14

Exchange Rates I: The Monetary Approach in the Long Run

Our willingness to pay a certain price for foreign money must ultimately and essentially be due to the fact that this money possesses a purchasing power as against commodities and services in that foreign country.

Gustav Cassel, of the Swedish school of economics, 1922

The fundamental things apply / As time goes by.

Herman Hupfeld, songwriter, 1931
(from the film *Casablanca,* 1942)

The cost of living is usually rising, but it rises in some places more than others. From 1970 to 1990, for example, a standardized Canadian basket of consumer goods rose in price considerably. In 1970 a Canadian would have spent C$100 (100 Canadian dollars) to purchase this basket; by 1990 the same basket cost C$392. Thus, Canadian prices rose by 292%. Over the same period, in the United States, a basket of goods that initially cost $100 in 1970 had risen in cost to $336 by 1990. Thus, U.S. prices rose by 236%. Both countries witnessed serious inflation, but Canadian prices rose more.

So did Canadian goods end up more expensive in 1990? Did higher inflation in Canada cause Canadians to start spending more on U.S. goods? Did it cause Americans to spend less on Canadian goods?

The answer to all three questions is no. In 1970 C$1 was worth almost exactly $1 (1 U.S. dollar). So in 1970 both baskets cost the same *when their cost was expressed in a common currency,* about C$100 = $100. By 1990, however, the Canadian dollar (also called the loonie) had depreciated relative to its 1970 value and C$1.16 was needed to buy $1.00. Thus the $336 U.S. basket in 1990 actually cost $336 × 1.16 = C$390 when expressed in Canadian currency—almost the same price as the C$392 Canadian basket! (Conversely, expressed in U.S. currency, the Canadian basket cost about 392/1.16 = $338, almost the same as the $336 U.S. basket.)

The loonie.

In this example, although Canadian prices rose about 16% more than U.S. prices, U.S. residents also found that each of their U.S. dollars could buy about 16% more loonies. From the U.S. point of view, the cost of the baskets in each country *expressed in U.S. dollars* rose by about the same amount. The same was true from the Canadian perspective with all prices expressed in loonies. Economists (such as Gustav Cassel, quoted previously) would say that the relative *purchasing power* of each currency (in terms of U.S. versus Canadian goods) had remained the same.

Is it a coincidence that the changes in prices and exchange rates just happened to turn out that way? A fundamental economic hypothesis asserts that this outcome is *not* a coincidence at all—and that *in the long run,* this relationship between prices and exchange rates will always prevail. This observation provides another building block in the theory of how exchange rates are determined. How?

In Chapter 13, uncovered interest parity provided us with a theory of how the spot exchange rate is determined, given knowledge of three variables: the expected future exchange rate, the home interest rate, and the foreign interest rate. The next two chapters explain how all three variables are determined and provide a complete theory of exchange rates. Chapter 15 discusses the determinants of interest rates in each country. In this chapter, we focus on the determinants of the expected future exchange rate.

If investors are to make forecasts of future exchange rates, they need a plausible long-run theory of the exchange rate. The theory we develop in this chapter has two parts. In the first part, we develop a theory of purchasing power, which links the exchange rate to price levels in each country in the long run. This theory provides a partial answer but raises another question: Where do price levels come from? In the second part of the chapter, we explore how price levels are related to monetary conditions in each country. Combining the monetary theory of price levels with the purchasing power theory, we emerge with a *long-run* theory known as the **monetary approach to exchange rates.** The goal of this chapter is to set out this approach so that we can understand the long-run relationship between money, prices, and exchange rates.

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

Just as arbitrage occurs in the international market for financial assets, it also occurs in the international markets for goods. The result of goods market arbitrage is that the prices of goods in different countries expressed in a common currency must be equalized. Applied to a single good, this idea is referred to as the *law of one price;* applied to an entire basket of goods, it is called the theory of *purchasing power parity*.

Why should these "laws" hold? If the price of a good were not the same in two locations, buyers would rush to buy at the cheap location (forcing prices up there) and would shy away from the expensive location (forcing prices down there). Some factors, such as the costs of transporting the goods from one location to another, may hinder the process of arbitrage, and later on we will study models that take transaction costs into account. For now, however, our goal is to develop a simple yet useful theory based on an idealized world of *frictionless trade,* that is, a world in which transaction costs can be neglected. We start at the microeconomic level with single goods and the law of one price. We then work up to the macroeconomic level to consider baskets of goods and purchasing power parity.

The Law of One Price

The **law of one price (LOOP)** states that in the absence of trade frictions (such as transport costs and tariffs) and under conditions of free competition (where no individual sellers or buyers have power to manipulate prices), identical goods sold in different locations must sell for the same price when the prices are expressed in a common currency.

To see how the law of one price operates, consider the trade in diamonds that takes place between the United States and the Netherlands. Suppose that a diamond of a given quality is priced at €2,000 in the Amsterdam market, and the exchange rate is \$1.40 per euro. If the law of one price holds, the same-quality diamond should sell in New York for (€2,000 per diamond) × (1.40 \$/€) = \$2,800 per diamond.

Why will the prices be the same? Under competitive conditions and frictionless trade, arbitrage will ensure this outcome. If diamonds were more expensive in New York, arbitragers would buy at a low price in Holland and sell at a high price in Manhattan. If Dutch prices were higher, arbitragers would profit from the reverse trade. *By definition,* in a market equilibrium there are no arbitrage opportunities. If diamonds can be freely moved between New York and Amsterdam, both markets must offer the same price. Economists refer to this situation in the two locations as an *integrated market*.

We can mathematically state the law of one price as follows, for the case of any good g sold in two locations, say, Europe (EUR, meaning the Eurozone) and the United States (US). The *relative price* of good g (denoted $q^g_{EUR/US}$) is the ratio of the good's price in Europe relative to the good's price in the United States where both prices are expressed in a common currency. Using subscripts, as before, to indicate locations and currencies, the law of one price states that

$$\underbrace{q^g_{EUR/US}}_{\substack{\text{Relative price of good } g \\ \text{in Europe versus U.S.}}} = \underbrace{(E_{\$/€}\, P^g_{EUR})}_{\substack{\text{European price} \\ \text{of good } g \text{ in } \$}} / \underbrace{P^g_{US}}_{\substack{\text{U.S. price} \\ \text{of good } g \text{ in } \$}},$$

where P^g_{US} is the good's price in the United States, P^g_{EUR} is the good's price in Europe, and $E_{\$/€}$ is the dollar-euro exchange rate used to convert euro prices into dollar prices.

The law of one price may or may not hold. Recall from Chapter 13 that there are three possibilities in an arbitrage situation of this kind: the ratio exceeds 1 and the good is cheaper in the United States; the ratio is less than 1 and the good is cheaper in Europe; or, $E_{\$/€}\, P^g_{EUR} = P^g_{US}$, and the ratio is 1, $q^g_{EUR/US} = 1$, so that the good is the same price in both locations.

Again, as in Chapter 13, only one of these cases is a market equilibrium: in the first case, arbitrage will occur since the good is cheaper in the United States; in the second case, arbitrage will occur because the good is cheaper in Europe; only in the final case is there no arbitrage, the condition that defines market equilibrium. In equilibrium, European and U.S. prices, expressed in the same currency, are equal; the relative price of the good in the two locations is equal to 1, and the law of one price holds.

How can the law of one price further our understanding of exchange rates? We can rearrange the equation for price equality, $E_{\$/€}\, P^g_{EUR} = P^g_{US}$, to show that if the law of one price holds, then the exchange rate must equal the ratio of the goods' prices expressed in the two currencies:

$$\underbrace{E_{\$/€}}_{\substack{\text{Exchange}\\ \text{rate}}} = \underbrace{P^g_{US}/P^g_{EUR}}_{\substack{\text{Ratio of}\\ \text{goods' prices}}}.$$

One final word of caution: given our concerns in Chapter 13 about the right way to define the exchange rate, we must take care when using expressions that are ratios to ensure that the units on each side of the equation correspond. In the last equation, we know we have it right because the left-hand side is expressed in dollars per euro and the right-hand side is also a ratio of dollars to euros ($ per unit of goods divided by € per unit of goods).

Purchasing Power Parity

The principle of **purchasing power parity (PPP)** is essentially the macroeconomic counterpart to the microeconomic law of one price (LOOP). The law of one price relates exchange rates to the relative prices of individual goods, while purchasing power parity relates exchange rates to relative price levels for a basket of goods. In studying international macroeconomics, purchasing power parity is the more relevant concept.

Suppose we compute a *price level* (denoted P) in each location as a weighted average of the prices of all goods g in a basket, using the same goods and weights in both locations. Let P_{US} be the basket's price in the United States and P_{EUR} the basket's price in Europe. If the law of one price holds for each good in the basket, it will also hold for the price of the basket as a whole.[1]

[1] For example, if the law of one price holds and $P^g_{US} = (E_{\$/€}) \times (P^g_{EUR})$ for all goods g, this implies that for N goods, the *arithmetic* weighted average satisfies $\Sigma^N_{g=1}\omega^g P^g_{US} = (E_{\$/€}) \times \Sigma^N_{g=1}\omega^g P^g_{EUR}$ for any set of weights ω^g that sum to 1, so PPP holds. The same is also true for *geometric* averages. Technically speaking, this follows for *any* price index definition that satisfies the usually required property that the index be homogeneous of degree 1 in the individual goods' prices.

To express PPP algebraically, we can compute the relative price of the two baskets of goods in each location, denoted $q_{EUR/US}$:

$$\underbrace{q_{EUR/US}}_{\substack{\text{Relative price of}\\ \text{basket in Europe}\\ \text{versus U.S.}}} = \underbrace{(E_{\$/€}\ P_{EUR})}_{\substack{\text{European price}\\ \text{of basket}\\ \text{expressed in \$}}} / \underbrace{P^g_{US}}_{\substack{\text{U.S. price}\\ \text{of basket}\\ \text{expressed in \$}}}.$$

Just as there were three cases for the law of one price, there are three cases for PPP: the basket is cheaper in the United States; or the basket is cheaper in Europe; or $E_{\$/€}\, P_{EUR} = P_{US}$, or $q_{EUR/US} = 1$, and the basket is the same price in both locations. In the first two cases, the basket is cheaper in one location and profitable arbitrage on the baskets is possible. Only in the third case is there no arbitrage. PPP holds *when price levels in two countries are equal when expressed in a common currency.* This statement about equality of price levels is also called **absolute PPP.**

For example, suppose the European basket costs €400, and the exchange rate is \$1.25 per euro. For PPP to hold, the U.S. basket would have to cost $1.25 \times 400 = \$500$.

The Real Exchange Rate

The relative price of the two countries' baskets (denoted q) is the macroeconomic counterpart to the microeconomic relative price of individual goods (q^g). The relative price of the baskets is one of the most important variables in international macroeconomics, and it has a special name: it is known as the **real exchange rate.** The real exchange rate $q_{EUR/US} = E_{\$/€}\, P_{EUR}/P_{US}$ tells us how many U.S. baskets are needed to purchase one European basket.

As with the nominal exchange rate, we need to be careful about what is in the numerator of the real exchange rate and what is in the denominator. According to our definition (based on the case we just examined), we will refer to $q_{EUR/US} = E_{\$/€}\ P_{EUR}/P_{US}$ as the home country, or U.S. real exchange rate: it is the price of the European basket in terms of the U.S. basket (or, in a Home-Foreign example, the price of a Foreign basket in terms of a Home basket).

To avoid confusion, it is essential to understand the difference between nominal exchange rates (which we have studied so far) and real exchange rates. The exchange rate for currencies is a *nominal* concept; it says how many dollars trade for one euro. The real exchange rate is a *real* concept; it says how many U.S. baskets trade for one European basket.

The real exchange rate has some terminology similar to that used with the nominal exchange rate:

- If the real exchange rate rises (more Home goods are needed in exchange for Foreign goods), we say Home has experienced a **real depreciation.**
- If the real exchange rate falls (fewer Home goods are needed in exchange for Foreign goods), we say Home has experienced a **real appreciation.**

Absolute PPP and the Real Exchange Rate

We can restate absolute PPP in terms of real exchange rates: *purchasing power parity states that the real exchange rate is equal to 1.* Under absolute PPP, all baskets have the same price when expressed in a common currency, so their relative price is 1.

It is common practice to use the absolute PPP-implied level of 1 as a benchmark or reference level for the real exchange rate. This leads naturally to some new terminology:

- If the real exchange rate $q_{EUR/US}$ is below 1 by x%, then Foreign goods are relatively cheap, x% cheaper than Home goods, the Home currency (the dollar) is said to be *strong,* the euro is *weak,* and we say the euro is **undervalued** by x%.
- If the real exchange rate $q_{EUR/US}$ is above 1 by x%, then Foreign goods are relatively expensive, x% more expensive than Home goods, the Home currency (the dollar) is said to be *weak,* the euro is *strong,* and we say the euro is **overvalued** by x%.

For example, if the European basket costs $E_{\$/€} P_{EUR} = \$550$ in dollar terms, and the U.S. basket costs only $P_{US} = \$500$, then $q_{EUR/US} = E_{\$/€} P_{EUR}/P_{US} = \$550/\$500 = 1.10$, and the euro is 10% overvalued against the dollar.

Absolute PPP, Prices, and the Nominal Exchange Rate

Finally, just as we did with the law of one price, we can rearrange the equation for the equality of price levels, $E_{\$/€} P_{EUR} = P_{US}$, to solve for the exchange rate that would be implied by absolute PPP:

$$\text{(14-1)} \qquad \text{Absolute PPP:} \quad \underbrace{E_{\$/€}}_{\substack{\text{Exchange}\\ \text{rate}}} = \underbrace{P_{US}/P_{EUR}}_{\substack{\text{Ratio of}\\ \text{price levels}}}.$$

This is one of the most important equations in the book because it shows how PPP (or absolute PPP) makes a clear prediction about exchange rates:

Purchasing power parity implies that the exchange rate at which two currencies trade is equal to the relative price levels of the two countries.

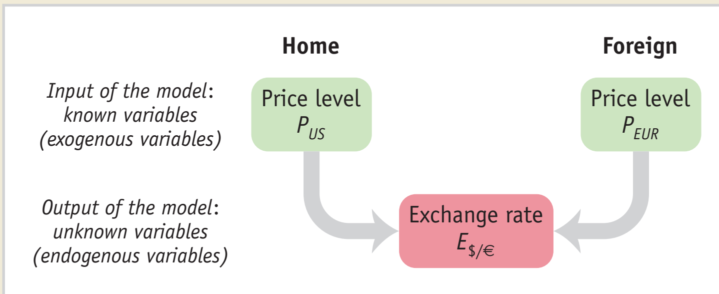
For example, if a basket of goods costs \$520 in the United States and the same basket costs €400 in Europe, the theory of PPP would predict an exchange rate of \$520/€400 = \$1.30 per euro.

Thus, if we know the price levels in different locations, we can use PPP to determine the exchange rate. PPP applies at any point in time, and applied to the future it means that if we can forecast future price levels, then we can forecast the expected future exchange rate, which is the main goal of this chapter. Here, then, is a key building block in our theory, as shown in Figure 14-1.

Relative PPP, Inflation, and Exchange Rate Depreciation

PPP in its absolute PPP form involves price levels, but in macroeconomics we are often more interested in the rate at which price levels change than we are in the price levels themselves. The rate of change of the price level is known as the *rate of inflation,* or simply **inflation.** For example, if the price level today is 100 and next year it is 123, then the rate of inflation is 23% (per year).

FIGURE 14-1



Building Block: Price Levels and Exchange Rates in the Long Run According to the PPP Theory In this model, the price levels are treated as known exogenous variables (in the green boxes). The model uses these variables to predict the unknown endogenous variable (in the red box), which is the exchange rate.

Because inflation is such an important variable in macroeconomics, we examine the implications of PPP for the study of inflation.

To consider changes over time, we introduce a subscript t to denote the time period, and calculate the rate of change of both sides of Equation (14-1). On the left-hand side, the rate of change of the exchange rate in Home is the rate of exchange rate depreciation in Home given by[2]

$$\frac{\Delta E_{\$/€,t}}{E_{\$/€,t}} = \underbrace{\frac{E_{\$/€,t+1} - E_{\$/€,t}}{E_{\$/€,t}}}_{\text{Rate of depreciation of the nominal exchange rate}}.$$

On the right of Equation (14-1), the rate of change of the ratio of two price levels equals the rate of change of the numerator minus the rate of change of the denominator:[3]

$$\frac{\Delta(P_{US}/P_{EUR})}{(P_{US}/P_{EUR})} = \frac{\Delta P_{US,t}}{P_{US,t}} - \frac{\Delta P_{EUR,t}}{P_{EUR,t}}$$

$$= \underbrace{\left(\frac{P_{US,t+1} - P_{US,t}}{P_{US,t}}\right)}_{\substack{\text{Rate of inflation in} \\ \text{U.S. } \pi_{US,t}}} - \underbrace{\left(\frac{P_{EUR,t+1} - P_{EUR,t}}{P_{EUR,t}}\right)}_{\substack{\text{Rate of inflation in} \\ \text{Europe } \pi_{EUR,t}}} = \pi_{US} - \pi_{EUR},$$

where the terms in brackets are the inflation rates in each location, denoted π_{US} and π_{EUR}, respectively.

