Chapter 1

Arbitrage, Hedging, and Speculation: The Foreign Exchange Market

Arbitrage, hedging, and speculation are three distinct acts in market transactions in any items of trade—goods, securities, and currencies. In this book, we will discuss these three operational strategies in the foreign exchange market, but some of these strategies can be duplicated in other markets as well. On our chapter-by-chapter exposition and exploration throughout this book, we will delineate arbitrage, hedging, and speculation from the standpoint of a market participant—a trader, an individual, or an institution—with access to market data, economic judgment, and analytical skill.

ARBITRAGE

Arbitrage is the simultaneous purchase and sale of a commodity or asset in different markets with the sole intent to make profit from the difference in buying and selling prices. Here the asset is a currency. If, for example, the dollar price of a British pound sterling is $1.60 in Frankfurt but $1.50 in Paris, a trader can buy £1 in Paris, sell that pound in Frankfurt, and make a profit of $0.10 per pound, and if the trader buys 15 million pounds (£15,000,000), he makes $1,500,000 before any transaction costs, if they exist. Therefore, arbitrage is an exploitation of misalignment of market quotes. If the market is perfectly competitive, this sort of price differential cannot exist, thus, arbitrage profit cannot exist. In this sense, arbitrage profit is a possible outcome of market imperfection in which "buy cheap and sell dear" is a feasible act of a vigilant trader.

It should be pointed out that markets are mostly efficient, and hysteresis fades away pretty soon by the forces unleashed by the acts of buying low and selling high. In the scenario described above, if it persists, then the Paris market will feel a higher demand for the pound, and the Frank-

... demand will force the Paris price of the pound to rise and the Frankfurt price to fall, narrowing the differential continuously until it is reduced to zero. Arbitrage in this sense is a process of bringing the law of one price into reality, which can be called market equilibrium.

It should be noted that in the foreign exchange market, traders can buy and sell continuously—exchanging one currency for another and again for another currency, finally getting back to the original currency in the series of instantaneous transactions, and thus making profits by market quotes misalignment. This is a case of triangular arbitrage, and it is further discussed at the end of this chapter. But there is another arbitrage that involves other economic variable(s), such as interest rate(s), along with foreign currency, and currencies a trader can engage in profit making, finally bringing the market to equilibrium. In chapter 5, we will provide a better description of this type of arbitrage.

HEDGING

Hedging is a safety net—an insurance policy against any open position of a trader. It is an underlying cover. Consider an investor who converts his \$15,000,000 at the cash market (where \$1.50 = £1) for the British pound, and puts his £10,000,000 at the British bank for a year at 9.5 percent to get £10,950,000. But when he gets that British amount, if the exchange rate becomes \$1 = £1, he is turning his \$15,000,000 into \$10,950,000, which is a total loss of \$4,050,000 (27 percent).

To prevent such potential economic loss, many financial instruments have been created and are in existence for the investor. If at the time the investor exchanges his \$15,000,000 and puts his converted amount into British pound, he has the option to sell his British amount at the rate \$1.72 = £1 a year later, he can then turn his £10,950,000 into \$18,834,000. This is a total gain of \$3,834,000 (25.56 percent). Selling the future British amount at the available rate of \$1.72 = £1 is an example of hedging. In the book, we bring out different instruments of hedging and explain how hedging works.

SPECULATION

Speculation is the polar opposite of hedging. It is the deliberate assumption of risk. This risk is a calculated risk assumed by the investor in anticipation of a bigger profit. Consider the example once again. Given the market quotes on the price of the British pound and the interest rate, he can, as we have noted, turn his \$15,000,000 into £10,950,000 via currency conversion and deposit creation. If he decides not to sell that British amount at the available rate \$1.72 = £1, but feels that the British pound will go up to, say, \$1.80 = £1, he may not hedge and wait with his uncovered position. This is an act of speculation. By staying with his gut feeling (honestly, his assessment of the expected value of future British pound by probability calculation), he can make \$19,710,000 if his expectation is realized, and thus end up with a total profit of \$4,710,000 (31.4 percent). If, however, his expectation is mismatched, he may end up with a potentially lower profit or loss, depending on the actual price of the British pound a year later.

Many scenarios will be drawn up with different instruments with which an investor or a trader may speculate in the market.

MARKET

Now—what is a market? In the world of economics and finance, the term *market* means acts of transactions, buying and selling, the visible and invisible interactions of supply and demand. Market does not necessarily denote a place such as a mall or supermarket, where the business of buying and selling takes place. Foreign exchange market, in that spirit, is the market in which different national currencies are traded. It refers to the buying and selling of, for example, U.S. dollars for British pounds, German deutsche marks for Japanese yen, and so on. In our world, when one country's customers buy or sell goods and services from and to another country, the need to pay for those things in terms of the seller's monetary units (currency) is immediately created, and this leads to buying the seller's currency. However, the need for other countries' currencies does not arise only for merchandise trade alone; it may be due to buying financial assets—that is, for financial investments in different countries, for visiting other countries for touristic pleasure, for exploring overseas business possibilities, for stabilizing foreign exchange markets, and so on.

