	1.96[‡]	+21
Canada	C$3.63	3.08	1.13	1.18	−4
Chile	Peso 1,670	3.07	519	544	−5
China	Yuan 11.0	1.41	3.42	7.77	−56
Colombia	Peso 6,900	3.06	2,143	2,254	−5
Costa Rica	Colones 1,130	2.18	351	519	−32
Czech Republic	Koruna 52.1	2.41	16.2	21.6	−25
Denmark	Dkr27.75	4.84	8.62	5.74	+50
Egypt	Pound 9.09	1.60	2.82	5.70	−50
Estonia	Kroon 30	2.49	9.32	12.0	−23
Euro area[§]	€2.94	3.82	1.10[**]	1.30[**]	+19
Hong Kong	HK$12.0	1.54	3.73	7,81	−52
Hungary	Forint 590	3.00	183	197	−7
Iceland	Kronur 509	7.44	158	68.4	+131
Indonesia	Rupiah 15,900	1.75	4,938	9,100	−46
Japan	¥280	2.31	87.0	121	−28
Latvia	Lats 1.35	2.52	0.42	0.54	−22
Lithuania	Litas 6.50	2.45	2.02	2.66	−24
Malaysia	Ringgit 5.50	1.57	1.71	3.50	−51
Mexico	Peso 29.0	2.66	9.01	10.9	−17
New Zealand	NZ$4.60	3.16	1.43	1.45	−2
Norway	Kroner 41.5	6.63	12.9	6.26	+106
Pakistan	Rupee 140	2.31	43.5	60.7	−28
Paraguay	Guarani 10,000	1.90	3,106	5,250	−41
Peru	New Sol 9.50	2.97	2.95	3.20	−8
Philippines	Peso 85.0	1.74	26.4	48.9	−46
Poland	Zloty 6.90	2.29	2.14	3.01	−29
Russia	Rouble 49.0	1.85	15.2	26.5	−43
Saudi Arabia	Riyal 9.00	2.40	2.80	3.75	−25
Singapore	S$ 3.60	2.34	1.12	1.54	−27
Slovakia	Crown 57.98	2.13	18.0	27.2	−34
South Africa	Rand 15.5	2.14	4.81	7.25	−34
South Korea	Won 2,900	3.08	901	942	−4
Sri Lanka	Rupee 190	1.75	59.0	109	−46
Sweden	SKr32.0	4.59	9.94	6.97	+43
Switzerland	SFr6.30	5.05	1.96	1.25	+57
Taiwan	NT$75.0	2.28	23.3	32.9	−29
Thailand	Baht 62.0	1.78	19.3	34.7	−45
Turkey	Lire 4.55	3.22	1.41	1.41	nil
UAE	Dirhams 10.0	2.72	3.11	3.67	−15
Ukraine	Hryvina 9.00	1.71	2.80	5.27	−47
Uruguay	Peso 55.0	2.17	17.1	25.3	−33
Venezuela	Bolivar 6,800	1.58	2,112	4,307	−51

Sources: McDonald; *The Economist, February 2007. Exchange rates are local currency per dollar, except where noted.*

*Purchasing-power parity: local price divided by price in United States; ‡Average of New York, Atlanta, Chicago and San Francisco; ‡Dollars per pound; §Weighted average of prices in euro area; **Dollars per euro

In January 2003, for example, the price of a Volkswagen Passat was 39 percent higher in Germany than in Greece, despite those countries' shared currency (the euro) and despite the European Union's efforts over many years to remove intra-European trade barriers (see Chapter 20). Such discriminatory pricing would be difficult to enforce if it were not costly for consumers to buy autos in Greece and drive or ship them to Germany, or if consumers viewed cheaper cars available in Germany as good substitutes for the Passat.[11] The combination of product differentiation and segmented markets, however, leads to large violations of the law of one price and absolute PPP. Shifts in market structure and demand over time can invalidate relative PPP.

Differences in Consumption Patterns and Price Level Measurement

Government measures of the price level differ from country to country. One reason for these differences is that people living in different countries spend their income in different ways. In general, people consume relatively higher proportions of their own country's products—including its tradable products—than of foreign-made products. The average Norwegian consumes more reindeer meat than her American counterpart, the average Japanese more sushi, and the average Indian more chutney. In constructing a reference commodity basket to measure purchasing power, it is therefore likely that the Norwegian government will put a relatively high weight on reindeer, the Japanese government a high weight on sushi, and the Indian government a high weight on chutney.

Because relative PPP makes predictions about price *changes* rather than price *levels*, it is a sensible concept regardless of the baskets used to define price levels in the countries being compared. If all U.S. prices increase by 10 percent and the dollar depreciates against foreign currencies by 10 percent, relative PPP will be satisfied (assuming there are no changes abroad) for any domestic and foreign choices of price level indexes.

Change in the relative prices of basket components, however, can cause relative PPP to fail tests that are based on official price indexes. For example, a rise in the relative price of fish would raise the dollar price of a Japanese government reference commodity basket relative to that of a U.S. government basket, simply because fish takes up a larger share of the Japanese basket. Relative price changes could lead to PPP violations like those shown in Figure 15-2 even if trade were free and costless.

PPP in the Short Run and in the Long Run

The factors we have examined so far in explaining the PPP theory's poor empirical performance can cause national price levels to diverge even in the long run, after all prices have had time to adjust to their market-clearing levels. As we discussed in Chapter 14, however, many prices in the economy are sticky and take time to adjust fully. Departures from PPP may therefore be even greater in the short run than in the long run.

An abrupt depreciation of the dollar against foreign currencies, for example, makes farm equipment in the United States cheaper relative to similar equipment produced abroad. As farmers throughout the world shift their demand for tractors and reapers to U.S. producers, the price of American farm equipment tends to rise to reduce the divergence from the law of one price caused by the dollar's depreciation. It takes time for this process of

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[11]See European Commission, "Car Prices: Despite Price Convergence, Buying Abroad Often Remains a Good Deal," Press Release IP/04/285, February 3, 2004. As of October 1, 2005, car dealers within the European Union (EU) have the right to set up sales outlets in other EU countries. Because dealers have access to lower-cost means of shipping autos than do individual consumers, arbitrage possibilities are enhanced by this change.

price increase to be complete, however, and prices for U.S. and foreign farm equipment may differ considerably while markets adjust to the exchange rate change.

You might suspect that short-run price stickiness and exchange rate volatility help explain a phenomenon we noted in discussing Figure 15-2, that violations of relative PPP have been much more flagrant over periods when exchange rates have floated. Empirical research supports this interpretation of the data. Figure 14-11, which we used to illustrate the stickiness of goods prices compared with exchange rates, is quite typical of floating-rate episodes. In a careful study covering many countries and historical episodes, economist Michael Mussa of the Institute of International Economics compared the extent of short-run deviations from PPP under fixed and floating exchange rates. He found that floating exchange rates systematically lead to much larger and more frequent short-run deviations from relative PPP.[12] The box on pp. 396–397 provides an especially vivid illustration of how price stickiness can generate violations of the law of one price even for absolutely identical goods.

Recent research suggests that short-run deviations from PPP such as those due to volatile exchange rates die away over time, with only half the effect of a temporary departure from PPP remaining after four years.[13] Even when these temporary PPP deviations are removed from the data, however, it still appears that the cumulative effect of certain long-run trends causes predictable departures from PPP for many countries. The Case Study entitled, "Why Price Levels Are Lower in Poorer Countries," discusses one of the major mechanisms behind such trends.

Case Study

Why Price Levels Are Lower in Poorer Countries

Research on international price level differences has uncovered a striking empirical regularity: When expressed in terms of a single currency, countries' price levels are positively related to the level of real income per capita. In other words, a dollar, when converted to local currency at the market exchange rate, generally goes much farther in a poor country than in a rich one. Figure15-3 illustrates the relation between price levels and income, with each dot representing a different country.

