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Introduction to Exchange Rates and the Foreign Exchange Market

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The chapter on the Fall of the Rupee you may omit. It is somewhat too sensational.
Miss Prism, in Oscar Wilde's *The Importance of Being Earnest*, 1895

The people who benefit from roiling the world currency market are speculators and as far as I am concerned they provide not much useful value.
Paul O'Neill, U.S. Secretary of the Treasury, 2002

Every few years, George, an American, takes a vacation in Paris. To make purchases in Paris, he buys foreign currency, or *foreign exchange.* He can purchase euros, the currency used in France, by trading his U.S. dollars for them in the *market for foreign exchange* at the prevailing market *exchange rate.* In 2003, 1 euro could be purchased for $1.10, so the €100 he spent on a night at the hotel cost him $110 in U.S. currency. In 2007, 1 euro cost $1.32, so each night at the same hotel (where the room price hadn't changed) made a $132 dent in his vacation budget. In 2010, 1 euro cost $1.24, not as much as in 2007, but still expensive enough in dollar terms to make George think about vacationing in northern California, where he reckoned he might find equally good hotels, restaurants, fine food, and wine at prices that were more affordable.

Tourists like George are not the only people affected by exchange rates. Exchange rates affect large flows of international trade by influencing the prices in different currencies of the imported goods and services we buy and the exported goods and services we sell. Foreign exchange also facilitates massive flows of international investment, which include the direct investments made by multinationals in overseas firms as well as the stock and bond trades made by individual investors and fund managers seeking to diversify their portfolios.

Individual foreign exchange transactions are far removed from deep macroeconomic and political consequences. In the aggregate, however, activity in the foreign exchange market can be responsible for "sensational" events (and we are not being ironic, unlike Oscar Wilde in the chapter opening quote) and can arouse strong passions (Paul O'Neill is only one of many to criticize the activities of foreign exchange traders). In the foreign exchange market, trillions of dollars are traded each day and the economic implications of shifts in the market can be dramatic. In times of crisis, the fates of nations and their leaders seem to hang, in part, on the state of the currency market. Why is that so?

In this chapter, we begin to study the nature and impact of activity in the foreign exchange market. We first survey exchange rate basics: the key definitions of exchange rates and related concepts. We then examine the evidence to see how exchange rates behave in the real world and establish some basic facts about exchange rate behavior that require explanation. We next look at the workings of the foreign exchange market, including the role of private participants as well as interventions by governments. Finally, we look in detail at how foreign exchange markets work, and we emphasize two key market mechanisms: *arbitrage* and *expectations*.

1 Exchange Rate Essentials

An **exchange rate** (E) is the price of some foreign currency expressed in terms of a home (or domestic) currency. Because an exchange rate is the relative price of two currencies, it may be quoted in either of two ways:

1. The number of home currency units that can be exchanged for one unit of foreign currency. For example, if the United States is considered home, the dollar/euro exchange rate might be $1.15 per euro (or 1.15 $/€). To buy one euro, you would have to pay $1.15.
2. The number of foreign currency units that can be exchanged for one unit of home currency. For example, the 1.15$/€ exchange rate can also be expressed as €0.87 per U.S. dollar (or 0.87 €/$). To buy one dollar, you would have to pay €0.87.

Knowing the format in which exchange rates are quoted is essential to avoid confusion, so we now establish a systematic rule, even if it is arbitrary.

Defining the Exchange Rate

It is common practice to quote the prices of items traded, whether goods or assets, as units of home currency per unit purchased. In the United States, coffee might be sold at 10 dollars per pound ($/lb); in France, at 20 euros per kilogram (€/kg).[1]

The usual way to quote the price of foreign currency is no different: units of home currency per unit of foreign currency. Confusion may arise because the price then depends on the perspective of the observer. Consider the dollar-euro exchange rate. For the U.S. citizen, who is accustomed to prices expressed as $/unit, the price of a foreign currency (say, the euro) is in terms of $/€. For someone in the Eurozone, however, the convention is to quote prices as €/unit, so €/$ would be the natural choice.

To avoid confusion, we must specify which country is the home country and which is foreign. Throughout the remaining chapters of this book, when we refer to a particular

[1] Coffee prices could also be quoted as 0.1 lb/$ or 0.05 kg/€, but this format is not the norm.

country's exchange rate, we will quote it in terms of units of home currency per units of foreign currency. For example, Denmark's exchange rate with the Eurozone is quoted as Danish krone per euro (or kr/€).

From now on, $E_{1/2}$ will denote the exchange rate in units of country 1 currency per unit of country 2 currency; it is the rate at which country 1's currency can be exchanged for one unit of country 2's currency. For example, $E_{\$/€}$ is the U.S. exchange rate (against the euro) in U.S. dollars per euro. In our previous example, $E_{\$/€}$ was 1.15 $/€.

We see different expressions of the same exchange rate all the time—even on the same page in the same publication! So it is important to keep things straight. Table 2-1 presents a typical display of exchange rate information as one might see it in the financial press.[2] Column (1) shows the reported price of U.S. dollars in various currencies (e.g., €/$); columns (2) and (3) show, respectively, the most recent price of British pounds sterling (e.g., $/£) and euros (e.g., $/€) on June 30, 2010.[3] Thus, the first three entries show the Canadian dollar's exchange rate against the U.S. dollar, the pound, and the euro. For comparison, columns (4) to (6) show the same rates one year earlier.

TABLE 2-1

Exchange Rate Quotations This table shows major exchange rates as they might appear in the financial media. Columns (1) to (3) show rates on June 30, 2010. For comparison, columns (4) to (6) show rates on June 30, 2009. For example, column (1) shows that on June 30, 2010, one U.S. dollar was worth 1.063 Canadian dollars, 6.081 Danish krone, 0.816 euros, and so on. The euro-dollar rates appear in bold type.

		EXCHANGE RATES ON JUNE 30, 2010			EXCHANGE RATES ON JUNE 30, 2009 *ONE YEAR PREVIOUSLY*		
		(1)	(2)	(3)	(4)	(5)	(6)
Country (currency)	Currency Symbol	Per $	Per £	Per €	Per $	Per £	Per €
Canada (dollar)	C$	1.063	1.590	1.302	1.161	1.913	1.629
Denmark (krone)	DKr	6.081	9.098	7.449	5.309	8.743	7.447
Euro (euro)	€	**0.816**	1.221	—	**0.713**	1.174	—
Japan (yen)	¥	88.49	132.39	108.39	96.49	158.90	135.34
Norway (krone)	NKr	6.503	9.729	7.966	6.437	10.600	9.028
Sweden (krona)	SKr	7.782	11.643	9.532	7.748	12.760	10.868
Switzerland (franc)	SFr	1.078	1.613	1.321	1.088	1.791	1.526
United Kingdom (pound)	£	0.668	—	0.819	0.607	—	0.852
United States (dollar)	$	—	1.496	**1.225**	—	1.647	**1.403**

Source: ft.com

[2] These are typically *midrange* or *central* rates—an end-of-day average of buying and selling rates from the market. As we discuss later in the chapter, such rates do not allow for the differences or *spreads*, between the prices at which currencies are bought and sold. In any market in which intermediaries are present, commissions and fees push buying prices above selling prices.
[3] The currency's price in terms of itself equals 1 and is omitted.

The four bold entries in this table correspond to the dollar-euro exchange rate. On June 30, 2010, for example, the euro was quoted at $1.225 per euro. According to our definition, this is the price from the U.S. perspective and it is sometimes called the *American terms*. Conversely, the dollar is quoted at €0.816 per dollar, the *European terms*.

We write these exchange rates using mathematical symbols as follows, with care given to the explicit expression of the relevant units:

$$E_{\$/€} = 1.225 = \text{U.S. exchange rate (American terms)}$$

$$E_{€/\$} = 0.816 = \text{Eurozone exchange rate (European terms)}$$

Just as there is complete equivalence when we express the relative price of coffee and dollars at 10 $/lb or 0.1 lb/$, the price of the euro in terms of dollars always equals the reciprocal (or inverse) of the price of dollars in terms of euros. Hence,

$$E_{\$/€} = \frac{1}{E_{€/\$}}$$

In our example,

$$1.225 = \frac{1}{0.816}$$

Similar calculations and notations apply to any pair of currencies.

Appreciations and Depreciations

Like many financial tables, Table 2-1 includes information on how prices have changed over time. Over the previous 12 months, the Eurozone exchange rate *increased* from $E_{€/\$} = 0.713$ a year ago to $E_{€/\$} = 0.816$ on June 30, 2010. The value of the euro relative to the dollar went down—more euros were needed to buy one dollar. This change is often described by saying that the euro got "weaker" or "weakened" against the dollar.

Symmetrically, the value of the dollar in euro terms also changed. We see this by computing the reciprocal American terms. Over the same year, the U.S exchange rate *decreased* from $E_{\$/€} = 1/0.713 = 1.403$ a year ago to $E_{\$/€} = 1/0.816 = 1.225$ on June 30, 2010. The value of the dollar relative to the euro went up—fewer dollars were needed to buy one euro. This change is often described by saying that the dollar got "stronger" or "strengthened" against the euro.

If one currency buys more of another currency, we say it has experienced an **appreciation**—its value has *risen*, *appreciated*, or *strengthened*. If a currency buys less of another currency, we say it has experienced a **depreciation**—its value has *fallen*, *depreciated*, or *weakened*.

In our example, we can understand appreciation and depreciation from both the U.S. and European perspective; this lesson generalizes to all other currency pairs.

In U.S. terms, the following holds true:

- When the U.S. exchange rate $E_{\$/€}$ *rises*, more dollars are needed to buy one euro. The price of one euro goes up in dollar terms, and the U.S. dollar experiences a depreciation.
- When the U.S. exchange rate $E_{\$/€}$ *falls*, fewer dollars are needed to buy one euro. The price of one euro goes down in dollar terms, and the U.S. dollar experiences an appreciation.

Similarly, in European terms, the following holds true:

- When the Eurozone exchange rate $E_{€/\$}$ *rises*, the price of one dollar goes up in euro terms and the euro experiences a depreciation.
- When the Eurozone exchange rate $E_{€/\$}$ *falls*, the price of one dollar goes down in euro terms and the euro experiences an appreciation.

If the dollar is appreciating against the euro, the euro must simultaneously be depreciating against the dollar. Because they are the reciprocal of each other, changes in $E_{\$/€}$ and $E_{€/\$}$ must always move in opposite directions.

It may seem confusing or counterintuitive that a fall in the U.S. exchange rate means the dollar is appreciating. Yet it is reasonable because we express the price of foreign currency in dollars, just as we express the prices of other goods. When the price of coffee falls from \$10 to \$9 per pound, it seems sensible to say that coffee is depreciating or falling in value—but relative to what? The dollars—the currency in which the price is denominated. Conversely, dollars are *appreciating* against coffee because it takes fewer dollars to buy the same amount of coffee! If we keep this analogy in mind, it makes sense that when the dollar price of a euro falls, the dollar has appreciated against the euro.

In addition to knowing whether a currency has appreciated or depreciated, we are often interested in the knowing the size of an appreciation or depreciation. To do this, we can calculate the proportional or fractional change in the foreign-currency value of the home currency. This proportional change is usually expressed in percentage terms.

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Exchange rate humor.

In the previous example, we would describe these changes as follows:

- In 2009, at time t, the dollar value of the euro was $E_{\$/€,t} = \$1.403$.
- In 2010, at time $t + 1$, the dollar value of the euro was $E_{\$/€,t+1} = \$1.225$.
- The change in the dollar value of the euro was $\Delta E_{\$/€,t} = 1.225 - 1.403 = \$-0.178$.
- The percentage change was $\Delta E_{\$/€,t} / E_{\$/€,t} = -0.178/1.403 = -12.7\%$.
- Thus, the euro *depreciated* against the dollar by 12.7%.

Similarly, over the same year:

- In 2009, at time t, the euro value of the dollar was $E_{€/\$,t} = €0.713$.
- In 2010, at time $t + 1$, the euro value of the dollar was $E_{€/\$,t+1} = €0.816$.
- The change in the euro value of the dollar was $\Delta E_{€/\$,t} = 0.816 - 0.713 = €+0.103$.
- The percentage change was $\Delta E_{€/\$,t} / E_{€/\$,t} = +0.103/0.713 = +14.4\%$.
- Thus, the dollar *appreciated* against the euro by 14.4%.

Note that the size of one country's appreciation (here 14.4%) does not exactly equal the size of the other country's depreciation (here 12.7%). For small changes, however, the opposing movements are *approximately* equal. For example, if the

U.S. terms move slightly from \$1.00 to \$1.01 per euro, the European terms move from €1.00 to €0.99099; a 1% euro appreciation is approximately a 1% dollar depreciation.[4]

Multilateral Exchange Rates

Our discussion of exchange rates has focused on the simplest type of exchange rate between two countries or currencies, what economists refer to as a *bilateral* exchange rate. In reality, we live in a world of many countries and many currencies, and it is of great practical importance to ask whether a particular currency has strengthened or weakened not just against one other currency, but against other currencies in general.

The answer is not always obvious. For example, the U.S. dollar may be depreciating against some currencies, while remaining fixed or appreciating against others. To aggregate these different trends in bilateral exchange rates into one measure, economists calculate *multilateral* exchange rate changes for baskets of currencies using *trade weights* to construct an average of all the bilateral changes for each currency in the basket. The resulting measure is called the change in the **effective exchange rate.**

For example, suppose 40% of Home trade is with country 1 and 60% is with country 2; Home's currency appreciates 10% against 1 but depreciates 30% against 2. To calculate the change in Home's effective exchange rate, we multiply each exchange rate change by the corresponding trade share and then add up: $(-10\% \cdot 40\%) + (30\% \cdot 60\%) = (-0.1 \cdot 0.4) + (0.3 \cdot 0.6) = -0.04 + 0.18 = 0.14 = +14\%$. In this example, Home's effective exchange rate has depreciated by 14%.

