1 Foreign Exchange Markets and Exchange Rates

The foreign exchange market (FOREX) is undoubtedly the world's largest financial market. By some estimates, about 2 trillion USD worth of currency changes hands every day. It is the market where one country's currency is traded for another's. Most of the trading takes place in a few currencies: the U.S. dollar ($), British pound sterling (£), Euro (€), Japanese yen (¥) and Swiss franc (SF).

The foreign exchange market is an over-the-counter (OTC) market. There is no single location where traders get together. Instead, traders are located in the major commercial and investment banks around the world. They communicate using computer terminals, telephones, and other telecommunication devices. One element in the communications network for foreign transactions is the Society for Worldwide Interbank Financial Telecommunications (SWIFT). It is a Belgian not-for-profit cooperative. A bank in Bratislava can send messages to a bank in London via SWIFT's regional processing centers. The connection is through data-transmission lines.

The many different types of participants in the foreign exchange market include the following:

1. Importers who convert their domestic currency to foreign currency to pay for goods from foreign countries.
2. Exporters who receive foreign currency and may want to convert to the domestic currency.
3. Portfolio managers who buy and sell foreign stocks and bonds.
4. Foreign exchange brokers who match buy and sell orders.
5. Traders who make the market in foreign exchange.

1.1 Exchange Rates: Quotations

An exchange rate is the price of one country's currency for another's. In finance, the exchange rate (also known as the foreign-exchange rate, forex rate or FX rate) between two currencies specifies how much one currency is worth in terms of the other.

Three types of trades take place in the foreign exchange market: spot, forward, and swap. Spot trades involve an agreement on the exchange rate today for settlement in two days. The rate is called the spot exchange rate. Forward trades involve an agreement on exchange rates today for settlement in the future. The rate is called the forward exchange rate. The maturities for forward trades are usually 1 to 52 weeks. A swap is the sale (purchase) of a foreign currency with a simultaneous agreement to repurchase (resell) it sometime in the future. The difference between the sale price and the repurchase price is called the swap rate.

The spot exchange rate refers to the current exchange rate. The forward exchange rate refers to an exchange rate that is quoted and traded today but for delivery and payment on a specific future date.

An exchange rate quotation is given by stating the number of units of "term currency" or "price currency" that can be bought in terms of 1 unit currency (also called base currency). For example, in a quotation that says the EURUSD exchange rate is 1.3 (1.3 USD per EUR), the term currency is USD and the base currency is EUR.

Quotes using a country's home currency as the price currency (e.g., EUR 1.00 = $1.45 in the US) are known as direct quotation or price quotation (from that country's perspective) and are used by most countries.

Quotes using a country's home currency as the unit currency (e.g., £0.4762 = $1.00 in the US) are known as indirect quotation or quantity quotation and are used in British newspapers and are also common in Australia, New Zealand and the eurozone.

- direct quotation: 1 home currency unit = x foreign currency units
- indirect quotation: 1 foreign currency unit = x home currency units

Note that, using direct quotation, if the home currency is strengthening (i.e., appreciating, or becoming more valuable) then the exchange rate number decreases. Conversely if the foreign currency is strengthening, the exchange rate number increases and the home currency is depreciating. When looking at a currency pair such as EURUSD, the first component (EUR in this case) will be called the base currency. The second is called the term currency. For example: EURUSD = 1.33866, means EUR is the base and USD the term, so 1 EUR = 1.33866 USD.

1.2 Nominal and Real Exchange Rates

The nominal exchange rate e is the price in domestic currency of one unit of a foreign currency.

The real exchange rate (*RER*) is defined as

$$RER = e\left(\frac{P^*}{P}\right),$$

where P is the domestic price level and P^* the foreign price level. P and P^* must have the same arbitrary value in some chosen base year. Hence in the base year, $RER = e$.