If Equation (14-1) holds for levels of exchange rates and prices, then it must also hold for rates of change in these variables. By combining the last two expressions, we obtain

$$\text{(14-2)} \qquad \text{Relative PPP:} \quad \underbrace{\frac{\Delta E_{\$/€,t}}{E_{\$/€,t}}}_{\substack{\text{Rate of depreciation of} \\ \text{the nominal exchange rate}}} = \underbrace{\pi_{US,t} - \pi_{EUR,t}}_{\text{Inflation differential}}.$$

[2] The rate of depreciation at Home and the rate of appreciation in Foreign are equal, as an approximation, as we saw in Chapter 13.

[3] This expression is exact for small changes and otherwise holds true as an approximation.

This way of expressing PPP is called **relative PPP,** and it *implies that the rate of depreciation of the nominal exchange rate equals the inflation differential,* the difference between the inflation rates of two countries.

We saw relative PPP in action in the example at the start of this chapter. Over 20 years, Canadian prices rose 16% more than U.S. prices, and the Canadian dollar depreciated 16% against the U.S. dollar. Converting these to annual rates, Canadian prices rose by 0.75% per year more than U.S. prices (the inflation differential), and the loonie depreciated by 0.75% per year against the dollar. Relative PPP held in this case.[4]

Two points should be kept in mind about relative PPP. First, unlike absolute PPP, relative PPP predicts a relationship between *changes* in prices and *changes* in exchange rates, rather than a relationship between their levels. Second, remember that relative PPP is derived from absolute PPP. Hence, the latter implies the former. *If absolute PPP holds, then relative PPP must hold also.* But the converse need not be true. For example, imagine that all goods consistently cost 20% more in country A than in country B, so absolute PPP fails; but it still can be the case that the inflation differential between A and B (say 5%) is equal to the rate of depreciation (say 5%), so relative PPP may still hold.

Summary

The purchasing power parity theory, whether in the absolute PPP or relative PPP form, suggests that price levels in different countries and exchange rates are tightly linked, either in their absolute levels or in the rate at which they change. To assess how useful this theory is, let's look at some empirical evidence to see how well the theory matches reality. We then reexamine the workings of PPP and reassess its underlying assumptions.

APPLICATION

Evidence for PPP in the Long Run and Short Run

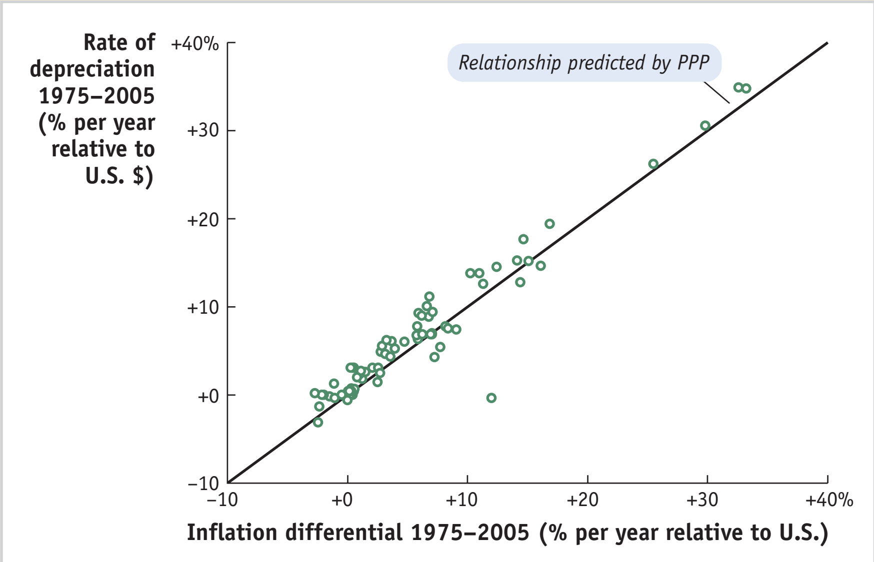
Is there evidence for PPP? The data offer some support for relative PPP most clearly over the long run, when even moderate inflation mounts up and leads to large cumulative changes in price levels and, hence, substantial cumulative inflation differentials.

The scatter plot in Figure 14-2 shows average rates of depreciation and inflation differentials for a sample of countries compared with the United States over three decades from 1975 to 2005. If relative PPP were true, then the depreciation of each country's currency would exactly equal the inflation differential, and the data would line up on the 45-degree line. We see that this is not literally true in the data, but the correlation is close. Relative PPP is an approximate, useful guide to the relationship between prices and exchange rates in the long run, over horizons of many years or decades.

But the purchasing power theory turns out to be a pretty useless theory in the short run, over horizons of just a few years. This is easily seen by examining the

[4] Note that the rates of change are approximate, with $1.0075^{20} = 1.16$.

FIGURE 14-2



Inflation Differentials and the Exchange Rate, 1975–2005 This scatter plot shows the relationship between the rate of exchange-rate depreciation against the U.S. dollar (the vertical axis) and the inflation differential against the United States (horizontal axis) over the long run, based on data for a sample of 82 countries. The correlation between the two variables is strong and bears a close resemblance to the theoretical prediction of PPP that all data points would appear on the 45-degree line.

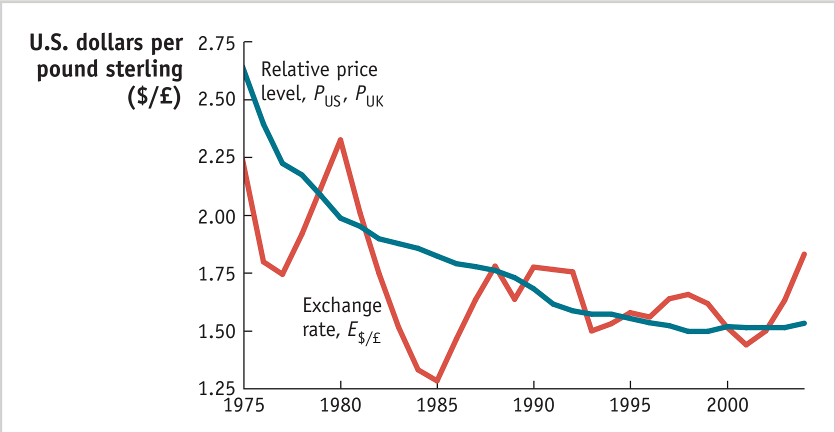
Source: International Monetary Fund (IMF), International Financial Statistics.

time series of relative price ratio and exchange rates for any pair of countries, and looking at the behavior of these variables from year to year and not just over the entire period. If absolute PPP held at all times, then the exchange rate would always be equal to the relative price ratio. Figure 14-3 shows 30 years of data for the United States and United Kingdom from 1975 to 2004. While this figure reinforces the relevance of PPP in the long run, it shows substantial and persistent deviations from PPP in the short run. The two series drift together over 30 years, but in any given year the differences between the two can be 10%, 20%, or more. Differences in levels show that absolute PPP fails; not surprisingly, relative PPP fails too. For example, from 1980 to 1985, the pound depreciated by 45% (from \$2.32 to \$1.28), but the cumulative inflation differential over these five years was only 9%. ■

How Slow Is Convergence to PPP?

The evidence suggests that PPP works better in the long run but not in the short run. If PPP were taken as a strict proposition for the short run, it would require price adjustment via arbitrage to happen fully and instantaneously, rapidly closing the gap between common-currency prices in different countries for all goods in the basket. This doesn't happen.

FIGURE 14-3



Exchange Rates and Relative Price Levels Data for the United States and United Kingdom for 1975 to 2004 show that the exchange rate and relative price levels do not always move together in the short run. Relative price levels tend to change slowly and have a small range of movement; exchange rates move more abruptly and experience large fluctuations. Therefore, relative PPP does *not* hold in the short run. However, it is a better guide to the long run, and we can see that the two series do tend to drift together over the decades.

Source: Penn World Tables, version 6.2.

SIDE BAR

Forecasting when the Real Exchange Rate Is Undervalued or Overvalued

Relative PPP makes forecasting exchange rate changes simple: just compute the inflation differential. But what about situations in which PPP doesn't hold, as is often the case? Even if the real exchange rate is not equal to 1, knowledge of the real exchange rate and the convergence speed may still allow us to construct a forecast of real and nominal exchange rates.

To see how, let's take an example. Start with the definition of the real exchange rate, $q_{EUR/US} = E_{\$/€}P_{EUR}/P_{US}$. Rearranging, we find $E_{\$/€} = q_{EUR/US} \times (P_{US}/P_{EUR})$. By taking the rate of change of that expression, we find that the rate of change of the nominal exchange rate equals the rate of change of the real exchange rate plus home inflation minus foreign inflation:

$$\underbrace{\frac{\Delta E_{\$/€,t}}{E_{\$/€,t}}}_{\substack{\text{Rate of depreciation}\\ \text{of the nominal}\\ \text{exchange rate}}} = \underbrace{\frac{\Delta q_{EUR/US,t}}{q_{EUR/US,t}}}_{\substack{\text{Rate of depreciation}\\ \text{of the real}\\ \text{exchange rate}}} + \underbrace{\pi_{US,t} - \pi_{EUR,t}}_{\text{Inflation differential}}.$$

When q is constant, the first term on the right is zero and we are back to the simple world of relative PPP and Equation (14-2). For forecasting purposes, the predicted nominal depreciation is then just the second term on the right, the inflation differential. For example, if the forecast is for U.S. inflation to be 3% next year and European inflation to be 1%, then the inflation differential is +2% and we would forecast a U.S. dollar depreciation, or rise in $E_{\$/€}$, of +2% next year.

What if q isn't constant and PPP fails? If there is currently a deviation from absolute PPP, but we still think that there will be convergence to absolute PPP in the long run, the first term on the right of the formula is nonzero. However, we can still estimate it given the right information.

To continue the example, suppose you are told that a U.S. basket of goods currently costs \$100, but the European basket of the same goods costs \$130. You would compute a U.S. real exchange rate, $q_{EUR/US}$, of 1.30 today. But what will it be next year? If you expect absolute PPP to hold in the long run, the U.S. real exchange rate will move toward 1. How fast? Now we need to know the convergence speed. Using the 15% rule of thumb, we would estimate that 15% of the 0.3 gap between 1 and 1.3 (i.e., 0.045) would dissipate over one year. Hence, the U.S. real exchange would be forecast to fall from 1.3 to 1.255, implying a change of −3.46% in the next year. In this case, adding the two terms on the right of the expression given previously, we would forecast that the approximate change in E next year would be the change in $q_{EUR/US}$ of −3.46% plus the inflation differential of +2%, for a total of −1.46%, a dollar appreciation of 1.46% against the euro.

The intuition for the result is as follows: the U.S. dollar is undervalued against the euro. If convergence to PPP is to happen, then some of that undervaluation will dissipate over the course of the year through a real appreciation of the dollar (predicted to be 3.46%). That real appreciation can be broken down into two components: U.S. goods may experience higher inflation than European goods (predicted to be +2%), and the rest has to be accomplished via nominal dollar appreciation (thus predicted to be 1.46%).

In reality, research shows that price differences, the deviations from PPP, can be large and persistent in the short run. Estimates suggest that these deviations may die out at a rate of about 15% per year. This kind of measure is often referred to as a *speed of convergence:* in this case, it implies that after one year, 85% (0.85) of an initial price difference persists; compounding, after two years 72% of the gap persists ($0.72 = 0.85^2$); and after four years, 52% ($0.52 = 0.85^4$). Thus approximately half of any PPP deviation still remains after four years: economists would refer to this as a four-year *half-life*.

Such estimates provide a rule of thumb that is useful as a guide to forecasting real exchange rates. For example, suppose the home basket costs $100 and the foreign basket $90, in home currency. Home's real exchange rate is 0.9, and the home currency is overvalued, with foreign goods less expensive than home goods. The deviation of the real exchange rate from the PPP-implied level of 1 is equal to −0.1. Our rule of thumb tells us that next year 15% of this deviation will have disappeared, so it would be only −0.085, meaning that home's real exchange rate would be forecast to be 0.915 next year and thus end up a little bit closer to 1, after a small depreciation. (See **Side Bar: Forecasting when the Real Exchange Rate Is Undervalued or Overvalued.)**

What Explains Deviations from PPP?

It is a slow process when it takes four years for even half of any given price difference to dissipate, but economists have found a variety of reasons why the tendency for PPP to hold is relatively weak in the short run:

- *Transaction costs.* Trade is not frictionless because costs of international transportation are significant for most goods and because some goods also bear additional costs, such as tariffs and duties, when they cross borders. By some recent estimates, transportation costs may add about 20% on average to the price of goods moving internationally, while tariffs (and other policy barriers) may add another 10%.[5] Other costs arise due to the time it takes to ship goods and the costs and time delays associated with developing distribution networks and satisfying legal and regulatory requirements in foreign markets.
- *Nontraded goods.* Some goods are inherently nontradable; one can think of them as having infinitely high transaction costs. Most goods and services fall somewhere between tradable and nontradable. Consider a restaurant meal; it includes traded goods such as some raw foods and nontraded goods such as the work of the chef. As a result, PPP may not hold. (See **Headlines: The Big Mac Index.**)

[5] There is also evidence of other significant border-related barriers to trade. See James Anderson and Eric van Wincoop, 2004, "Trade Costs," *Journal of Economic Literature,* 42, September, 691–751.

- *Imperfect competition and legal obstacles.* Many goods are not simple undifferentiated commodities, as LOOP and PPP assume, but are differentiated products with brand names, copyrights, and legal protection. For example, consumers have the choice of cheaper generic acetaminophen or a pricier brand-name product such as Tylenol, but these are not seen as perfect substitutes. Such differentiated goods create conditions of *imperfect competition* because firms have some power to set the price of their good. With this kind of *market power,* firms can charge different prices not just across brands but also across countries (pharmaceutical companies, for example, charge different prices for drugs in different countries). This practice is possible because arbitrage can be shut down by legal threats or regulations. If you try to import large quantities of a firm's pharmaceutical and resell them, then, as an unauthorized distributor, you will probably hear very quickly from the firm's lawyers and/or from the government regulators. The same would apply to many other goods such as automobiles and consumer electronics.

HEADLINES

The Big Mac Index

For more than 20 years, the Economist newspaper has been engaged in a whimsical attempt to judge PPP theory based on a well-known, globally uniform consumer good: the McDonald's Big Mac. The over- or undervaluation of a currency against the U.S. dollar is gauged by comparing the relative prices of a burger in a common currency, and expressing the difference as a percentage deviation:

$$\text{Big Mac Index} = q^{\text{Big Mac}} - 1 = \left(\frac{E_{\$/\text{local currency}} P^{\text{Big Mac}}_{\text{local}}}{P^{\text{Big Mac}}_{\text{US}}}\right) - 1.$$

Table 14-1 shows the 2007 survey results, and you can read in the following excerpt the Economist's attempt to digest these findings.

AP Photo/Greg Baker

Home of the undervalued burger?

The Economist's Big Mac index is based on the theory of purchasing-power parity (PPP), according to which exchange rates should adjust to equalise the price of a basket of goods and services around the world. Our basket is a burger: a McDonald's Big Mac.

The table below shows by how much, in Big Mac PPP terms, selected currencies were over- or undervalued at the end of January. Broadly, the pattern is such as it was last spring, the previous time this table was compiled. The most overvalued currency is the Icelandic krona: the exchange rate that would equalise the price of an Icelandic Big Mac with an American one is 158 kronur to the dollar; the actual rate is 68.4, making the krona 131% too dear. The most undervalued currency is the Chinese yuan, at 56% below its PPP rate; several other Asian currencies also appear to be 40–50% undervalued.

The index is supposed to give a guide to the direction in which currencies should, in theory, head in the long run. It is only a rough guide, because its price reflects non-tradable elements—such as rent and labour. For that reason, it is probably least rough when comparing countries at roughly the same stage of development. Perhaps the most telling numbers in this table are therefore those for the Japanese yen, which is 28% undervalued against the dollar, and the euro, which is 19% overvalued. Hence European finance ministers' beef with the low level of the yen.

Source: "The Big Mac Index," Economist, *February 1, 2007.*

Continued on next page.

TABLE 14-1

The Big Mac Index The table shows the price of a Big Mac in January 2007 in local currency (column 1) and converted to U.S. dollars (column 2) using the actual exchange rate (column 4). The dollar price can then be compared with the average price of a Big Mac in the United States ($3.22 in column 1, row 1). The difference (column 5) is a measure of the overvaluation (+) or undervaluation (–) of the local currency against the U.S. dollar. The exchange rate against the dollar implied by PPP (column 3) is the hypothetical price of dollars in local currency that would have equalized burger prices, which may be compared with the actual observed exchange rate (column 4).