In general, suppose there are N currencies in the basket, and Home's trade with the N partners is $\text{Trade} = \text{Trade}_1 + \text{Trade}_2 + \ldots + \text{Trade}_N$. Applying trade weights to each bilateral exchange rate change, the home country's effective exchange rate ($E_{\text{effective}}$) will change according to the following weighted average:

$$\frac{\Delta E_{\text{effective}}}{E_{\text{effective}}} = \underbrace{\frac{\Delta E_1}{E_1}\frac{\text{Trade}_1}{\text{Trade}} + \frac{\Delta E_2}{E_2}\frac{\text{Trade}_2}{\text{Trade}} + \ldots + \frac{\Delta E_N}{E_N}\frac{\text{Trade}_N}{\text{Trade}}}_{\text{Trade-weighted average of bilateral nominal exchange rate changes}}$$

Many discussions among policy makers and in the financial press focus on the effective exchange rate. An especially contentious topic in the last decade has been the path of the United States' effective exchange rate, shown in Figure 2-1. It is clear that, since

[4] In general, suppose that the home exchange rate is a, so one unit of home currency buys $1/a$ units of foreign currency. Now the home exchange rate depreciates to $b > a$, and one unit of home currency buys $1/b$ units of foreign currency, with $1/b < 1/a$. The size of the depreciation D of the home currency is

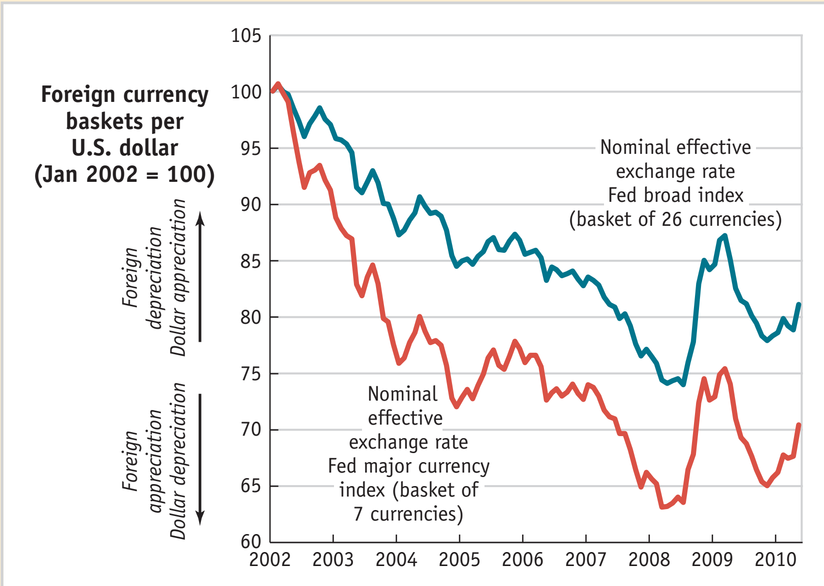
$$D = \left(\frac{1}{a} - \frac{1}{b}\right) \Big/ \left(\frac{1}{a}\right) = \left(1 - \frac{a}{b}\right) = \left(\frac{b-a}{b}\right)$$

Symmetrically, the foreign currency was initially worth a units of home currency but is now worth b. Thus, the size of the appreciation A of the foreign currency is

$$A = \frac{(b-a)}{a} = \frac{b}{a}D$$

Thus, the percentage appreciation A will be approximately equal to the percentage depreciation D when b/a is close to 1, or when b is approximately equal to a, that is, when the change in the exchange rate is small.

FIGURE 2-1



Effective Exchange Rates: Change in the Value of the U.S. Dollar, 2002–2010 The chart shows the value of the dollar measured by the U.S. Federal Reserve using two different baskets of foreign currencies, starting with the index set to 100 foreign baskets in January 2002. Against a basket of 7 major currencies, the dollar had depreciated by more than 25% by late 2004, and 35% by early 2008. But against a broad basket of 26 currencies, the dollar had lost only 15% of its value by 2004, and 25% by 2008. This is because the dollar was floating against the major currencies, but the broad basket included important U.S. trading partners (such as China and other Asian economies) that maintained fixed or tightly managed exchange rates against the dollar. These trends reversed somewhat after the global financial crisis of 2008.

Source: U.S. Federal Reserve.

2002, the U.S. dollar steadily has fallen in value against a basket of other currencies. It lost quite a lot of value against many well-known major currencies, such as the euro, the pound sterling, the Canadian dollar, and the Swiss franc. But on average, the weakening of the dollar was not as pronounced when measured against *all* U.S. trading partners. The simple reason for this was the fact that Japan and China, along with several other developing countries in Asia, sought to peg or control their exchange rates to limit their appreciation against the dollar. Thus in the figure, the downward trend for the broad basket of currencies is not as steep as that for the basket of seven major currencies.

Example: Using Exchange Rates to Compare Prices in a Common Currency

To make comparisons of prices across nations, we must convert prices to a common currency. The following examples show how we use exchange rates to accomplish this task.

James Bond is back from another mission and, what with all the explosions and shootouts, his wardrobe is looking ragged. He needs a new tuxedo. Bond will be in numerous cities On Her Majesty's Secret Service in the next few days, so he can shop around the globe. Although style is important, price is a key factor in Bond's choice, given the paltry MI6 clothing allowance. Should he visit a new tailor in Manhattan? Go back to his favorite cutter in Hong Kong? Or simply nip around the corner to Savile Row in London?

The London tailor sells a tux for £2,000; the Hong Kong shop is asking HK$30,000; and in New York, the going rate is $4,000. In the near future, when the decision must be made, these prices are fixed in their respective home currencies. Which tux will 007 choose?

TABLE 2-2

Using the Exchange Rate to Compare Prices in a Common Currency Now pay attention, 007! This table shows how the hypothetical cost of James Bond's next tuxedo in different locations depends on the exchange rates that prevail.

Scenario		1	2	3	4
Cost of the tuxedo in local currency	London	£2,000	£2,000	£2,000	£2,000
	Hong Kong	HK$30,000	HK$30,000	HK$30,000	HK$30,000
	New York	$4,000	$4,000	$4,000	$4,000
Exchange rates	HK$/£	15	16	14	14
	$/£	2.0	1.9	2.1	1.9
Cost of the tuxedo in pounds	London	£2,000	£2,000	£2,000	£2,000
	Hong Kong	£2,000	£1,875	£2,143	£2,143
	New York	£2,000	£2,105	£1,905	£2,105

To choose among goods priced in different currencies, Bond must first convert all the prices into a common currency; for this he uses the exchange rate (and a calculator disguised as a toothbrush). Table 2-2 shows the prices, in local currency and converted into pounds, under different hypothetical exchange rates.

Scenario 1 In the first column, the Hong Kong suit costs HK$30,000 and the exchange rate is HK$15 per £. Dividing HK$30,000 by 15, we find that this suit costs £2,000 in British currency. The U.S. suit has a price of $4,000, and at an exchange rate of $2 per pound we obtain a British currency price of £2,000. Here the exchange rates are such that all prices are the same when measured in a common currency (pounds). Bond has a difficult choice.

Scenario 2 Moving to the next column, the Hong Kong dollar has depreciated against the pound compared with scenario 1: it takes more HK$ (16 instead of 15) to buy £1. In contrast, the U.S. dollar has appreciated against the pound: it takes fewer dollars (1.9 instead of 2.0) to buy £1. At the new exchange rates, the cost of the New York tux has gone up to £2,105 (4,000/1.9), and the Hong Kong tux has fallen to £1,875 (30,000/16). Hong Kong now has the lowest price.

Scenario 3 Compared with scenario 1, the Hong Kong dollar has appreciated: it takes fewer $HK to buy £1 (14 instead of 15), and the price of the Hong Kong tux has risen to £2,143 (30,000/14). The U.S. dollar, on the other hand, has depreciated: it takes more dollars (2.1 instead of 2) to buy £1. With the dollar's depreciation, New York now has the best price of £1,905 (4,000/2.1).

Scenario 4 In this case, compared with scenario 1, the pound has depreciated against both of the other currencies, and they have each appreciated against the pound. It takes fewer Hong Kong dollars (14 instead of 15) and fewer U.S. dollars (1.9 instead of 2.0) to buy £1. Now London has the bargain price of £2,000 and the other cities have higher prices.

This example illustrates a key point. We assumed that while exchange rates may change, the prices of goods in each country are fixed in the short run (in domestic-currency terms). An economist would say the prices are *sticky* in the short run, and, as we see later, this is not an unreasonable assumption. Given that assumption, changes in exchange rates will cause changes in the common-currency prices of goods from different countries.

Generalizing The same logic applies to any exchange rate. All else equal, when the prices of goods are constant in each country, the following conclusions will apply:

- *Changes in the exchange rate cause changes in prices of foreign goods expressed in the home currency.*
- *Changes in the exchange rate cause changes in the relative prices of goods produced in the home and foreign countries.*
- *When the home country's exchange rate depreciates, home exports become less expensive as imports to foreigners, and foreign exports become more expensive as imports to home residents.*
- *When the home country's exchange rate appreciates, home exports become more expensive as imports to foreigners, and foreign exports become less expensive as imports to home residents.*

2 Exchange Rates in Practice

Having seen Table 2-1, it might be tempting to use the same figures as a guide to today's exchange rates between countries, but this would be a big mistake. Exchange rates fluctuate. They depreciate and appreciate. A lot. On a single day, in a matter of hours or even minutes, they can change substantially. Over a year, they move up and down, and may drift considerably in one direction or another. Any complete theory of exchange rate determination must account for observed behavior, so we should familiarize ourselves with the various patterns we seek to explain.

Exchange Rate Regimes: Fixed Versus Floating

Economists group different patterns of exchange rate behavior into categories known as **exchange rate regimes.** These regimes reflect choices made by governments, and the causes and consequences of exchange rate regimes are a major focus of our study.

There are two major regime types:

- **Fixed** (or **pegged**) exchange rate regimes are those in which a country's exchange rate fluctuates in a narrow range (or not at all) against some *base currency* over a sustained period, usually a year or longer. A country's exchange rate can remain rigidly fixed for long periods only if the government intervenes in the foreign exchange market in one or both countries.
- **Floating** (or **flexible**) exchange rate regimes are those in which a country's exchange rate fluctuates in a wider range, and the government makes no attempt to fix it against any base currency. Appreciations and depreciations may occur from year to year, each month, by the day, or every minute.

For example, earlier in the book we saw data for two of the most talked about exchange rates in the world today: the U.S. dollar-euro and the Chinese yuan-U.S. dollar rates. The dollar-euro rate fluctuated considerably and was said to be floating; the yuan-dollar rate held steady or changed very slowly and was said to be fixed.

However, the "fixed versus floating" classification is not without its problems. First, in practice, to judge whether a regime is fixed or floating, we have to decide where we draw the line between "narrow" and "wide" fluctuations. One rule of thumb is to use the size of annual variations (say, within ±2% or ±1%) as the sign of a fixed regime. Second, "fixed versus floating" is only a very broad description of exchange rate regimes. In reality, the distinctions are not so cut and dried. Fixed and floating provide important benchmarks throughout this book and deliver great insights, but we sometimes need more precise ways of describing *intermediate regimes*, as the following application illustrates.

APPLICATION

Recent Exchange Rate Experiences

If we spend a moment looking at recent exchange rate experiences in a variety of countries, we see not only some helpful illustrations of the differences between floating and fixed rate regimes but also some of the different varieties of fixed and floating behavior. We also encounter the phenomenon of regime change, in which one type of regime gives way to another, either smoothly or catastrophically.

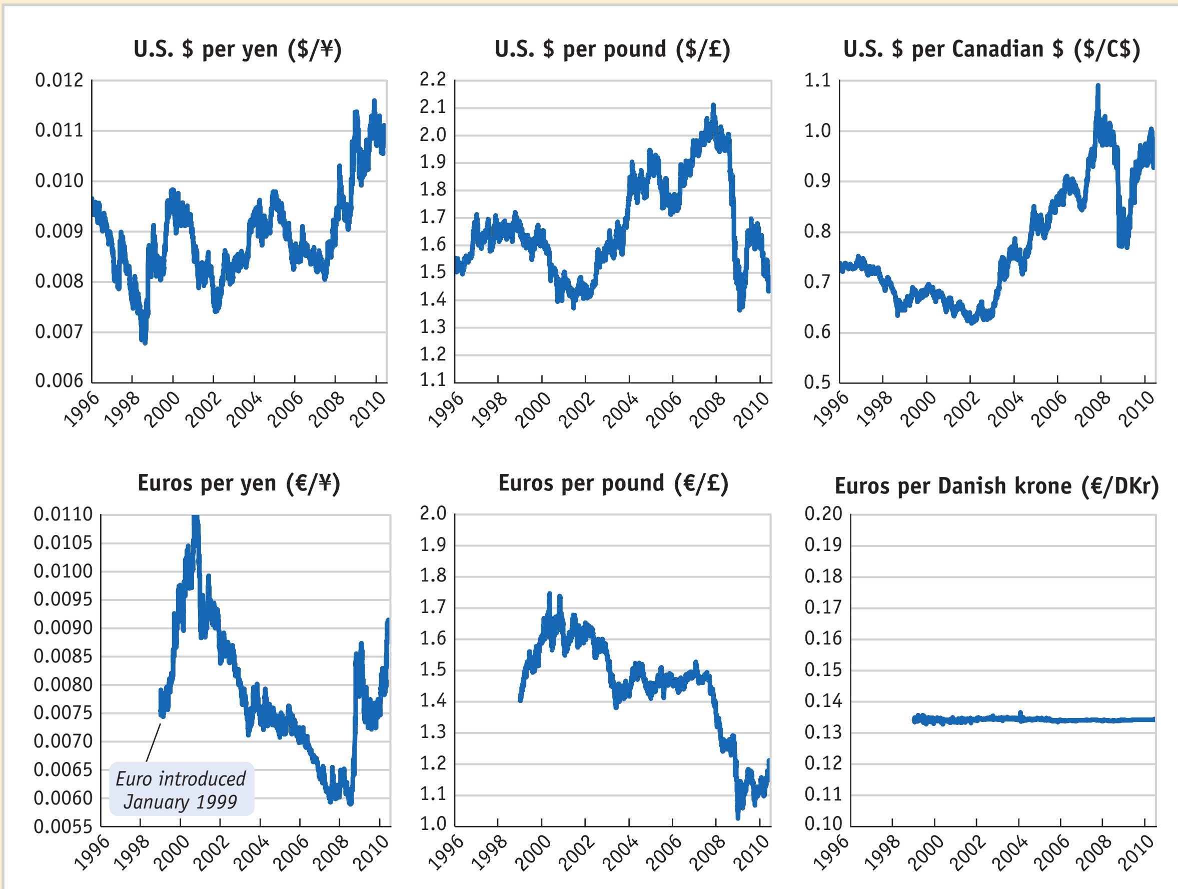
Evidence from Developed Countries Figure 2-2 shows the daily exchange rates from 1996 to 2010 for various currency pairs. The top row shows the U.S. dollar exchange rate against two major currencies (the Japanese yen, the British pound) and against the currency of a neighboring country (the Canadian dollar, also called the *loonie* because it has a loon on it). The bottom row shows the exchange rate of the euro against the yen, the pound, and the Danish krone. In all six charts, the vertical scale varies by a factor of 2 from maximum to minimum, so all of these charts are comparable in terms of their representation of these exchange rates' volatility.