The *RER* is only a theoretical ideal. In practice, there are many foreign currencies and price level values to take into consideration. Correspondingly, the model calculations become increasingly more complex. Furthermore, the model is based on purchasing power parity (PPP), which implies a constant *RER*. The empirical determination of a constant *RER* value could never be realised, due to limitations on data collection. PPP would imply that the *RER* is the rate at which an organization can trade goods and services of one economy (e.g. country) for those of another. For example, if the price of good increases 10% in the UK, and the Japanese currency simultaneously appreciates 10% against the UK currency, then the price of the good remains constant for someone in Japan. The people in the UK, however,

would still have to deal with the 10% increase in domestic prices. It is also worth mentioning that government-enacted tariffs can affect the actual rate of exchange, helping to reduce price pressures. PPP appears to hold only in the long term (3–5 years) when prices eventually correct towards parity.
More recent approaches in modelling the *RER* employ a set of macroeconomic variables, such as relative productivity and the real interest rate differential.

2 The Law of One Price and Purchasing-Power Parity

What determines the level of the spot exchange rate? One answer is the **law of one price (LOP)**. The law of one price says that a commodity will cost the same regardless of the country in which it is purchased. More formally, let $S_£(t)$ be the spot exchange rate, that is a number of dollars needed to purchase a British pound at time *t*. Let $P^{US}(t)$ and $P^{UK}(t)$ be the current U.S. and British prices of a particular commodity, say, wheat. The law of one price says that

$$P^{US}(t) = S_£(t)\, P^{UK}(t)$$

for wheat.

For the LOP to be strictly true, three assumptions are needed:
1. The transactions cost of trading wheat – shipping, insurance, wastage, and so on – must be zero.
2. No barriers to trading wheat, such as tariffs or taxes, can exist.
3. Finally, wheat in New York must be identical to wheat in London.

Given the fact that the transactions costs are not zero and that the other conditions are rarely exactly met, the LOP is really applicable only to traded goods, and then only to very uniform ones. Because consumers purchase many goods, economists speak of **purchasing-power parity (PPP)**, the idea that the exchange rate adjusts so that a market basket of goods costs the same, regardless of the country in which it is purchased. In addition, a relative version of purchasing-power parity has evolved.

Relative purchasing-power parity (RPPP) says that the rate of change in the price level of commodities in one country relative to the rate of change in the price level in another determines the rate of change of the exchange rate between the two countries. Formally,

$$\frac{P^{US}(t+1)}{P^{US}(t)} = \frac{S_£(t+1)}{S_£(t)} \times \frac{P^{UK}(t+1)}{P^{UK}(t)}$$

1 + U.S. inflation rate = 1 + Change in foreign exchange rate × 1 + British inflation rate

This states that the rate of inflation in the United States relative to that in Great Britain determines the rate of change in the value of the dollar relative to that of the pound during the interval *t* to *t + 1*. It is common to write Π_{US} as the rate of inflation in the United States. $1 + \Pi_{US}$ is equal to $P^{US}(t+1)/P^{US}(t)$. Similarly, Π_{UK} is the rate of inflation in Great Britain. $1 + \Pi_{UK}$ is equal to $P^{UK}(t+1)/P^{UK}(t)$.

Using Π to represent the rate of inflation, the above equation can be rearranged as

$$\frac{1+\prod_{US}}{1+\prod_{UK}} = \frac{S_{£}(t+1)}{S_{£}(t)}$$

We can rewrite this in an approximate form as

$$\prod_{US} \cong \prod_{UK} + \frac{\dot{S}_{£}}{S_{£}}$$

where $\frac{\dot{S}_{£}}{S_{£}}$ now stands for the rate of exchange in the dollars-per-pound exchange rate.

Example

We suppose that inflation in Switzerland during the year is equal to 4 percent and inflation in the United States is equal to 10 percent. Then, according to the RPPP, the price of the Swiss franc in terms of the U.S. dollar should rise, that is, the U.S. dollar declines in value in terms of the Swiss franc. Using our approximation, the dollar-per-franc exchange rate should rise by

$$\frac{\dot{S}_{SF}}{S_{SF}} \approx \prod_{US} - \prod_{S}$$
$$= 10\% - 4\% = 6\%$$

where $\frac{\dot{S}_{SF}}{S_{SF}}$ stands for the rate of change in the dollars-per-franc exchange rate. That is, if the Swiss franc is worth USD 1.03 at the beginning of the period, it should be worth approximately USD 1.09 (1.03 × 1.06) at the end of the period.