DEFINITION OF FOREIGN EXCHANGE

Foreign exchange means the price of one national currency in terms of another national currency. If two U.S. dollars can buy one British pound (\$2 = £1), then the foreign exchange rate is: $^2/_1 = 2$.

Note that the price of one British pound is two U.S. dollars, and it is measured exactly the same way as the price of one gallon of milk. In the denominator, we have 1 unit—whether it is 1 British pound or 1 gallon of milk, and in the numerator, we put the units of U.S. dollars needed for it. It should be clear now that the currency or commodity should be measured at 1 (meaning one unit) in the denominator, and the price in terms of which it is expressed must be in the numerator. That is, $^2/_1$ the dollar price of 1 British pound. Similarly, if seven French francs can buy one U.S. dollar, then $^7/_1$ (= 7) is the French franc price of one U.S. dollar. Each currency can thus be priced in terms of itself as well as in terms of each other's currency. When the price of a foreign currency is denominated, or expressed,

Cross Rates (*The Wall Street Journal*, February 26, 2002)

Currency Sold	Currency Purchased			
	U.S. ($)	U K (£)	France (FF)	Japan (¥)
U.S. ($)	1	0.7018	7.5471	133.86
U K (£)	1.4249	1	10.7539	190.74
France (FF)	0.1325	0.09299	1	17.737
Japan (¥)	0.00747	0.00524	0.05638	1

Source: The Wall Street Journal, February 26, 2002

in terms of the home currency (e.g., British pound in terms of U.S. dollars), the foreign exchange rate is said to be in *direct* quote. The direct quote is also known as an American quote, or a U.S. dollar equivalent quote. When the price of the home currency is denominated in foreign currency (e.g., U.S. dollars in terms of French francs), the foreign exchange rate is an *indirect* quote (or alternatively, European quote or foreign currency per U.S. dollar quote). Table 1.1 presents a matrix of direct and indirect quotations of foreign exchange rates among four currencies.

The first row in the table shows that one U.S. dollar can buy $1, £0.7018, 7.5471 FF, and ¥133.86. Similarly, the second row states that one U.K. pound can purchase $1.4249, £1, 10.7539 FF, ¥190.74. The second column, on the other hand, shows that one U.S. dollar can be sold to get $1, $1.4249 can be sold to obtain £1, $0.1325 U.S. dollar can be sold to get 1 FF, and $0.00747 is needed to purchase ¥1. Other entries in the matrix should be read in the same fashion. These rates are known as currency cross rates or exchange cross rates, regularly noted in *The Wall Street Journal* and in *Financial Times*.

SPOT RATE OF EXCHANGE AND FORWARD RATE OF EXCHANGE

In the foreign exchange market, there is one quote for most currencies, and there are two, or more, quotes of the rate of foreign exchange for some exchange rate at which one currency is exchanged for another currency immediately. The term immediately, however, should be interpreted as follows: if the trading takes place in the continental America, the transactions must be completed within one business day; but if the parties to the transactions are on a further global scale, exchange may involve two consecutive business days. Forward rate of exchange means that the rate of exchange is agreed upon at that moment, but actual delivery (settlement of transactions) will take place at a future date. If 1.4225 is the 30-day forward rate of an exchange of a British pound for a U.S. dollar, it means that the parties agree that for £1, one must pay $1.4225, but the payer of $1.4225 receives £1 on the 30th day from the time of agreement. If, on the other hand, the spot rate of exchange of a Canadian dollar for a U.S. dollar is 0.6245, then the person holding the U.S. dollar pays $0.6245 and receives one Canadian dollar within a business day from the time of agreement. Forward rate is thus a rate of exchange with a delayed delivery. There are forward rates with different maturities such as a 30-day, 60-day, 90-day, 180-day, 52-week, and a few other maturities that can be customized according to the parties' needs and preferences. At this point, it may be instructive to take a look at *The Wall Street Journal* (or any other financial press, e.g., *Financial Times*). Look at Table 1.2.