We can clearly see that the U.S. dollar is in a floating relationship with all three foreign currencies shown in the top row—the yen, pound, and loonie. How volatile are the exchange rates? The range of variation in each case is about the same, with the maximum being about one and a half times the minimum: the yen ranges from about \$0.0065 to \$0.0110, the pound from \$1.3 to almost \$2, the loonie from \$0.6 to about \$1. The movements between these peaks and troughs may take many months or years to occur, but the exchange rate also shows a great deal of short-run volatility, with lots of up-and-down movement from day to day. A floating regime of this sort is called a **free float.**

Similarly, the bottom row of Figure 2-2 shows that the euro floats against the yen and the pound. In the sixth and final chart, the Danish krone provides a contrast—an example of a fixed exchange rate in a developed country. Denmark is part of the European Union, but like Britain, it has kept its own national currency, at least for now, and does not use the euro as its currency. Unlike Britain, however, Denmark has fixed its exchange rate against the euro, keeping it very close to 7.44 krone per euro (0.134 euro per krone). There is only a tiny variation around this rate, no more than plus or minus 2%. This type of fixed regime is known as a **band.**

Evidence from Developing Countries Figure 2-3 shows the daily exchange rates against the U.S. dollar from 1996 to 2010 for some developing countries. Exchange rates in developing countries can be much more volatile than those in developed countries. The charts in the top row illustrate exchange rate behavior in three Asian

FIGURE 2-2



Exchange Rate Behavior: Selected Developed Countries, 1996–2010 This figure shows exchange rates of three currencies against the U.S. dollar and three against the euro. The euro rates begin in 1999 when the currency was introduced. The yen, pound, and Canadian dollar all float against the U.S. dollar. The pound and yen float against the euro. The Danish krone is fixed against the euro. The vertical scale ranges by a factor of 2 on all charts.

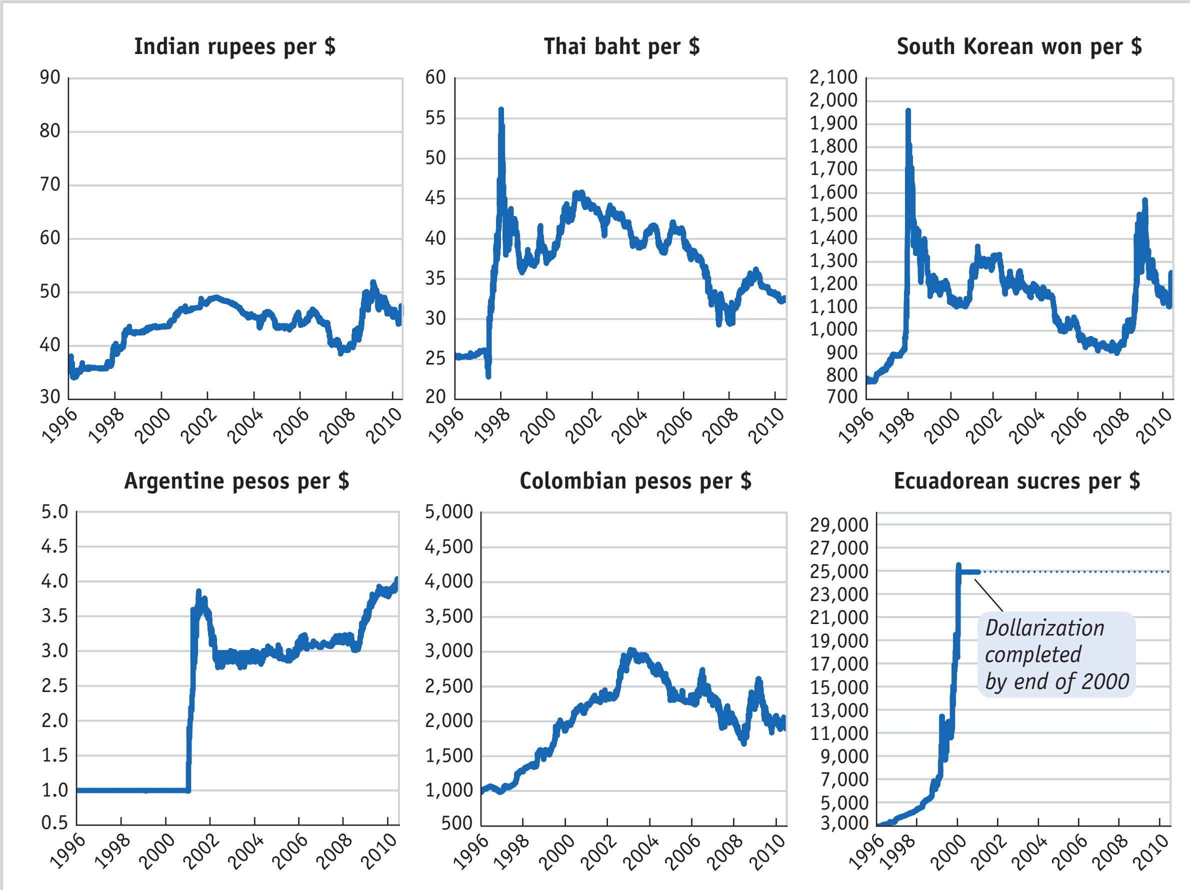
Source: oanda.com.

countries (India, Thailand, and South Korea); the maximum on the vertical axis is three times the minimum.

India had what looked like a fixed rate of about 35 rupees per dollar until a depreciation in 1997; there was then a period of pronounced movement more like a float. However, the government still acted to prevent abrupt currency movements even after 1997. This middle ground, somewhere between a fixed rate and a free float, is called a **managed float** (also known as a *dirty float*, or a policy of *limited flexibility*).

Thailand and South Korea show more extreme versions of the same pattern, except that in these cases the depreciation in 1997 was large and sudden, with the baht and the won exchange rates more than doubling in a matter of weeks. Such dramatic depreciations are called **exchange rate crises** and they are more common in developing countries than in developed countries. Indeed, South Korea had another mini-crisis in 2008.

FIGURE 2-3



Exchange Rate Behavior: Selected Developing Countries, 1996–2010 Exchange rates in developing countries show a wide variety of experiences and greater volatility. Pegging is common but is punctuated by periodic crises (you can see the effects of these crises in graphs for Thailand, South Korea, and Argentina). Rates that are unpegged may show some flexibility (India). Some rates crawl gradually (Colombia). Dollarization can occur (Ecuador). The vertical scale ranges by a factor of 3 on the upper charts and by a factor of 10 on the lower charts.

Source: oanda.com.

The bottom row of Figure 2-3 shows some Latin American countries and more varieties of exchange rate experience. The maximum on the vertical scale is now ten times the minimum, a change made necessary by the even more volatile exchange rates in this region.

Argentina initially had a fixed rate (of one peso per dollar), followed in 2001 by an exchange rate crisis. After a period of limited flexibility, Argentina returned to an almost fixed rate with a band that appeared to be centered at about three pesos per dollar, before drifting higher after 2008.

Colombia presents an example of a different kind of fixed exchange rate. Here the authorities did not target the level of the Colombian peso but allowed it to steadily depreciate at an almost constant rate for several years from 1996 to 2002. This type of fixed arrangement is called a **crawl** (if the exchange rate follows a simple trend, it is a *crawling peg;* if some variation about the trend is allowed, it is termed a *crawling band*).

In the final figure, Ecuador displays a different crisis pattern. Here a period of floating was followed by a fixed rate rather than the other way around. Episodes of very rapid depreciation like this represent a distinct form of exchange rate behavior; some economists have suggested, not jokingly, that these regimes be identified separately as *freely falling* exchange rate regimes.[5] The Ecuadorean currency stabilized at a fixed rate of 25,000 sucres per dollar, but then the sucre ceased to be. Ecuador took the remarkable step of dollarizing: abolishing its own national currency and adopting the U.S. dollar as its legal tender.

Currency Unions and Dollarization Almost every economy issues its own currency and jealously guards this sovereign right. There are only two exceptions: groups of economies that agree to form a currency or monetary union and adopt a common currency and individual economies that dollarize by adopting the currency of another country as their own.

Under a **currency union** (or **monetary** union), there is some form of transnational structure such as a single central bank or monetary authority that is accountable to the member nations. The most prominent example of a currency union is the Eurozone. Other currency unions include the CFA and CFP Franc zones (among some former French colonies in Africa and the Pacific) and the Eastern Caribbean Currency Union of nine member states.

Under **dollarization** one country unilaterally adopts the currency of another country. The reasons for this choice can vary. The adopting country may be very small, so the costs of running its own central bank and issuing its own currency may be prohibitive. Such is the case, for example, for the 50 or so Pitcairn Islanders (who use New Zealand as their standard currency). Other countries may have a poor record of managing their own monetary affairs and may end up "importing" a better policy from abroad. The currency changeover could be a de jure policy choice; or it may happen de facto if people are so fed up that they stop using the national currency and switch en masse to an alternative. Many of these economies use the U.S. dollar, but other popular choices include the euro, and the Australian and New Zealand dollars.

Exchange Rate Regimes of the World To move beyond specific examples, Figure 2-4 shows an IMF classification of exchange rate regimes around the world, which allows us to see the prevalence of different regime types across the whole spectrum from fixed to floating.[6]

The classification covers 192 economies for the year 2008, and regimes are ordered from the most rigidly fixed to the most freely floating. The first 46 countries are those

[5] Carmen M. Reinhart and Kenneth S. Rogoff, February 2004, "The Modern History of Exchange Rate Arrangements: A Reinterpretation," *Quarterly Journal of Economics*, 119(1), 1–48.

[6] The IMF now uses an unofficial classification based on observed exchange rate behavior. Most economists prefer this type of classification to the often misleading official classifications that were based on countries' official policy announcements. For example, as we saw in Figure 2-3, Thailand pegged to the dollar before the 1997 crisis, even though official statements denied this and the Thai authorities claimed the baht was floating. On unofficial or de facto classifications, see Carmen M. Reinhart and Kenneth S. Rogoff, February 2004, "The Modern History of Exchange Rate Arrangements: A Reinterpretation," *Quarterly Journal of Economics*, 119(1), 1–48. Jay C. Shambaugh, February 2004, "The Effect of Fixed Exchange Rates on Monetary Policy," *Quarterly Journal of Economics*, 119(1), 301–352. Eduardo Levy Yeyati and Federico Sturzenegger, August 2005, "Classifying Exchange Rate Regimes: Deeds vs. Words," *European Economic Review*, 49(6), 1603–1635.

FIGURE 2-4

Increasingly fixed ↑ / *Increasingly floating* ↓

No separate legal tender (46 countries)	*Another currency as legal tender*: East Timor, Ecuador, El Salvador, Kiribati, Marshall Islands, Micronesia, Montenegro, Palau, Panama, San Marino *Eastern Caribbean Currency Union*: Antigua and Barbuda, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines *West African CFA Franc Zone*: Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, Togo *Central African CFA Franc Zone*: Cameroon, Central African Rep., Chad, Rep. of Congo, Equatorial Guinea, Gabon *Eurozone*: Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain
Currency boards (7)	Bosnia and Herzegovina, Brunei, Bulgaria, Djibouti, Estonia, Hong Kong, Lithuania
Other fixed pegs (58)	Angola, Argentina, Aruba, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belize, Bhutan, Capre Verde, Comoros, Croatia, Denmark, Eritrea, Fiji, Guyana, Honduras, Jordan, Kazakhstan, Kuwait, Latvia, Lebanon, Lesotho, Libya, Macedonia, Malawi, Maldives, Mongolia, Morocco, Namibia, Nepal, Netherlands Antillies, Oman, Qatar, Russia, Rwanda, Samoa, Saudi Arabia, Seychelles, Sierra Leone, Solomon Islands, Sri Lanka, Suriname, Swaziland, Tajikistan, Trinidad and Tobago, Tunisia, Turkmenistan, United Arab Emirates, Venezuela, Vietnam, Yemen, Zimbabwe
Pegged within horizontal bands (2)	Syria, Tonga
Crawling pegs (8)	Bolivia, Botswana, China, Ethiopia, Iran, Iraq, Nicaragua, Uzbekistan
Crawling bands (2)	Azerbaijan, Costa Rica
Managed floating with no predetermined path for the exchange rate (44)	Afghanistan, Algeria, Armenia, Bangladesh, Burundi, Cambodia, Colombia, Dominican Rep., Egypt, Gambia, Georgia, Ghana, Guatemala, Guinea, Haiti, India, Indonesia, Jamaica, Kenya, Kyrgyzstan, Laos, Liberia, Madagascar, Malaysia, Mauritania, Mauritius, Moldova, Mozambique, Myanmar, Nigeria, Pakistan, Papua New Guinea, Paraguay, Peru, Romania, São Tomé and Príncipe, Serbia, Singapore, Sudan, Tanzania, Thailand, Uganda, Ukraine, Uruguay, Vanuatu
Independently floating (25)	Albania, Australia, Brazil, Canada, Chile, Czech Rep. Dem. Rep. of Congo, Hungary, Iceland, Israel, Japan, Mexico, New Zealand, Norway, Philippines, Poland, Somalia, South Africa, South Korea, Sweden, Switzerland, Turkey, United Kingdom, United States, Zambia

A Spectrum of Exchange Rate Regimes The chart shows a recent classification of exchange rate regimes around the world.