The RPPP says that the change in the ratio of domestic commodity prices of two countries must be matched in the exchange rate. This version of the law of one price suggests that to estimate changes in the spot rate of exchange, it is necessary to estimate the differences in relative inflation rates. In other words, we can express our formula in expectational terms as

$$E\left(\frac{\dot{S}_{SF}}{S_{SF}}\right) = E(\prod_{US}) - E(\prod_{S})$$

If we expect the U.S. inflation rate to exceed the Swiss inflation rate, we should expect the dollar price of Swiss francs to rise, which is the same as saying that the dollar is expected to fall against the franc.

2.1 Interest Rates and Exchange Rates: Interest-Rate Parity

The forward exchange rate and the spot exchange rate are tied together by the same sort of arbitrage that underlies the law of one price. If forward exchange rates are greater than the spot exchange rate in a particular currency, the forward foreign currency is said to be at a premium (this implies the domestic currency is at a discount). If the values of forward exchange rates are less than the spot exchange rate, the forward rate on foreign currency is at a discount.

Suppose we observe that the spot EUR rate is EUR 0.65 = USD 1.00 and the one-month forward EUR is EUR 0.67 = USD 1.00. Because fewer marks are needed to buy a dollar at the forward rate than are needed to buy a dollar at the spot rate, the mark is more valuable in the forward market than in the spot market. This means that the one-month forward rate is at premium. Of course, whatever we say for the mark must be opposite of what we say for the dollar. In this example, the dollar is at a discount because the forward value is less than the spot value. Forward exchange is quoted in terms of the premium or discount that is to be added onto the spot rate.

Whether forward rates are at a premium or at a discount when compared to a domestic currency depends on the relative interest rates in the foreign and domestic currency markets. The interest-rate-parity theorem implies that, if interest rates are higher domestically than in a particular foreign country, the foreign country's currency will be selling at a premium in the forward market, and if the interest rates are lower domestically, the foreign currency will be selling at a discount in the forward market.

Let $S(0)$ be the current domestic-currency price of spot foreign exchange (current time is denoted by 0). If the domestic currency is the euro and the foreign exchange is the U.S. dollar, we might observe $S(0)$ = EUR 0.65/USD. $S(0)$ is in direct terms. Let $F(0,1)$ be the domestic-currency price of forward exchange for a contract that matures in one month. Thus, the contract is for forward exchange one month hence. Let i and i^* be the yearly rates of interest on deposits denominated in the domestic (i) and foreign (i^*) currencies. Of course, the maturity of the deposits can be chosen to coincide with the maturity of the forward contract. Now consider a trader who has Access to the interbank market in foreign exchange and deposits. Suppose the trader has some euros to invest for one month. The trader can make a euro loan or a dollar loan. The annual interest rate is 10 percent in dollars and 6 percent in euros. Which is better?

The Euro Investment
Given an annual interest rate of 6 percent, the one-month rate of interest is 0.5 percent, ignoring compounding. If the trader invests EUR 1 million now, the trader will get EUR 1 million × 1.005 = EUR 1.005 million at the end of the month. Following is an illustration:

Time 0	
Lend 1 unit of euros	EUR 1,000,000
Time 1	
Obtain 1 + i × (1/12) units of domestic currency	EUR 1,000,000 × (1 + 0.05) = EUR 1,005,000

The Dollar Investment

The current spot rate is EUR 0.65/USD. This means the trader can currently obtain EUR 1 million/0.65 = USD 1,538,462. The rate of interest on one year USD loans is 10 percent. For one month, the interest rate is 0.10/12 = 0.0083. Thus, at the end of one month the trader will obtain USD 1,538,462 × 1.0083 = USD 1,551,231. Of course, if the trader wants euros at the end of the month, the trader must convert the U.S. dollars back into euros. The trader can fix the exchange rate for one-month conversion. Suppose the one-month forward is EUR 0.64787/USD. Then the reader can sell U.S. dollars forward. This will ensure that the trader gets EUR 1,551,231 × 0.64787 = EUR 1,005 million at the end of the month. The general relationships are set forth here:

Time 0

- Purchase 1 unit [1/S(0)] of foreign exchange
- USD 1,538,462
- Sell forward [1/*S(0)*] × [1 + i* × (1/12)] units of forward exchange at the forward rate *F(0,1)*

Time 1

- Deposit matures and pays [1/*S(0)*] × [1 + i × (1/12)] units of foreign exchange
- USD 1,538,462 × 1.0083 = USD 1,551,231