The previous section's discussion of the role of nontraded goods in the determination of national price levels suggests that international variations in the prices of nontradables may contribute to price level discrepancies between rich and poor nations. The available data indeed show that nontradables tend to be more expensive (relative to tradables) in richer countries.

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[12]See Mussa, "Nominal Exchange Rate Regimes and the Behavior of Real Exchange Rates: Evidence and Implications," in Karl Brunner and Allan H. Meltzer, eds., *Real Business Cycles, Real Exchange Rates and Actual Policies*, Carnegie-Rochester Conference Series on Public Policy 25 (Amsterdam: North-Holland, 1986), pp. 117–214. Charles Engel of the University of Wisconsin has found that under a floating exchange rate, international price differences for the *same* good can be more variable than the relative price of *different* goods within a single country. See Engel, "Real Exchange Rates and Relative Prices: An Empirical Investigation," *Journal of Monetary Economics* 32 (August 1993), pp. 35–50.

[13]See, for example, Jeffrey A. Frankel and Andrew K. Rose, "A Panel Project on Purchasing Power Parity: Mean Reversion Within and Between Countries," *Journal of International Economics* 40 (February 1996), pp. 209–224. The statistical validity of these results is challenged by Paul G. J. O'Connell in "The Overvaluation of Purchasing Power Parity," *Journal of International Economics* 44 (February 1998), pp. 1–19.

Price level relative to U.S. (U.S. = 100)
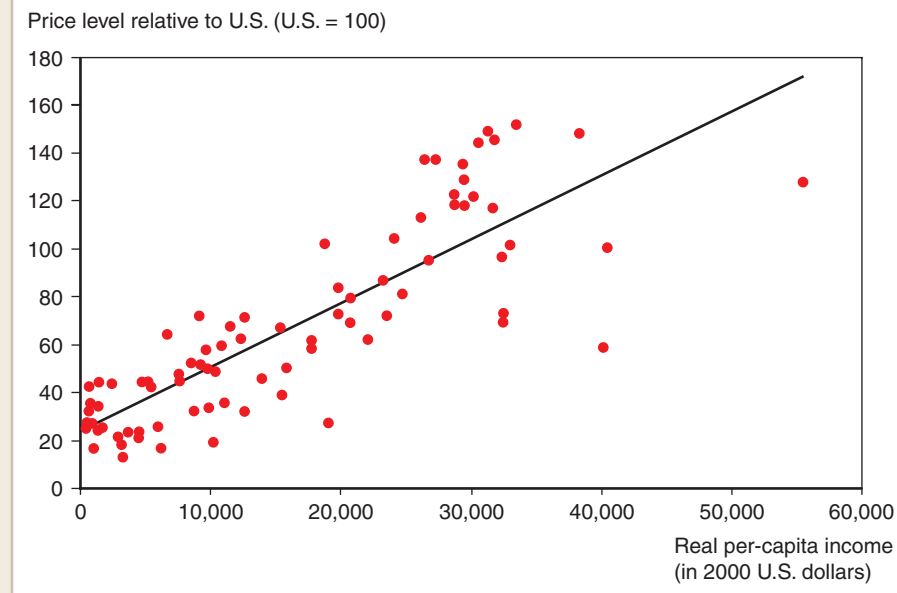
Figure 15-3

Price Levels and Real Incomes, 2004

Countries' price levels tend to rise as their real incomes rise. Each dot represents a country. The straight line indicates a statistician's best prediction of a country's price level relative to the United States based on knowing its real per-capita income.

Source: Penn World Table, Mark 6.2.

One reason for the lower relative price of nontradables in poor countries was suggested by Bela Balassa and by Paul Samuelson.[14] The Balassa-Samuelson theory assumes that the labor forces of poor countries are less productive than those of rich countries in the tradables sector but that international productivity differences in nontradables are negligible. If the prices of traded goods are roughly equal in all countries, however, lower labor productivity in the tradables industries of poor countries implies lower wages than abroad, lower production costs in nontradables, and therefore a lower price of nontradables. Rich countries with higher labor productivity in the tradables sector will tend to have higher nontradables prices and higher price levels. Productivity statistics give some empirical support to the Balassa-Samuelson differential productivity postulate. And it is plausible that international productivity differences are sharper in traded than in nontraded goods. Whether a country is rich or poor, a barber can give only so many haircuts in a week, but there may be significant scope for productivity differences across countries in the manufacture of traded goods like personal computers.

[14]See Balassa, "The Purchasing Power Parity Doctrine: A Reappraisal," *Journal of Political Economy* 72 (December 1964), pp. 584–596, and Samuelson, "Theoretical Notes on Trade Problems," *Review of Economics and Statistics* 46 (May 1964), pp. 145–154. The Balassa-Samuelson theory was foreshadowed by some observations of Ricardo. See Jacob Viner, *Studies in the Theory of International Trade* (New York: Harper & Brothers, 1937), p. 315.

An alternative theory that attempts to explain the lower price levels of poor countries was put forth by Jagdish Bhagwati of Columbia University and by Irving Kravis of the University of Pennsylvania and Robert Lipsey of the City University of New York.[15] The Bhagwati-Kravis-Lipsey view relies on differences in endowments of capital and labor rather than productivity differences, but it also predicts that the relative price of nontradables increases as real per-capita income increases. Rich countries have high capital-labor ratios, while poor countries have more labor relative to capital. Because rich countries have higher capital-labor ratios, the marginal productivity of labor is greater in rich countries than in poor countries, and the former will therefore have a higher wage level than the latter.[16] Nontradables, which consist largely of services, are naturally labor-intensive relative to tradables. Because labor is cheaper in poor countries and is used intensively in producing nontradables, nontradables also will be cheaper there than in the rich, high-wage countries. Once again, this international difference in the relative price of nontradables suggests that overall price levels, when measured in a single currency, should be higher in rich countries than in poor.

Beyond Purchasing Power Parity: A General Model of Long-Run Exchange Rates

Why devote so much discussion to the purchasing power parity theory when it is fraught with exceptions and apparently contradicted by the data? We examined the implications of PPP so closely because its basic idea of relating long-run exchange rates to long-run national price levels is a very useful starting point. The monetary approach presented above, which assumed PPP, is too simple to give accurate predictions about the real world, but we can generalize it by taking account of some of the reasons why PPP predicts badly in practice. In this section we do just that.

The long-run analysis below continues to ignore short-run complications caused by sticky prices. An understanding of how exchange rates behave in the long run is, as mentioned earlier, a prerequisite for the more complicated short-run analysis that we undertake in the next chapter.

The Real Exchange Rate

As the first step in extending the PPP theory, we define the concept of a **real exchange rate.** The real exchange rate between two countries' currencies is a broad summary measure of the prices of one country's goods and services relative to the other's. It is natural to introduce the real exchange rate concept at this point because the major prediction of PPP is that real exchange rates never change, at least not permanently. To extend our model so that it

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[15]See Kravis and Lipsey, *Toward an Explanation of National Price Levels*, Princeton Studies in International Finance 52 (International Finance Section, Department of Economics, Princeton University, November 1983); and Bhagwati, "Why Are Services Cheaper in the Poor Countries?" *Economic Journal* 94 (June 1984), pp. 279–286.

[16]This argument assumes that factor endowment differences between rich and poor countries are sufficiently great that factor-price equalization cannot hold.

describes the world more accurately, we need to examine systematically the forces that can cause dramatic and permanent changes in real exchange rates.

As we will see, real exchange rates are important not only for quantifying deviations from PPP but also for analyzing macroeconomic demand and supply conditions in open economies. When we wish to differentiate a real exchange rate, which is the relative price of two output baskets, from a relative price of two currencies, we will refer to the latter as a **nominal exchange rate.** But when there is no risk of confusion we will continue to use the shorter term *exchange rate* to cover nominal exchange rates.