Source: With the exception of Slovakia (which joined the Eurozone on January 1, 2009, and is classified as such) all classifications are for April 2008 and based on the IMF's "De Facto Classification of Exchange Rate Regimes and Monetary Policy Frameworks." Note that Estonia is expected to join the Eurozone on January 1, 2011.

that have no currency of their own—they are either dollarized or in a currency union. Next are 7 countries using an ultrahard peg called a **currency board,** a type of fixed regime that has special legal and procedural rules designed to make the peg "harder"—that is, more durable. Then come 58 conventional pegs, with variations of less than ±1%, some fixed to a single currency and a few pegging against a basket of currencies. These are followed by the less rigidly fixed arrangements such as the 2 bands, 8 crawling pegs, and 2 crawling bands. We then encounter two kinds of flexible regimes: the 44 regimes of managed floating rates, in which the authorities seem to restrict exchange rate movements to a noticeable degree, and lastly the 25 independently floating regimes.

Looking Ahead This brief look at the evidence supplies important motivation for the analysis in the remainder of this book. First, the world is divided into fixed and floating rate regimes, so we need to understand how *both* types of regime work. Studying fixed and floating regimes side by side will occupy much of our attention for the next few chapters. Second, when we look at who is fixed and who is floating, we start to notice patterns. Most of the floaters are advanced countries and most of the fixers are developing countries (the major exception is the euro area). The important question of why some countries fix while others float is covered in more detail in later chapters. ■

3 The Market for Foreign Exchange

Day by day, and minute by minute, exchange rates the world over are set in the **foreign exchange market** (or **forex** or **FX** market), which, like any market, is a collection of private individuals, corporations, and some public institutions that buy and sell. When two currencies are traded for each other in a market, the exchange rate is the price at which the trade was done, a price that is determined by market forces.

The forex market is not an organized exchange: trade is conducted "over the counter" between parties at numerous interlinked locations around the world. The forex market is massive and has grown dramatically in recent years. According to the Bank for International Settlements, in April 2007 the global forex market traded $3,210 billion per day in currency, 70% more than in 2004 and 290% more than in 1992. The three major foreign exchange centers—the United Kingdom ($1,359 billion per day, almost all in London), the United States ($664 billion, mostly in New York), and Japan ($238 billion, principally in Tokyo)—played home to more than half of the trade.[7] Other important centers for forex trade include Hong Kong, Paris, Singapore, Sydney, and Zurich. Thanks to time-zone differences, when smaller trading centers are included, there is not a moment in the day when foreign exchange is not being traded somewhere in the world. This section briefly examines the basic workings of this market.

The Spot Contract

The simplest forex transaction is a contract for the immediate exchange of one currency for another between two parties. This is known as a **spot contract** because it happens "on the spot." Accordingly, the exchange rate for this transaction is often called the **spot exchange rate.** In this book, the use of the term "exchange rate" always refers to the spot rate. Spot trades are now essentially riskless: technology permits settlement for most trades in real time, so that the risk of one party failing to deliver on its side of the transaction (*default risk* or *settlement risk*) is essentially zero.[8]

Most of our personal transactions in the forex market are small spot transactions via retail channels, but this represents just a tiny fraction of the activity in the foreign

[7] Data from BIS, *Triennial Central Bank Survey: Foreign Exchange and Derivatives Market Activity in 2007* (Basle, Switzerland: Bank for International Settlements, December 2007).
[8] Spot trades formerly took two days for settlement. If a bank failed in that period, spot trades could suffer occasional settlement failure. However, since 1997 a *continuously linked settlement* (CLS) system has been used by the major trading banks and now covers a substantial majority of cross-currency transactions all over the world.

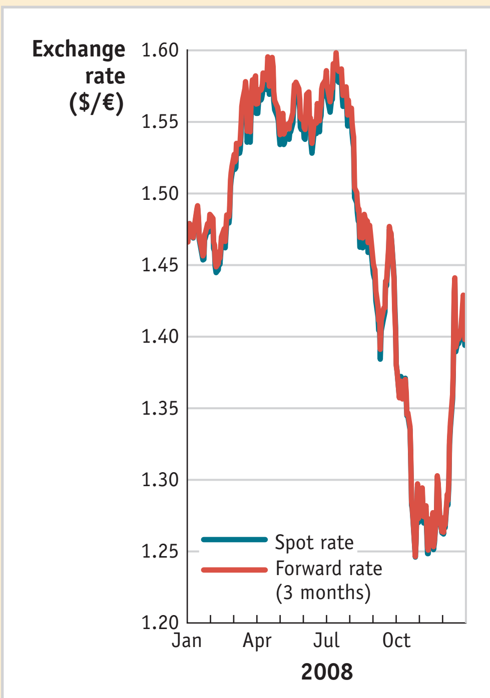
exchange market each day. The vast majority of trading involves commercial banks in major financial centers around the world. But even there the spot contract is the most common type of trade and appears in almost 90% of all forex transactions, either on its own as a single contract or in trades where it is combined with other forex contracts.

Transaction Costs

When individuals buy a little foreign currency through a retail channel (such as a bank), they pay a higher price than the midrange quote typically seen in the press; and when they sell, they are paid a lower price. The difference or **spread** between the "buy at" and "sell for" prices may be large, perhaps 2% to 5%. These fees and commissions go to the many middlemen that stand between the person on the street and the forex market. But when a big firm or a bank needs to exchange millions of dollars, the spreads and commissions are very small. Spreads are usually less than 0.1%, and for actively traded major currencies, they are approximately 0.01% to 0.03%.

Spreads are an important example of **market frictions** or **transaction costs.** These frictions create a wedge between the price paid by the buyer and the price received by the seller. Although spreads are potentially important for any microeconomic analysis of the forex market, macroeconomic analysis usually proceeds on the assumption that, in today's world of low-cost trading, the transaction-cost spreads in markets are so low for the key investors that they can be ignored for all purposes.

FIGURE 2-5



Spot and Forward Rates The chart shows the U.S. spot and three-month forward exchange rates for the euro in dollars per euro in the year 2008. The spot and forward rates closely track each other.

Source: Federal Reserve Bank of New York.

Derivatives

The spot contract is undoubtedly the most important contract in the forex market, but there are many other related forex contracts. These contracts include *forwards*, *swaps*, *futures*, and *options*. Collectively, all these related forex contracts are termed **derivatives** because the contracts and their pricing are derived from the spot rate.

With the exception of forwards, the forex derivatives market is small relative to the entire global forex market. According to April 2007 data from the Bank for International Settlements, the trade in spot contracts amounted to $1,005 billion per day, while the trade in forward contracts (including swaps) was $2,076 billion per day. All other derivative trades amounted to just $291 billion per day, or less than 10% of all forex trades.

For the rest of this chapter, we focus on the two most important contracts—the spot and the forward. Figure 2-5 shows recent trends in the spot and forward rates in the dollar-euro market. The forward rate tends to track the spot rate fairly closely, and we will explore this relationship further in a moment.

The full study of derivative markets requires an in-depth analysis of risk that is beyond the scope of a course in international macroeconomics. Such topics are reserved for advanced courses in finance that explore derivative contracts in great detail. The following application supplies a basic guide to derivatives.

APPLICATION

Foreign Exchange Derivatives

There are many derivative contracts in the foreign exchange market, of which the following are the most common.

Forwards A **forward** contract differs from a spot contract in that the two parties make the contract today, but the *settlement date* for the delivery of the currencies is in the future, or forward. The time to delivery, or *maturity*, varies—30 days, 90 days, six months, a year, or even longer—depending on the contract. However, because the price is fixed as of today, the contract carries no risk.

Swaps A **swap** contract combines a spot sale of foreign currency with a forward repurchase of the same currency. This is a common contract for counterparties dealing in the same currency pair over and over again. Combining two transactions reduces transactions costs because the broker's fees and commissions are lower than on a spot and forward purchased separately.

Futures A **futures** contract is a promise that the two parties holding the contract will deliver currencies to each other at some future date at a prespecified exchange rate, just like a forward contract. Unlike the forward contract, however, futures contracts are standardized, mature at certain regular dates, and can be traded on an organized futures exchange. Hence, the futures contract does not require that the parties involved at the delivery date be the same two parties that originally made the deal.

Options An **option** provides one party, the buyer, with the right to buy (*call*) or sell (*put*) a currency in exchange for another at a prespecified exchange rate at a future date. The other party, the seller, must perform the trade if asked to do so by the buyer, but a buyer is under no obligation to trade and, in particular, will not exercise the option if the spot price on the expiration date turns out to be more favorable.

All of these products exist to allow investors to trade foreign currency for delivery at different times or with different contingencies. Thus, derivatives allow investors to engage in *hedging* (risk avoidance) and *speculation* (risk taking).

- Example 1: Hedging. As chief financial officer of a U.S. firm, you expect to receive payment of €1 million in 90 days for exports to France. The current spot rate is $1.20 per euro. Your firm will incur losses on the deal if the euro weakens to less than $1.10 per euro. You advise that the firm buy €1 million in call options on dollars at a rate of $1.15 per euro, ensuring that the firm's euro receipts will sell for at least this rate. This locks in a minimal profit even if the spot rate falls below $1.15. This is hedging.
- Example 2: Speculation. The market currently prices one-year euro futures at $1.30, but you think the dollar will weaken to $1.43 in the next 12 months. If you wish to make a bet, you would buy these futures, and if you are proved right, you will realize a 10% profit. Any level above $1.30 will generate a profit. If the dollar is at or below $1.30 a year from now, however, your investment in futures will be a total loss. This is speculation. ■

Private Actors

The key actors in the forex market are the traders. Most forex traders work for **commercial banks.** These banks trade for themselves and also serve clients who want to import or export goods, services, or assets. Such transactions usually involve a change of currency, and commercial banks are the principal financial intermediaries that provide this service.

For example, suppose Apple Computer Inc. has sold €1 million worth of computers to a German distributor and wishes to receive payment for them in U.S. dollars. The German distributor informs its commercial bank, Deutsche Bank, which then debits €1 million from the distributor's bank account. Deutsche Bank then sells the €1 million bank deposit in the forex market in exchange for a $1.3 million deposit and credits that $1.3 million to Apple's bank in California, which, in turn, deposits $1.3 million into Apple's account. (In this example, we assume a euro is worth $1.3.)

This is an example of **interbank trading.** This business is highly concentrated: about three-quarters of all forex market transactions globally are handled by just ten banks, led by names such as Deutsche Bank, UBS, Citigroup, HSBC, and Barclays. They trade currencies not just for their clients but also on their own account in search of profit. The vast majority of forex transactions are profit-driven interbank trades, and it is the exchange rates for these trades that underlie quoted market exchange rates. Consequently, we focus on profit-driven trading as the key force in the forex market that affects the determination of the spot exchange rate.

Other actors are increasingly participating directly in the forex market. Some **corporations** may trade in the market if they are engaged in extensive transactions either to buy inputs or sell products in foreign markets. It may be costly for them to do this, but by doing so, they can bypass the fees and commissions charged by commercial banks. Similarly, some **nonbank financial institutions** such as mutual fund companies may invest so much overseas that they can justify setting up their own foreign exchange trading operations.

Government Actions

We have so far described the forex market in terms of the private actors. Our discussion of the forex market is incomplete, however, without mention of actions taken by government authorities. Such activities are by no means present in every market at all times, but they are sufficiently frequent that we need to fully understand them. In essence, there are two primary types of actions taken by governments in the forex market.

At one extreme, it is possible for a government to try to completely control the market by preventing its free operation, by restricting trading or movement of forex, or by allowing the trading of forex only through government channels. Policies of this kind are a form of **capital control,** a restriction on cross-border financial transactions. In the wake of the 1997 Asian exchange rate crisis, the Malaysian government temporarily imposed capital controls, an event that prompted Prime Minister Mahathir Mohamad to declare that "currency trading is unnecessary, unproductive and totally immoral. It should be stopped, it should be made illegal."[9]

[9] From a speech at the World Bank meeting in Hong Kong, September 20, 1997, in which Mr. Mohamad also referred to the legendary currency trader George Soros as a "moron." See Edward A. Gargan, "Premier of Malaysia Spars with Currency Dealer; Mahathir Says Soros and His Ilk Are 'Impoverishing Others' for Profit," *New York Times*, September 22, 1997, p. A1.

Capital controls are never 100% successful, however. Illegal trades will inevitably occur and are almost impossible to stop. The government may set up an **official market** for foreign exchange and issue a law requiring people to buy and sell in that market at officially set rates. But illicit dealings can persist "on the street" in **black markets** or *parallel markets* where individuals may trade at exchange rates determined by market forces and not set by the government. For example, in Italy in the 1930s, the Mussolini regime set harsh punishments for trading in foreign currency that gradually rose to include the death penalty, but trading still continued on the black market.

A less drastic action taken by the authorities is to let the private market for foreign exchange function but to fix or control forex prices in the market through **intervention,** a job typically given to a nation's central bank.

How do central banks intervene in the forex market? Indeed, how can a government control a price in any market? This is an age-old problem. Consider the issue of food supply in medieval and premodern Europe, one of the earliest examples of government intervention in markets. Rulers faced the problem that droughts or harvest failures lead to famines—and political unrest. Governments reacted by establishing state-run granaries, where wheat would be stored up in years of plenty and then released to the market in years of scarcity. The price could even be fixed if the government stood ready to buy or sell grain at a preset price—*and always had enough grain in reserve to do so.* Some authorities successfully followed this strategy for many years. Others failed when they ran out of grain reserves. Once a reserve is gone, market forces take over. If there is a heavy demand that is no longer being met by the state, a rapid price increase will inevitably follow.

Government intervention in the foreign exchange market works similarly. To maintain a fixed exchange rate, the central bank must stand ready to buy or sell its own currency, in exchange for the base foreign currency, at a fixed price. In practice, this means keeping some foreign currency reserves as a buffer, but having this buffer raises many problems. For one thing, it is costly—resources are tied up in foreign currency when they could be invested in more profitable activities. Second, these reserves are not an unlimited buffer, and if they run out, the game is up. In later chapters, we will explore why countries peg, how a peg is maintained, and under what circumstances pegs fail, leading to an exchange rate crisis.

To conclude, the extent of government intervention can vary. However, even with complete and watertight capital controls, including the suppression of the black market, private actors are always present in the market. Our first task is to understand how private economic motives and actions affect the forex market.