Look at the four columns of quotes of different currencies in Table 1.2. The first two columns provide the *direct* (U.S. dollar equivalent) quotes of different currencies in two successive business days. The next two columns give the *indirect* (foreign currency per one U.S. dollar) quotes of the currencies concerned. Now, take a closer look at the table. One Argentine peso is worth $0.4751, one Australian dollar is worth $0.5140 at the end of the day on Monday in New York, February 25, 2002, and reported by *The Wall Street Journal* on Tuesday, February 26, 2002, and so on. When you move to the third column, you get the value of one U.S. dollar in terms of the other currencies. On Monday, 2.1050 Argentine pesos are worth one U.S. dollar; 1.9457 Australian dollars have been exchanged for one U.S. dollar, and so on. Next, look at the British pound. You see four quotes on each column. On Monday, 1.4249 is the spot rate of exchange—that is, £1 = $1.4249; next quote (one-month forward) is 1.4225. That means traders lock in this rate of exchange, but delivery of currencies for one another will take place one month from that Monday. In *The Wall Street Journal*, two other forward rates, three-month forward and six-month forward, are given. One can have almost any customized maturity, usually up to two years. Another notable point is that only a limited number of currencies—the British pound, the Canadian dollar, the French franc, the Japanese yen, the Swiss franc, the German deutsche mark, and the U.S. dollar have only forward quotes, and other currencies have only spot quotes.

Table 1.2
The Wall Street Journal Quotes

CURRENCY TRADING

Monday, February 25,2002
EXCHANGE RATES

The New York foreign exchange mid-range rates below apply to trading among banks in amounts of $1 million and more, as quoted at 4 p.m. Eastern time by Reuters and other sources. Retail transactions provide fewer units of foreign currency per dollar. Rates for the 12 Euro currency countries are derived from the latest dollar-euro rate using the exchange ratios set 1/1/99

Country	U.S. $ Equivalent Mon	Fri	Currency Per U.S. $ Mon	Fri
Argentina(Peso)-y....	.4571	.4866	2.1050	2.0550
Australia(Dollar)....	.5140	.5125	1.9457	1.9514
Austria (Schilling)....	.06316	.06363	15.832	15.715
Bahrain (Dinar)....	2.6525	2.6525	.3770	.3770
Belgium (Franc)....	.0215	.0217	46.4130	46.0712
Brazil(Real)....	.4177	.4129	2.3940	2.4220
Britain(Pound)....	1.4240	1.4326	.7018	.6980
1-month forward....	1.4225	1.4302	.7030	.6992
3-months forward....	1.4175	1.4252	.7055	.7017
6-months forward....	1.4102	1.4180	.7091	.7052
Canada(Dollar)....	.6245	.6264	1.6012	1.5963
1-month forward....	.6243	.6263	1.6015	1.5966
3-months forward....	.6241	.6261	1.6022	1.5975
6-months forward....	.6238	.6257	1.6030	1.5992
Chile(Peso)....	.001480	.001480	673.65	675.45
China(Renminbi)....	.1208	.1208	8.2765	8.2765
Colombia(Peso)..	.0004323	.0004323	2313.50	2313.40
Czech.Rep(akoruna)....				
Commercial rate..	.02740	.02766	36.501	36.156
Denmark(Krone)....	.1169	.1178	8.5525	8.4875
Ecuador(US Dollar)-e...	1.0000	1.0000	1.0000	1.0000
Finland(Makka)....	.1462	.1473	6.8409	6.7905
France (Franc)....	.1325	.1335	7.5471	7.4915
Germany(Mark)....	.4444	.4477	2.2503	2.2337
Greece(Drachma)...	.002551	.002570	392.05	389.12
Hong Kong(Dollar)....	.1282	.1282	7.7993	7.7994
Hungary(Forint)....	.003568	.003593	280.28	278.32
India(Rupee)....	.02050	.02052	48.770	48.740
Indonesia(Rupiah)....	.0000983	.0000979	10178	10215
Ireland (Punt)....	1.1036	1.1117	.9061	.8995
Israel(Shekel)....	.2160	.2131	4.6300	4.6925
Italy(Lira)....	.0004489	.0004522	2227.77	2211.36
Japan(Yen)....	.007430	.007460	133.86	134.04
1-month forward....	.007481	.007471	133.67	133.85
3-months forward....	.007505	.007495	133.25	133.42
6-months forward....	.007544	.007534	132.56	132.73

Table 1.2
(Continued)