Real exchange rates are defined in terms of nominal exchange rates and price levels. Before we can give a more precise definition of real exchange rates, however, we need to clarify the price level measure we will be using. Let P_{US}, as usual, be the price level in the United States, and P_E the price level in Europe. Since we will not be assuming absolute PPP (as we did in our discussion of the monetary approach), we no longer assume the price level can be measured by the same basket of commodities in the United States as in Europe. Because we will soon want to link our analysis to monetary factors, we require instead that each country's price index give a good representation of the purchases that motivate its residents to demand its money supply.

No measure of the price level does this perfectly, but we must settle on some definition before the real exchange rate can be defined formally. To be concrete, you can think of P_{US} as the dollar price of an unchanging basket containing the typical weekly purchases of U.S. households and firms; P_E, similarly, is based on an unchanging basket reflecting the typical weekly purchases of European households and firms. The point to remember is that *the United States price level will place a relatively heavy weight on commodities produced and consumed in America, the European price level a relatively heavy weight on commodities produced and consumed in Europe*.[17]

Having described the reference commodity baskets used to measure price levels, we can now formally define the *real dollar/euro exchange rate*, denoted $q_{\$/€}$, as the dollar price of the European basket relative to that of the American. We can express the real exchange rate as the dollar value of Europe's price level divided by the U.S. price level or, in symbols, as

$$q_{\$/€} = (E_{\$/€} \times P_E)/P_{US}. \tag{15-6}$$

A numerical example will clarify the concept of the real exchange rate. Imagine that the European reference commodity basket costs €100 (so that P_E = €100 per European basket), that the U.S. basket costs $120 (so that P_{US} = $120 per U.S. basket), and that the nominal exchange rate is $E_{\$/€}$ = $1.20 per euro. The real dollar/euro exchange rate would then be

$$
\begin{aligned}
q_{\$/€} &= \frac{(\$1.20 \text{ per euro}) \times (€100 \text{ per European basket})}{(\$120 \text{ per U.S. basket})} \\
&= (\$120 \text{ per European basket})/(\$120 \text{ per U.S. basket}) \\
&= 1 \text{ U.S. basket per European basket.}
\end{aligned}
$$

A rise in the real dollar/euro exchange rate $q_{\$/€}$, (which we call a **real depreciation** of the dollar against the euro) can be thought of in several equivalent ways. Most obviously, (15-6) shows this change to be a fall in the purchasing power of a dollar within Europe's

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[17]A similar presumption was made in our discussion of the transfer problem in Chapter 5. As we observed in that chapter, nontradables are one important factor behind the relative preference for home products.

borders relative to its purchasing power within the United States. This change in relative purchasing power occurs because the dollar prices of European goods ($E_{\$/€} \times P_E$) rise relative to those of U.S. goods (P_{US}).

In terms of our numerical example, a 10 percent nominal dollar depreciation, to $E_{\$/€}$ = \$1.32 per euro, causes $q_{\$/€}$ to rise to 1.1 U.S. baskets per European basket, a *real* dollar depreciation of 10 percent against the euro. (The same change in $q_{\$/€}$ could result from a 10 percent rise in P_E or a 10 percent fall in P_{US}.) The real depreciation means that the dollar's purchasing power over European goods and services falls by 10 percent relative to its purchasing power over U.S. goods and services.

Alternatively, even though many of the items entering national price levels are nontraded, it is useful to think of the real exchange rate $q_{\$/€}$ as the relative price of European products in general in terms of American products, that is, the price at which hypothetical trades of American for European commodity baskets would occur if trades at domestic prices were possible. The dollar is considered to *depreciate* in real terms against the euro when $q_{\$/€}$ rises because the hypothetical purchasing power of America's products in general over Europe's declines. America's goods and services become cheaper relative to Europe's.

A **real appreciation** of the dollar against the euro is a fall in $q_{\$/€}$. This fall indicates a decrease in the relative price of products purchased in Europe, or a rise in the dollar's European purchasing power compared with that in the United States.[18]

Our convention for describing real depreciations and appreciations of the dollar against the euro is the same one we use for nominal exchange rates (that is, $E_{\$/€}$ up is a dollar depreciation, $E_{\$/€}$ down an appreciation). Equation (15-6) shows that at *unchanged* output prices, nominal depreciation (appreciation) implies real depreciation (appreciation). Our discussion of real exchange rate changes thus includes, as a special case, an observation we made in Chapter 13: With the domestic money prices of goods held constant, a nominal dollar depreciation makes U.S. goods cheaper compared with foreign goods, while a nominal dollar appreciation makes them more expensive.

Equation (15-6) makes it easy to see why the real exchange rate can never change when relative PPP holds. Under relative PPP, a 10 percent rise in $E_{\$/€}$, for instance, would always be exactly offset by a 10 percent fall in the price level ratio P_E/P_{US}, leaving $q_{\$/€}$ unchanged.

Demand, Supply, and the Long-Run Real Exchange Rate

It should come as no surprise that in a world where PPP does not hold, the long-run values of real exchange rates, just like other relative prices that clear markets, depend on demand and supply conditions. Since a real exchange rate tracks changes in the relative price of two countries' expenditure baskets, however, conditions in *both* countries matter. Changes in countries' output markets can be complex, and we do not want to digress into an exhaustive (and exhausting) catalogue of the possibilities. We focus instead on two specific cases that are both easy to grasp and important in practice for explaining why the long-run values of real exchange rates can change.

    1. *A change in world relative demand for American products.* Imagine that total world spending on American goods and services rises relative to total world spending on European goods and services. Such a change could arise from several sources,

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[18]Since $E_{€/\$} = 1/E_{\$/€}$, so that $q_{\$/€} = P_E/(E_{€/\$} \times P_{US}) = 1/q_{€/\$}$, a real depreciation of the dollar against the euro is the same as a real appreciation of the euro against the dollar (that is, a rise in the purchasing power of the euro within the United States relative to its purchasing power within Europe, or a fall in the relative price of American products in terms of European products).

Sticky Prices and the Law of One Price: Evidence from Scandinavian Duty-Free Shops

Sticky nominal prices and wages are central to macroeconomic theories, but just why might it be difficult for money prices to change from day to day as market conditions change? One reason is based on the idea of "menu costs." Menu costs could arise from several factors, such as the actual costs of printing new price lists and catalogs. In addition, firms may perceive a different type of menu cost due to their customers' imperfect information about competitors' prices. When a firm raises its price, some customers will shop around elsewhere and find it convenient to remain with a competing seller even if all sellers have raised their prices. In the presence of these various types of menu cost, sellers will often hold prices constant after a change in market conditions until they are certain the change is permanent enough to make incurring the costs of price change worthwhile.[*]

If there were truly no barriers between two markets with goods priced in different currencies,

sticky prices would be unable to survive in the face of an exchange rate change. All buyers would simply flock to the market where a good had become cheapest. But when some trade impediments exist, deviations from the law of one price do not induce unlimited arbitrage, so it is feasible for sellers to hold prices constant despite exchange rate changes. In the real world, trade barriers appear to be significant, widespread, and often subtle in nature.