4 Arbitrage and Spot Exchange Rates

The most basic of activities pursued by private actors in any market is **arbitrage,** a trading strategy that exploits any profit opportunities arising from price differences. Understanding arbitrage is one of the keys to thinking like an economist in any situation and is essential in studying exchange rates.

In the simplest terms, arbitrage means to buy low and sell high. If such profit opportunities exist in a market, then it is considered to be out of equilibrium. If no such profit opportunities exist, there will be no arbitrage; the market is in **equilibrium** and satisfies a **no-arbitrage condition.**

Arbitrage with Two Currencies

Suppose you trade dollars and pounds for a bank with branches in New York and London. You can electronically transfer the funds cost free between the two branch locations. Forex trading commissions are the same in each city and so small as to be negligible. Suppose the exchange rate in New York is $E^{\text{N.Y.}}_{£/\$} = £0.50$ per dollar, in London $E^{\text{London}}_{£/\$} = £0.55$ per dollar. Can you make a profit for the bank?

Yes. You can buy \$1 for £0.50 in New York and sell it for £0.55 in London for an instant, riskless profit. Indeed, everyone would buy in New York and sell in London.

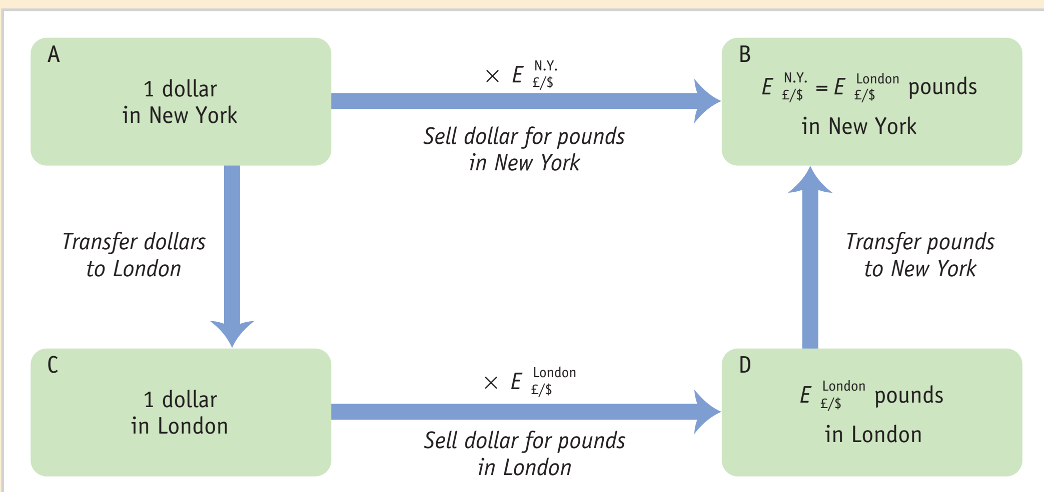
In general, one of the three outcomes can occur in the forex market. The spot rate can be higher in London: $E^{\text{N.Y.}}_{£/\$} < E^{\text{London}}_{£/\$}$; the spot rate can be higher in New York: $E^{\text{N.Y.}}_{£/\$} > E^{\text{London}}_{£/\$}$; or the spot rate can be the same in both locations: $E^{\text{N.Y.}}_{£/\$} = E^{\text{London}}_{£/\$}$. Arbitrage will occur in the first two cases. Only in the last case, in which spot rates are equal, does no arbitrage occur. Hence, the no-arbitrage condition for spot rates is

$$E^{\text{N.Y.}}_{£/\$} = E^{\text{London}}_{£/\$}$$

The no-arbitrage condition is shown diagrammatically in Figure 2-6. Following both sets of arrows, we see that on each path we start with a dollar and end up with pounds, but we are indifferent between these paths only when the end result is identical. That would be an equilibrium, where no arbitrage is possible.

If the market were out of equilibrium, arbitrage would drive up the price in the low-price market and drive down the price in the high-price market. In our example,

FIGURE 2-6



Arbitrage and Spot Rates Arbitrage ensures that the trade of currencies in New York along the path AB occurs at the same exchange rate as via London along path ACDB. At B the pounds received must be the same. Regardless of the route taken to get to B, $E^{\text{N.Y.}}_{£/\$} = E^{\text{London}}_{£/\$}$.

everyone buying dollars in New York and selling them in London would bid up the spot rate in New York from £0.50 and would bid down the spot rate in London from £0.55. This process would continue until the prices converged, arbitrage ceased, and equilibrium was attained. In forex markets, these adjustments happen nearly instantaneously, whether in the high-tech electronic markets of world financial centers or in the markets on street corners in the developing world.

©Alex Segre/Alamy

AP Photo/Aijaz Rahi

Forex traders at their desks in London and money changers on the street in Kabul.

Arbitrage with Three Currencies

The same logic that we just applied to transactions between two currencies can also be applied to transactions involving three currencies. Again, as the trader in New York, you are considering trading dollars and pounds, but you also consider indirect or "triangular" trade via a third currency, say, the euro. Triangular arbitrage works as follows: you sell dollars in exchange for euros, then immediately sell the same euros in exchange for pounds. This roundabout way to acquire pounds is feasible, but is it sensible? Perhaps.

For example, suppose euros can be obtained at $E_{€/\$} = €0.8$ per dollar, and pounds can be obtained at $E_{£/€} = £0.7$ per euro. Starting with \$1, you can obtain 0.8 euros, and with those 0.8 euros, you can obtain 0.7×0.8 pounds. Thus, setting aside the negligibly small commissions, the resulting pound-dollar exchange rate on the combined trade is $E_{£/€} \times E_{€/\$} = 0.7 \times 0.8 = 0.56$ pounds per dollar. If, say, the exchange rate on the direct trade from dollars to pounds is a less favorable $E_{£/\$} = 0.5$, we can trade \$1 for £0.56 via the euro, and then trade the £0.56 for \$1.12 by way of a direct trade (because $1.12 = 0.56/0.5$), a riskless profit of 12 cents.

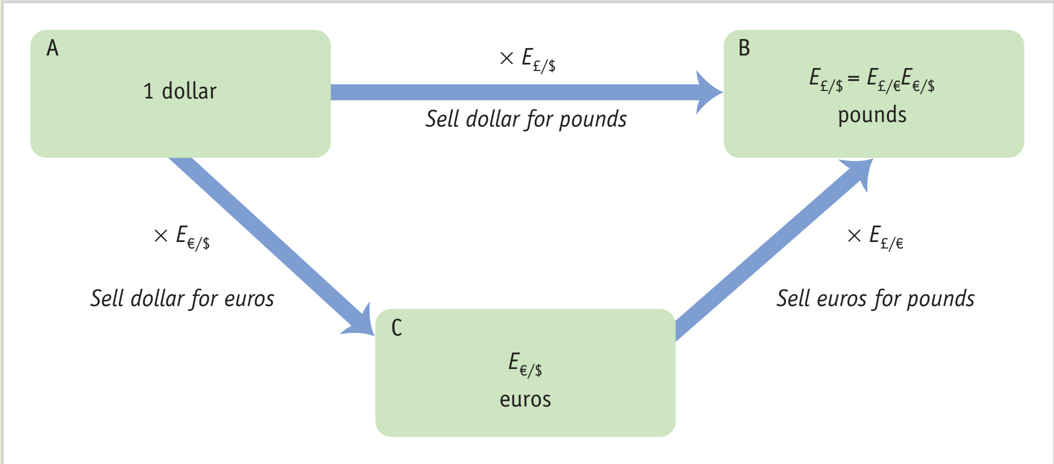
In general, three outcomes are again possible. The direct trade from dollars to pounds has a better rate: $E_{£/\$} > E_{£/€}E_{€/\$}$; the indirect trade has a better rate: $E_{£/\$} < E_{£/€}E_{€/\$}$; or the two trades have the same rate and yield the same result: $E_{£/\$} = E_{£/€}E_{€/\$}$. Only in the last case are there no profit opportunities. This no-arbitrage condition can be written in two ways:

$$\underbrace{E_{£/\$}}_{\text{Direct exchange rate}} = E_{£/€}E_{€/\$} = \underbrace{\frac{E_{£/€}}{E_{\$/€}}}_{\text{Cross rate}}$$

The right-hand expression, a ratio of two exchange rates, is called a **cross rate.** Examine the units carefully and notice how the two € cancel out. This no-arbitrage condition applies to all currency combinations. It is shown diagrammatically in Figure 2-7, and you can see why it is called *triangular arbitrage.*

The cross rate formula is very convenient. It means that we do not need to keep track of the exchange rate of every currency at all times. For example, if we know the exchange rates against, say, the dollar, for every currency, then for *any* pair of currencies A and B we can use the dollar rates of each currency and the cross rate formula to work out the rate at which the two currencies will trade: $E_{A/B} = E_{A/\$}/E_{B/\$}$. In practice, this is how most exchange rates are calculated.

FIGURE 2-7



Arbitrage and Cross Rates Triangular arbitrage ensures that the direct trade of currencies along the path AB occurs at the same exchange rate as via a third currency along path ACB. The pounds received at B must be the same on both paths, and $E_{£/\$} = E_{£/€}E_{€/\$}$.

Cross Rates and Vehicle Currencies

The study of cross rates is not just an academic exercise because the vast majority of currency pairs are exchanged for one another through a third currency. There are 160 distinct currencies in the world at the time of this writing. If you write down every possible currency pair, then count them up, you would be expecting to see 12,720 forex markets in operation. You would be disappointed, however, and find only a fraction of this number. Why?

The vast majority of the world's currencies trade directly with only one or two of the major currencies, such as the dollar, euro, yen, or pound, and perhaps a few other currencies from neighboring countries. This is not too surprising. After all, to take some obscure examples, how often does somebody want to trade a Kenyan shilling for a Paraguayan guaraní? Or Mauritanian ouguiya for a Tongan pa'anga? These are small, far-apart countries between which there is very little international trade or investment. It is hard to find counterparties for forex trade in these currencies—so hard that the costs of trading become prohibitive. And there is no need to bear these costs because, to continue our example, Kenya, Paraguay, Mauritania, and Tonga do conduct a lot of business in major currencies such as the U.S. dollar, so individuals always have the option to engage in a triangular trade at the cross rate to convert shillings to dollars to guaranís (or ouguiyas to dollars to pa'angas), all for a reasonable commission.

When a third currency, such as the U.S. dollar, is used in these transactions, it is called a **vehicle currency** because it is not the home currency of either of the parties involved in the trade and is just used for intermediation. Market data illustrate the importance of vehicle currencies. According to year 2007 data from the Bank for International Settlements, the most common vehicle currency is the U.S. dollar, which appears on one side of more than 86% of all global trades. The euro is next, playing a role in 37% of all trades (many of them with the U.S. dollar). The yen appears in 17% of all trades and the British pound in 15% (many with the U.S. dollar and the euro).

5 Arbitrage and Interest Rates

So far, our discussion of arbitrage has shown how actors in the forex market—for example, the banks—exploit profit opportunities if currencies trade at different prices. But this is not the only type of arbitrage activity affecting the forex market.

An important question for investors is in which currency they should hold their liquid cash balances. Their cash can be placed in bank deposit accounts denominated in various currencies where it will earn a modest interest rate. For example, a trader working for a major bank in New York could leave the bank's cash in a euro deposit for one year earning a 2% euro interest rate or she could put the money in a U.S. dollar deposit for one year earning a 4% dollar interest rate. How can she decide which asset, the euro or the dollar deposit, is the best investment?

This is the final problem that we address in this chapter, and this analysis provides the tools we need to understand the forex market in the rest of this book. The analysis again centers on arbitrage. Would selling euro deposits and buying dollar deposits make a profit for the banker? Decisions like these drive the demand for dollars versus euros and the exchange rate between the two currencies.

The Problem of Risk A key issue for the trader is the exchange rate risk. The trader is in New York, and her bank cares about returns in U.S. dollars. The dollar deposit pays a known return, in dollars. But the euro deposit pays a return in euros, and one year from now we cannot know for sure what the dollar-euro exchange rate will be. Thus, how we analyze arbitrage in the sections that follow depends on how exchange rate risk is handled by the investor.

As we know from our discussion of derivatives, an investor may elect to cover or hedge their exposure to exchange rate risk by using a forward contract, and their decision then simplifies to a case of *riskless arbitrage.* On the other hand, an investor may choose not to use a forward, and instead wait to use a spot contract when their investment matures, whereupon their decision is a case of *risky arbitrage.* These two ways of doing arbitrage lead to two important implications, called *parity conditions*, which describe equilibria in the forward and spot markets. We now examine each one in turn.

Riskless Arbitrage: Covered Interest Parity

Suppose that contracts to exchange euros for dollars in one year's time carry an exchange rate of $F_{\$/€}$ dollars per euro. This is known as the **forward exchange rate** and it allows investors to be absolutely sure of the price at which they can trade forex in the future.

Assume you are trading for the bank in New York, and you have to decide whether to invest $1 for one year in either a dollar or euro bank deposit that pays interest. The interest rate offered in New York on dollar deposits is $i_{\$}$ and in Europe the interest rate offered on euro deposits is $i_{€}$. Which investment offers the higher return?

If you invest in a dollar deposit, your \$1 placed in a U.S. bank account will be worth $(1 + i_\$)$ dollars in one year's time. The dollar value of principal and interest for the U.S. dollar bank deposit is called the *dollar return*. Note that we explicitly specify in what currency the return is measured, so that we may compare returns.