Jordan(Dinar)....	1.4104	1.4104	.7090	.7090
Kuwait(Dinar)....	3.2489	3.2510	.3078	.3076
Lebonan(Pound)....	.0006605	.0006605	1514.00	1514.00
Malaysia(Ringgit)-b....	.2632	.2632	3.8001	3.8000
Malta(Lira)....	2.1925	2.1993	.4561	.4547
Mexico(Peso)....				
Floating rate....	.1103	.1099	9.0655	9.0985
Netherlands(Guilder)....	.3944	.3973	2.5355	2.5168
New Zealand(Dollar)....	.4175	.4184	2.3952	2.3901
Norway(Krone)....	.1123	.1127	8.9035	8.8740
Pakistan(Rupee)....	.01665	.01665	60.050	60.050
Peru(New Sol)....	.2876	.2874	3.4768	3.4795
Phillipines(Peso)....	.01946	.01946	51.375	51.375
Poland(Zloty)-D....	.2388	.2398	4.1872	4.1695
Portugal(Escudo)....	.004335	.004367	230.66	228.97
Russia(Ruble)-a....	.03230	.03230	30.957	30.957
Saudi Arabia(Riyal)....	.2666	.2666	3.7506	3.7505
Singapore(Dollar)....	.5463	.5459	1.8306	1.8320
Slovak Rep.(Koruna)....	.02075	.02090	48.200	47.848
S.Afrika(Rand)....	.0872	.0877	11.4720	11.4020
S.Korea(Won)....	.0007582	.0007593	1318.90	1317.00
Spain(Peseta)....	.005224	.005262	191.44	190.03
Sweden(Krona)....	.0956	.0957	10.4577	10.4510
Switzerland(Franc)....	.5888	.5918	1.6983	1.6897
1-months forward....	.5889	.5919	1.6980	1.6895
3-months forward....	.5891	.5921	1.6975	1.6889
6-months forward....	.5897	.5926	1.6959	1.6875
Taiwan(Dollar)....	.02854	.02853	35.040	35.050
Thailand(Baht)....	.02282	.02278	43.820	43.900
Turkey(Lira)-f....	.00000072	.00000072	1387000	1388000
United Arab(Dirham)....	.2722	.2722	3.6731	3.6731
Uruquay(Peso)....	.06780	.06757	14.750	14.800
Venezuela(Bolivar)....	.000914	.000900	1094.35	1110.60
SDR....	1.2466	1.2449	.8022	8033
Euro......	.8692	.8756	1.1505	1.1421

(continued)

Special Drawing Rights (SDR) are based on exchange rates for the U.S., German, British, French, and Japanese Currencies, *Source:* International Monetary Fund. a-Russian Central Bank rate. b-Government rate. d-Floating Rate; trading band suspended on 4/11/00, e-Adopted U.S. dollar as of 9/11/00. f-floating rate, eff. Feb. 22, y-Floating rate.

Table 1.2
(Continued)

KEY CURRENCY CROSS RATES
Late New York Trading Monday, February 25, 2002

	Dollar	Euro	Pound	Sfranc	Guilder	Peso	Yen	Lira	D-Mark	Ffranc	CdnClr
Canada....	1.6012	1.3918	2.2815	0.9428	.63151	.17663	.01196	.00072	.71155	.21216	....
France....	7.5471	6.5599	10.7539	4.4439	2.9766	.83251	.05638	.00339	3.3538	....	4.7134
Germany....	2.2503	1.9560	3.2065	1.3250	.88752	.24823	.01681	.00101	....	.29817	1.4054
Italy....	2227.8	1936.4	3174.3	1311.8	878.63	245.74	16.643	....	989.99	295.18	1391.3
Japan....	133.86	116.35	190.74	78.820	52.794	14.766	....	.06009	59.485	17.737	83.600
Mexico....	9.0655	7.8797	12.917	5.3380	3.5754	....	.06772	.00407	4.0286	1.2012	5.6617
Netherlands	2.5355	2.2039	3.6128	1.4930	....	.27969	.01894	.00114	1.1267	.33596	1.5835
Switzerland	1.6983	1.4762	2.4199	....	.66981	.18734	.01269	.00076	.75470	.22503	1.0606
U.K....	.70180	.6100	....	.4132	.27679	.07741	.00524	.00032	.31187	.09299	.43830
Euro...	1.15050	....	1.6393	.67743	.45375	.12691	.00859	.00052	.51126	.15244	.71851
U.S....	....	.8692	1.4249	.58882	.39440	.11031	.00747	.00045	.44439	.13250	.62453

Source: The Wall Street Journal, February 26, 2002

Table 1.3
Financial Times Quotes

	U.S. $ equivalent		Foreign currency per U.S. $	
	bid	ask	bid	ask
British pound	1.4278	1.4280	0.700280	0.700378
French franc	0.132813	0.132874	7.5259	7.5294
Japanese yen	0.007469	0.007473	133.820	133.880

Source: Financial Times, February 26, 2002

These are quotes on bank drafts on wholesale spot rates and forward rates. Note also that these are the New York foreign exchange mid-rate rates that apply to trading among banks in amounts of 1 million dollars or more, as quoted at 4 P.M. Eastern time by Banker's Trust Company of New York. Retail transactions provide fewer units of foreign currency per U.S. dollar. The selling rates are called banks' (or foreign exchange dealers') *ask* or *offer* rate. When a bank buys a currency, the rate is called *bid* rate. If you walk into a bank or an office of any exchange dealer, you will find two different rates: the *ask* rate and the *bid* rate. In direct (U.S. dollar equivalent) quotes, the ask rate is usually higher than the bid rates. Table 1.3 shows these rates.