Apparently, arbitrage between two markets may be limited even when the physical distance between them is zero, as a surprising study of pricing behavior in Scandinavian duty-free outlets shows. Swedish economists Marcus Asplund and Richard Friberg studied pricing behavior in the duty-free stores of two Scandinavian ferry lines whose catalogs quote the prices of each good in several currencies for the convenience of customers

[*]It is when economic conditions are very volatile that prices seem to become most flexible. For example, restaurant menus will typically price their catch of the day at "market" so that the price charged (and the fish offered) can reflect the high variability in fishing outcomes.

for example, a shift in private U.S. demand away from European goods and toward American goods; a similar shift in private foreign demand toward American goods; or an increase in U.S. government demand falling primarily on U.S. output. Any increase in relative world demand for U.S. products causes an excess demand for them at the previous real exchange rate. To restore equilibrium, the relative price of American output in terms of European output will therefore have to rise: The relative prices of U.S. nontradables will rise and the prices of tradables produced in the United States, and consumed intensively there, will rise relative to the prices of tradables made in Europe. These changes all work to reduce $q_{\$/\euro}$, the relative price of Europe's reference expenditure basket in terms of the United States.' We conclude that *an increase in world relative demand for U.S. output causes a long-run real appreciation of the dollar against the euro (a fall in $q_{\$/\euro}$). Similarly, a fall in world relative demand for U.S. output causes a long-run real depreciation of the dollar against the euro (a rise in $q_{\$/\euro}$).*

2. *A change in relative output supply*. Suppose that the productive efficiency of U.S. labor and capital rises. Since Americans spend part of their increased income on foreign goods, the supplies of all types of U.S. goods and services increase relative to the demand for them, the result being an excess relative supply of American output at

from different countries.[†] Since it is costly to print the catalogs, they are reissued only from time to time with revised prices. In the interim, however, fluctuations in exchange rates induce multiple, changing prices for the *same* good. For example, on the Birka Line of ferries between Sweden and Finland, prices were listed in both Finnish markka and Swedish kronor between 1975 and 1998, implying that a relative depreciation of the markka would make it cheaper to buy cigarettes or vodka by paying markka rather than kronor.

Despite such price discrepancies, Birka Line was always able to do business in both currencies—passengers did not rush to buy at the lowest price. Swedish passengers, who held relatively large quantities of their own national currency, tended to buy at the kronor prices, whereas Finnish customers tended to buy at markka prices.

Often, Birka Line would take advantage of publishing a new catalog to reduce deviations from the law of one price. The average deviation from the law of one price in the month just before such a price adjustment was 7.21 percent, but only 2.22 percent in the month of a price adjustment. One big impediment to taking advantage of the arbitrage opportunities was the cost of changing currencies at the onboard foreign exchange booth—roughly 7.5 percent. That transaction cost, given different passengers' currency preference at the time of embarkation, acted as an effective trade barrier.[‡]

Surprisingly, Birka Line did not completely eliminate law of one price deviations when it changed catalog prices. Instead, Birka Line practiced a kind of pricing to market on its ferries. Usually, exporters who price to market discriminate among different consumers based on their different locations, but Birka was able to discriminate based on different nationality and currency preference, even with all potential consumers located on the same ferry boat.

[†]"The Law of One Price in Scandinavian Duty-Free Stores," *American Economic Review* 91 (September 2001), pp. 1072–1083.

[‡]Customers could pay in the currency of their choice not only with cash, but also with credit cards, which involve much lower foreign exchange conversion fees but convert at an exchange rate prevailing a few days after the purchase of the goods. Asplund and Friberg suggest that for such small purchases, uncertainty and the costs of calculating relative prices (in addition to the credit-card exchange fees) might have been a sufficient deterrent to transacting in a relatively unfamiliar currency.

the previous real exchange rate. A fall in the relative price of American products—both nontradables and tradables—shifts demand toward them and eliminates the excess supply. This price change is a real depreciation of the dollar against the euro, that is, an increase in $q_{\$/€}$. *A relative expansion of U.S. output causes a long-run real depreciation of the dollar against the euro ($q_{\$/€}$ rises). A relative expansion of European output causes a long-run real appreciation of the dollar against the euro ($q_{\$/€}$ falls).*[19]

A useful diagram summarizes our discussion of demand, supply, and the long-run real exchange rate. In Figure 15-4, the supply of U.S. output relative to European output, Y_{US}/Y_E,

[19]Our discussion of the Balassa-Samuelson effect in the Case Study on pages 399–401 would lead you to expect that a productivity increase concentrated in the U.S. tradables sector might cause the dollar to appreciate in real terms against the euro, rather than depreciate. In the last paragraph, however, we have in mind a balanced productivity increase which benefits the traded and nontraded sectors in equal proportion. It causes a real dollar depreciation by causing a drop in the prices of nontraded goods and in those of traded goods that are more important in America's consumer price index than in Europe's.
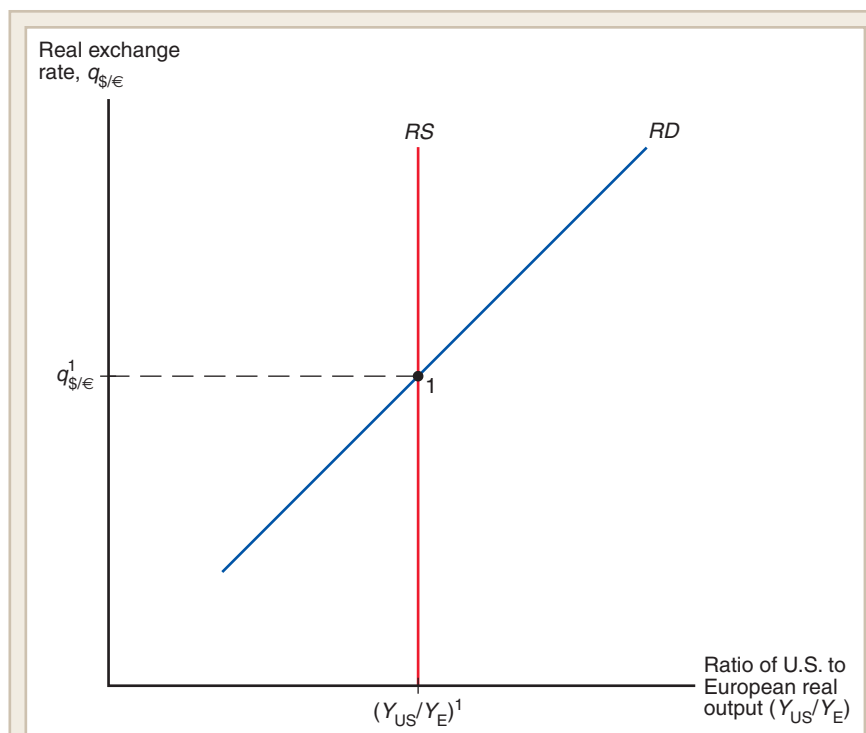
Figure 15-4

Determination of the Long-Run Real Exchange Rate

The long-run equilibrium real exchange rate equates world relative demand to the full-employment level of relative supply.

is plotted along the horizontal axis while the real dollar/euro exchange rate, $q_{\$/€}$, is plotted along the vertical axis.

The equilibrium real exchange rate is determined by the intersection of two schedules. The upward-sloping schedule *RD* shows that the relative demand for U.S. products in general, relative to the demand for European products, rises as $q_{\$/€}$ rises, that is, as American products become relatively cheaper. This "demand" curve for U.S. relative to European goods has a positive slope because we are measuring a *fall* in the relative price of U.S. goods by a move *upward* along the vertical axis. What about relative supply? In the long run, relative national output levels are determined by factor supplies and productivity, with little, if any, effect of the real exchange rate. The relative supply curve, *RS*, therefore is vertical at the long-run (that is, full-employment) relative output ratio $(Y_{US}/Y_E)^1$. The equilibrium long-run real exchange rate is the one that sets relative demand equal to long-run relative supply (point 1).[20]

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[20]Notice that these *RD* and *RS* schedules differ from the ones used in Chapter 5. The earlier ones referred to relative world demand for and supply of two products that could be produced in either of two countries. In contrast, the *RD* and *RS* curves in this chapter refer to the relative world demand for and supply of one country's overall output (its GDP) relative to another's.

The diagram easily illustrates how changes in world markets affect the real exchange rate. Suppose world gasoline prices fall, making American sport utility vehicles more desirable for people everywhere. This change would be a rise in world relative demand for American goods, and it shifts *RD* to the right, causing $q_{\$/€}$ to fall (a real dollar appreciation against the euro). Suppose the U.S. improves its health-care system, reducing illness throughout the American workforce. If workers are able to produce more goods and services in an hour as a result, the rise in U.S. productivity shifts *RS* to the right, causing $q_{\$/€}$ to rise (a real dollar depreciation against the euro).