	Big Mac Prices		Exchange rate (local currency per U.S. dollar)		Over (+)/ under (–) valuation against dollar, %
	In local currency (1)	In U.S. dollars (2)	Implied by PPP (3)	Actual, Jan 31st (4)	(5)
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 6.40	3.01	1.99	2.13	–6
Britain	£1.99	3.90	0.62	0.51	+21
Canada	C$3.63	3.08	1.13	1.18	–4
Chile	Peso 1670	3.07	519	544	–5
China	Yuan 11.0	1.41	3.42	7.77	–56
Columbia	Peso 6900	3.06	2,143	2,254	–5
Costa Rica	Colones 1130	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	0.91	0.77	+19
Hong Kong	HK$12.00	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	M$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 49.00	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	SKr 32.0	4.59	9.94	6.97	+43
Switzerland	SFr 6.30	5.05	1.96	1.25	+57
Taiwan	NT$75.00	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	+0
UAE	Dirhams 10.0	2.72	3.11	3.67	–15
Ukraine	Hryvnia 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

Source: "The Big Mac index," The Economist, *February 1, 2007.*

NET WORK

The Big Mac Index isn't alone. In 2004 the *Economist* made a Starbuck's Tall Latte Index, which you can try to find online. (Hint: Google "cnn tall latte index.") In 2007 two new indices appeared: the iPod Index (based on the local prices of Apple's iPod music player) and iTunes Index (based on the local prices of a single song downloaded from Apple's iTunes store). Find those indices online and the discussions surrounding them. (Hint: Google "ipod itunes index big mac.") Do you think that either the iPod Index or iTunes Index is a better guide to currency overvaluation/undervaluation than the Big Mac Index?

- *Price stickiness.* One of the most common assumptions of macroeconomics is that prices are "sticky" in the short run—that is, they do not or cannot adjust quickly and flexibly to changes in market conditions. PPP assumes that arbitrage can force prices to adjust, but adjustment will be slowed down by price stickiness. Empirical evidence shows that many goods' prices do not adjust quickly in the short run. For example, in Figure 14-3, we saw that the nominal exchange rate moves up and down in a very dramatic fashion but that price levels are much more sluggish in their movements and do not fully match exchange rate changes.

Despite these problems, the evidence suggests that as a long-run theory of exchange rates, PPP is still a useful approach.[6] And PPP may become even more relevant in the future as arbitrage becomes more efficient and more goods and services are traded. Years ago we might have taken it for granted that certain goods and services (such as pharmaceuticals, customer support, health care services) were strictly nontraded and thus not subject to arbitrage, at the international level. Today, many consumers shop for pharmaceuticals overseas to save money. If you dial a U.S. software support call center, you may find yourself being assisted by an operator in India. In some countries, citizens motivated by cost considerations may travel overseas for dental treatment, eye care, hip replacements, and other health services (so-called "medical tourism" or "health tourism"). These globalization trends may well continue.

2 Money, Prices, and Exchange Rates in the Long Run: Money Market Equilibrium in a Simple Model

It is time to take stock of the theory developed so far in this chapter. Up to now, we have concentrated on PPP, which says that in the long run the exchange rate is determined by the ratio of the price levels in two countries. But what determines those price levels?

Monetary theory supplies an answer: according to this theory, in the long run, price levels are determined in each country by the relative demand and supply of money. You may recall this theory from previous macroeconomics courses in the context of a closed economy. This section recaps the essential elements of monetary theory and shows how they fit into our theory of exchange rates in the long run.

What Is Money?

We recall the distinguishing features of this peculiar asset that is so central to our everyday economic life. Economists think of **money** as performing three key functions in an economy:

[6] Alan M. Taylor and Mark P. Taylor, 2004, "The Purchasing Power Parity Debate," *Journal of Economic Perspectives,* 8, Fall, 135–158.

1. Money is a *store of value* because, as with any asset, money held from today until tomorrow can still be used to buy goods and services in the future. Money's rate of return is low compared with many other assets. Because we earn no interest on it, there is an opportunity cost to holding money. If this cost is low, we will hold money more willingly than we hold other assets (stocks, bonds, and so on).
2. Money also gives us a *unit of account* in which all prices in the economy are quoted. When we enter a store in France, we expect to see the prices of goods to read something like "100 euros"—not "10,000 Japanese yen" or "500 bananas," even though, in principle, the yen or the banana could also function as a unit of account in France (bananas would, however, be a poor store of value).
3. Money is a *medium of exchange* that allows us to buy and sell goods and services without the need to engage in inefficient barter (direct swaps of goods). The ease with which we can convert money into goods and services is a measure of how *liquid* money is compared with the many illiquid assets in our portfolios (such as real estate). Money is the most liquid asset of all.

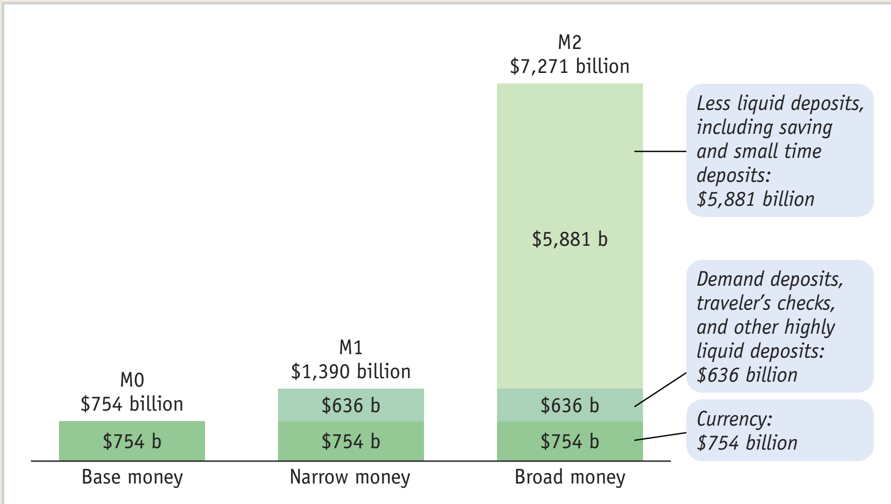
The Measurement of Money

What counts as money? Clearly the currency we hold is money. But do checking accounts count as money? What about savings accounts, mutual funds, and other securities? Figure 14-4 depicts the most widely used measures of the money supply and illustrates their relative magnitudes with recent data from the United States. The narrowest definition of money includes only currency, and it is called M0 (or "base money"). The next measure of money, M1, includes highly liquid instruments such as demand deposits in checking accounts and traveler's checks. The broad measure of money, M2, includes slightly less liquid assets such as savings and small time deposits.[7]

For our purposes, money is defined as the *stock of liquid assets that are routinely used to finance transactions,* in the sense implied by the "medium of exchange" function of money. When we speak of money (denoted M), we will generally mean M1, currency plus demand deposits. Many important assets are excluded from M1, including longer-term assets held by individuals and the voluminous interbank deposits used in the foreign exchange market discussed in Chapter 13. These assets do not count as money in the sense used here because they are relatively illiquid and not used routinely for transactions.

[7] There is little consensus on the right broad measure of money. Until 2006 the U.S. Federal Reserve collected data on M3, which included large time deposits, repurchase agreements, and money market funds. This was discontinued because the data were costly to collect and of limited use to policy makers. In the United Kingdom, a slightly different broad measure, M4, is still used. Some economists now prefer a money aggregate called MZM, or "money of zero maturity," as the right broad measure, but its use is not widespread.

FIGURE 14-4



The Measurement of Money This figure shows the major kinds of monetary aggregates (M0, M1, and M2) in U.S. dollars for the United States as of April 2007.

Source: U.S. Federal Reserve.

The Supply of Money

How is the supply of money determined? In practice, a country's **central bank** controls the **money supply.** Strictly speaking, by issuing notes and coins, the central bank controls directly only the level of M0, or base money, the amount of currency in the economy. However, it can *indirectly* control the level of M1 by using monetary policy to influence the behavior of the private banks that are responsible for checking deposits. The intricate mechanisms by which monetary policy affects M1 are beyond the scope of this book. We make the simplifying assumption that the central bank's policy tools are sufficient to allow it to control indirectly, but accurately, the level of M1.[8]

The Demand for Money: A Simple Model

A simple theory of household money demand is motivated by the assumption that the need to conduct transactions is in proportion to an individual's income. For example, if an individual's income doubles from $20,000 to $40,000, we expect his or her demand for money (expressed in dollars) to double also.

Moving from the individual or household level up to the aggregate or macroeconomic level, we can infer that the aggregate **money demand** will behave similarly. *All else equal, a rise in national dollar income (nominal income) will cause a proportional increase in transactions and, hence, in aggregate money demand.*

[8] A full treatment of this topic can be found in a textbook on money and banking. See Laurence M. Ball, *The Financial System, Money and the Global Economy,* New York: Worth, forthcoming.

This insight suggests a simple model in which the demand for money is proportional to dollar income. This model is known as the **quantity theory of money:**

$$\underbrace{M^d}_{\substack{\text{Demand for}\\ \text{money (\$)}}} = \underbrace{\overline{L}}_{\text{A constant}} \times \underbrace{PY.}_{\substack{\text{Nominal}\\ \text{income (\$)}}}$$

Here, PY measures the total nominal dollar value of income in the economy, equal to the price level P times real income Y. $\overline{L}$ is a constant that measures how much demand for liquidity is generated for each dollar of nominal income. To emphasize this point, we assume for now that every \$1 of nominal income requires \$ $\overline{L}$ of money for transactions purposes and that this relationship is constant. (Later, we can relax this assumption.)

If the price level rises by 10% and real income is fixed, we are paying a 10% higher price for all goods, so the dollar cost of transactions rises by 10%. Similarly, if real income rises by 10% but prices stay fixed, the dollar amount of transactions will rise by 10%. Hence, the *demand for nominal money balances,* M^d, is proportional to the *nominal* income, PY.

Another way to look at the quantity theory is to convert all quantities into real quantities by dividing the previous equation by P, the price level (the price of a basket of goods). Quantities are then converted from nominal dollars to real units (specifically, into units of baskets of goods). This allows us to derive the *demand for real money balances:*

$$\underbrace{\frac{M^d}{P}}_{\substack{\text{Demand for}\\ \text{real money}}} = \underbrace{\overline{L}}_{\text{A constant}} \times \underbrace{Y.}_{\text{Real income}}$$

Real money balances are simply a measure of the purchasing power of the stock of money in terms of goods and services. The expression just given says simply that the demand for real money balances is proportional to real income. The more real income we have, the more real transactions we have to perform and the more real money we need. Moreover, the relationship is assumed to be one of strict proportionality: a 10% increase in real income would imply a 10% increase in real money demand.

Equilibrium in the Money Market

The condition for equilibrium in the money market is simple to state: the demand for money M^d must equal the supply of money M, which we assume to be under the control of the central bank. Imposing this condition on the last two equations, we find that nominal money supply equals nominal money demand:

$$M = \overline{L}PY,$$

and that real money supply equals real money demand:

$$\frac{M}{P} = \overline{L}Y.$$

A Simple Monetary Model of Prices

We are now in a position to put together a simple model of the exchange rate, using two building blocks. The first building block is a model that links prices to monetary conditions—the quantity theory. The second building block is a model that links exchange rates to prices—PPP.

We consider two countries, as before, and for simplicity we will consider the United States as the home country and Europe as the foreign country. (The model generalizes to any pair of countries.)

Let's consider the last equation given and apply it to the United States, adding U.S. subscripts for clarity. We can rearrange this formula to obtain an expression for the U.S. price level:

$$P_{US} = \frac{M_{US}}{\bar{L}_{US}Y_{US}}.$$

Note that the price level is determined by how much nominal money is issued relative to the demand for real money balances: the numerator on the right-hand side is the total supply of *nominal* money; the denominator is the total demand for *real* money balances.

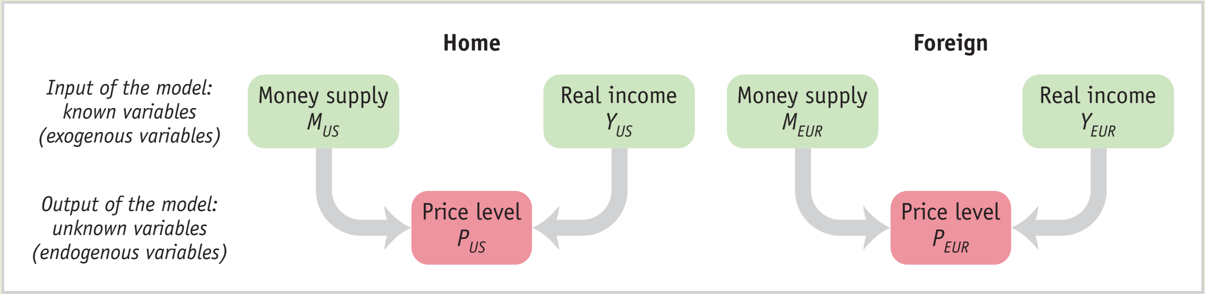
We can do the same rearrangement for Europe to obtain the analogous expression for the European price level:

$$P_{EUR} = \frac{M_{EUR}}{\bar{L}_{EUR}Y_{EUR}}.$$

The last two equations are examples of the **fundamental equation of the monetary model of the price level.** Two such equations, one for each country, give us another important building block for our theory of prices and exchange rates as shown in Figure 14-5.

In the long run, we assume prices are flexible and will adjust to put the money market in equilibrium. For example, if the amount of money in circulation (the nominal money supply) rises, say, by a factor of 100, and real

FIGURE 14-5



Building Block: The Monetary Theory of the Price Level According to the Long-Run Monetary Model In these models, the money supply and real income are treated as known exogenous variables (in the green boxes). The models use these variables to predict the unknown endogenous variables (in the red boxes), which are the price levels in each country.

income stays the same, then there will be "more money chasing the same quantity of goods." This leads to inflation, and in the long run, the price level will rise by a factor of 100. In other words, we will be in the same economy as before except that all prices will have two zeroes tacked on to them.

A Simple Monetary Model of the Exchange Rate

A long-run model of the exchange rate is close at hand. If we take the last two equations, which use the monetary model to find the price level in each country, and plug them into Equation (14-1), we can use absolute PPP to solve for the exchange rate:

$$\underbrace{E_{\$/€}}_{\substack{\text{Exchange}\\\text{rate}}} = \underbrace{\frac{P_{US}}{P_E}}_{\substack{\text{Ratio of}\\\text{price}\\\text{levels}}} = \frac{\left(\dfrac{M_{US}}{\overline{L}_{US}Y_{US}}\right)}{\left(\dfrac{M_{EUR}}{\overline{L}_{EUR}Y_{EUR}}\right)} = \underbrace{\frac{(M_{US}/M_{EUR})}{(\overline{L}_{US}Y_{US}/\overline{L}_{EUR}Y_{EUR})}}_{\substack{\text{Relative nominal money}\\\text{supplies divided by relative}\\\text{real money demands}}}. \tag{14-3}$$

This is the **fundamental equation of the monetary approach to exchange rates.** By substituting the price levels from the monetary model into PPP, we have put together the two building blocks from Figures 14-1 and 14-5. The implications of this equation are intuitive.

- Suppose the U.S. money supply increases, all else equal. The right-hand side increases (the U.S. nominal money supply increases relative to Europe), causing the exchange rate to increase (the U.S. dollar depreciates against the euro). For example, if the U.S. money supply doubles, then all else equal, the U.S. price level doubles. That is, a bigger U.S. supply of money leads to a weaker dollar. That makes sense—there are more dollars around, so you expect each dollar to be worth less.
- Now suppose the U.S. real income level increases, all else equal. Then the right-hand side decreases (the U.S. real money demand increases relative to Europe), causing the exchange rate to decrease (the U.S. dollar appreciates against the euro). For example, if the U.S. real income doubles, then all else equal, the U.S. price level falls by a factor of one-half. That is, a stronger U.S. economy leads to a stronger dollar. That makes sense—there is more demand for the same quantity of dollars, so you expect each dollar to be worth more.

Money Growth, Inflation, and Depreciation

The model just presented uses absolute PPP to link the level of the exchange rate to the level of prices and uses the quantity theory to link prices to monetary conditions in each country. But as we have said before, macroeconomists are often more interested in rates of change of variables (e.g., inflation) rather than levels.

Can our theory be extended for this purpose? Yes, but this task takes a little work. We convert Equation (14-3) into growth rates by taking the rate of change of each term.

The first term of Equation (14-3) is the exchange rate $E_{\$/€}$. Its rate of change is the rate of depreciation, $\Delta E_{\$/€}/E_{\$/€}$. When this term is positive, say 1%, the dollar is depreciating at 1% per year; if negative, say −2%, the dollar is appreciating at 2% per year.

The second term of Equation (14-3) is the ratio of the price levels P_{US}/P_{EUR}, and as we saw when we derived relative PPP at Equation (14-2), its rate of change is the rate of change of the numerator (U.S. inflation) minus the rate of change of the denominator (European inflation), which equals the inflation differential $\pi_{US,t} - \pi_{EUR,t}$.