The difference between ask and bid quotes is called a *spread*, which usually is the measure of transaction costs, but for small amounts of conversion such as a few hundred dollars, a dealer may charge a fixed amount per every $100 or every $1,000 on top of the bid and ask quotes at the time. The banks or exchange dealers sell currency at a higher price than the price they pay to get the same currency, and thus make a profit. Note that if the quote is in foreign currency per U.S. dollar (indirect), the ask rate is lower than bid rate (see Table 1.3). In a direct quote, if the ask-and-bid prices of British pounds are $1.4278 and $1.4280, then the spread is $0.0002. In technical jargon, in this illustrative case, it is stated that the ask price is 2 points above the bid price. However, for currency such as the Japanese yen, the ask-bid quotes are in six decimal points (e.g., the ask quote is $0.007473 and the bid quote is $0.007469, and thus, the spread is $0.000004). Here also the spread is 4 points. The point refers to the difference in the last digits in the ask-bid quotes.

CONVENTIONS ON QUOTATIONS

Foreign exchange rates are quoted in two different ways. One style is to quote the rate in an *outright* form, and the other style is known as a *swap* quote. An example will illustrate these quotes in clear terms. If you call a bank for the spot forward quotes on, say, British pounds in terms of U.S. dollars, you may have the following quotations.

Rate of exchange	Bank's bid	Bank's ask
Spot	1.4278	1.4280
One-month forward	1.4281	1.4284
Three-month forward	1.4283	1.4287
Six-month forward	1.4268	1.4272

These quotations are straightforward. The bank's buying price and the selling price of the British pound in the spot cash market are $1.4278 and $1.4280, respectively. Similarly, the one-month forward rates for buying and selling the British pound are $1.4281 and $1.4284. These straightforward quotes are known as *outright* quotes. There is, however, an alternative way of quoting the rates—swap quotes. They are as follows:

Spot	One-month forward	Three-month forward	Six-month forward
1.4278/80	3/4	5/7	10/8

Here the spot quote 1.4278/80 means that the bank's bid rate and ask rate are 1.4278 and 1.4280. The one-monthly forward quote 3/4 here means that the one-month forward bid rate is 1.4281 (that is, 3 points are added to the last digit of 1.4278) and the ask rate is 1.4284 (4 points are added to the last digit to 1.4280). The three-month forward quote 5/7 means then that the three-month forward bid-and-ask rates are 1.4283 and 1.4287, respectively. Note here 3/4 and 5/7 are points in *ascending* order: 3 followed by the higher number 4, and 5 followed by 7. When you note this ascending order of points, these points must be *added* to the spot bid and spot ask rates. However, if the points are in *descending* order, as in the quote of six-month forward (10/8), the points must be *subtracted* from the spot bid-and-ask rates. That is, six-month forward bid-and-ask rates, in this instance, are 1.4268 and 1.4272. A caveat should be in order now. The points in ascending (descending) order with the slash (/) in between should be added (subtracted) if the spot rates (bid and ask) are in *direct* quotes. If the spot rates are in indirect quotation, the points in ascending (descending) order must be subtracted (added) to the spot quotes to determine the forward quotes in outright terms. Here is the summary of the conversion from swap quotes to outright quotes:

	Quotes	
Point Order	Direct	Indirect
Ascending	Add swap points to spot quotes	Subtract swap points from spot quotes
Descending	Subtract swap points from spot quotes	Add swap points to spot quotes

Let us summarize and review the exposition further in a diagrammatic framework as follows:

Spot Rates (S)
Means
Immediate exchange (not delayed) of currencies, for example, usually within one or two consecutive business days

Forward Rate (F)
Means
Delayed exchanges of currencies
One-month forward
Three-month forward
Six-month forward
One-year forward

Ask (S_A)	Bid (S_B)	Ask (F_A)	Bid (F_B)
Bank's selling rate in spot market	Bank's buying rate in spot market	Bank's telling rate in forward market	Bank's buying rate in forward market
1.4780	1.4278	1.4284	1.4281

Once again, we re-express the quotation structure in the schematic form as follows.

Quotes

Direct	Indirect
or	or
American	European
or	or
U.S. Dollar Equivalent	Foreign Currency Equivalent
≡	≡
Price of one unit of foreign currency in terms of home currency	Price of one unit of home currency in terms of foreign currency
$1.4278 = £1 ($1.42782/£1)	£0.50 = $1 (£0.50/$1)
or $S^D = 1.4278$	or $S^I = 0.7004$

If in direct quote:

Ask price – Bid price = Spread
$S_A - S_B$ = Spot spread
$F_A - F_B$ = Forward spread
{(Ask rate – Bid rate)/Ask rate} × 100 = Percent spread
$\{(S_A - S_B)/S_A\} \times 100$ = % Spot spread, and
$\{(F_A - F_B)/F_A\} \times 100$ = % Forward spread.