Nominal and Real Exchange Rates in Long-Run Equilibrium

We now pull together what we have learned in this chapter and the last one to show how long-run nominal exchange rates are determined. One central conclusion is that changes in national money supplies and demands give rise to the proportional long-run movements in nominal exchange rates and international price level ratios predicted by the relative purchasing power parity theory. Demand and supply shifts in national output markets, however, cause nominal exchange rate movements that do not conform to PPP.

Recall our definition of the real dollar/euro exchange rate as

$$q_{\$/€} = (E_{\$/€} \times P_{E})/P_{US}.$$

(See equation (15-6).) If we now solve this equation for the nominal exchange rate, we get an equation that gives us the nominal dollar/euro exchange rate as the real dollar/euro exchange rate times the U.S.–Europe price level ratio:

$$E_{\$/€} = q_{\$/€} \times (P_{US}/P_{E}). \tag{15-7}$$

Formally speaking, the only difference between (15-7) and equation (15-1), on which we based our exposition of the monetary approach to the exchange rate, is that (15-7) accounts for possible deviations from PPP by adding the *real* exchange rate as an additional determinant of the nominal exchange rate. *The equation implies that for a given real dollar/euro exchange rate, changes in money demand or supply in Europe or the United States affect the long-run nominal dollar/euro exchange rate as in the monetary approach. Changes in the long-run real exchange rate, however, also affect the long-run nominal exchange rate.* The long-run theory of exchange rate determination implied by equation (15-7) thus includes the valid elements of the monetary approach, but in addition it corrects the monetary approach by allowing for nonmonetary factors that can cause sustained deviations from purchasing power parity.

Assuming that all variables start out at their long-run levels, we can now understand the most important determinants of long-run swings in nominal exchange rates:

1. *A shift in relative money supply levels*. Suppose the Fed wishes to stimulate the economy and therefore carries out an increase in the level of the U.S. money supply. As you will remember from Chapter 14, a permanent one-time increase in a country's money supply has no effect on the long-run levels of output, the interest rate, or any relative price (including the real exchange rate). Thus, (15-3) implies once again that P_{US} rises in proportion to M_{US}, while (15-7) shows that the U.S. price level is the sole variable changing in the long run along with the nominal exchange rate $E_{\$/€}$. Because the real exchange rate $q_{\$/€}$ does not change, the nominal exchange rate change is consistent with relative PPP: The only long-run effect of the U.S. money supply increase is to raise all dollar prices, including the dollar price of the euro, in proportion to the increase in

the money supply. It should be no surprise that this result is the same as the one we found using the monetary approach, since that approach is designed to account for the long-run effects of monetary changes.

2. *A shift in relative money supply growth rates.* Suppose the Fed concludes, to its distress, that over the next few years the U.S. price level will fall. (A falling price level is called *deflation*.) A permanent increase in the *growth rate* of the U.S. money supply raises the long-run U.S. inflation rate and, through the Fisher effect, raises the dollar interest rate relative to the euro interest rate. Because relative U.S. real money demand therefore declines, equation (15-3) implies that P_{US} rises (as shown in Figure 15-1). Because the change bringing this outcome about is purely monetary, however, it is neutral in its long-run effects; specifically, it does not alter the long-run *real* dollar/euro exchange rate. According to (15-7), then, $E_{\$/\euro}$ rises in proportion to the increase in P_{US} (a depreciation of the dollar against the euro). Once again, a purely monetary change brings about a long-run nominal exchange rate shift in line with relative PPP, just as the monetary approach predicted.

3. *A change in relative output demand.* This type of change is *not* covered by the monetary approach, so now the more general perspective we've developed, in which the real exchange rate can change, is essential. Since a change in relative output demand does not affect long-run national price levels—these depend solely on the factors appearing in equations (15-3) and (15-4)—the long-run nominal exchange rate in (15-7) will change only insofar as the real exchange rate changes. Consider an increase in world relative demand for U.S. products. Earlier in this section we saw that a rise in demand for U.S. products causes a long-run real appreciation of the dollar against the euro (a fall in $q_{\$/\euro}$); this change is simply a rise in the relative price of U.S. output. Given that long-run national price levels are unchanged, however, (15-7) tells us that a long-run *nominal* appreciation of the dollar against the euro (a fall in $E_{\$/\euro}$) must also occur. This prediction highlights the important fact that even though exchange rates are nominal prices, they respond to nonmonetary as well as monetary events, even over long horizons.

4. *A change in relative output supply.* As we saw earlier in this section, an increase in relative U.S. output supply causes the dollar to depreciate in real terms against the euro, lowering the relative price of U.S. output. This rise in $q_{\$/\euro}$ is not, however, the only change in equation (15-7) implied by a relative rise in U.S. output. In addition, the U.S. output increase raises the transactions demand for real U.S. money balances, raising aggregate U.S. real money demand and, by (15-3), pushing the long-run U.S. price level down. Referring back to equation (15-7), you will see that since $q_{\$/\euro}$ rises while P_{US} falls, the output and money market effects of a change in output supply work in opposite directions, so that the net effect on $E_{\$/\euro}$ is *ambiguous*. Our analysis of an output-supply change illustrates that even when a disturbance originates in a single market (in this case, the output market), its influence on exchange rates may depend on repercussion effects that are channeled through other markets.

We conclude that when all disturbances are monetary in nature, exchange rates obey relative PPP in the long run. In the long run, a monetary disturbance affects only the general purchasing power of a currency, and this change in purchasing power changes equally the currency's value in terms of domestic and foreign goods. When disturbances occur in output markets, the exchange rate is unlikely to obey relative PPP, even in the long run. Table 15-1 summarizes these conclusions regarding the effects of monetary and output market changes on long-run nominal exchange rates.

In the chapters that follow, we will appeal to this section's general long-run exchange rate model even when we are discussing *short-run* macroeconomic events. Long-run factors are important for the short run because of the central role expectations about the future play

TABLE 15-1	Effects of Money Market and Output Market Changes on the Long-Run Nominal Dollar/Euro Exchange Rate, $E_{\$/€}$
Change	**Effect on the long-run nominal dollar/euro exchange rate, $E_{\$/€}$**
Money market	
1. Increase in U.S. money supply level	Proportional increase (nominal depreciation of $)
2. Increase in European money supply level	Proportional decrease (nominal depreciation of euro)
3. Increase in U.S. money supply growth rate	Increase (nominal depreciation of $)
4. Increase in European money supply growth rate	Decrease (nominal depreciation of euro)
Output market	
1. Increase in demand for U.S. output	Decrease (nominal appreciation of $)
2. Increase in demand for European output	Increase (nominal appreciation of euro)
3. Output supply increase in the United States	Ambiguous
4. Output supply increase in Europe	Ambiguous

in the day-to-day determination of exchange rates. That is why news about the current account, for example, can have a big impact on the exchange rate. The long-run exchange rate model of this section will provide the anchor for market expectations, that is, the framework market participants use to forecast future exchange rates on the basis of information at hand today.

International Interest Rate Differences and the Real Exchange Rate

Earlier in this chapter we saw that relative PPP, when combined with interest parity, implies that international interest rate differences equal differences in countries' expected inflation rates. Because relative PPP does not hold true in general, however, the relation between international interest rate differences and national inflation rates is likely to be more complex in practice than that simple formula suggests. Despite this complexity, economic policy makers who hope to influence exchange rates, as well as private individuals who wish to forecast them, cannot succeed without understanding the factors that cause countries' interest rates to differ.

In this section we therefore extend our earlier discussion of the Fisher effect to include real exchange rate movements. We do this by showing that in general, interest rate differences between countries depend not only on differences in expected inflation, as the monetary approach asserts, but also on expected changes in the real exchange rate.