If you invest in a euro deposit, you first need to convert the dollar to euros. Using the spot exchange rate, \$1 buys $1/E_{\$/€}$ euros today. These $1/E_{\$/€}$ euros would be placed in a euro account earning $i_€$, so in a year's time they would be worth $(1 + i_€)/E_{\$/€}$ euros. You would then convert the euros back into dollars, but you cannot know for sure what the future spot rate will be. To avoid that risk, you engage in a forward contract today to make the future transaction at a forward rate $F_{\$/€}$. The $(1 + i_€)/E_{\$/€}$ euros you will have in one year's time can then be exchanged for $(1 + i_€)F_{\$/€}/E_{\$/€}$ dollars, the dollar value of principal and interest, or the dollar return on the euro bank deposit.[10]

Three outcomes are possible when you compare the dollar returns from the two deposits. The U.S. deposit has a higher dollar return, the euro deposit has a higher dollar return, or both deposits have the same dollar return. In the first case, you would advise your bank to sell its euro deposits and buy dollar deposits; in the second case, you would advise the bank to sell its dollar deposits and buy euro deposits. Only in the third case is there no expected profit from arbitrage, so the corresponding no-arbitrage condition can be written as follows:

$$\text{Covered interest parity (CIP): } \underbrace{(1 + i_\$)}_{\substack{\text{Dollar return on}\\ \text{dollar deposits}}} = \underbrace{(1 + i_€)\frac{F_{\$/€}}{E_{\$/€}}}_{\substack{\text{Dollar return on}\\ \text{euro deposits}}} \tag{2-1}$$

This expression is called **covered interest parity (CIP)** because all exchange rate risk on the euro side has been "covered" by use of the forward contract. We say that such a trade employs *forward cover*. The condition is illustrated in Figure 2-8.

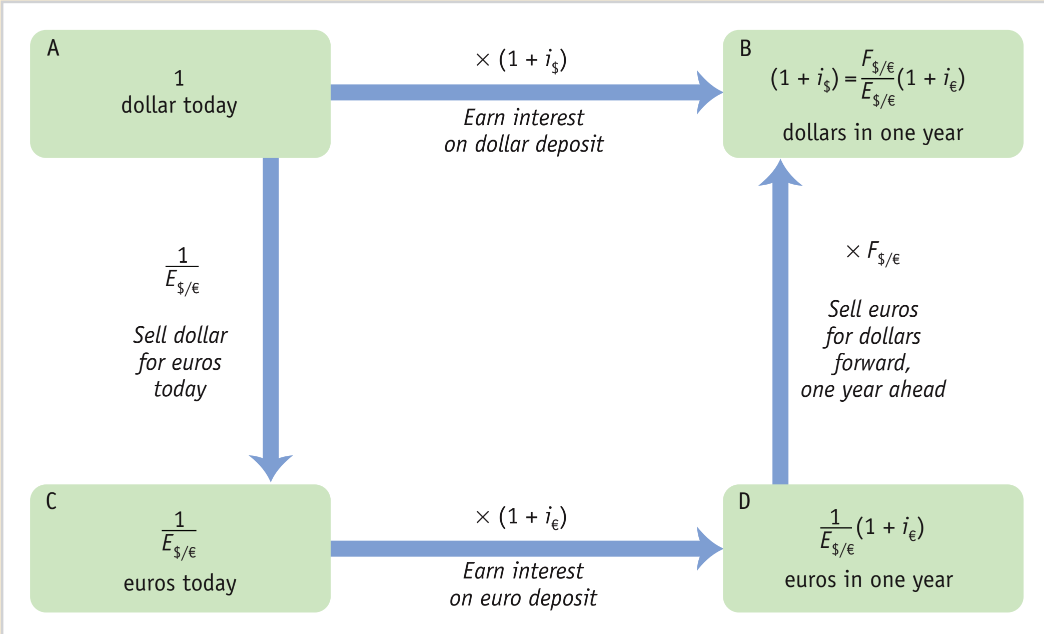
What Determines the Forward Rate? Covered interest parity is a no-arbitrage condition that describes an equilibrium in which investors are indifferent between the returns on interest-bearing bank deposits in two currencies and exchange risk has been eliminated by the use of a forward contract. Because one of the returns depends on the forward rate, covered interest parity can be seen as providing us with a theory of what determines the forward exchange rate. We can rearrange the above equation and solve for the forward rate:

$$F_{\$/€} = E_{\$/€}\frac{1 + i_\$}{1 + i_€}$$

Thus, if covered interest parity holds, we can calculate the forward rate if we know all three right-hand side variables: the spot rate $E_{\$/€}$, the dollar interest rate $i_\$$, and the euro interest rate $i_€$. For example, suppose the euro interest rate is 3%, the dollar interest rate is 5%, and the spot rate is \$1.30 per euro. Then the preceding equation says the forward rate would be $1.30 \times (1.05)/(1.03) = \$1.3252$ per euro.

[10] Note that this arbitrage strategy requires a spot and a forward contract. The two can be combined in a swap contract, and this helps explain the prevalence of swaps in the forex market.

FIGURE 2-8



Arbitrage and Covered Interest Parity Under CIP, returns to holding dollar deposits accruing interest going along the path AB must equal the returns from investing in euros going along the path ACDB with risk removed by use of a forward contract. Hence, at B, the riskless payoff must be the same on both paths, and $(1 + i_\$) = \frac{F_{\$/€}}{E_{\$/€}}(1 + i_€)$.

In practice, this is exactly how the forex market works and how the price of a forward contract is set. Traders at their computers all around the world can see the interest rates on bank deposits in each currency, and the spot exchange rate. We can now also see why the forward contract is called a "derivative" contract: to establish the price of the forward contract (the forward rate F), we first need to know the price of the spot contract (the spot rate E). That is, the pricing of the forward contract is derived from the pricing of the underlying spot contract, using additional information on interest rates.

This result raises a new question: How are the interest rates and the spot rate determined? We return to that question in a moment, after looking at some evidence to verify that covered interest parity does indeed hold.

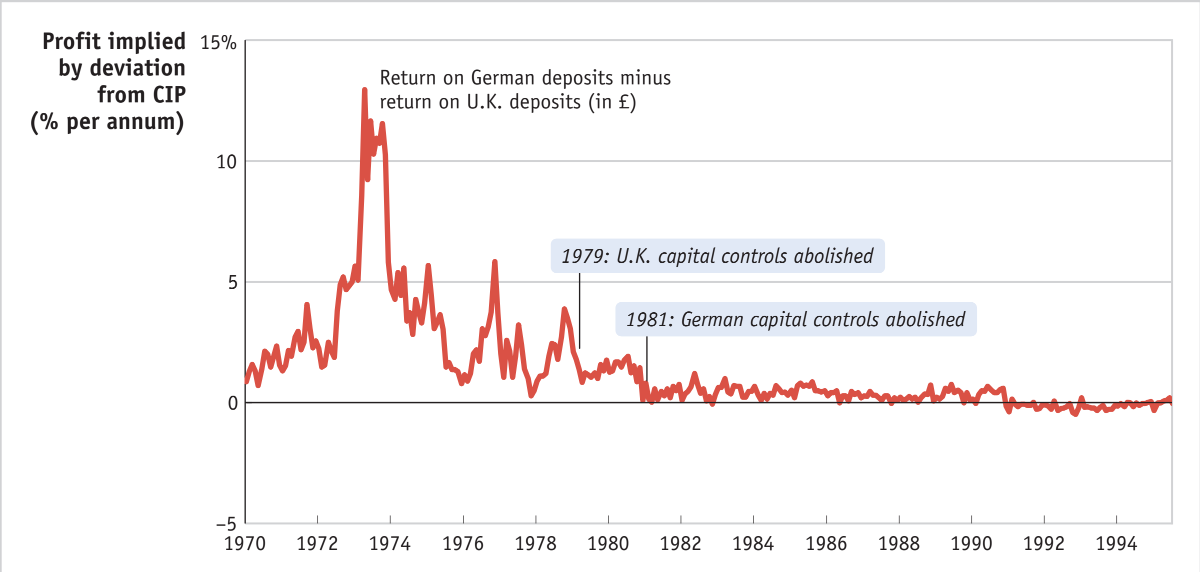
APPLICATION

Evidence on Covered Interest Parity

Does covered interest parity hold? We expect returns to be equalized only if arbitrage is possible. But if governments impose capital controls, there is no way for traders to exploit profit opportunities and no reason for the returns on different currencies to equalize.

For example, Figure 2-9 shows that covered interest parity held for the United Kingdom and Germany after the two countries abolished their capital controls in

FIGURE 2-9



Financial Liberalization and Covered Interest Parity: Arbitrage between the United Kingdom and Germany The chart shows the difference in monthly pound returns on deposits in British pounds and German marks using forward cover from 1970 to 1995. In the 1970s, the difference was positive and often large: traders would have profited from arbitrage by moving money from pound deposits to mark deposits, but capital controls prevented them from freely doing so. After financial liberalization, these profits essentially vanished, and no arbitrage opportunities remained. The CIP condition held, aside from small deviations resulting from transactions costs and measurement errors.

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, UK: Cambridge University Press).*

the period from 1979 to 1981. (The German deposits shown here were denominated in marks prior to 1999; after 1999, the euro replaced the mark as the German currency.)

The chart shows the profit that could have been made (measured in percent per annum in British currency, before transaction costs) if the investor had been able to move funds from the United Kingdom to Germany with forward cover (or, when the line is in negative territory, the profit from moving funds from Germany to the United Kingdom). From Equation (2-1), we know that the profit from this riskless arbitrage would be

$$\text{Profit} = \underbrace{(1 + i_{GER})\frac{F_{UK/GER}}{E_{UK/GER}}}_{\substack{\text{Pound return on} \\ \text{German deposits}}} - \underbrace{(1 + i_{UK})}_{\substack{\text{Pound return on} \\ \text{U.K. deposits}}}$$

This profit would be zero only if covered interest parity held. In the 1960s and 1970s, the *hypothetical* profits implied by this expression were large—or would have been had arbitrage been allowed. Instead, capital controls in both countries prevented arbitrage. Covered interest parity therefore failed to hold. Following the financial liberalization from 1979 to 1981, arbitrage became possible. From that time until the present, profits have been essentially zero. Computed profits are not exactly zero because of regulations, fees, other transaction costs, and measurement error. Once we allow for these factors, there are no profit opportunities left. Covered interest parity holds when capital markets are open, and, using similar calculations, this can be confirmed for all freely traded currencies today. ■

Risky Arbitrage: Uncovered Interest Parity

As we noted above, the second way to engage in arbitrage is to use spot contracts, and accept that the future exchange rate is then subject to risk. We now examine this case, and by doing so, we will arrive at an understanding of how the exchange rate is determined in the spot market.

To keep things simple, let us suppose, for now, that investors focus *exclusively* on the expected dollar return of the two bank deposits and not on any other characteristics of the investment. (See **Side Bar: Assets and Their Attributes.**) Imagine you are

SIDE BAR

Assets and Their Attributes

The bank deposits traded in the forex market pay interest and are part of the wider portfolio of assets held by banks and other private actors. As we have argued, the forex market is heavily influenced by the demand for these deposits as assets.

An investor's entire portfolio of assets may include stocks, bonds, real estate, art, bank deposits in various currencies, and so on. What influences the demand for all these different kinds of assets? Viewed from a financial viewpoint (i.e., setting aside the beauty of a painting or sea-side mansion), all assets have three key attributes that influence demand: return, risk, and liquidity.

An asset's **rate of return** is the total net increase in wealth (measured in a given currency) resulting from holding the asset for a specified period of time, typically one year. For example, you start the year by buying one share of DotBomb Inc., a hot Internet stock, for $100. At year's end, the share is worth $150 and has paid you a dividend of $5. Your total return is $55: a $50 capital gain from the change in the stock price plus a $5 dividend. Your total annual rate of return is 55/100, or 55%. The next year, the stock falls from $150 to $75 and pays no dividend. You lose half of your money in the second year: your rate of return for that year equals −75/150, or −50%. All else equal, investors prefer investments with high returns.

The **risk** of an asset refers to the volatility of its rate of return. The **liquidity** of an asset refers to the ease and speed with which it can be liquidated, or sold. A stock may seem to have high risk because its rate of return bounces up and down quite a lot, but its risk must be considered in relation to the riskiness of other investments. Its degree of risk could be contrasted with the rate of interest your bank offers on a money market deposit, a return that is usually very stable over time. You will lose your bank deposit only if your bank fails, which is unlikely. Your bank deposit is also very liquid. You can go to a cash machine or write a check to instantly access that form of wealth. In contrast, a work of art, say, is much less liquid. To sell the art for the greatest amount, you usually need the services of an auctioneer. Art is also risky. Works by different artists go in and out of fashion. All else equal, investors prefer assets with low risk and high liquidity.

This discussion of an asset's attributes allows us to make two observations. First, because all else is never equal, investors are willing to trade off among these attributes. You may be willing to hold a relatively risky and illiquid asset if you expect it will pay a relatively high return. Second, what you expect matters. Most investments, like stocks or art, do not have a fixed, predictable, guaranteed rate of return. As a result, all investors have to forecast. We refer to the forecast of the rate of return as the **expected rate of return.**

once again trading for a bank in New York, and you must decide whether to invest \$1 for one year in a dollar or euro bank deposit that pays interest. This time, however, you use spot contracts only and make no use of the forward contract to hedge against the riskiness of the future exchange rate.

The \$1 invested in a dollar deposit will be worth $(1 + i_\$)$ in one year's time; this is the dollar return, as before.

If you invest in a euro deposit, a dollar buys $1/E_{\$/€}$ euros today. With interest, these will be worth $(1 + i_€)/E_{\$/€}$ euros in one year. At that time, you will convert the euros back into dollars using a spot contract at the exchange rate that will prevail in one year's time. In this case, traders like you face exchange rate risk and must make a *forecast* of the future spot rate. We refer to the forecast as $E^e_{\$/€}$, which we call the **expected exchange rate.** Based on the forecast, you expect that the $(1 + i_€)/E_{\$/€}$ euros you will have in one year's time will be worth $(1 + i_€)E^e_{\$/€}/E_{\$/€}$ when converted into dollars; this is the *expected dollar return* on euro deposits; that is, the expected dollar value of principal and interest for euro deposits.

Again, three outcomes are possible: the U.S. deposit has a higher expected dollar return, the euro deposit has a higher expected dollar return, or both deposits have the same expected dollar return.