- Deliver foreign exchange in fulfillment of forward contract, receiving [1/*S(0)*] × [1 + i* × (1/12)] × [*F(0,1)*]
- USD 1,538,462 × 1.0083 × 0.64787 = EUR 1,005,000

In our example, the investment earned exactly the same rate of return and 1 + i × (1/12) = [1/S(0)] × [1 + i* × (1/12)] × [F(0,1)]. In competitive financial markets, this must be true for risk-free investments. When the trader makes the U.S. dollar loan, he or she gets a higher interest rate. But the return is the same because the U.S. dollar must be sold forward at a lower price that it can be exchanged for initially. If the domestic interest rates were different from the covered foreign interest rate, the trader would have arbitrage opportunities.

To summarize, to prevent arbitrage possibilities from existing, we must have equality of domestic interest rate and covered foreign interest rates:

$$1 + i = \frac{1}{S(0)} \times (1 + i^*) \times F(0,1)$$

or

$$\frac{1+i}{1+i^*} = \frac{F(0,1)}{S(0)}.$$

The last equation is the famous interest-rate-parity theorem. It relates the forward exchange rate and the spot exchange rate to interest-rate differentials. Notice that, if $i > i^*$, the spot rate will be less than the forward rate.

2.2 The Forward Discount and Expected Spot Rates

A close connection exists between forward exchange rates and expected spot rates. A trader's buy and sell decisions in today's forward market are based on the trader's market expectation of the future spot rate. In fact, if traders were completely indifferent to risk, the forward rate of exchange would depend soley on expectations about the future spot rate. For example, suppose the one-year forward rate on euros is EUR 0.65/USD. This must mean that traders expect the spot rate to be EUR 0.65/USD in one year [*E(S(1)*) = EUR 0.65/USD]. If they thought it would be higher, it would create an arbitrage opportunity. Traders would buy U.S. dollars forward at the low price and sell dollars one year later at the expected higher price.

This implies that the forward rate of exchange is equal to the expected spot, or (in general terms)

$$F(0,1) = E[S(1)]$$

and

$$\frac{F(0,1)}{S(0)} = \frac{E[S(1)]}{S(0)}.$$

Equilibrium is achieved only when the forward discount (or premium) equals the expected change in the spot exchange rate.

2.3 Exchange-Rate Risk

Exchange-rate risk is the natural consequence of international operations in a world where foreign currency values move up and down. International firms usually enter into some contracts that require payments in different currencies. For example, suppose that the treasurer of an international firm knows that one month from today the firm must pay GBP 2 million for goods it will receive in England. The current exchange rate is USD 2.00/GBP, and if that rate prevails in one month, the dollar cost of the goods to the firm will be USD 2.00/GBP × GBP 2 million = USD 4 million. The treasurer in this case is obligated to pay pounds in one month. (Alternately, we say that he is short in pounds). A net short or long position of this type can be very risky. If the pound rises in the month to USD 2.5/GBP, the treasurer must pay USD 2.5/GBP × GBP 2 million = USD 5 million, an extra USD 1 million.

This is the essence of foreign-exchange risk. The treasurer may want to hedge his position. When forward markets exist, the most convenient means of hedging is the purchase or sale of forward contracts. In this example, the treasurer may want to consider buying 2 million pounds sterling one month forward. If the one-month forward rate quoted today is also USD 2.00/GBP, the treasurer will fulfill the contract by exchanging USD 4 million for GBP 2 million in one month. The GBP 2 million he receives from the contract can then be used to pay for the goods. By hedging today, he fixes the outflow one month from now to exactly USD 4 million.

Should the treasurer hedge or speculate? There are usually two reasons why the treasurer should hedge:

1. In an efficient foreign-exchange-rate market, speculation is a zero NPV activity. Unless the treasurer has special information, nothing will be gained from foreign exchange speculation.
2. The costs of hedging are not large. The treasurer can use forward contracts to hedge, and if the forward rate is equal to the expected spot, the costs of hedging are negligible. Of course, there are ways to hedge foreign exchange risk other than to use forward contracts. For example, the treasurer can borrow dollars and buy pounds sterling in the spot market today and lend them for one month in London. By the interest-rate-parity theorem, this will be the same as buying the pounds sterling forward.