We begin by recalling that the change in $q_{\$/€}$, the real dollar/euro exchange rate, is the *deviation* from relative PPP; that is, the change in $q_{\$/€}$ is the percentage change in the nominal dollar/euro exchange rate less the international difference in inflation rates between

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the United States and Europe. We thus arrive at the corresponding relationship between the *expected* change in the real exchange rate, the *expected* change in the nominal rate, and *expected* inflation:

$$(q^e_{\$/€} - q_{\$/€})/q_{\$/€} = [(E^e_{\$/€} - E_{\$/€})/E_{\$/€}] - (\pi^e_{US} - \pi^e_{E}), \qquad \text{(15-8)}$$

where $q^e_{\$/€}$ (as per our usual notation) is the real exchange rate expected for a year from today.

Now return to the interest parity condition between dollar and euro deposits,

$$R_\$ - R_€ = (E^e_{\$/€} - E_{\$/€})/E_{\$/€}.$$

An easy rearrangement of (15-8) shows that the expected rate of change in the *nominal* dollar/euro exchange rate is just the expected rate of change in the *real* dollar/euro exchange rate *plus* the U.S.-Europe expected inflation difference. Combining (15-8) with the above interest parity condition, we thus are led to the following breakdown of the international interest rate gap:

$$R_\$ - R_€ = [(q^e_{\$/€} - q_{\$/€})/q_{\$/€}] + (\pi^e_{US} - \pi^e_{E}). \qquad \text{(15-9)}$$

Notice that when the market expects relative PPP to prevail, $q^e_{\$/€} = q_{\$/€}$ and the first term on the right side of this equation drops out. In this special case, (15-9) reduces to the simpler (15-5), which we derived by assuming relative PPP.

In general, however, the dollar/euro interest difference is the sum of *two* components: (1) the expected rate of real dollar depreciation against the euro and (2) the expected inflation difference between the United States and Europe. For example, if U.S. inflation will be 5 percent per year forever and European inflation zero, the long-run interest difference between dollar and euro deposits need not be the 5 percent that PPP (when combined with interest parity) would suggest. If, in addition, everyone knows that output demand and supply trends will make the dollar decline against the euro in real terms at a rate of 1 percent per year, the international interest spread will actually be 6 percent.

Real Interest Parity

Economics makes an important distinction between **nominal interest rates,** which are rates of return measured in monetary terms, and **real interest rates,** which are rates of return measured in *real* terms, that is, in terms of a country's output. Because real rates of return often are uncertain, we usually will refer to *expected* real interest rates. The interest rates we discussed in connection with the interest parity condition and the determinants of money demand were nominal rates, for example, the dollar return on dollar deposits. But for many other purposes, economists need to analyze behavior in terms of real rates of return. No one who is thinking of investing money, for example, could make a decision knowing only that the nominal interest rate is 15 percent. The investment would be quite attractive at zero inflation, but disastrously unattractive if inflation were bounding along at 100 percent per year![21]

We conclude this chapter by showing that when the nominal interest parity condition equates nominal interest rate differences between currencies to expected changes in *nominal*

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[21]We could get away with examining nominal return *differences* in the foreign exchange market because (as Chapter 13 showed) nominal return differences equal real return differences for any given investor. In the context of the money market, the *nominal* interest rate is the *real* rate of return you sacrifice by holding interest-barren currency.

exchange rates, a *real* interest parity condition equates expected real interest rate differences to expected changes in *real* exchange rates. Only when relative PPP is expected to hold (meaning no real exchange rate change is anticipated) are expected real interest rates in all countries identical.

The expected real interest rate, denoted r^e, is defined as the nominal interest rate, R, less the expected inflation rate, π^e:

$$r^e = R - \pi^e.$$

In other words, the expected real interest rate in a country is just the real rate of return a domestic resident expects to earn on a loan of its currency. The definition of the expected real interest rate clarifies the generality of the forces behind the Fisher effect: Any increase in the expected inflation rate that does not alter the expected real interest rate must be reflected, one for one, in the nominal interest rate.

A useful consequence of the preceding definition is a formula for the difference in expected real interest rates between two currency areas such as the United States and Europe:

$$r^e_{US} - r^e_E = (R_\$ - \pi^e_{US}) - (R_\euro - \pi^e_E).$$

If we rearrange equation (15-9) and combine it with the equation above, we get the desired *real interest parity condition:*

$$r^e_{US} - r^e_E = (q^e_{\$/\euro} - q_{\$/\euro})/q_{\$/\euro}. \tag{15-10}$$

Equation (15-10) looks much like the nominal interest parity condition from which it is derived, but it explains differences in expected *real* interest rates between the United States and Europe by expected movements in the dollar/euro *real* exchange rate.

Expected real interest rates are the same in different countries when relative PPP is expected to hold (in which case (15-10) implies that $r^e_{US} = r^e_E$). More generally, how-ever, expected real interest rates in different countries need not be equal, even in the long run, if continuing change in output markets is expected.[22] Suppose, for example, that productivity in the South Korean tradables sector is expected to rise during the next two decades while productivity stagnates in South Korean nontradables and in all U.S. industries. If the Balassa-Samuelson hypothesis is valid, people should expect the U.S. dollar to depreciate in real terms against South Korea's currency, the won, as the prices of South Korea's nontradables trend upward. Equation (15-10) thus implies that the expected real interest rate should be higher in the United States than in South Korea.

Do such real interest differences imply unnoticed profit opportunities for international investors? Not necessarily. A cross-border real interest difference does imply that residents of two countries perceive different real rates of return on wealth. Nominal interest parity tells us, however, that any *given* investor expects the same real return on domestic and for-eign currency assets. Two investors residing in different countries need not calculate this single real rate of return in the same way if relative PPP does not link the prices of their consumption baskets, but there is no way either can profit from their disagreement by shifting funds between currencies.

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[22]The two-period analysis of international borrowing and lending in Chapter 7 assumed that all countries face a single worldwide real interest rate. Relative PPP must hold in that analysis, however, because there is only one consumption good in each period.

SUMMARY

1. The *purchasing power parity* theory, in its absolute form, asserts that the exchange rate between countries' currencies equals the ratio of their price levels, as measured by the money prices of a reference commodity basket. An equivalent statement of PPP is that the purchasing power of any currency is the same in any country. Absolute PPP implies a second version of the PPP theory, *relative PPP,* which predicts that percentage changes in exchange rates equal differences in national inflation rates.

2. A building block of the PPP theory is the *law of one price,* which states that under free competition and in the absence of trade impediments, a good must sell for a single price regardless of where in the world it is sold. Proponents of the PPP theory often argue, however, that its validity does not require the law of one price to hold for every commodity.

3. The *monetary approach to the exchange rate* uses PPP to explain long-term exchange rate behavior exclusively in terms of money supply and demand. In that theory, long-run international interest differentials result from different national rates of ongoing inflation, as the *Fisher effect* predicts. Sustained international differences in monetary growth rates are, in turn, behind different long-term rates of continuing inflation. The monetary approach thus finds that a rise in a country's interest rate will be associated with a depreciation of its currency. Relative PPP implies that international interest differences, which equal the expected percentage change in the exchange rate, also equal the international expected inflation gap.

4. The empirical support for PPP and the law of one price is weak in recent data. The failure of these propositions in the real world is related to trade barriers and departures from free competition, factors that can result in *pricing to market* by exporters. In addition, different definitions of price levels in different countries bedevil attempts to test PPP using the price indices governments publish. For some products, including many services, international transport costs are so steep that these products become nontradable.

5. Deviations from relative PPP can be viewed as changes in a country's *real exchange rate,* the price of a typical foreign expenditure basket in terms of the typical domestic expenditure basket. All else equal, a country's currency undergoes a long-run *real appreciation* against foreign currencies when the world relative demand for its output rises. In this case, the country's real exchange rate, as just defined, falls. The home currency undergoes a long-run *real depreciation* against foreign currencies when home output expands relative to foreign output. In this case, the real exchange rate rises.