What is the rate of change of the third term in Equation (14-3)? The numerator represents the U.S. price level, $P_{US} = M_{US}/\overline{L}_{US}Y_{US}$. Again, the growth rate of a fraction equals the growth rate of the numerator minus the growth rate of the denominator. In this case, the numerator is the money supply M_{US}, and its growth rate is μ_{US},

$$\mu_{US,t} = \underbrace{\frac{M_{US,t+1} - M_{US,t}}{M_{US,t}}}_{\text{Rate of money supply growth in U.S.}}.$$

The denominator is $\overline{L}_{US}Y_{US}$, which is a constant $\overline{L}_{US}$ times real income Y_{US}. $\overline{L}_{US}Y_{US}$ grows at a rate equal to the growth rate of real income, g_{US}:

$$g_{US,t} = \underbrace{\frac{Y_{US,t+1} - Y_{US,t}}{Y_{US,t}}}_{\text{Rate of real income growth in U.S.}}.$$

Putting all the pieces together, the growth rate of $P_{US} = M_{US}/\overline{L}_{US}Y_{US}$ equals the money supply growth rate μ_{US} minus the real income growth rate g_{US}. We have already seen that the growth rate of P_{US} on the left-hand side is the inflation rate π_{US}. Thus, we know that

$$\pi_{US,t} = \mu_{US,t} - g_{US,t}. \tag{14-4}$$

The denominator of the third term of Equation (14-3) represents the European price level, $P_{EUR} = M_{EUR}/\overline{L}_{EUR}Y_{EUR}$, and its rate of change is calculated similarly:

$$\pi_{EUR,t} = \mu_{EUR,t} - g_{EUR,t}. \tag{14-5}$$

The intuition for these expressions echoes what we said previously. When money growth is higher than income growth, we have "more money chasing fewer goods" and this leads to inflation.

Combining Equation (14-4) and Equation (14-5), we can now solve for the inflation differential in terms of monetary fundamentals and finish our task of computing the rate of depreciation of the exchange rate:

$$\underbrace{\frac{\Delta E_{\$/€,t}}{E_{\$/€,t}}}_{\substack{\text{Rate of depreciation of}\\\text{the nominal exchange rate}}} = \underbrace{\pi_{US,t} - \pi_{EUR,t}}_{\text{Inflation differential}} = (\mu_{US,t} - g_{US,t}) - (\mu_{EUR,t} - g_{EUR,t}) \tag{14-6}$$

$$= \underbrace{(\mu_{US,t} - \mu_{EUR,t})}_{\substack{\text{Differential in}\\\text{nominal money supply}\\\text{growth rates}}} - \underbrace{(g_{US,t} - g_{EUR,t})}_{\substack{\text{Differential in real}\\\text{output growth rates}}}.$$

The last term here is the rate of change of the fourth term in Equation (14-3).

Equation (14-6) is the fundamental equation of the monetary approach to exchange rates expressed in rates of change, and much of the same intuition we applied in explaining Equation (14-3) carries over here.

- If the United States runs a looser monetary policy in the long run measured by a faster money growth rate, the dollar will depreciate more rapidly, all else equal. For example, suppose Europe has a 5% annual rate of change of money and a 2% rate of change of real income; then its inflation would be the difference, 5% minus 2% equals 3%. Now suppose the United States has a 6% rate of change of money and a 2% rate of change of real income, then its inflation would be the difference, 6% minus 2% equals 4%. And the rate of depreciation of the dollar would be U.S. inflation minus European inflation, 4% minus 3%, or 1% per year.
- If the U.S. economy grows faster in the long run, the dollar will appreciate more rapidly, all else equal. In the last numerical example, suppose the U.S. growth rate of real income in the long run increases from 2% to 5%, all else equal. Now U.S. inflation equals the money growth rate of 6% minus the new real income growth rate of 5%, so inflation is just 1% per year. Now the rate of dollar depreciation is U.S. inflation minus European inflation, that is, 1% minus 3%, or −2% per year (meaning the U.S. dollar would now appreciate at 2% per year).

With a change of notation to make the United States the foreign country, the same lessons could be derived for Europe and the euro.

3 The Monetary Approach: Implications and Evidence

The monetary approach to exchange rates is a workhorse model with many practical applications in the study of long-run exchange rate movements. In this section, we illustrate its main application to forecasting and examine some empirical evidence.

Exchange Rate Forecasts Using the Simple Model

The most important practical application for us, presently, is to understand how the monetary approach can be used to forecast the future exchange rate. Remember from Chapter 13 that forex market arbitragers need to form such a forecast to be able to make arbitrage calculations using uncovered interest parity. If we use the monetary model to forecast exchange rates, then Equation (14-3) says that a forecast of future exchange rates (the left-hand side) can be constructed as long as we know how to make a forecast of future money supplies and real income.

In practice, this is why expectations about money and real income in the future are so widely reported in the financial media, and especially in the forex market. The discussion returns with obsessive regularity to two questions. The first question, "What are central banks going to do?" leads to all manner of attempts to decode the statements and remarks of central bank officials. The second question, "How is the economy expected to grow in real terms?" leads to a keen interest in any indicators such as productivity data or investment activity that might hint at changes in the rate of growth. There is great uncertainty in trying to answer these questions, and forecasts of economic variables years in the future are likely to be subject to large errors. Nonetheless, this is one of the key tasks of financial markets.

Note that if one uses the monetary model for forecasting, one is answering a hypothetical question that the forecaster might ask: What path would exchange rates follow from now on *if prices were flexible and PPP held*? Admittedly, as we know, and as any forecaster knows, in the short run, there might be deviations from this prediction about exchange rate changes, but in the longer run, the prediction will supply a more reasonable guide.

Forecasting Exchange Rates: An Example To see how forecasting might work, let's look at a simple scenario. Assume that U.S. and European real income growth rates are identical and equal to zero (0%) so that real income levels are constant. Assume also that the European money supply is constant. If the money supply and real income in Europe are constant, then the European price level is constant, and European inflation is zero, as we can see from Equation (14-5). These assumptions allow us to perform a controlled thought-experiment, and focus on changes on the U.S. side of the model, all else equal. Let's look at two cases.

Case 1: A one-time increase in the money supply. In the first, and simpler, case, suppose at some time T that the U.S. money supply has risen by a fixed proportion, say 10%, all else equal. Assuming that prices are flexible, what does our model predict will happen to the level of the exchange rate after time T? To spell out the argument in detail, we look at the implications of our model for some key variables.

a. There is a 10% increase in the money supply M.

b. Real money balances M/P remain constant, because real income is constant.

c. These last two statements imply that price level P and money supply M must move in the same proportion, so there is a 10% increase in the price level P.

d. PPP implies that the exchange rate E and price level P must move in the same proportion, so there is a 10% increase in the exchange rate E; that is, the dollar depreciates by 10%.

A quicker solution uses the fundamental equation of the monetary approach at Equation (14-3): the price level and exchange rate are proportional to the money supply, all else equal.

Case 2: An increase in the rate of money growth. The model also applies to more complex scenarios. Consider a second case in which U.S. money supply is not constant but grows at a steady fixed rate μ. Then suppose we learn at time T that the United States will raise the rate of money supply growth from some previously fixed rate μ to a slightly higher rate. How would people expect the exchange rate to behave assuming price flexibility? Let's work through this case step by step:

a. Money supply is growing at a constant rate.

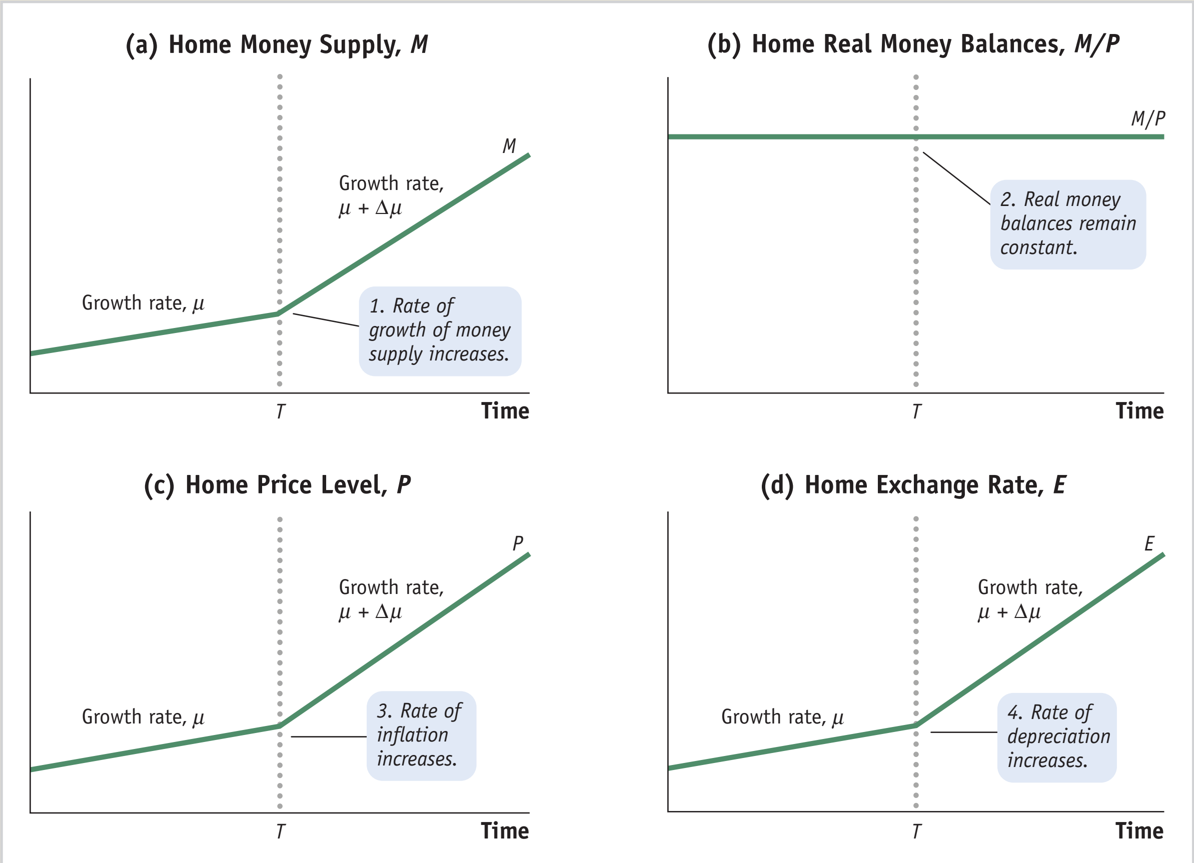
b. Real money balances M/P remain constant, as before.

c. These last two statements imply that price level P and money supply M must move in the same proportion, so M is always a constant multiple of P.

d. PPP implies that the exchange rate E and price level P must move in the same proportion, so E is always a constant multiple of P (and hence of M).

Corresponding to these four steps, the four panels of Figure 14-6 illustrate the path of the key variables in this example. This figure shows that if we can

FIGURE 14-6



An Increase in the Growth Rate of the Money Supply in the Simple Model Before time T, money, prices, and the exchange rate all grow at rate μ. Foreign prices are constant. In panel (a), we suppose at time T there is an increase $\Delta\mu$ in the rate of growth of home money supply M. In panel (b), the quantity theory assumes that the level of real money balances remains unchanged. After time T, if real money balances (M/P) are constant, then money M and prices P still grow at the same rate, which is now $\mu + \Delta\mu$, so the rate of inflation rises by $\Delta\mu$, as shown in panel (c). PPP and an assumed stable foreign price level imply that the exchange rate will follow a path similar to that of the domestic price level, so E also grows at the new rate $\mu + \Delta\mu$, and the rate of depreciation rises by $\Delta\mu$, as shown in panel (d).

forecast the money supply at any future period as in (a), and if we know real money balances remain constant as in (b), then we can forecast prices as in (c) and exchange rates as in (d). These forecasts are good in any future period, under the assumptions of the monetary approach. Again, the fundamental equation (14-3) supplies the answer more quickly; under the assumptions we have made, money, prices, and exchange rates all move in proportion to one another.

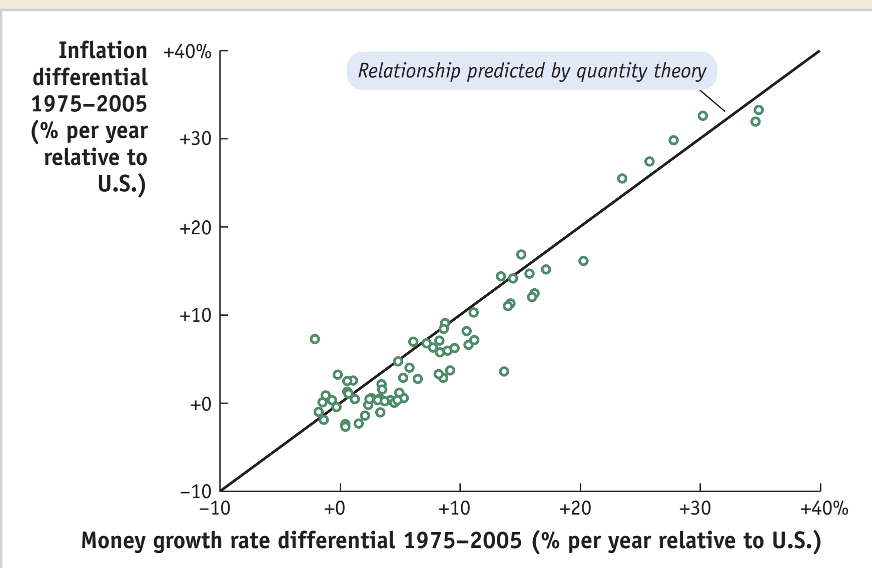
APPLICATION

Evidence for the Monetary Approach

The monetary approach to prices and exchange rates suggests that, all else equal, increases in the rate of money supply growth should be the same size as increases in the rate of inflation and the rate of exchange rate depreciation. Looking for evidence of this relationship in real-world data is one way to put this theory to the test.

The scatter plots in Figure 14-7 and Figure 14-8 show data from the 1975 to 2005 period for a large sample of countries. The results offer fairly strong support for the monetary theory. Equation (14-6) predicts that an x% difference in money growth rates (relative to the United States) should be associated with an x% difference in inflation rates (relative to the United States) and an x% depreciation of the home exchange rate (against the U.S. dollar). If this association were literally true in the data, then the scatter plots would show each country on the 45-degree line. This is not exactly true, but the actual relationship is very close and offers some support for the monetary approach.

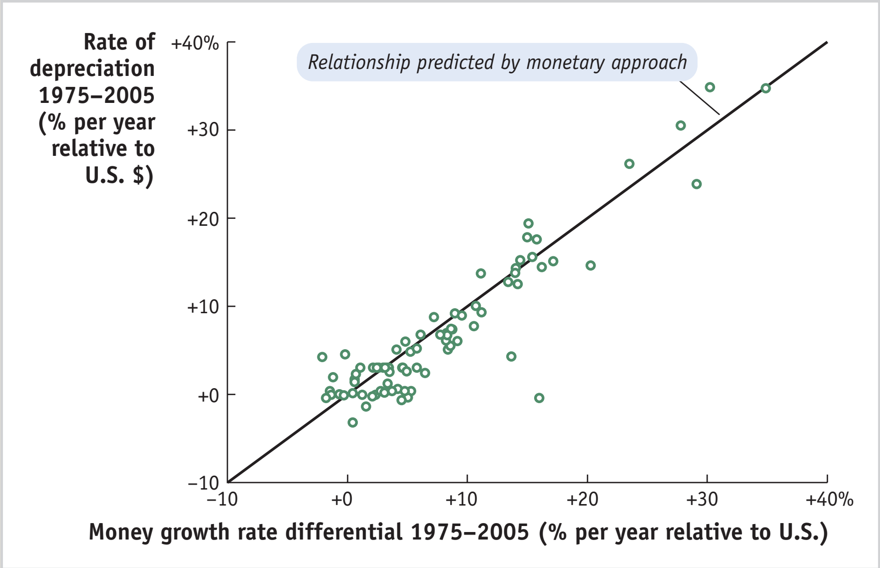
FIGURE 14-7



Inflation Rates and Money Growth Rates, 1975–2005 This scatter plot shows the relationship between the rate of inflation and the money supply growth rate over the long run, based on data for a sample of 76 countries. The correlation between the two variables is strong and bears a close resemblance to the theoretical prediction of the monetary model that all data points would appear on the 45-degree line.

Source: IMF, International Financial Statistics.

FIGURE 14-8



Money Growth Rates and the Exchange Rate, 1975–2005 This scatter plot shows the relationship between the rate of exchange-rate depreciation against the U.S. dollar and the money growth rate differential versus the United States over the long run, based on data for a sample of 82 countries. The data show a strong correlation between the two variables and a close resemblance to the theoretical prediction of the monetary approach to exchange rates, which would predict that all data points would appear on the 45-degree line.

Source: IMF, International Financial Statistics.

One reason the data do not sit on the 45-degree line is that all else is *not* equal in this sample of countries. In Equation (14-6), countries differ not only in their relative money supply growth rates but also in their real income growth rates. Another explanation is that we have been assuming that the money demand parameter L is constant, and this may not be true in reality. This is an issue we must now confront.[9] ■

APPLICATION

Hyperinflations of the Twentieth Century

The monetary approach assumes long-run PPP, which has some support. But we have been careful to note, again, that PPP works poorly in the short run. However, there is one notable exception to this general principle: hyperinflations.