We have assumed that traders like you are indifferent to risk and care only about expected returns. Thus, in the first two cases, you have expected profit opportunities and risky arbitrage is possible: you would sell the deposit with the low expected return and buy the deposit with the higher expected return. Only in the third case is there no expected profit from arbitrage. This no-arbitrage condition can be written as follows:

$$\text{Uncovered interest parity (UIP):} \quad \underbrace{(1 + i_\$)}_{\substack{\text{Dollar return on}\\ \text{dollar deposits}}} = \underbrace{(1 + i_€)\frac{E^e_{\$/€}}{E_{\$/€}}}_{\substack{\text{Expected dollar return}\\ \text{on euro deposits}}} \qquad \text{(2-2)}$$

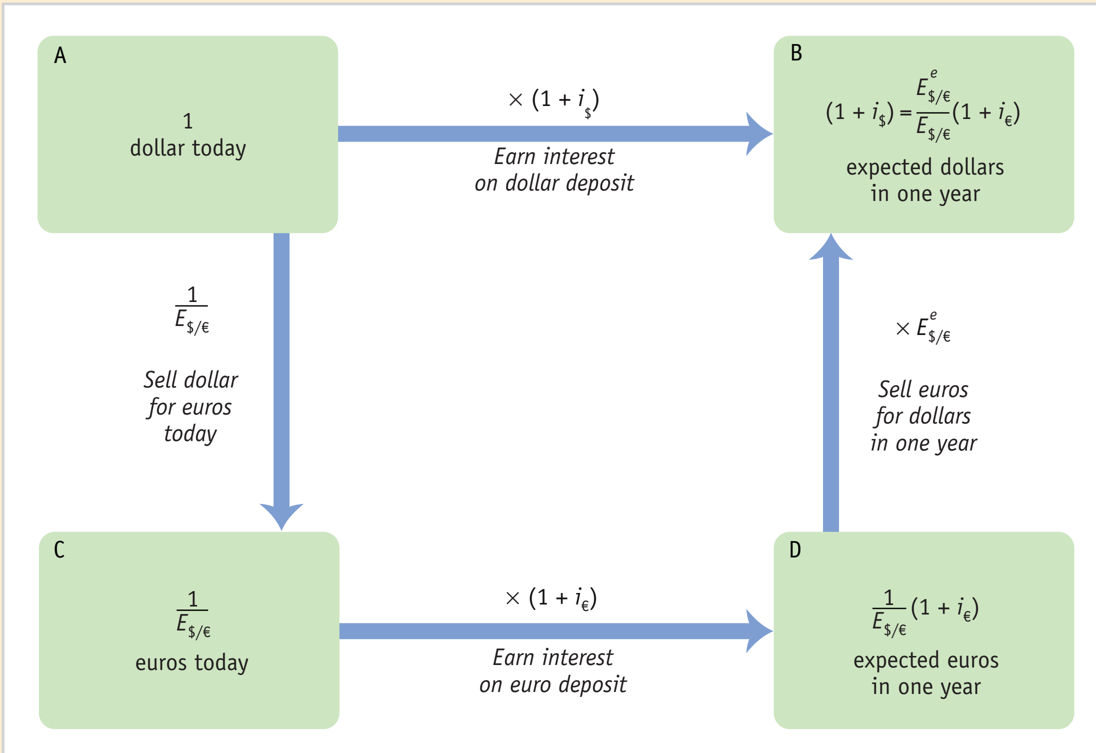
This expression is called **uncovered interest parity (UIP)** because exchange rate risk has been left "uncovered" by the decision not to hedge against exchange rate risk by using a forward contract and instead simply wait to use a spot contract in a year's time. The condition is illustrated in Figure 2-10.

What Determines the Spot Rate? Uncovered interest parity is a no-arbitrage condition that describes an equilibrium in which investors are indifferent between the returns on unhedged interest-bearing bank deposits in two currencies (where forward contracts are not employed). Because one of the returns depends on the spot rate, uncovered interest parity can be seen as providing us with a theory of what determines the spot exchange rate. We can rearrange the above equation and solve for the spot rate:

$$E_{\$/€} = E^e_{\$/€}\frac{1 + i_€}{1 + i_\$}$$

Thus, if uncovered interest parity holds, we can calculate today's spot rate if we know all three right-hand-side variables: the expected future exchange rate $E^e_{\$/€}$; the

FIGURE 2-10



Arbitrage and Uncovered Interest Parity Under UIP, returns to holding dollar deposits accruing interest going along the path AB must equal the *expected* returns from investing in euros going along the risky path ACDB. Hence, at B, the expected payoff must be the same on both paths, and $(1 + i_\$) = \frac{E^e_{\$/€}}{E_{\$/€}}(1 + i_€)$.

dollar interest rate $i_\$$; and the euro interest rate $i_€$. For example, suppose the euro interest rate is 2%, the dollar interest rate is 4%, and the expected future spot rate is \$1.40 per euro. Then the preceding equation says today's spot rate would be $1.40 \times (1.02)/(1.04) = \$1.3731$ per euro.

However, this result raises more questions: How can the expected future exchange rate $E^e_{\$/€}$ be forecast? And, as we asked in the case of covered interest parity, how are the two interest rates determined?

In the next two chapters, we will address these unanswered questions, as we continue to develop the building blocks needed for a complete theory of exchange rate determination. We start by looking at the determinants of the expected future exchange rate $E^e_{\$/€}$, and developing a model of exchange rates in the long run, and then by looking at the determinants of the interest rates $i_\$$ and $i_€$. We will soon appreciate that future expectations make the solution of forward-looking economic problems tricky: we have to solve backward from the future to the present, and this motivates the order of the material in this textbook—we must understand exchange rates in the long run before we can understand them in the short run.

APPLICATION

Evidence on Uncovered Interest Parity

Does uncovered interest parity hold? The two interest parity equations seen previously are very similar. Equation (2-1), the CIP equation, uses the forward rate; Equation (2-2), the UIP equation, uses the expected future spot rate:

$$\text{CIP:}\ \ (1 + i_{\$}) = (1 + i_{€})\frac{F_{\$/€}}{E_{\$/€}}$$

$$\text{UIP:}\ \ (1 + i_{\$}) = (1 + i_{€})\frac{E^e_{\$/€}}{E_{\$/€}}$$

To allow us to see what this implies about the relationship between the expected future spot rate and the forward rate, we divide the second equation by the first, to obtain

$$1 = E^e_{\$/€}/F_{\$/€},\ \text{or}$$

$$F_{\$/€} = E^e_{\$/€}$$

We can now clearly see how the expected future spot rate and the forward rate differ: although they may be the instruments employed in two different forms of arbitrage—risky and riskless—in equilibrium, we now see that they should not differ at all; they should be exactly the same!

Thus, if *both* covered interest parity *and* uncovered interest parity hold, an important relationship emerges: *the forward rate* $F_{\$/€}$ *must equal the expected future spot rate* $E^e_{\$/€}$. The result is intuitive. In equilibrium, and *if investors do not care about risk* (as we have assumed in our presentation of UIP), then they have no reason to prefer to avoid risk by using the forward rate, or to embrace risk by awaiting the future spot rate; for them to be indifferent, as market equilibrium requires, the two rates must be equal.

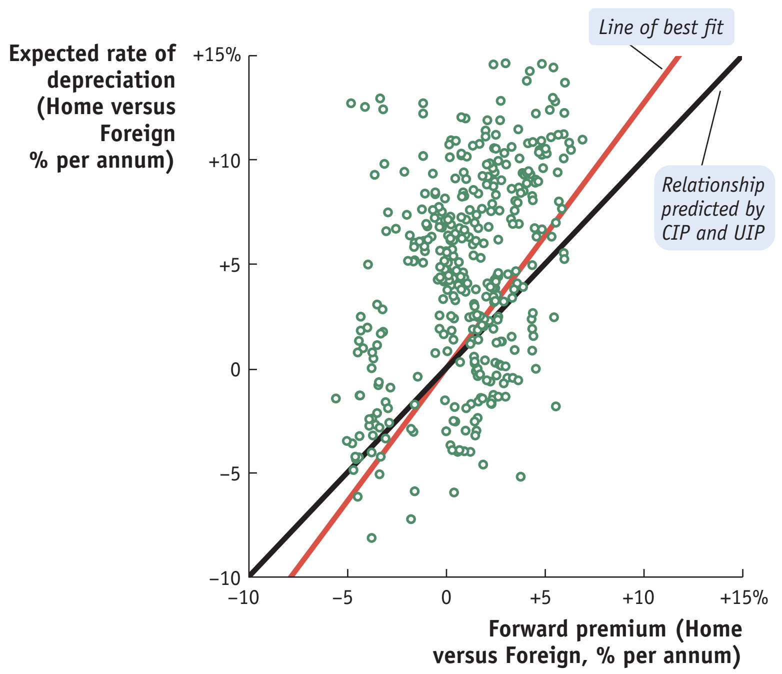
With this result we can find an approach to testing UIP that is fairly easy to describe and implement. Because the evidence in favor of CIP is strong, as we have seen, we may assume that it holds. In that case, the previous equation then provides a test for whether UIP holds. But if the forward rate equals the expected spot rate, then we can also express this equivalence relative to today's spot rate, to show that the **expected rate of depreciation** (between today and the future period) equals the **forward premium** (the proportional difference between the forward and spot rates):

$$\underbrace{\frac{F_{\$/€}}{E_{\$/€}} - 1}_{\text{Forward premium}} = \underbrace{\frac{E^e_{\$/€}}{E_{\$/€}} - 1}_{\text{Expected rate of depreciation}}$$

For example, if the spot rate is \$1.00 per euro, and the forward rate is \$1.05, the forward premium is 5%. But if $F_{\$/€} = E^e_{\$/€}$, the expected future spot rate is also \$1.05, and there is a 5% expected rate of depreciation.

The left-hand side of the preceding equation, the forward premium, is easily observed, since both the current spot and forward rates are data we can collect in the market. The difficulty is on the right-hand side: expectations are typically unobserved.

FIGURE 2-11



Evidence on Interest Parity When UIP and CIP hold, the 12-month forward premium should equal the 12-month expected rate of depreciation. A scatterplot showing these two variables should be close to the diagonal 45-degree line. Using evidence from surveys of individual forex traders' expectations over the period 1988 to 1993, UIP finds some support, as the line of best fit is close to the diagonal.

Notes: Line of best fit is through the origin. Data are monthly for the German mark, Swiss franc, Japanese yen, British pound, and Canadian dollar against the U.S. dollar from February 1988 to October 1993.

Source: Menzie Chinn and Jeffrey A. Frankel, 2002, "Survey Data on Exchange Rate Expectations: More Currencies, More Horizons, More Tests." In W. Allen and D. Dickinson, eds., Monetary Policy, Capital Flows and Financial Market Developments in the Era of Financial Globalisation: Essays in Honour of Max Fry *(London: Routledge), pp. 145–167.*

Still, the test can be attempted using surveys in which traders are asked to report their expectations. Using data from one such test, Figure 2-11 shows a strong correlation between expected rates of depreciation and the forward premium, with a slope close to 1. Still, the points do not lie exactly on the 45-degree line, so sometimes expected depreciation does not equal the interest differential. Does this profit opportunity mean that arbitrage is not working? Not necessarily. The deviations may be caused by sampling errors or noise (differences in opinion of individual traders). In addition, there may be limits to risky arbitrage in reality because of various factors such as transactions costs (market frictions) and aversion to risk, which we have so far neglected, but which we discuss in more detail in later chapters. That the slope "on average" is close to 1 provides some support for UIP. ■

Uncovered Interest Parity: A Useful Approximation

Because it provides a theory of how the spot exchange rate is determined, the uncovered interest parity equation (2-2) is one of the most important conditions in international macroeconomics. Yet for most purposes, a simpler and more convenient concept can be used.

The intuition behind the approximation is as follows. Holding dollar deposits rewards the investor with dollar interest. Holding euro deposits rewards investors in two ways: they receive euro interest, but they also receive a gain (or loss) on euros equal to the rate of euro appreciation that approximately equals the rate of dollar depreciation. Thus, for UIP to hold, and for an investor to be indifferent between dollar deposits and euro deposits, any interest shortfall (excess) on the euro side must be offset by an expected gain (loss) in the form of euro appreciation or dollar depreciation.

We can write the approximation formally as follows:

$$\text{UIP approximation:} \quad \underbrace{i_\$}_{\substack{\text{Interest rate}\\ \text{on dollar}\\ \text{deposits =}\\ \text{Dollar rate of}\\ \text{return on}\\ \text{dollar deposits}}} = \underbrace{\underbrace{i_€}_{\substack{\text{Interest rate on}\\ \text{euro deposits}}} + \underbrace{\frac{\Delta E^e_{\$/€}}{E_{\$/€}}}_{\substack{\text{Expected rate of}\\ \text{depreciation of the}\\ \text{dollar}}}}_{\substack{\text{Expected dollar rate of return on}\\ \text{euro deposits}}} \tag{2-3}$$

There are three terms in this equation. The left-hand side is the interest rate on dollar deposits. The first term on the right is the interest rate on euro deposits. The second term on the right can be expanded as $\Delta E^e_{\$/€}/E_{\$/€} = (E^e_{\$/€} - E_{\$/€})/E_{\$/€}$ and is the expected fractional change in the euro's value, or the expected rate of appreciation of the euro. As we have seen, this expression equals the appreciation of the euro exactly, but for small changes it approximately equals the expected rate of depreciation of the dollar.[11]

The UIP approximation equation, Equation (2-3), says that the home interest rate equals the foreign interest rate plus the expected rate of depreciation of the home currency.

A numerical example illustrates the UIP approximation formula. Suppose the dollar interest rate is 4% per year and the euro interest rate 3% per year. If UIP is to hold, then the expected rate of dollar depreciation over a year must be 1%. In that case, a dollar investment put into euros for a year will grow by 3% due to euro interest and in dollar terms will grow by an extra 1% due to euro appreciation, so the total dollar return on the euro deposit is approximately equal to the 4% that is offered by dollar deposits.[12]

To sum up, the uncovered interest parity condition, whether in its exact form (2-2) or its approximate form (2-3), states that there must be parity between expected returns, *expressed in a common currency*, in the two markets.