6. The long-run determination of *nominal exchange rates* can be analyzed by combining two theories: the theory of the long-run *real* exchange rate and the theory of how domestic monetary factors determine long-run price levels. A stepwise increase in a country's money stock ultimately leads to a proportional increase in its price level and a proportional fall in its currency's foreign exchange value, just as relative PPP predicts. Changes in monetary growth rates also have long-run effects consistent with PPP. Supply or demand changes in output markets, however, cause exchange rate movements that do not conform to PPP.

7. The interest parity condition equates international differences in *nominal interest rates* to the expected percentage change in the nominal exchange rate. If interest parity holds in this sense, a real interest parity condition equates international differences in expected *real interest rates* to the expected change in the real exchange rate. Real interest parity also implies that international differences in nominal interest rates equal the difference in expected inflation *plus* the expected percentage change in the real exchange rate.

KEY TERMS

Fisher effect, p. 389
law of one price, p. 383
monetary approach to the
    exchange rate, p. 386
nominal exchange rate, p. 402
nominal interest rate, p. 410
pricing to market, p. 395

purchasing power parity (PPP), p. 382
real appreciation, p. 403
real depreciation, p. 402
real exchange rate, p. 401
real interest rate, p. 410
relative PPP, p. 385

PROBLEMS

1. Suppose Russia's inflation rate is 100 percent over one year but the inflation rate in Switzerland is only 5 percent. According to relative PPP, what should happen over the year to the Swiss franc's exchange rate against the Russian ruble?

2. Discuss why it is often asserted that exporters suffer when their home currencies appreciate in real terms against foreign currencies and prosper when their home currencies depreciate in real terms.

3. Other things equal, how would you expect the following shifts to affect a currency's real exchange rate against foreign currencies?

   a. The overall level of spending doesn't change, but domestic residents decide to spend more of their income on nontraded products and less on tradables.

   b. Foreign residents shift their demand away from their own goods and toward the home country's exports.

4. Large-scale wars typically bring a suspension of international trading and financial activities. Exchange rates lose much of their relevance under these conditions, but once the war is over governments wishing to fix exchange rates face the problem of deciding what the new rates should be. The PPP theory has often been applied to this problem of postwar exchange rate realignment. Imagine that you are a British Chancellor of the Exchequer and World War I has just ended. Explain how you would figure out the dollar/pound exchange rate implied by PPP. When might it be a bad idea to use the PPP theory in this way?

5. In the late 1970s, Britain seemed to have struck it rich. Having developed its North Sea oil-producing fields in earlier years, Britain suddenly found its real income higher as a result of a dramatic increase in world oil prices in 1979–1980. In the early 1980s, however, oil prices receded as the world economy slid into a deep recession and world oil demand faltered.

   In the following chart, we show index numbers for the average real exchange rate of the pound against several foreign currencies. (Such average index numbers are called real *effective* exchange rates.) A rise in one of these numbers indicates a real *appreciation* of the pound, that is, an increase in Britain's price level relative to the average price level abroad measured in pounds. A fall is a real depreciation.

Real Effective Exchange Rate of the Pound Sterling, 1976–1984 (**1980 = 100**)

1976	1977	1978	1979	1980	1981	1982	1983	1984
68.3	66.5	72.2	81.4	100.0	102.8	100.0	92.5	89.8

Source: International Monetary Fund, *International Financial Statistics*. The real exchange rate measures are based on indices of net output prices called value-added deflators.

Use the clues we have given about the British economy to explain the rise and fall of the pound's real effective exchange rate between 1978 and 1984. Pay particular attention to the role of nontradables.

6. Explain how permanent shifts in national real money demand functions affect real and nominal exchange rates in the long run.

7. In Chapter 5, we discussed the effect of transfers between countries, such as the indemnity imposed on Germany after World War I. Use the theory developed in this chapter to discuss the mechanisms through which a permanent transfer from Poland to the Czech Republic would affect the real zloty/koruna exchange rate in the long run.

8. Continuing with the preceding problem, discuss how the transfer would affect the long-run *nominal* exchange rate between the two currencies.

9. A country imposes a tariff on imports from abroad. How does its action change the long-run real exchange rate between home and foreign currency? How is the long-run nominal exchange rate affected?

10. Imagine that two identical countries have restricted imports to identical levels, but one has done so using tariffs while the other has done so using quotas. After these policies are in place, both countries experience identical, balanced expansions of domestic spending. Where should the demand expansion cause a greater real currency appreciation, in the tariff-using country or in the quota-using country?

11. Explain how the nominal dollar/euro exchange rate would be affected (all else equal) by permanent changes in the expected rate of real depreciation of the dollar against the euro.

12. Can you suggest an event that would cause a country's nominal interest rate to rise and its currency to appreciate simultaneously, in a world of perfectly flexible prices?

13. Suppose that the expected real interest rate in the United States is 9 percent per year while that in Europe is 3 percent per year. What do you expect to happen to the real dollar/euro exchange rate over the next year?

14. In the short run of a model with sticky prices, a reduction in the money supply raises the nominal interest rate and appreciates the currency (see Chapter 14). What happens to the expected real interest rate? Explain why the subsequent path of the real exchange rate satisfies the real interest parity condition.

15. Discuss the following statement: "When a change in a country's nominal interest rate is caused by a rise in the expected real interest rate, the domestic currency appreciates. When the change is caused by a rise in expected inflation, the currency depreciates." (It may help to refer back to Chapter 14.)

16. Nominal interest rates are quoted at a variety of maturities, corresponding to different lengths of loans. For example, in late 2004 the U.S. government could take out 10-year loans at an annual interest rate of slightly over 4 percent, whereas the annual rate it paid on loans of only three months' duration was slightly under 2 percent. (An annualized interest rate of 2 percent on a three-month loan means that if you borrow a dollar, you repay $\$1.005 = \$1 + (3/12) \times \$0.02$ at the end of three months.) Typically, though not always, long-term interest rates are above short-term rates, as in the preceding examples from 2004. In terms of the Fisher effect, what would that pattern say about expected inflation and/or the expected future real interest rate?

17. Continuing with the preceding problem, we can define short- and long-term *real* rates of interest. In all cases, the relevant real interest rate (annualized, that is, expressed in percent per year) is the annualized nominal interest rate at the maturity in question, less the annualized expected inflation rate over the period of the loan. Recall the evidence that relative PPP seems to hold better over long horizons than short. In that case, will

international real interest differentials be larger at short than at long maturities? Explain your reasoning.

18. Why might it be that relative PPP holds better in the long run than the short run? (Think about how international trading firms might react to large and persistent cross-border differences in the prices of a tradable good.)

19. Can you think of any forces that might help bring about long-run PPP for *nontradable* goods? (It will help a bit here if you have understood the discussion in Chapter 4 of factor-price equalization.)

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John Williamson, ed. *Estimating Equilibrium Exchange Rates.* Washington, D.C.: Institute for International Economics, 1994. More essays on alternative approaches to calculating long-run real exchange rates in practice.

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The Fisher Effect, the Interest Rate, and the Exchange Rate Under the Flexible-Price Monetary Approach

The monetary approach to exchange rates, which assumes that the prices of goods are perfectly flexible, implies that a country's currency depreciates when its nominal interest rates rise because of higher expected future inflation. This appendix supplies a detailed analysis of that important result.

Consider again the dollar/euro exchange rate, and imagine that the Federal Reserve raises the future rate of U.S. money supply growth by the amount $\Delta\pi$. Figure 15A-1 provides a diagram that will help us keep track of how various markets respond to that change.

The lower right quadrant in the figure is our usual depiction of equilibrium in the U.S. money market. It shows that before the increase in U.S. money supply growth, the nominal interest rate on dollars equals $R_\$^1$ (point 1). The Fisher effect tells us that a rise $\Delta\pi$ in the future rate of U.S. money supply growth, all else equal, will raise the nominal interest rate on dollars to $R_\$^2 = R_\$^1 + \Delta\pi$ (point 2).