Economists traditionally define a **hyperinflation** as occurring when the inflation rises to a sustained rate of more than 50% per month (which means that prices are doubling every 51 days). In common usage, some lower inflation episodes are also called hyperinflations; for example, an annual inflation rate of 1,000% is a common rule of thumb (when inflation is "only" 22% per month).

There have been many hyperinflations worldwide since the early twentieth century, usually when governments face a budget crisis, are unable to borrow to finance a deficit, and instead choose to print money to cover their

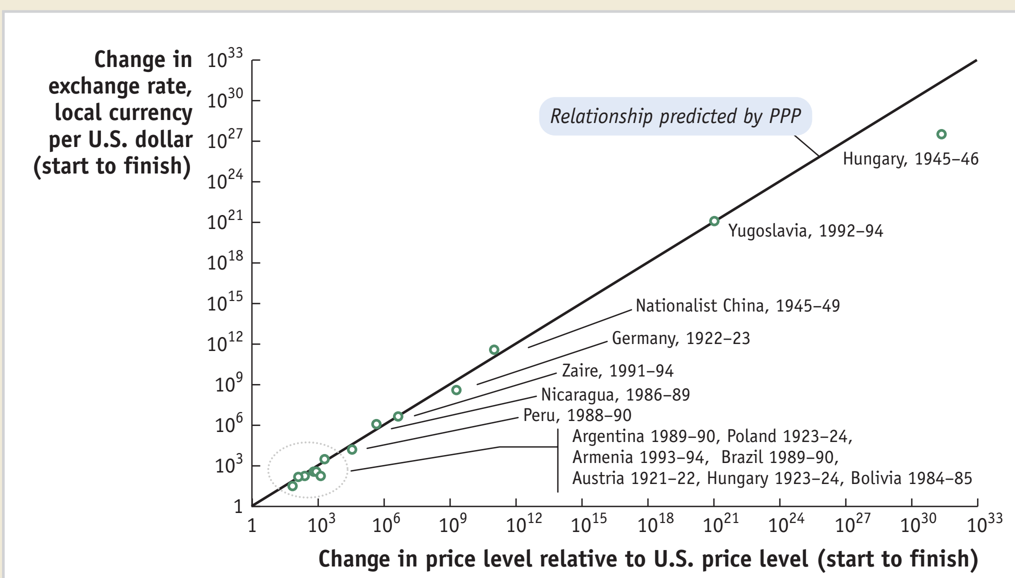
[9] Economists can use sophisticated statistical techniques to address these issues and still find results favorable to the monetary approach in the long run. See David E. Rapach and Mark E. Wohar, 2002, "Testing the Monetary Model of Exchange Rate Determination: New Evidence from a Century of Data," *Journal of International Economics,* 58(2), 359–385.

financing needs. The situation is not sustainable and usually leads to economic, social, and political crisis, which is eventually resolved with a return to price stability. Nonetheless, each crisis provides a unique laboratory for testing the predictions of the PPP theory.

The scatter plot in Figure 14-9 looks at the data using changes in levels (from start to finish, expressed as multiples). The change in the exchange rate (with the United States) is on the vertical axis and the change in the price level (compared with the United States) is on the horizontal axis. Because of the huge changes involved, both axes use log scales in powers of 10. For example, 10^{12} on the vertical axis means the exchange rate rose (the currency depreciated) by a factor of a trillion against the U.S. dollar during the hyperinflation.

PPP would imply that changes in prices and exchange rates should be equal. If so, all observations would be on the 45-degree line, and mostly they do follow this pattern, providing support for PPP. What the hyperinflations have in common is that a very large depreciation was about equal to a very large inflation differential. In an economy with fairly stable prices and exchange rates, large changes in exchange rates and prices only develop over

FIGURE 14-9



Purchasing Power Parity during Hyperinflations The scatter plot shows the relationship between the cumulative start-to-finish exchange-rate depreciation against the U.S. dollar and the cumulative start-to-finish rise in the local price level for hyperinflations in the twentieth century. Note the use of logarithmic scales. The data show a strong correlation between the two variables and a *very* close resemblance to the theoretical prediction of PPP that all data points would appear on the 45-degree line.

Sources: IMF, International Financial Statistics; Global Financial Data; Phillip Cagan, "The Monetary Dynamics of Hyperinflation," in Milton Friedman, ed., 1956, Studies in the Quantity Theory of Money, *Chicago: University of Chicago Press, pp. 25–117; Pavle Petrovic and Zorica Mladenovic, 2000, "Money Demand and Exchange Rate Determination under Hyperinflation: Conceptual Issues and Evidence from Yugoslavia,"* Journal of Money, Credit and Banking, *32, 785–806.*

the very long run of years and decades; but in a hyperinflation, large inflations and large depreciations are compressed into the short run of years or months.

Some price changes were outrageously large. Austria's hyperinflation of 1921 to 1922 was the first on record, and prices rose by a factor of about 100 (10^2). In Germany from 1922 to 1923, prices rose by a factor of about 20 billion (2×10^{10}); in the worst month, prices were doubling on average every two days. In Hungary from 1945 to 1946, pengö prices rose by a factor of about 10^{31}, the current record, and in July 1946, prices were doubling on average every 15 hours. Serbia's inflation from 1992 to 1994 came close to breaking the record for cumulative price changes. In comparison, Argentina's 700-fold inflation and Brazil's 200-fold inflation in 1989 to 1990 look deceptively modest. (For more discussion of hyperinflation and its consequences see **Side Bar: Currency Reform** and **Headlines: The First Hyperinflation of the Twenty-First Century.**)

There is one other important lesson to be learned from hyperinflations. In our simple monetary model, the money demand parameter L was assumed to be *constant* and equal to $\overline{L}$. This implied that real money balances were proportional to real income, with $M/P = \overline{L}Y$ as shown in Equation (14-5). Is this assumption of stable real money balances justified?

SIDE BAR

Currency Reform

Hyperinflations help us understand how some currencies become extinct if they cease to function well and lose value rapidly. Dollarization in Ecuador is a recent example. Other currencies survive such travails, only to be reborn. But the low denomination bills—the ones, fives, tens—usually become essentially worthless and normal transactions can require you to be a millionaire. The eradication of a few pesky zeroes might then be a good idea. A new unit of currency defined as 10^N (10 raised to the power N) old units may then be created by the authorities.

Sometimes N can get quite large. In the 1980s, Argentina suffered hyperinflation. On June 1, 1983, the *peso argentino* replaced the (old) peso at a rate of 10,000 to 1. Then on June 14, 1985, the *austral* replaced the peso argentino at 1,000 to 1. Finally, on January 1, 1992, the *convertible peso* replaced the austral at a rate of 10,000 to 1 (i.e., 10,000,000,000 old pesos). After all this, if you had owned 1 new peso in 1983 (and had changed it into the later monies), it would have lost 99.99997% of its U.S. dollar value by 2003.

In 1946 the Hungarian *pengö* became so worthless that the authorities no longer printed the denomination on each note in numbers, but only in words—perhaps to avert distrust (unsuccessful), to hide embarrassment (also unsuccessful), or simply because there wasn't room to print all those zeroes. By July 15, 1946, there were 76,041,000,000,000,000,000,000,000 pengö in circulation. A stable new currency, the *forint,* was finally introduced on July 26, 1946, with each forint worth 400,000 quadrillion pengö (4×10^{20} = 400,000,000,000,000,000,000 pengö).

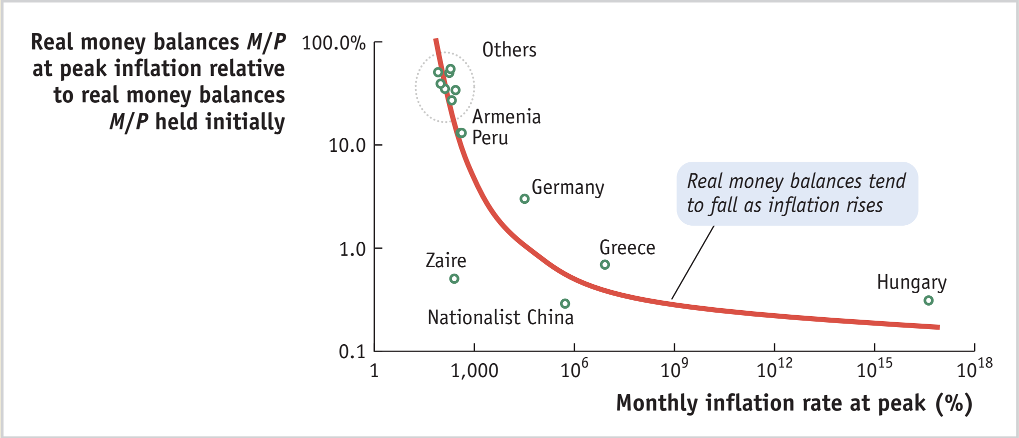
Above left to right are an Argentine 500,000 austral bill of 1990; a 500,000,000,000 Yugoslav dinara of 1993, a record for the most zeroes on a banknote; a 1923 one billion German mark note (1 German billion = 1 U.S. trillion); and a Hungarian 100 Million B-pengö of 1946, with the "B" denoting the Hungarian billion, or a million million: this 100,000,000,000,000,000,000 pengö note is the highest denomination of currency ever issued by any country.

The evidence shown in Figure 14-10 suggests this assumption is not justified, based on a subset of the hyperinflations. For each point, on the horizontal axis of this figure we see the peak monthly inflation rate (the moment when prices were rising most rapidly); on the vertical axis, we see the level of real money balances in that month relative to their initial level (in the month just before the hyperinflation began). If real money balances were stable, there ought to be no variation in the vertical dimension aside from fluctuations in real income. But there is, and with a clear pattern: the higher the level of inflation, the lower the level of real money balances. These declines are far too severe to be explained by just the fall in real incomes experienced during hyperinflations, though such income declines did occur.

This finding may not strike you as very surprising. If prices are doubling every few days (or every few hours), the money in people's pockets is rapidly turning into worthless pieces of paper. They will try to minimize their money holdings—and will do so even more as inflation rises higher and higher, just as the figure shows. It becomes just too costly to hold very much money, despite one's need to use it for transactions.

If you thought along these lines, you have an accurate sense of how people behave during hyperinflations. You also anticipated the extensions to the simple model that we make in the next section to make it more realistic. Even during "normal" inflations—situations that are less pathological than a hyperinflation—it is implausible to assume that real money balances are perfectly stable. Instead, we will assume that people make the trade-off highlighted previously: comparing the benefits of holding money for transactions purposes with the costs of holding money as compared with other assets. ■

FIGURE 14-10



The Collapse of Real Money Balances during Hyperinflations This figure shows that real money balances tend to collapse in hyperinflations as people economize by reducing their holdings of rapidly depreciating notes. The horizontal axis shows the peak monthly inflation rate (%), and the vertical axis shows the ratio of real money balances in that peak month relative to real money balances at the start of the hyperinflationary period. The data are shown using log scales for clarity.

Sources: Global Financial Data; Phillip Cagan, "The Monetary Dynamics of Hyperinflation," in Milton Friedman, ed., 1956, Studies in the Quantity Theory of Money, *Chicago: University of Chicago Press, pp. 25–117.*

HEADLINES

The First Hyperinflation of the Twenty-First Century

By 2007 the long-suffering people of Zimbabwe faced an accelerating descent into economic chaos. The country was almost at a standstill, except for the printing presses churning out the banknotes. A creeping inflation—58% in 1999, 132% in 2001, 385% in 2003, and 586% in 2005—was about to become hyperinflation.

Zimbabwe's annual inflation rate surged to an unprecedented 3,714 percent at the end of April, the official state newspaper reported Thursday, as the government set up a new commission to try to bring price hikes down to single digit levels.

Prices more than doubled last month as shown by a 100.7 percent increase—the highest on record—in the consumer price index calculated by the state Central Statistical Office, the *Herald* newspaper said. In the past year they increased 36-fold.

The *Herald* said that President Robert Mugabe on Monday signed into law new regulations to enforce wage and price controls through "comprehensive price surveys and inspections," with a penalty of up to five years in jail for violators. The ultimate aim would be to bring inflation into single digits.

In recent years, the government has tried to freeze prices for corn meal, bread, cooking oil, meat, school fees and transport costs with little success. Socialist-style controls have driven a thriving black market in scarce commodities.

For instance sugar, unavailable in regular stores for weeks, fetches at least 10 times the government's designated price at a dirty, seething market in Harare's impoverished western township of Mbare.

Minibus drivers, the country's main commuter transport, routinely ignore government directives on fares, citing soaring black market prices for gasoline. Commuters questioned at police roadblocks often lie about the fare they paid or risk being thrown off the bus and left stranded.

The independent Confederation of Zimbabwe Industries estimates most factories across the country are running at around 30 percent capacity or less, and countless businesses have shut down, fueling record unemployment of about 80 percent.

Many consumer items have disappeared altogether, forcing supermarkets to fill out their shelves with empty packaging behind the few goods on display.

The worst economic crisis since independence in 1980 is blamed on corruption, mismanagement and the often-violent seizures of thousands of white-owned commercial farms since 2000 that disrupted the agriculture-based economy.

Hikes in prices of power, other fuels, passenger transport, vegetables and meat contributed to April's surge in the consumer price index, which was double the increase in March of 50.3 percent, the Central Statistical Office said, according to the *Herald*.

The international benchmark for hyperinflation is a 50 percent month-on-month increase.

The government warned Wednesday that the price of bread is likely to rise because only a fraction of the normal wheat crop has been planted. . . .

On Monday, the state postal service upped its charges by 600 percent, the second increase in three months. A stamp for a local letter weighing 20 grams (0.7 of an ounce) went up to Zimbabwean $40,000, or US$2.60 (€1.90). . . .

The Reserve Bank last year introduced sweeping currency reforms knocking off the final three digits—thus Zimbabwean $250,000 became Zimbabwean $250—in a vain attempt to tame inflation.

Even so, consumers are still forced to carry around huge bricks of notes to pay for scarce supplies and basic services.

For example, a pest control service on Wednesday charged Zimbabwean $1 million as a callout charge to a homeowner whose house was plagued by the rats which are thriving as the country's sanitation and garbage collection collapses.

Howard Burditt/Reuters/Landov

STR/AFP/Getty Images

AP Photo/Tsvangirayi Mukwashi

Ink on their hands: Under President Robert Mugabe and Central Bank Governor Gideon Gono, Zimbabwe is the latest country to join a rather exclusive club. On the right, a Z$100,000 note.

Source: Excerpted from the Associated Press, "Inflation in Zimbabwe Surges to Record 3,714 Percent, the Highest in the World," International Herald Tribune, *May 17, 2007.*

4 Money, Interest, and Prices in the Long Run: A General Model

So far we have a theory that links exchange rates to the price levels in each country: PPP. We also have a simple monetary model that links price levels in each country to underlying conditions of money supply and demand: the *quantity theory*. The quantity theory provides basic intuition for the links between money, prices, and exchange rates.

The trouble is that the quantity theory makes what seems to be an implausible assumption about the stability of the demand for money. In this section, we explore a general model of money demand that addresses this shortcoming by allowing money demand to vary with the nominal interest rate. This theory, in turn, brings another variable into play: How is the nominal interest rate determined in the long run? Answering this question will lead us to consider the links between inflation and the nominal interest rate in an open economy. With these new models in hand, we then return to the question of how best to forecast exchange rates in the long run.

The Demand for Money: The General Model

The general model of money demand is motivated by two insights, the first of which carries over from the simple model we studied earlier in this chapter, the quantity theory.

- *Benefits of holding money.* As before, the benefit of money is that individuals can conduct transactions with it. As in the simple quantity theory, we continue to assume that transactions demand is in proportion to income, all else equal.
- *Costs of holding money.* The nominal interest rate on money is zero, $i_{money} = 0$. By holding money and not earning interest, people incur the opportunity cost of holding money. For example, an individual could hold an interest-earning asset paying $i_\$$. The difference in nominal returns between this asset and money would be $i_\$ - i_{money} = i_\$ > 0$. This is one way of expressing the opportunity cost.

Moving from the individual or household level up to the macroeconomic level, we can infer that aggregate money demand in the economy as a whole will behave similarly:

All else equal, a rise in national dollar income (nominal income) will cause a proportional increase in transactions and, hence, in aggregate money demand.

All else equal, a rise in the nominal interest rate will cause the aggregate demand for money to fall.

Based on these insights, we arrive at the general model of the demand for money, in which demand is proportional to nominal income and a decreasing function of the nominal interest rate:

$$\underbrace{M^d}_{\substack{\text{Demand for}\\ \text{money (\$)}}} = \underbrace{L(i)}_{\substack{\text{A decreasing}\\ \text{function}}} \times \underbrace{P \times Y.}_{\substack{\text{Nominal}\\ \text{income (\$)}}}$$

Formerly, in the quantity theory, the parameter L (the liquidity ratio, the amount of money needed for transactions per dollar of nominal GDP) was a constant. But now we assume it is a decreasing function of the nominal interest rate i. Dividing by P, we can derive the demand for real money balances:

$$\underbrace{\frac{M^d}{P}}_{\substack{\text{Demand for}\\ \text{real money}}} = \underbrace{L(i)}_{\substack{\text{A decreasing}\\ \text{function}}} \times \underbrace{Y.}_{\substack{\text{Real}\\ \text{income}}}$$

Figure 14-11(a) shows a typical **real money demand function** of this form, with the quantity of real money balances demanded on the horizontal axis and the nominal interest rate on the vertical axis. The downward slope of the demand curve reflects the inverse relationship between the demand for real money balances and the nominal interest rate *at a given level of real income* (Y).