Summary

All economic models produce an output (some unknown or *endogenous* variable to be explained) and require a set of inputs (some known or *exogenous* variables that are treated as given). The two interest parity conditions provide us with models that

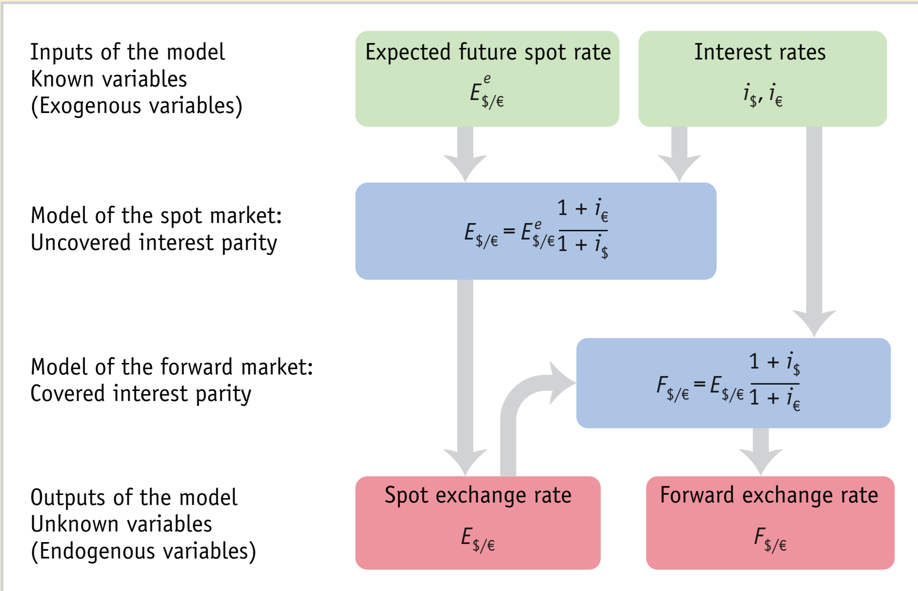
[11] To derive Equation (2-3), we can write $E^e_{\$/€}/E_{\$/€} = (1 + \Delta E^e_{\$/€}/E_{\$/€})$, and so Equation (2-2) becomes

$$1 + i_\$ = (1 + i_€)\left(1 + \frac{\Delta E^e_{\$/€}}{E_{\$/€}}\right) = 1 + i_€ + \frac{\Delta E^e_{\$/€}}{E_{\$/€}} + \left[i_€ \frac{\Delta E^e_{\$/€}}{E_{\$/€}}\right]$$

When the euro interest rate and the expected rate of depreciation are small, the last term in brackets is very small and may be neglected in an approximation. We can then cancel out the 1 that appears in the first and third terms of the above equation to obtain Equation (2-3).

[12] Note that the \$1 investment in euros will be worth $(1.03) \times (1.01) = \$1.0403$ after one year, which is very close to \$1.04, the value of the dollar deposit after one year. The difference is just the approximation error. See the previous footnote.

FIGURE 2-12



How Interest Parity Relationships Explain Spot and Forward Rates In the spot market, UIP provides a model of how the spot exchange rate is determined. To use UIP to find the spot rate, we need to know the expected future spot rate and the prevailing interest rates for the two currencies. In the forward market, CIP provides a model of how the forward exchange rate is determined. When we use CIP, we derive the forward rate from the current spot rate (from UIP) and the interest rates for the two currencies.

explain how the prices of the two most important forex contracts are determined in market equilibrium with no arbitrage possibilities. Uncovered interest parity applies to the spot market and determines the spot rate, based on interest rates and exchange rate expectations. Covered interest parity applies to the forward market and determines the forward rate based on interest rates and the spot rate. Figure 2-12 sums up what we have learned.

6 Conclusions

The foreign exchange market has a long and often tumultuous record and, in today's globalized world, exchange rates matter more than ever. They affect the prices of international transactions, can be a focus of government policy, and often play a major role in economic and political crises.

This chapter has set the stage for our study of exchange rates. We learned what exchange rates are and how they are used. We have also seen how they have behaved in reality under different exchange rate regimes. History shows a vast range of past experiences, and this experimentation continues.

These observations underscore the importance of understanding different regimes and their causes and consequences. We have prepared ourselves by examining the workings of the foreign exchange market in some detail. Government intervention (or its absence) in this market determines the nature of the exchange rate regime in operation, from fixed to floating. The workings of actors in the forex market then ultimately determine equilibrium values of exchange rates.

How is forex market equilibrium determined? We can now see that two key forces operate in the foreign exchange market: arbitrage and expectations. Through expectations, news about the future can affect expected returns. Through arbitrage, differences in expected returns are equalized, as summed up by the two important interest parity conditions, covered interest parity and uncovered interest parity. In the next two chapters, we build on these ideas to develop a complete theory of exchange rates.

KEY POINTS

1. The exchange rate in a country is the price of a unit of foreign currency expressed in terms of the home currency. This price is determined in the spot market for foreign exchange.
2. When the home exchange rate rises, less foreign currency is bought/sold per unit of home currency; the home currency has depreciated. If home currency buys x% less foreign currency, the home currency is said to have depreciated by x%.
3. When the home exchange rate falls, more foreign currency is bought/sold per unit of home currency; the home currency has appreciated. If home currency buys x% more foreign currency, the home currency is said to have appreciated by x%.
4. The exchange rate is used to convert the prices of goods and assets into a common currency to allow meaningful price comparisons.
5. Exchange rates may be stable over time or they may fluctuate. History supplies examples of the former (fixed exchange rate regimes) and the latter (floating exchange rate regimes) as well as a number of intermediate regime types.
6. An exchange rate crisis occurs when the exchange rate experiences a sudden and large depreciation. These events are often associated with broader economic and political turmoil, especially in developing countries.
7. Some countries may forgo a national currency to form a currency union with other nations (e.g., the Eurozone), or they may unilaterally adopt the currency of another country ("dollarization").
8. Looking across all countries today, numerous fixed and floating rate regimes are observed, so we must understand both types of regime.
9. The forex market is dominated by spot transactions, but many derivative contracts exist, such as forwards, swaps, futures, and options.
10. The main actors in the market are private investors and (frequently) the government authorities, represented usually by the central bank.

11. Arbitrage on currencies means that spot exchange rates are approximately equal in different forex markets. Cross rates (for indirect trades) and spot rates (for direct trades) are also approximately equal.
12. Riskless interest arbitrage leads to the covered interest parity (CIP) condition. CIP says that the dollar return on dollar deposits must equal the dollar return on euro deposits, where forward contracts are used to cover exchange rate risk.
13. Covered interest parity says that the forward rate is determined by home and foreign interest rates and the spot exchange rate.
14. Risky interest arbitrage leads to the uncovered interest parity (UIP) condition. UIP says that when spot contracts are used and exchange rate risk is not covered, the dollar return on dollar deposits must equal the expected dollar returns on euro deposits.
15. Uncovered interest parity explains how the spot rate is determined by the home and foreign interest rates and the expected future spot exchange rate.

KEY TERMS

exchange rate, p. 26
appreciation, p. 28
depreciation, p. 28
effective exchange rate, p. 30
exchange rate regimes, p. 33
fixed (or pegged) exchange rate regime, p. 33
floating (or flexible) exchange rate regime, p. 33
free float, p. 34
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exchange rate crises, p. 35
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currency (or monetary) union, p. 37
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expected rate of depreciation, p. 54
forward premium, p. 54

PROBLEMS

1. Refer to the exchange rates given in the following table:

	Today June 25, 2010		One Year Ago June 25, 2009	
Country	Per $	Per £	Per €	Per $
Australia	1.152	1.721	1.417	1.225
Canada	1.037	1.559	1.283	1.084
Denmark	6.036	9.045	7.443	5.238
Euro	0.811	1.215	1.000	0.703
Hong Kong	7.779	11.643	9.583	7.750
India	46.36	69.476	57.179	48.16
Japan	89.35	134.048	110.308	94.86
Mexico	12.697	18.993	15.631	13.22
Sweden	7.74	11.632	9.577	7.460
United Kingdom	0.667	1.000	0.822	0.609
United States	1.000	1.496	1.232	1.000

Source: U.S. Federal Reserve Board of Governors, H.10 release: Foreign Exchange Rates.

Based on the table provided, answer the following questions:

a. Compute the U.S. dollar-yen exchange rate $E_{\$/¥}$ and the U.S. dollar-Canadian dollar exchange rate $E_{\$/C\$}$ on June 25, 2010, and June 25, 2009.

b. What happened to the value of the U.S. dollar relative to the Japanese yen and Canadian dollar between June 25, 2009, and June 25, 2010? Compute the percentage change in the value of the U.S. dollar relative to each currency using the U.S. dollar-foreign currency exchange rates you computed in (a).

c. Using the information in the table for June 25, 2010, compute the Danish krone-Canadian dollar exchange rate $E_{\text{krone}/C\$}$.

d. Visit the website of the Board of Governors of the Federal Reserve System at http://www.federalreserve.gov/. Click on "Economic Research and Data" and then "Statistics: Releases and Historical Data." Download the H.10 release Foreign Exchange Rates (weekly data available). What has happened to the value of the U.S. dollar relative to the Canadian dollar, Japanese yen, and Danish krone since June 25, 2010?

e. Using the information from (d), what has happened to the value of the U.S. dollar relative to the British pound and the euro? *Note:* The H.10 release quotes these exchange rates as U.S. dollars per unit of foreign currency in line with long-standing market conventions.

2. Consider the United States and the countries it trades with the most (measured in trade volume): Canada, Mexico, China, and Japan. For simplicity, assume these are the only four countries with which the United States trades. Trade shares and exchange rates for these four countries are as follows:

Country (currency)	Share of Trade	$ per FX in 2009	$ per FX in 2010
Canada (dollar)	36%	0.9225	0.9643
Mexico (peso)	28%	0.0756	0.0788
China (yuan)	20%	0.1464	0.1473
Japan (yen)	16%	0.0105	0.0112

a. Compute the percentage change from 2009 to 2010 in the four U.S. bilateral exchange rates (defined as U.S. dollars per units of foreign exchange, or FX) in the table provided.

b. Use the trade shares as weights to compute the percentage change in the nominal effective exchange rate for the United States between 2009 and 2010 (in U.S. dollars per foreign currency basket).

c. Based on your answer to (b), what happened to the value of the U.S. dollar against this basket between 2009 and 2010? How does this compare with the change in the value of the U.S. dollar relative to the Mexican peso? Explain your answer.

3. Go to the website for Federal Reserve Economic Data (FRED): http://research.stlouisfed.org/fred2/. Locate the monthly exchange rate data for the following:

a. Canada (dollar), 1980–2009

b. China (yuan), 1999–2005 and 2005–2009

c. Mexico (peso), 1993–1995 and 1995—2009
d. Thailand (baht), 1986–1997 and 1997—2009
e. Venezuela (bolivar), 2003–2009

Look at the graphs and make a judgment as to whether each currency was fixed (peg or band), crawling (peg or band), or floating relative to the U.S. dollar during each time frame given.

4. Describe the different ways in which the government may intervene in the foreign exchange market. Why does the government have the ability to intervene in this way, while private actors do not?

5. Suppose quotes for the dollar-euro exchange rate $E_{\$/€}$ are as follows: in New York \$1.50 per euro, and in Tokyo \$1.55 per euro. Describe how investors use arbitrage to take advantage of the difference in exchange rates. Explain how this process will affect the dollar price of the euro in New York and Tokyo.

6. Consider a Dutch investor with 1,000 euros to place in a bank deposit in either the Netherlands or Great Britain. The (one-year) interest rate on bank deposits is 2% in Britain and 4.04% in the Netherlands. The (one-year) forward euro-pound exchange rate is 1.575 euros per pound and the spot rate is 1.5 euros per pound. Answer the following questions, using the *exact* equations for UIP and CIP as necessary.

   a. What is the euro-denominated return on Dutch deposits for this investor?
   b. What is the (riskless) euro-denominated return on British deposits for this investor using forward cover?
   c. Is there an arbitrage opportunity here? Explain why or why not. Is this an equilibrium in the forward exchange rate market?
   d. If the spot rate is 1.5 euros per pound, and interest rates are as stated previously, what is the equilibrium forward rate, according to covered interest parity (CIP)?
   e. Suppose the forward rate takes the value given by your answer to (d). Compute the forward premium on the British pound for the Dutch investor (where exchange rates are in euros per pound). Is it positive or negative? Why do investors require this premium/discount in equilibrium?
   f. If uncovered interest parity (UIP) holds, what is the expected depreciation of the euro (against the pound) over one year?
   g. Based on your answer to (f), what is the expected euro-pound exchange rate one year ahead?

7. You are a financial adviser to a U.S. corporation that expects to receive a payment of 40 million Japanese yen in 180 days for goods exported to Japan. The current spot rate is 100 yen per U.S. dollar ($E_{\$/¥} = 0.01000$). You are concerned that the U.S. dollar is going to appreciate against the yen over the next six months.

   a. Assuming the exchange rate remains unchanged, how much does your firm expect to receive in U.S. dollars?
   b. How much would your firm receive (in U.S. dollars) if the dollar appreciated to 110 yen per U.S. dollar ($E_{\$/¥} = 0.00909$)?
   c. Describe how you could use an options contract to hedge against the risk of losses associated with the potential appreciation in the U.S. dollar.

8. Consider how transactions costs affect foreign currency exchange. Rank each of the following foreign exchanges according to their probable spread (between the "buy at" and "sell for" bilateral exchange rates) and justify your ranking.

   a. An American returning from a trip to Turkey wants to exchange his Turkish lira for U.S. dollars at the airport.
   b. Citigroup and HSBC, both large commercial banks located in the United States and United Kingdom, respectively, need to clear several large checks drawn on accounts held by each bank.
   c. Honda Motor Company needs to exchange yen for U.S. dollars to pay American workers at its Ohio manufacturing plant.
   d. A Canadian tourist in Germany pays for her hotel room using a credit card.

NET WORK

Visit the ft.com website (or another financial website such as oanda.com or xe.com), and download the same exchange rates shown in Table 2-1 for today's date. For all currencies (other than the dollar), compute the one-year percentage appreciation or depreciation against the dollar. For the dollar, compute the one-year percentage appreciation or depreciation against each currency. (*Hint:* Google "ft.com cross rates.")

Visit the OANDA website (oanda.com) to explore recent exchange rate trends for any pair of countries in the world. Download some series to a spreadsheet for manipulation, or use the FXGraph online graphing tools to plot trends. Try to plot examples of some fixed and floating rates. See whether you can locate data for an exchange rate crisis during recent years. Can you tell from the data which countries are fixed and which are floating?

Next visit the IMF's website (imf.org) and locate the latest classification of the de facto exchange rate regimes in all countries around the world, the same source used in Figure 2-4. Do your regime classifications agree with the IMF's?