Forward Premium and Discount:

The foreign currency (when quoted in direct, i.e., in U.S. dollar equivalent terms) is said to be in:

forward premium if: $\{(F - S)/S\}\cdot(1/n) > 0$;
forward par if: $\{(F - S)/S\}\cdot(1/n) = 0$;
forward discount if: $\{(F - S)/S\}\cdot(1/n) < 0$,

where n stands for forward contract maturity in terms of year. That means, 1 month = 1/12 year, 2 months = 2/12 = 1/6 year, and so on.

Examples:

$F = 2.15$ (1 month forward)
$S = 2.00$
Here: forward premium = $\{(2.15 - 2.00)/2.00\}\cdot\{1/(1/12)\} = 0.9$.

$F = 1.95$ (1 year forward)
$S = 2.00$
Here: forward discount = $\{(1.95 - 2.00)/2.00\}\cdot(1/1) = -0.025$.

TRIANGULAR ARBITRAGE

As pointed out earlier, arbitrage is the act of buying cheap and selling dear in order to make a profit. Consider a situation in which you know that Store A is selling VCRs for the price of $400, but in Store B, the same VCR is selling for $500. With this knowledge you will try to buy VCRs from Store A at $400 a piece and sell the same VCRs for around $490 a piece to the buyers who are about to enter Store B, thus making a nice profit of $90 per VCR. This will continue as long as the situation is unchanged. But most likely, perhaps within a short period, Store B, having no customers at all, will be forced to reduce the price of its VCR to, say, $470 a piece. On the other hand, Store A, faced with an increasing demand for VCRs, will jack up the VCR price to, say, $420 a piece. In this new situation, the man who is buying low and selling high (we call him *arbitrageur*), will continue to do exactly what he was doing before even though the profit margin is much reduced for him. The reasons for which Store B lowered its price and Store A raised its price still continue, and as a result, both the stores will continue revising their prices in the same fashion until the uniform price, somewhere between the original $400 and $500 (say, $454), is established because of arbitrage, and the arbitrageur is thrown out of business (of making profit). The force of competition finally wipes out the market imperfection and price alignment becomes perfect. In the

currency market, foreign exchange rates are not fully aligned at every moment of business hours, and therefore, the scope for arbitrage exists exactly in the same way as in the case of Store A and Store B in our example. In fact, in a currency market, since there are different currencies and hence different rates of exchange, one can barter one currency for another, and then the second currency for a third currency, and so on, eventually getting back to the original currency the currency trader started with. This process is called *triangular arbitrage.* Triangular arbitrage is the buying and selling of one currency for another, ending with a return to the original currency for the purpose of making a profit.

Triangular arbitrage rests on the product of *cross rates.* The cross rate between dollar and DM (in the spot market) is defined as follows:

$$S(\$/DM) = S(\$/£)\cdot S(£/DM).$$

If the rate of exchange between the pound and the dollar is known and the rate of exchange between the deutsche mark (DM) and the pound is known, one can swiftly get the exchange rate between the dollar and DM by cross-multiplying those rates. Suppose you note the following rates between the dollar and the pound, and the pound and DM, respectively: $1.6420 = £1 (that is, $S(\$/£) = 1.6420$), and £0.4196 = DM1 (i.e., $S(£/DM) = 0.4196$). The cross rate of exchange between the dollar and DM then is $S(\$/DM) = S(\$/£).\ S(£/DM) = (1.6420)(0.4196) = 0.6890$. This means you can buy one DM for $0.6890 (or with one DM you can get $0.6890 in exchange).

Now, consider the following scenarios: note the following quotes: $S(\$/£) = 1.6420$ (in New York), and $S(DM/\$) = 1.4645$ (in Tokyo), and $S(£/DM) = 0.4196$ (in London).

In this case, you have $S(\$/£)\cdot S(DM/\$)\cdot S(£/DM) = (1.6420)\cdot(1.4645)\cdot(0.4196) = 1.0009$. Note here that $S(\$/£)\cdot S(DM/\$)$ yields the cross rate between DM and the pound ($\equiv S(DM/£)$), and then when it is further cross-multiplied by $S(£/DM)$, it becomes a pure number, denominated in no currency unit. The signification can be concretely stated in the following way: you can exchange your £1 for dollar in New York and get $1.6420; with this dollar amount, you get DM 2.4047 (≡1.6420H 1.4645) in Tokyo, and finally, with that DM amount you can get £1.0090 (≡2.4047H 0.4196) in London. This means exchanging your initial £1 into dollar, then dollar into DM, and then DM into pound to get £1.0090. It is a profitable situation for you, and it means that if you start off with £1,000,000 and go through these series of currency exchanges, you can make £9,000 without a doubt. Under the given scenario, you have just arbitraged and made a riskless profit out of a situation. This is the triangular arbitrage in currencies, and now you can see how triangular arbitrage rests on the product of cross rates. Diagrammatically, the process looks like the following:

Triangular arbitrage process

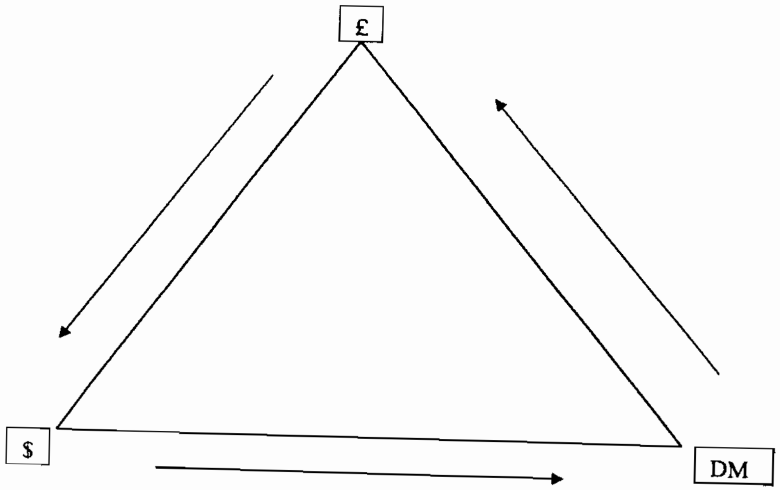

Figure 1.1 Triangular arbitrage

Figure 1.1 exhibits through the arrows the directions of currency conversion, starting initially from pound into dollar, then into DM, and finally DM into pound back. One can start with another currency, converting that into some other currency, and through this process finally coming back to the original currency. One should note that triangular arbitrage is just a way to refer to multicurrency conversion process of buying low and selling high for the explicit purpose of making a profit.

Triangular Arbitrage Profits (in the absence of transaction costs)

Usually, each buying and/or selling of any asset, be it a stock, bond, or currency, involves a brokerage fee—more generally known as a transaction cost. In this section, we assume away that transaction cost of buying and selling any currency. Under this situation of zero transaction costs, the conditions for positive, zero, and negative triangular arbitrage profits are as follows:

when $S(DM/\$)S(£/DM)\cdot S(\$/£) > 1$, triangular arbitrage is profitable;
$S(DM/\$)\cdot S(£/DM)\cdot S(\$/£) = 1$, triangular arbitrage yields zero profit;
$S(DM/\$)\cdot S(£/DM)\cdot S(\$/£) < 1$, triangular arbitrage is unprofitable.

Consider a matrix of exchange rates to ascertain if there is any scope for profitable arbitrage (Table 1.4).

Table 1.4
Matrix of Exchange Rates

	Currency Purchased			
	$	£	DM	¥
Currency Sold				
$	1	1.8930	0.4530	0.00437
£	0.5260	1	0.2390	0.00231
DM	2.2050	4.41900	1	0.00966
¥	228.2000	433.5000	103.5000	1

A person who is holding one U.S. dollar can exchange his currency for DM 2.2050. With £0.2390/DM, this person can use DM 2.2050 to obtain £0.5270 ($\equiv$ 2.2050 × 0.2390). This amount of pound sterling can then be converted back into U.S. dollars at the rate of \$1.8930/£, and he can receive \$0.9976 ($\equiv$ 0.5270 × 1.8/2.2050 × 0.2390 × 1.8930).

In this case, this person starts off with \$1 and ends up with \$0.9976. Therefore, it is an unprofitable situation.

Triangular Arbitrage Profits (in the presence of transaction costs)

Thus far, we have assumed away transaction cost in the arbitrage activities. In reality, any financial transaction activity involves some transaction costs, and so it is instructive and practical to factor in transaction costs in the calculation to determine when triangular arbitrage is profitable and when it is not. Let us use the following notations for convenience:

$S_B(\$/£)$/the price (say, in dollar amount) that must be paid to a bank (or exchange dealer) to buy £1 (e.g., the price the bank is asking); $S_{B(\$/£)}$ the dollar amount received from a bank (or an exchange dealer) for the sale of one £1 (that is, for the bank's purchase of £1), and $T \equiv$ average one-way cost of transaction in the foreign exchange market.

That means:

$$S_A(\$/£) = (1 + T)\cdot S_M(\$/£), \quad (1.1)$$
$$S_B(\$/£) = (1 - T)\cdot S_M(\$/£), \quad (1.2)$$

where $S_{M(\$/£)}$ is the middle rate—the midpoint between ask-and-bid rates. In numerical terms, if $S_A = 1.6230$, and $S_B = 1.6220$, then $S_M = 1.6225$.