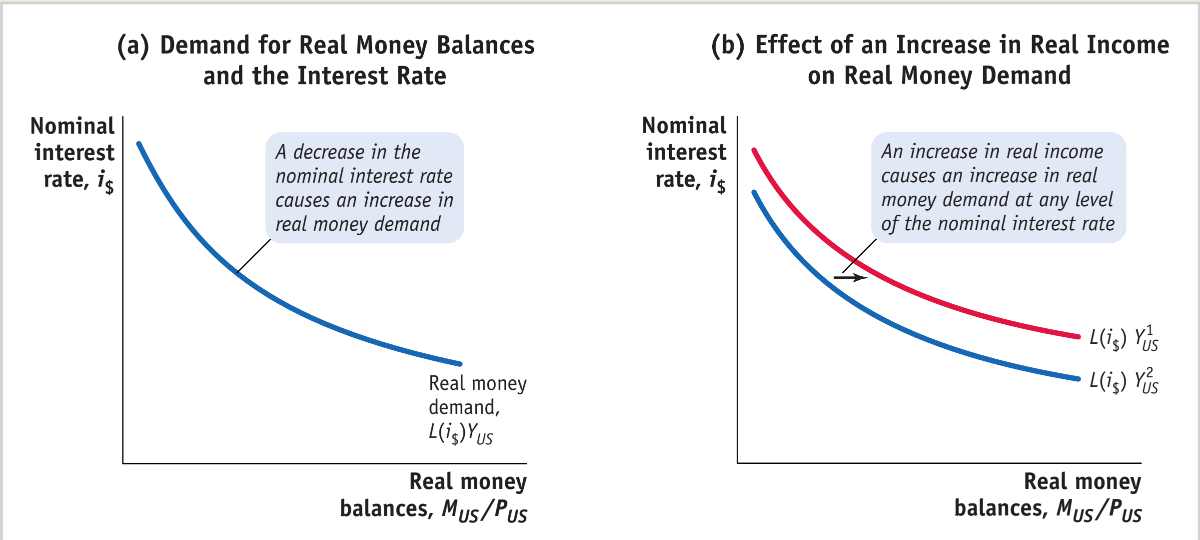
Figure 14-11(b) shows what happens when real income increases from Y_1 to Y_2. When real income increases (by x%), the demand for real money balances increases (by x%) at each level of the nominal interest rate.

Long-Run Equilibrium in the Money Market

The money market is in equilibrium when the real money supply (determined by the central bank) equals the demand for real money balances:

$$\underbrace{\frac{M}{P}}_{\text{Real money supply}} = \underbrace{L(i)Y.}_{\text{Real money demand}} \tag{14-7}$$

FIGURE 14-11



The Standard Model of Real Money Demand Panel (a) shows the real money demand function for the United States. The downward slope implies that the quantity of real money demand rises as the nominal interest rate $i_\$$ falls. Panel (b) shows that an increase in real income from Y^1_{US} to Y^2_{US} causes real money demand to rise at all levels of the nominal interest rate $i_\$$.

We will continue to assume that prices are flexible in the long run and that they adjust to ensure that equilibrium is maintained.

This all looks familiar. There is just one small problem remaining. Under the quantity theory, the nominal interest rate was ignored. Now it is a key variable in the determination of money demand. So now we need a theory to tell us what the level of the nominal interest rate *i* will be in the long run. Once we have solved this problem, we will be able to apply this new model of the money market to the analysis of exchange rate determination in the long run.

Inflation and Interest Rates in the Long Run

The tools we need to determine the nominal interest rate in an open economy are already at hand. So far in this chapter, we have developed the idea of purchasing power parity (PPP), which links prices and exchange rates. In the last chapter, we developed another parity idea, uncovered interest parity (UIP), which links exchange rates and interest rates. With only these two relationships in hand, PPP and UIP, we can derive a powerful and striking result concerning interest rates with profound implications for our study of open economy macroeconomics.

Relative PPP, as stated in Equation (14-2), states that the rate of depreciation equals the inflation differential. When market actors use this equation to make a forecast of future exchange rates, we refer to the forecast as the expected exchange rate, meaning that a statistical expectation has been used as a predictor. Thus, we use a superscript *e* to denote such expectations in Equation (14-2) and obtain

$$\underbrace{\frac{\Delta E^e}{E_{\$/€,t}}}_{\text{Expected rate of dollar depreciation}} = \underbrace{\pi^e_{US,t} - \pi^e_{EUR,t}}_{\text{Expected inflation differential}}.$$

Next we recall that uncovered interest parity (UIP) in its simplified approximate form (Equation 13–3) can be slightly rearranged to show that the expected rate of depreciation equals the interest differential:

$$\underbrace{\frac{\Delta E^e_{\$/€}}{E_{\$/€}}}_{\text{Expected rate of dollar depreciation}} = \underbrace{i_\$}_{\substack{\text{Net dollar}\\ \text{interest rate}}} - \underbrace{i_€}_{\substack{\text{Net euro}\\ \text{interest rate}}}.$$

This way of writing the UIP equation says that traders will be indifferent to a higher U.S. interest rate relative to the euro interest rates (making U.S. deposits look more attractive) only if it is offset by an expected dollar depreciation (making U.S. deposits look less attractive). For example, if the U.S. interest rate is 4% and the euro interest rate is 2%, the interest differential is 2% and the forex market can be in equilibrium only if traders expect a 2% depreciation of the U.S. dollar against the euro, which would exactly offset the higher U.S. interest rate.

The Fisher Effect

Because the left sides of the previous two equations are equal, the right sides must also be equal. Thus, the nominal interest differential equals the expected inflation differential:

$$\underbrace{i_{\$} - i_{€}}_{\text{Nominal interest rate differential}} = \underbrace{\pi^e_{US} - \pi^e_{EUR}}_{\text{Nominal inflation rate differential (expected)}}. \tag{14-8}$$

What does this important result say? To take an example, suppose expected inflation is 2% in the United States and 4% in Europe. The inflation differential on the right is then −2%. If interest rates in Europe are 3%, then to make the interest differential the same as the inflation differential, −2%, the interest rate in the United States must equal 1% (1% − 3% = −2%).

Now suppose expected inflation in the United States changes, rising by 1 percentage point to 3%. If the equation is to still hold, and nothing changes in Europe, then the U.S. interest rate must also rise by 1 percentage point to 2%. In general, this equation predicts that changes in the expected rate of inflation will be fully incorporated (one for one) into changes in nominal interest rates.

All else equal, a rise in the expected inflation rate in a country will lead to an equal rise in its nominal interest rate.

This result is known as the **Fisher effect,** named for the American economist Irving Fisher (1867–1947). Because this result depends on an assumption of PPP, it is therefore likely to hold only in the long run.

The Fisher effect makes clear the link between nominal inflation and interest rates under flexible prices, a finding that is widely applicable. For a start, it makes sense of the evidence we just saw on money holdings during hyperinflations (see Figure 14-10). As inflation rises, the Fisher effect tells us that the nominal interest rate i must rise by the same amount; the general model of money demand then tells us that $L(i)$ must fall because it is a decreasing function of i; thus, for a given level of real income, real money balances must fall.

In other words, the Fisher effect predicts that the change in the opportunity cost of money is equal not just to the change in the nominal interest rate but also to the change in the inflation rate. In times of very high inflation, people should, therefore, want to reduce their money holdings—and they do.

Real Interest Parity

As just described, the Fisher effect tells us something about nominal interest rates, but we can quickly derive the implications for real interest rates, too. Rearranging the last equation we find

$$i_{\$} - \pi^e_{US} = i_{€} - \pi^e_{EUR}.$$

The expressions on either side of this equation might look familiar from previous courses in macroeconomics. When the inflation rate (π) is subtracted from a *nominal* interest rate (i), the result is a **real interest rate** (r), the inflation-adjusted return on an interest-bearing asset. Given this definition, we can simplify the last equation further. On the left is the expected real interest rate in the United States, ($r^e_{US} = i_\$ - \pi^e_{US}$). On the right is the expected real interest rate in Europe, ($r^e_{EUR} = i_€ - \pi^e_{EUR}$).

Thus, using only two assumptions, PPP and UIP, we can show that

$$r^e_{US} = r^e_{EUR}. \tag{14-9}$$

This remarkable result states the following: *If PPP and UIP hold, then expected real interest rates are equalized across countries.*

This powerful condition is called **real interest parity** because it depends on an assumption of PPP; it is therefore likely to hold only in the long run.[10]

We have arrived at a strong conclusion about the potential for globalization to cause convergence in economic outcomes, since real interest parity implies the following: *Arbitrage in goods and financial markets alone is sufficient, in the long run, to cause the equalization of real interest rates across countries.*

We have considered two countries, but this argument applies to all countries integrated into the global capital market. In the long run, they will all share a common expected real interest rate, the long-run expected **world real interest rate** denoted r^*, so

$$r^e_{US} = r^e_{EUR} = r^*.$$

From now on, unless indicated otherwise, we treat r^* as a given, exogenous variable, something outside the control of a policy maker in any particular country.[11]

Under these conditions, the Fisher effect is even clearer, since, by definition,

$$i_\$ = r^e_{US} + \pi^e_{US} = r^* + \pi^e_{US}, \qquad i_€ = r^e_{EUR} + \pi^e_{EUR} = r^* + \pi^e_{EUR}.$$

In each country, the long-run expected nominal interest rate is the long-run world real interest rate plus that country's expected long-run inflation rate. For example, if the world real interest rate is $r^* = 2\%$, and the country's long-run inflation rate goes up by 2 percentage points from 3% to 5%, then its long-run nominal interest rate also goes up by 2 percentage points from the old level of 2 + 3 = 5% to a new level of 2 + 5 = 7%.

APPLICATION

Evidence on the Fisher Effect

Are the Fisher effect and real interest parity supported by empirical evidence? One might expect a problem here. We derived them from purchasing power parity. The evidence we have seen on PPP offers support only in the long run. Thus, we do not expect the Fisher effect and real interest parity to hold exactly and in the short run either but only as a long-run approximation.

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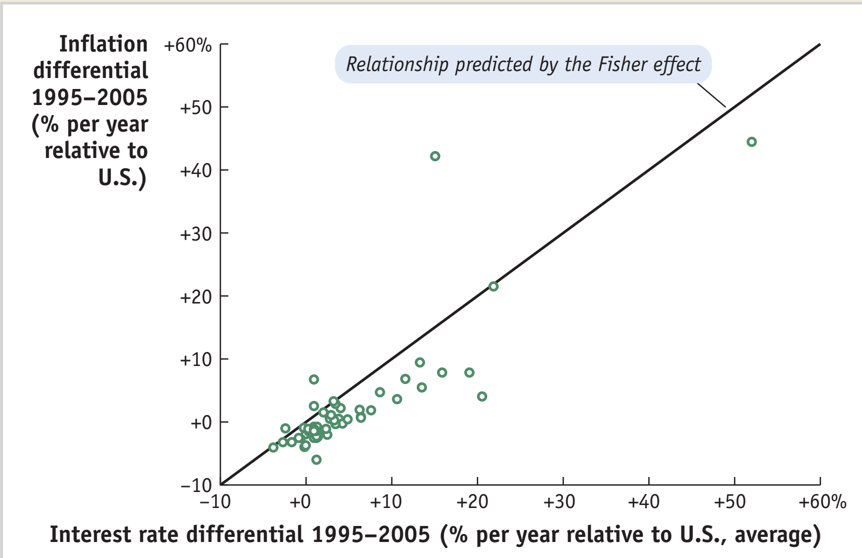
[10] You may have encountered other theories in which real interest rates are equalized across countries by other means. Countries may share common technologies (due to technology diffusion) or might have similar saving behavior (due to similar preferences). Such assumptions could lead to identical real interest rates even in two *closed* economies. But here we have derived the RIP condition *only* from UIP and PPP, meaning that, in *open* economies, these are *sufficient* conditions for real interest rates to be equalized. No other assumptions are needed!

[11] In advanced economic theories, the determinants of the world real interest rate are explored, with reference to consumption preferences of households and the extent to which they discount the future.

FIGURE 14-12

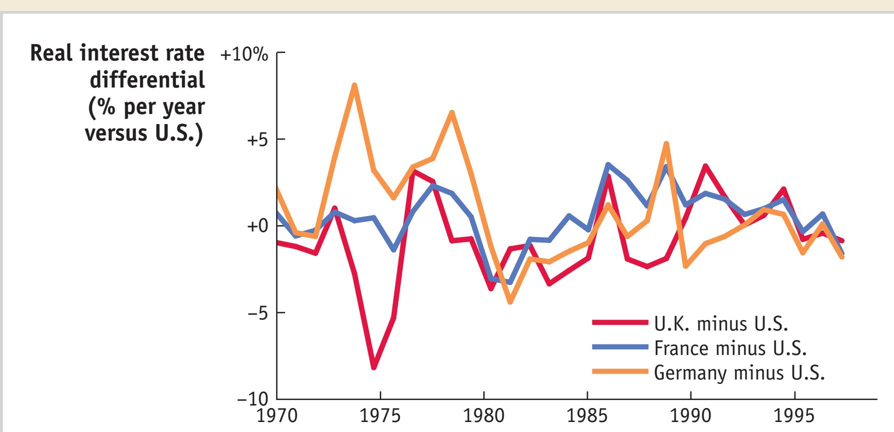


Inflation Rates and Nominal Interest Rates, 1995–2005 This scatter plot shows the relationship between the average annual nominal interest rate differential and the annual inflation differential relative to the United States over a ten-year period for a sample of 62 countries. The correlation between the two variables is strong and bears a close resemblance to the theoretical prediction of the Fisher effect that all data points would appear on the 45-degree line.

Source: IMF, International Financial Statistics.

Figure 14-12 shows that the Fisher effect is close to reality in the long run: on average, countries with higher inflation rates tend to have higher nominal interest rates, and the data line up fairly well with the predictions of the theory. Figure 14-13 shows that, for three developed countries, real interest

FIGURE 14-13



Real Interest Rate Differentials, 1970–1999 This figure shows actual real interest rate differentials over three decades for the United Kingdom, Germany, and France relative to the United States. These differentials were not zero, so real interest parity did not hold continuously. But the differentials were on average close to zero, meaning that real interest parity (like PPP) is a general long-run tendency in the data.

Source: Maurice Obstfeld and Alan M. Taylor, 2004, Global Capital Markets: Integration, Crisis, and Growth, *Japan-U.S. Center Sanwa Monographs on International Financial Markets, Cambridge: Cambridge University Press.*

parity holds fairly well in the long run: real interest differentials are not always zero, but they tend to fluctuate around zero in the long run. This could be seen as evidence in favor of long-run real interest parity. ■

The Fundamental Equation under the General Model

Now that we have an understanding of how the nominal interest rate is determined in the long run, we can apply the general model. This model differs from the simple model (the quantity theory) *only* by allowing L to vary as a function of the nominal interest rate i.

We can update our fundamental equations to allow for this change in how we treat L. For example, the fundamental equation of the monetary approach to exchange rates, Equation (14-3), can now be rewritten:

$$\textbf{(14-10)} \quad \underbrace{E_{\$/€}}_{\substack{\text{Exchange} \\ \text{rate}}} = \underbrace{\frac{P_{US}}{P_{EUR}}}_{\substack{\text{Ratio of} \\ \text{price} \\ \text{levels}}} = \frac{\left(\dfrac{M_{US}}{L_{US}(i_\$)Y_{US}}\right)}{\left(\dfrac{M_{EUR}}{L_{EUR}(i_€)Y_{EUR}}\right)} = \underbrace{\frac{(M_{US}/M_{EUR})}{(L_{US}(i_\$)Y_{US}/L_{EUR}(i_€)Y_{EUR})}}_{\substack{\text{Relative nominal money supplies divided} \\ \text{by relative real money demands}}}.$$

What have we gained from this refinement? We know that the simple model will remain valid in cases in which nominal interest rates remain unchanged in the long run. It is only when nominal interest rates change that the general model has different implications, and we now have the right tools for that situation. To explore those differences, we revisit one of the exchange rate forecasting problems we studied earlier.

Exchange Rate Forecasts Using the General Model

Earlier in the chapter, we looked at two forecasting problems *under the assumption of flexible prices*. The first was a one-time change in an otherwise constant U.S. money supply. Under the assumptions we made (stable real income in both countries and stable European money supply), this change caused a one-time increase in the U.S. price level but did not lead to a change in U.S. inflation (which was zero before and after the event). The Fisher effect tells us that if inflation rates are unchanged, then, in the long run, nominal interest rates remain unchanged. Thus, the predictions of the simple model remain valid. The more complex forecasting problem involved a change in U.S. money growth rates and it did lead to a change in inflation. It is here that the general model makes different predictions.