As the diagram shows, the rise in the nominal dollar interest rate reduces money demand and therefore requires an equilibrating fall in the real money supply. But the nominal money stock is unchanged in the short run because it is only the *future* rate of U.S. money-supply growth that has risen. What happens? Given the unchanged nominal money supply M_{US}^1, an upward jump in the U.S. price level, from P_{US}^1 to P_{US}^2, brings about the needed reduction in American real money holdings. The assumed flexibility of prices allows this jump to occur even in the short run.
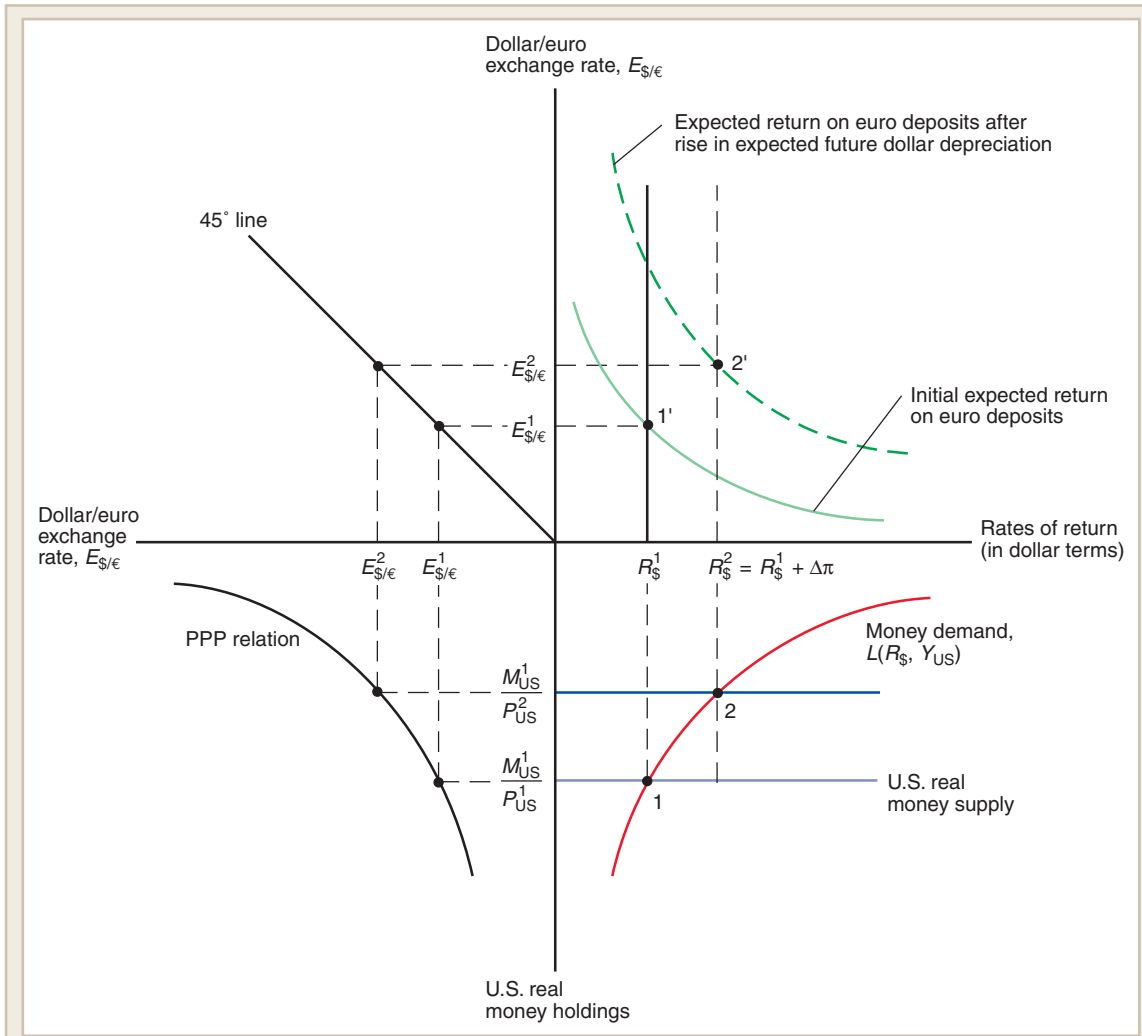
To see the exchange rate response, we turn to the lower left quadrant. The monetary approach assumes purchasing power parity, implying that as P_{US} rises (while the European price level remains constant, which we assume), the dollar/euro exchange rate $E_{\$/€}$ must rise (a depreciation of the dollar). The lower left quadrant of Figure 15A-1 graphs the implied relationship between U.S. real money holdings, M_{US}/P_{US}, and the nominal exchange rate, $E_{\$/€}$, given an unchanged *nominal* money supply in the United States and an unchanged European price level. Using PPP, we can write the equation graphed there (which is a downward-sloping *hyperbola*) as:

$$E_{\$/€} = P_{US}/P_E = \frac{(M_{US}/P_E)}{(M_{US}/P_{US})}.$$

This equation shows that the fall in the U.S. real money supply, from M_{US}^1/P_{US}^1 to M_{US}^1/P_{US}^2, is associated with a dollar depreciation in which the dollar/euro nominal exchange rate rises from $E_{\$/€}^1$ to $E_{\$/€}^2$ (shown as a movement to the left along the horizontal axis).

The 45-degree line in the upper left quadrant of Figure 15A-1 allows you to translate the exchange rate change given by the lower left quadrant to the vertical axis of the upper right quadrant's diagram. The upper right quadrant contains our usual portrayal of equilibrium in the foreign exchange market.

There you can see that the dollar's depreciation against the euro is associated with a move in the foreign exchange market's equilibrium from point $1'$ to point $2'$. The picture shows why the dollar depreciates, despite the rise in $R_\$$. The reason is an outward shift in

Figure 15A-1

How a Rise in U.S. Monetary Growth Affects Dollar Interest Rates and the Dollar/Euro Exchange Rate When Goods Prices Are Flexible

When goods prices are perfectly flexible, the money market equilibrium diagram (southeast quadrant) shows two effects of an increase, $\Delta\pi$, in the future rate of U.S. money supply growth. The change (i) raises the dollar interest rate from $R_\$^1$ to $R_\$^2 = R_\$^1 + \Delta\pi$, in line with the Fisher effect, and (ii) causes the U.S. price level to jump upward, from P_{US}^1 to P_{US}^2. Money market equilibrium therefore moves from point 1 to point 2. (Because M_{US}^1 doesn't change immediately, the real U.S. money supply falls to M_{US}^1/P_{US}^2, bringing the real money supply into line with reduced money demand.) The PPP relationship in the southwest quadrant shows that the price level jump from P_{US}^1 to P_{US}^2. requires a depreciation of the dollar against the euro (the dollar/euro exchange rate moves up, from $E_{\$/\euro}^1$ to $E_{\$/\euro}^2$). In the foreign exchange market diagram (northeast quadrant), this dollar depreciation is shown as the move from point 1' to point 2'. The dollar depreciates despite a rise in $R_\$$ because heightened expectations of future dollar depreciation against the euro cause an outward shift of the locus measuring the expected dollar return on euro deposits.

the downward-sloping schedule giving the expected dollar rate of return on euro deposits. Why does that schedule shift outward? Higher expected future monetary growth implies faster expected future depreciation of the dollar against the euro, and therefore a rise in the attractiveness of euro deposits. It is that change in expectations that leads simultaneously to a rise in the nominal interest rate on dollars and to a depreciation of the dollar in the foreign exchange market.

To summarize, we cannot predict how a rise in the dollar interest rate will affect the dollar's exchange rate without knowing *why* the nominal interest rate has risen. In a flexible-price model in which the home nominal interest rate rises because of higher expected future money supply growth, the home currency will depreciate, not appreciate, thanks to expectations of more rapid future depreciation.