Recall, we assumed that U.S. and European real income growth rates are identical and equal to zero (0%), so real income levels are constant. We also assumed that European money supply is constant, so that the European price level is constant, too. This allowed us to focus on changes on the U.S. side of the model, all else equal.

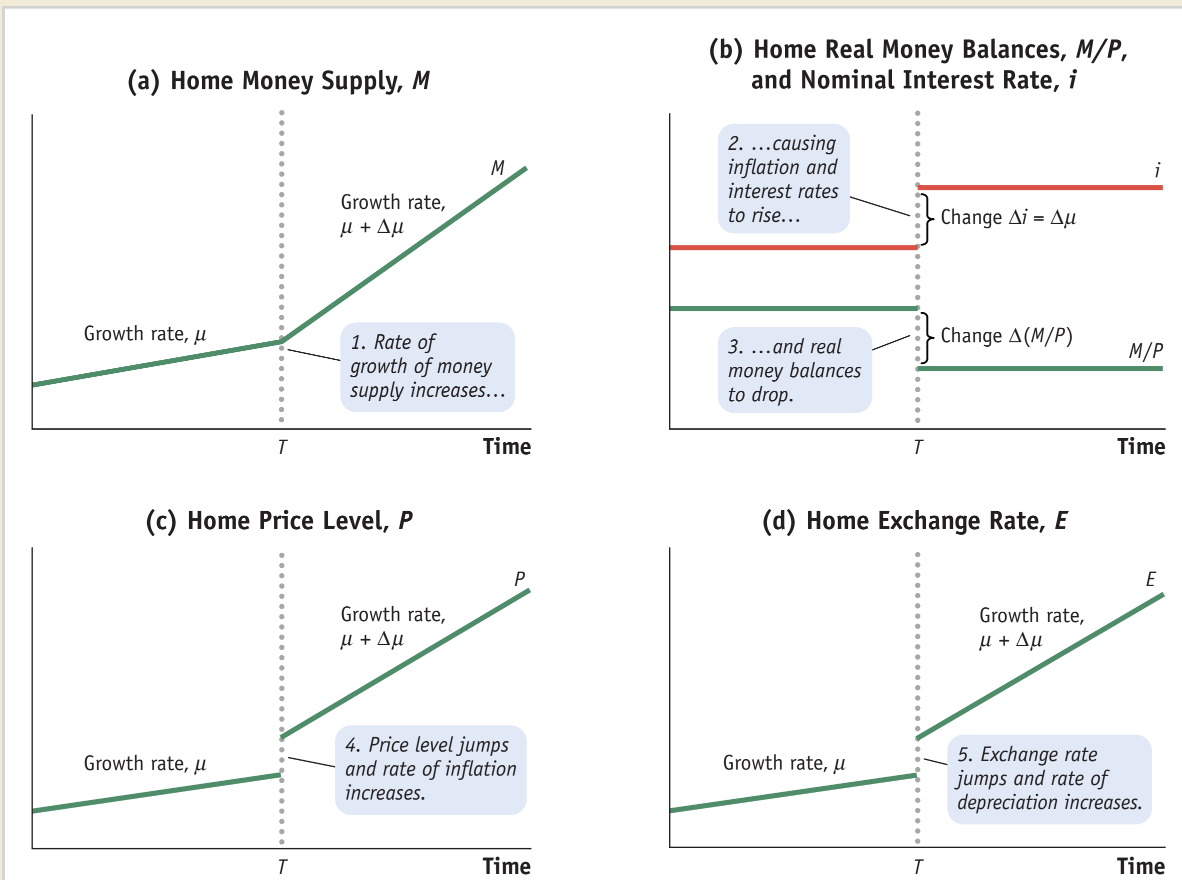
We now reexamine the forecasting problem for the case in which there is an increase in the U.S. rate of money growth. We learn at time T that the

United States will raise the rate of money supply growth from some fixed rate μ to a slightly higher rate, $\mu + \Delta\mu$.

For example, imagine an increase from 2% to 3% growth, so $\Delta\mu = 1\%$. How will the exchange rate behave in the long run? To solve the model, we make a provisional assumption that U.S. inflation rates and interest rates are constant before and after time T and focus on the differences between the two periods caused by the change in money supply growth. The story is told in Figure 14-14:

a. The money supply is growing at a constant rate. If the interest rate is constant in each period, then real money balances M/P remain constant, by assumption, since $L(i)Y$ is then a constant. If real money

FIGURE 14-14



An Increase in the Growth Rate of the Money Supply in the Standard Model Before time T, money, prices, and the exchange rate all grow at rate μ. Foreign prices are constant. In panel (a), we suppose at time T there is an increase $\Delta\mu$ in the rate of growth of home money supply M. This causes an increase $\Delta\mu$ in the rate of inflation; the Fisher effect means that there will be a $\Delta\mu$ increase in the nominal interest rate; as a result, as shown in panel (b), real money demand falls with a discrete jump at T. If real money balances are to fall when the nominal money supply expands continuously, then the domestic price level must make a discrete jump up at time T, as shown in panel (c). Subsequently, prices grow at the new higher rate of inflation; and given the stable foreign price level, PPP implies that the exchange rate follows a similar path to the domestic price level, as shown in panel (d).

balances are constant, then M and P grow at the same rate. Before T that rate is $\mu = 2\%$; after T that rate is $\mu + \Delta\mu = 3\%$. That is, U.S. inflation rises by an amount $\Delta\mu = 1\%$ at time T.

b. As a result of the Fisher effect, U.S. interest rates rise by $\Delta\mu = 1\%$ at time T. Consequently, real money balances M/P must fall at time T because $L(i)Y$ will decrease as i increases.

c. In (a) we have described the path of M. In (b) we found that M/P is constant up to T, then drops suddenly, and then is constant after time T. What path must the price level P follow? Up to time T, it is a constant multiple of M; the same applies after time T, but the constant has increased. Why? The nominal money supply grows smoothly, without a jump. So if real money balances are to drop down discontinuously at time T, the price level has to jump up discontinuously at time T. The intuition for this is that the rise in inflation and interest rates at time T prompts people to instantaneously demand less real money, but because the supply of nominal money is unchanged, the price level has to rise. Apart from this jump, P grows at a constant rate; before T that rate is $\mu = 2\%$; after T that rate is $\mu + \Delta\mu = 3\%$.

d. PPP implies that E and P must move in the same proportion, so E is always a constant multiple of P. Thus, E jumps like P at time T. Apart from this jump, E grows at a constant rate; before T that rate is $\mu = 2\%$; after T that rate is $\mu + \Delta\mu = 3\%$.

Corresponding to these four steps, Figure 14-14 illustrates the path of the key variables in this example. (Our provisional assumption of constant inflation rates and interest rates in each period is satisfied, so the proposed solution is internally consistent.)

Comparing Figure 14-14 with Figure 14-6, we can observe the subtle qualitative differences between the predictions of the simple quantity theory and those of the more general model. Shifts in the interest rate introduce jumps in real money demand. Because money supplies evolve smoothly, these jumps end up being reflected in the price levels and hence—via PPP—in exchange rates. The Fisher effect tells us that these interest rate effects are ultimately the result of changes in expected inflation.

Looking Ahead We can learn a little more by thinking through the market mechanism that produces this result. People learn at time T that money growth will be more rapid in the United States. This creates expectations of higher inflation in the United States. If people believe PPP holds in the long run, they will believe higher future inflation will cause the U.S. currency to depreciate in the future. This prospect makes holding dollars less attractive, by UIP. People try to sell dollars, and invest in euros. This creates immediate downward pressure on the dollar—even though at time T itself the supply of dollars does not change at all! This lesson underlines yet again the importance of expectations in determining the exchange rate. *Even if actual economic conditions today are completely unchanged, news about the future affects today's exchange* *rate.* This crucial insight can help us explain many phenomena relating to the volatility and instability in spot exchange rates, an idea we develop further in the chapters that follow.

5 Monetary Regimes and Exchange Rate Regimes

The monetary approach shows that, in the long run, all nominal variables—the money supply, interest rate, price level, and exchange rate—are interlinked. The approach also highlights important challenges for long-run economic policy design, to which we now turn. This is not mere digression. How these problems are solved will, in turn, have implications for exchange rate behavior and hence for the problem of forecasting the future exchange rate that we have examined.

We have repeatedly stressed the importance of inflation as an economic variable. Why is it so important? High or volatile inflation rates are considered undesirable. They may destabilize an economy or retard its growth.[12] Economies with low and stable inflation generally grow faster than those with high or volatile inflation. Inflationary crises, in which inflation jumps to a high or hyperinflationary level, are very damaging.[13]

Policy makers therefore aim to keep the price level or inflation within certain bounds. Economists would describe this kind of objective as an **inflation target,** which we can think of as an overarching aspect of the monetary policy framework. To achieve such an objective requires that policy makers be subject to some kind of constraint in the long run. Such constraints are called **nominal anchors** because they attempt to tie down a nominal variable that is potentially under the policy makers' control.

Policy makers cannot directly control prices, so the attainment of price stability in the *short run* is not feasible. The question is what can policy makers do to try to ensure that price stability is achieved in the long run and what tolerance for flexibility in policies will be allowed in the short run. Long-run nominal anchoring and short-run flexibility are the characteristics of the policy framework that economists call the **monetary regime.** In this section, we examine different types of monetary regimes in the open economy and their relationship to the exchange rate.

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[12] Macroeconomists can list numerous potential costs of inflation. Expected inflation generates a cost of holding money, a tax on transactions that adds friction to the economy; firms and workers use nominal contracts for prices and would have to change prices and recontract more often; inflation also distorts the economy when a tax system has significant nominal provisions (e.g., fixed deductions and exemptions). Unexpected inflation creates arbitrary redistributions from creditors to debtors, and this introduces risk into borrowing and lending, making interest rates and investment more costly. In short, if inflation is other than low and stable, economic life becomes at best inconvenient and at worst (as in a hyperinflation) dysfunctional. See N. Gregory Mankiw, 2007, *Macroeconomics,* 6th ed., ch. 4, New York: Worth.

[13] This evidence is merely suggestive: high inflation and slow growth may each be caused by other factors, such as weak institutions. Some studies have used sophisticated econometrics to address this problem. See Stanley Fischer, 1993, "The Role of Macroeconomic Factors in Growth," *Journal of Monetary Economics,* 32, 485–511; Robert J. Barro, 1997, *Determinants of Economic Growth,* Cambridge, MA: MIT Press; Michael Bruno and William Easterly, 1998, "Inflation Crises and Long-Run Growth," *Journal of Monetary Economics,* 41, 3–26.

The Long Run: The Nominal Anchor

Which variables could policy makers use as anchors to achieve an inflation objective in the long run? To answer the question, we can go back and rearrange the equations for relative PPP at Equation (14-2), the quantity theory in rates of change at Equation (14-6), and the Fisher effect at Equation (14-8), to obtain alternative expressions for the rate of inflation in the home country. To emphasize that these findings apply quite generally to all countries, we relabel the countries home (H) and foreign (F) instead of United States and Europe.

The three main nominal anchor choices are as follows:

- **Exchange rate target:** Relative PPP at Equation (14-2) says that the rate of depreciation equals the inflation differential, or $\Delta E_{H/F}/E_{H/F} = \pi_H - \pi_F$. Rearranging this expression suggests one way to anchor inflation is as follows:

$$\underbrace{\pi_H}_{\text{Inflation}} = \underbrace{\frac{\Delta E_{H/F}}{E_{H/F}}}_{\substack{\text{Rate of}\\\text{depreciation}}} + \underbrace{\pi_F}_{\substack{\text{Foreign}\\\text{inflation}}}.$$

Anchor variable

  Relative PPP says that home inflation equals the rate of depreciation plus foreign inflation. A simple rule would be to set the rate of depreciation equal to a constant. Under a fixed exchange rate, that constant is set at zero (a peg). Under a crawl, it is nonzero. Alternatively, there may be room for movement about a target (a band). Or there may be a vague goal to allow the exchange rate "limited flexibility." Such policies can deliver stable home inflation if PPP works well and if policy makers keep their commitment. The drawback is that PPP implies that over the long run the home country "imports" inflation from the foreign country over and above the chosen rate of depreciation. For example, under a peg, if foreign inflation rises by 1% per year, then so, too, does home inflation. Thus, countries almost invariably peg to a country with a reputation for price stability (e.g., the United States). This is a common policy choice: fixed exchange rates of some form are in use in more than half of the world's countries.

- **Money supply target:** The quantity theory suggests another way to anchor because the fundamental equation for the price level in the monetary approach says that inflation equals the excess of the rate of money supply growth over and above the rate of real income growth:

$$\underbrace{\pi_H}_{\text{Inflation}} = \underbrace{\mu_H}_{\text{Money supply growth}} - \underbrace{g_H}_{\text{Real output growth}}.$$

Anchor variable

A simple rule of this sort is: set the growth rate of the money supply equal to a constant, say 2% per annum. The printing presses are put on automatic pilot, and no human interference should be allowed. Essentially, the central bank is run by robots. This would be a truly hard rule, if applied. The drawback is that real income growth, the final term in the previous equation, can be unstable. In periods of high growth, inflation will be below target. In periods of low growth, inflation will be above target. For this reason, money supply targets are waning in popularity or are used in conjunction with other targets. For example, the European Central Bank claims to use monetary growth rates as a partial guide to policy, but nobody is quite sure how serious it is.

- **Inflation target plus interest rate policy:** The Fisher effect suggests yet another anchoring method:

$$\underbrace{\pi^e_H}_{\substack{\text{Inflation}\\\text{(expected)}}} = \underbrace{i_H}_{\text{Nominal interest rate}} - \underbrace{r^*}_{\text{World real interest rate}}.$$

Anchor variable

The Fisher effect says that home inflation is the home nominal interest rate minus the foreign real interest rate. If the latter can be assumed to be constant, then as long as the average nominal interest rate is kept stable, inflation can also be kept stable. This type of nominal anchoring framework is an increasingly common policy choice. Assuming a stable world real interest rate turns out not to be a bad assumption. (And in principle, the target level of the nominal interest rate could be adjusted if necessary.) More or less hard versions of the rule can be imagined. A central bank could peg the nominal interest rate at a fixed level at all times, but such rigidity is rarely seen and central banks usually adjust interest rates in the short run to meet other goals. For example, if the world real interest rate is $r^* = 2.5\%$, and the country's long-run inflation target is 2%, then its long-run nominal interest rate ought to be on average equal to 4.5% (because 2.5 = 4.5 minus 2). This would be termed the *neutral* level of the nominal interest rate. But in the short run, the central bank might use some discretion to set interest rates above or below this neutral level.

The Choice of a Nominal Anchor and Its Implications Under the assumptions we have made, any of the three nominal anchor choices are valid. If a particular long-run inflation objective is to be met, then, all else equal, the first equation says it will be consistent with one particular rate of depreciation the second equation says it will be consistent with one particular rate of money suppression; the third equation says it will be consistent with one particular rate of interest. But if policy makers announced targets for all three variables, they would be able to match all three consistently only by chance. Two observations follow.

First, using more than one target may be problematic. Under a fixed exchange rate regime, policy makers cannot employ any target other than the exchange rate. However, they may be able to use a mix of different targets if

NET WORK

Visit the websites of some central banks around the world, for example, the U.S. Federal Reserve (http://www.federalreserve.gov/) and the European Central Bank (http://www.ecb.int/). Read their main statements of policy. Try to find out what their policy goals are *in the long run*. Who sets them? Is there more than one goal? What about a nominal anchor—is controlling inflation a long-run goal? If so, what policy is used to try to ensure that the long-run inflation goal will be met? In the short run, is the main tool they use for implementing their policy the quantity of money, the exchange rate, or the interest rate?

SIDE BAR

Nominal Anchors in Theory and Practice

An appreciation of the importance of nominal anchors has transformed monetary policy making and inflation performance throughout the global economy in recent decades.

In the 1970s, most of the world was struggling with high inflation. An economic slowdown prompted central banks everywhere to loosen monetary policy. In advanced countries, a move to floating exchange rates allowed great freedom for them to loosen their monetary policy. Developing countries had already proven vulnerable to high inflation and now many of them were exposed to even worse inflation. Those who were pegged to major currencies imported high inflation via PPP. Those who weren't pegged struggled to find a credible nominal anchor as they faced economic downturns of their own. High oil prices everywhere contributed to inflationary pressure.

In the 1980s, inflationary pressure continued in many developed countries, and in many developing countries high levels of inflation, and even hyperinflations, were not uncommon. Governments were forced to respond to public demands for a more stable inflation environment. In the 1990s, policies designed to create effective nominal anchors were put in place in many countries.

One study found that the use of explicit targets, whether for the exchange rate, money, or inflation, grew markedly in the 1990s, replacing regimes in which there had previously been no explicit nominal anchor:

- The number of countries in the study with exchange rate targets increased from 30 to 47. The number with money targets increased from 18 to 39. The number with inflation targets increased most dramatically, almost sevenfold, from 8 to 54.
- Many countries had more than one target in use: in 1998 55% of the sample announced an explicit target (or monitoring range) for more than one of the exchange rate, money, and inflation.*

Most, but not all, of those policies have turned out to be credible, too, thanks to political developments in many countries that have fostered **central-bank independence.** Independent central banks stand apart from the interference of politicians: they have operational freedom to try to achieve the inflation target, and they may even play a role in setting that target.

Overall, these efforts are judged to have achieved some success, although in many countries inflation had already been brought down substantially in the early to mid-1980s before inflation targets and institutional changes were implemented.

Table 14-2 shows a steady decline in average levels of inflation since the early 1980s. The lowest levels of inflation are seen in the advanced economies, although developing countries have also started to make some limited progress. In the industrial countries, central-bank independence is now commonplace (it was not in the 1970s), but in developing countries it is still relatively rare.

TABLE 14-2

Global Disinflation Cross-country data from 1980 to 2004 show the gradual reduction in the annual rate of inflation around the world. This disinflation process began in the rich, advanced economies in the early 1980s. The poorer emerging markets and developing countries suffered from even higher rates of inflation, although these finally began to fall in the 1990s.

	Annual Inflation Rate (%)				
	1980–1984	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2004**
World	14.1	15.5	30.4	8.4	3.9
Advanced economies	8.7	3.9	3.8	2.0	1.8
Emerging markets and developing countries	31.4	48.0	53.2	13.1	5.6

Source: Kenneth Rogoff, 2003, "Globalization and Global Disinflation," Economic Review, *Federal Reserve Bank of Kansas City, IV, 45–78.*

* *Gabriel Sterne, 1999, "The Use of Explicit Targets for Monetary Policy: Practical Experiences of 91 Economies in the 1990s,"* Bank of England Quarterly Bulletin, *39(3), August, 272–281.*

they adopt an intermediate regime, such as a managed exchange rate with limited flexibility. Table 14-3 illustrates the ways in which the choice of a target as a nominal anchor affects the choice of exchange rate regime. Obviously, these are not independent choices. But a variety of choices do exist. Thus: *Nominal anchoring is possible with a variety of exchange rate regimes.*

TABLE 14-3

Exchange Rate Regimes and Nominal Anchors This table illustrates the possible exchange rate regimes that are consistent with various types of nominal anchors. Countries that are dollarized or in a currency union have a "superfixed" exchange rate target. Pegs, bands, and crawls also target the exchange rate. Managed floats have no preset path for the exchange rate, which allows other targets to be employed. Countries that float freely or independently are judged to pay no serious attention to exchange rate targets; if they have anchors, they will involve monetary targets or inflation targets with an interest rate policy. The countries with "freely falling" exchange rates have no serious target and have high rates of inflation and depreciation. It should be noted that many countries engage in implicit targeting (e.g., inflation targeting) without announcing an explicit target and that some countries may use a mix of more than one target.

	Compatible Exchange Rate Regimes				
Type of Nominal Anchor	**Countries without a Currency of Their Own**	**Pegs/ Bands/ Crawls**	**Managed Floating**	**Freely Floating**	**Freely Falling (rapid depreciation)**
Exchange rate target	✔	✔	✔		
Money supply target			✔	✔	
Inflation target (plus interest rate policy)			✔	✔	
None				✔	✔

Second, whatever target choice is made, a country that commits to a target as a way of nominal anchoring is committing itself to set future money supplies and/or interest rates in such a way as to meet the target. Only one such policy choice will be compatible with the target. Thus: *A country with a nominal anchor sacrifices monetary policy autonomy in the long run.* (See **Side Bar: Nominal Anchors in Theory and Practice.**)

6 Conclusions

This chapter emphasized the determinants of exchange rates in the long run using the monetary approach. We employed purchasing power parity and a simple monetary model (the quantity theory) to study an equilibrium in which goods are arbitraged and prices are flexible. Under these assumptions, in the home country, changes in the money supply pass through into proportional changes in the price level and the exchange rate.

We also found that uncovered interest parity and purchasing power parity implied that real interest rates are equalized across countries. This helped us develop a monetary model that was more complex—and more realistic—because it allowed money demand to fluctuate in response to changes in the interest rate. In that setting, increases in money growth lead to higher inflation and a higher nominal interest rate and, hence, via decreases in money demand, to even higher price levels. Still, the same basic intuition holds, and one-time changes in the money supply still lead to proportionate changes in prices and exchange rates.

The monetary approach to exchange rates provides a basis for certain kinds of forecasting and policy analysis using the flexible-price model in the long run. But such forecasts matter even in the short run because today's spot exchange rate depends, like all asset prices, on the exchange rate expected to prevail in the future. To make these connections clear, in the next chapter we bring ideas from Chapters 13 and 14 together to form a complete model of the exchange rate.

KEY POINTS

1. Purchasing power parity (PPP) implies that the exchange rate should equal the relative price level in the two countries, and the real exchange rate should equal 1.
2. Evidence for PPP is weak in the short run and more favorable in the long run. In the short run, deviations are common and changes in the real exchange rate do occur. The failure of PPP in the short run is primarily the result of price stickiness, and market frictions and imperfections that limit arbitrage.
3. A simple monetary model (the quantity theory) explains price levels in terms of money supply levels and real income levels. Because PPP can explain exchange rates in terms of price levels, the two together can be used to develop a monetary approach to the exchange rate.
4. If we can forecast money supply and income, we can use the monetary approach to forecast the level of the exchange rate at any time in the future. However, the monetary approach is valid only under the assumption that prices are flexible. This assumption is more likely to hold in the long run, so the short-run forecast is not reliable. Evidence for PPP and the monetary approach is more favorable in the long run.
5. PPP theory, combined with uncovered interest parity, leads to the strong implications of the Fisher effect (interest differentials between countries should equal inflation differentials). The Fisher effect says that changes in local inflation rates pass through one for one into changes in local nominal interest rates. The result implies real interest parity (expected real interest rates should be equalized across countries). Because these results rest on PPP, they should be viewed only as long-run results, and the evidence is somewhat favorable.
6. We can augment the simple monetary model (quantity theory) to allow for the demand for real money balances to decrease as the nominal interest rate rises. This leads to the general monetary model. Its predictions are similar to those of the simple model, except that a one-time rise in money growth rates leads to a one-time rise in inflation, which leads to a one-time drop in real money demand, which in turn causes a one-time jump in the price level and the exchange rate.
7. The monetary approach to exchange rate determination in the long run has implications for economic policy. Policy makers and the public generally prefer a low-inflation environment. Various policies based on exchange rates, money growth, or interest rates have been proposed as nominal anchors. Recent decades have seen a worldwide decline in inflation thanks to the explicit recognition of the need for nominal anchors.

KEY TERMS

monetary approach to exchange rates, p. 502
law of one price (LOOP), p. 503
purchasing power parity (PPP), p. 503
absolute PPP, p. 505
real exchange rate, p. 505
real depreciation, p. 505
real appreciation, p. 505
overvalued, p. 506
undervalued, p. 506
inflation, p. 506
relative PPP, p. 508

money, p. 514
central bank, p. 516
money supply, p. 516
money demand, p. 516
quantity theory of money, p. 517
fundamental equation of the monetary model of the price level, p. 518
fundamental equation of the monetary approach to exchange rates, p. 519
hyperinflation, p. 525
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Fisher effect, p. 533
real interest rate, p. 533
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world real interest rate, p. 534
inflation target, p. 539
nominal anchors, p. 539
monetary regime, p. 539
exchange rate target, p. 540
money supply target, p. 540
inflation target plus interest rate policy, p. 543
central-bank independence, p. 542

PROBLEMS

1. Suppose that two countries, Vietnam and Côte d'Ivoire, produce coffee. The currency unit used in Vietnam is the dong (VND). Côte d'Ivoire is a member of Communaute Financiere Africaine (CFA), a currency union of West African countries that use the CFA franc (XOF). In Vietnam, coffee sells for 5,000 dong (VND) per pound of coffee. The exchange rate is 30 VND per 1 CFA franc, $E_{VND/XOF} = 30$.
   a. If the law of one price holds, what is the price of coffee in Côte d'Ivoire, measured in CFA francs?
   b. Assume the price of coffee in Côte d'Ivoire is actually 160 CFA francs per pound of coffee. Compute the relative price of coffee in Côte d'Ivoire versus Vietnam. Where will coffee traders buy coffee? Where will they sell coffee in this case? How will these transactions affect the price of coffee in Vietnam? In Côte d'Ivoire?

2. Consider each of the following goods and services. For each, identify whether the law of one price will hold, and state whether the relative price $q^g_{Foreign/US}$ is greater than, less than, or equal to 1. Explain your answer in terms of the assumptions we make when using the law of one price.
   a. Rice traded freely in the United States and Canada
   b. Sugar traded in the United States and Mexico; the U.S. government imposes a quota on sugar imports into the United States
   c. The McDonald's Big Mac sold in the United States and Japan
   d. Haircuts in the United States and the United Kingdom

3. Use the table that follows to answer this question. Suppose the cost of the market basket in the United States is P_{US} = \$190. Check to see whether purchasing power parity (PPP) holds for each of the countries listed, and determine whether we should expect a real appreciation or real depreciation for each country (relative to the United States) in the long run. For the answer, create a table similar to the one shown and fill in the blank cells. (Hint: Use a spreadsheet application such as Excel.)

Country (currency measured in FX units)	Per \$, $E_{FX/\$}$	Price of Market Basket (in FX)	Price of U.S. Basket in FX (P_{us} times $E_{FX/\$}$)	Real Exchange Rate, q	Does PPP Hold? (yes/no)	Is FX Currency Overvalued or Undervalued?	Is FX Currency Expected to Have Real Appreciation or Depreciation?
Brazil (real)	2.1893	520					
Cyprus (Cy£)	0.45	75					
India (rupee)	46.6672	12,000					
Mexico (peso)	11.0131	1,800					
South Africa (rand)	6.9294	800					
Zimbabwe (ZW\$)	101,347	4,000,000					

4. Table 14-1 in the text shows the percentage undervaluation or overvaluation in the Big Mac, based on exchange rates in February 2007. Suppose purchasing power parity holds in the long run, so that these deviations would be expected to disappear. Suppose the local currency prices of the Big Mac remained unchanged. Exchange rates in June 2007 were as follows:

Country	Per U.S. $
Australia (A$)	1.20
Brazil (real)	2.02
Canada (C$)	1.12
Denmark (krone)	5.49
Eurozone (euro)	0.736
Japan (yen)	118.47
Mexico (peso)	10.97
Sweden (krona)	6.77

Based on the these data and Table 14-1, for which countries were the PPP-based exchange rate predictions derived from the Big Mac Index correct? For which were they incorrect? How might you explain the failure of the Big Mac Index to correctly predict the change in the nominal exchange rate between February and June 2007?

5. You are given the following information. The current dollar-pound exchange rate is $2 per pound. A U.S. basket that costs $100 would cost $120 in the United Kingdom. For the next year, the Fed is predicted to keep U.S. inflation at 2% and the Bank of England is predicted to keep U.K. inflation at 3%. The speed of convergence to absolute PPP is 15% per year.
   a. What is the expected U.S. minus U.K. inflation differential for the coming year?
   b. What is the current U.S. real exchange rate $q_{UK/US}$ with the United Kingdom?
   c. How much is the dollar overvalued/undervalued?
   d. What do you predict the U.S. real exchange rate with the United Kingdom will be in one year's time?
   e. What is the expected rate of real depreciation for the United States (versus the United Kingdom)?
   f. What is the expected rate of nominal depreciation for the United States (versus the United Kingdom)?
   g. What do you predict will be the dollar price of one pound a year from now?

6. Describe how each of the following factors might explain why PPP is a better guide for exchange rate movements in the long run, versus the short run: (i) transactions costs, (ii) nontraded goods, (iii) imperfect competition, (iv) price stickiness. As markets become increasingly integrated, do you suspect PPP will become a more useful guide in the future? Why or why not?

7. Consider two countries: Japan and Korea. In 1996 Japan experienced relatively slow output growth (1%), while Korea had relatively robust output growth (6%). Suppose the Bank of Japan allowed the money supply to grow by 2% each year, while the Bank of Korea chose to maintain relatively high money growth of 12% per year.

   For the following questions, use the simple monetary model (where L is constant). You will find it easiest to treat Korea as the home country and Japan as the foreign country.
   a. What is the inflation rate in Korea? In Japan?
   b. What is the expected rate of depreciation in the Korean won relative to the Japanese yen?
   c. Suppose the Bank of Korea increases the money growth rate from 12% to 15%. If nothing in Japan changes, what is the new inflation rate in Korea?
   d. Using time series diagrams, illustrate how this increase in the money growth rate affects the money supply M_K, Korea's interest rate, prices P_K, real money supply, and $E_{\text{won}/¥}$ over time. (Plot each variable on the vertical axis and time on the horizontal axis.)
   e. Suppose the Bank of Korea wants to maintain an exchange rate peg with the Japanese yen. What money growth rate would the Bank of Korea have to choose to keep the value of the won fixed relative to the yen?
   f. Suppose the Bank of Korea sought to implement policy that would cause the Korean won to appreciate relative to the Japanese yen. What ranges of the money growth rate

(assuming positive values) would allow the Bank of Korea to achieve this objective?

8. This question uses the general monetary model, where L is no longer assumed constant, and money demand is inversely related to the nominal interest rate. Consider the same scenario described in the beginning of the previous question. In addition, the bank deposits in Japan pay 3% interest, $i_{¥} = 3\%$.
   a. Compute the interest rate paid on Korean deposits.
   b. Using the definition of the real interest rate (nominal interest rate adjusted for inflation), show that the real interest rate in Korea is equal to the real interest rate in Japan. (Note that the inflation rates you computed in the previous question will be the same in this question.)
   c. Suppose the Bank of Korea increases the money growth rate from 12% to 15% and the inflation rate rises proportionately (one for one) with this increase. If the nominal interest rate in Japan remains unchanged, what happens to the interest rate paid on Korean deposits?
   d. Using time series diagrams, illustrate how this increase in the money growth rate affects the money supply, M_K; Korea's interest rate; prices, P_K; real money supply; and $E_{won/¥}$ over time. (Plot each variable on the vertical axis and time on the horizontal axis.)

9. Both advanced economies and developing countries have experienced a decrease in inflation since the 1980s (see Table 14-2 in the text). This question considers how the choice of policy regime has influenced this global disinflation. Use the monetary model to answer this question.
   a. The Swiss Central Bank currently targets its money growth rate to achieve policy objectives. Suppose Switzerland has output growth of 3% and money growth of 8% each year. What is Switzerland's inflation rate in this case? Describe how the Swiss Central Bank could achieve an inflation rate of 2% in the long run through the use of a nominal anchor.
   b. Like the Federal Reserve, the Reserve Bank of New Zealand uses an interest rate target. Suppose the Reserve Bank of New Zealand maintains a 6% interest rate target and the world *real* interest rate is 1.5%. What is the New Zealand inflation rate in the long run? In 1997 New Zealand adopted a policy agreement that required the bank to maintain an inflation rate no higher than 2.5%. What interest rate targets would achieve this objective?
   c. The National Bank of Slovakia maintains an exchange rate band relative to the euro. This is a prerequisite for joining the Eurozone. The Slovak Republic must keep its exchange rate within ±15% of the central parity of 35.4424 koruna per euro. Compute the exchange rate values corresponding to the upper and lower edges of this band. Suppose PPP holds. If Eurozone inflation is currently 2% per year and inflation in Slovakia is 5%, compute the rate of depreciation of the koruna. Will Slovakia be able to maintain the band requirement? For how long? Does your answer depend on where in the band the exchange rate currently sits? A primary objective of the European Central Bank is price stability (low inflation) in the current and future Eurozone. Is an exchange rate band a necessary or sufficient condition for the attainment of this objective?

10. Several countries that have experienced hyperinflation adopt dollarization as a way to control domestic inflation. For example, Ecuador has used the U.S. dollar as its domestic currency since 2000. What does dollarization imply about the exchange rate between Ecuador and the United States? Why might countries experiencing hyperinflation adopt dollarization? Why might they do this rather than just fixing their exchange rate?

11. You are the central banker for a country that is considering the adoption of a new nominal anchor. When you take the position as chairperson, the inflation rate is 4% and your position as the central bank chairperson requires that you achieve a 2.5% inflation target within the next year. The economy's growth in real output is currently 3%. The world real interest rate is currently 1.5%. The currency used in your country is the lira. *Assume prices are flexible.*

a. Why is having a nominal anchor important for you to achieve the inflation target? What is the drawback of using a nominal anchor?

b. What is the growth rate of the money supply in this economy? If you choose to adopt a money supply target, which money supply growth rate will allow you to meet your inflation target?

c. Suppose the inflation rate in the United States is currently 2% and you adopt an exchange rate target relative to the U.S. dollar. Compute the percent appreciation/depreciation in the lira needed for you to achieve your inflation target. Will the lira appreciate or depreciate relative to the U.S. dollar?

d. Your final option is to achieve your inflation target using interest rate policy. Using the Fisher equation, compute the current nominal interest rate in your country. What nominal interest rate will allow you to achieve the inflation target?