From the equations 1.1 and 1.2 (that is, by subtracting equation 1.2 from 1.1), one can obtain:

$S_A(\$/£) - S_B(\$/£) = 2T \cdot S_M(\$/£)$, whence:
$T = (S_A(\$/£) - S_B(\$/£))/2S_M(\$/£)$.

Again, if $S_A(\$/£) = 1.6230$, $S_B(\$/£) = 1.6220$, and hence $S_M(\$/£) = 1.6225$, then $T = (1.6230 - 1.6220)/2H1.6225 = 0.0003$.

Now the question is: under transaction cost (T), how long is it profitable to engage in triangular arbitrage?

Starting with the dollars (\$) and arbitraging around the triangle, an arbitrageur can buy deutsche marks (DM), sell these DM for pounds (£), and sell these pounds for dollars. Arbitrage should continue until it is no more profitable. Arbitrageurs who start off with dollars should participate until no more than the original dollar amount can at least be recovered, that is, until:

$$[S_B(£/DM) \cdot S_B(\$/£)]/\{1/S_A(\$/DM) \leq 1 \qquad (1.3)$$

Using the definitions of middle exchange rate and transaction cost, we can rewrite equation 1.3 as follows:

$$\{(1-T)^2/(1+T)\} \cdot S_M(£/DM) \cdot S_M(\$/£) \leq S_M(\$/DM) \qquad (1.4)$$

With the reversal of directions, the arbitrageur may also make profit by buying pound with dollars, then exchanging these pounds for deutsche marks, and then finally selling these deutsche marks for dollars. This arbitrage process should continue, with transaction cost (T), the following conditions develop:

$$\{(1+T)^2/(1-T)\} \cdot S_M(£/DM) \cdot S_M(\$/£) \geq S_M(\$/DM) \qquad (1.5)$$

The conditions, given by equations 1.4 and 1.5 together, define when triangular arbitrage with transaction cost (T) is unprofitable or profitable. Triangular arbitrage with transaction cost (T) is unprofitable if the following holds:

$$\{(1+T)^2/(1-T)\} \cdot S_M(£/DM) \cdot S_M(\$/£) \geq S_M(\$/DM) \geq \{(1-T)^2/(1+T)\} \cdot S_M(£/DM) \cdot S(\$/£). \qquad (1.6)$$

This means that whenever the middle rate $S_M(\$/DM)$ lies outside the upper and lower limits established by relation of equation 1.6, the arbitrage is profitable. Figure 1.2 exhibits the conditions graphically.

Arbitrage with transaction cost (T):

S_M(\$/DM) **profitable arbitrage opportunities**

→ **A: $\{(1+T)^2/(1-T)\}.S_M(£/DM).S_M(\$/£)$**

S_M(\$/DM) **no profitable arbitrage**

→ **B: $\{(1-T)^2/(1+T)\}.S_M(£/DM).S(\$/£)$**

profitable arbitrage opportunities

Figure 1.2 Zones of profitable and unprofitable arbitrage

Consider the following data: ask rate and bid rate for DM in terms of pound are as follows: $S_A(£/DM) = 0.4157$ and $S_B(£/DM) = 0.4152$; ask rate and bid rate pound in terms of dollar are: $S_A(\$/£) = 1.5530$ and $S_B(\$/£) = 1.5510$. Obviously then the middle rates are $S_M(£/DM) = 0.41545$, $S_M(\$/£) = 1.5520$, and the transaction cost is $T = 0.0006$. With all this information, the value of $\{(1+T)^2/(1-T)\} \cdot S_M(£/DM) \cdot S_M(\$/£) = 0.6459$, and $\{(1-T)^2/(1+T)\} \cdot S_M(£/DM) \cdot S(\$/£) = 0.6436$. If the middle rate of DM in terms of dollar $S_M(\$/DM)$ lies between 0.6436 and 0.6459, there is no scope for profitable triangular arbitrage with transaction cost of $T = 0.0006$. That means, under the given scenario, one will not be able to make profit of $S_M(\$/DM)$ equals, say, 0.6445. However, if the ask-and-bid rates move such that the middle rate of DM in terms of dollar equals either, say, 0.6438 or 0.6468, one can make a profit even with a transaction cost without taking any risk in the process since every bit of information for calculation is known with certainty.

FUTURES, SWAPS, AND OPTIONS

Like forward contracts, there are other instruments that a trader or an investor makes use of to stay and do well in the market—to arbitrage, to hedge, and to speculate—to gain and to manage risks. Currency futures are contracts similar to currency forwards, but there are important differences. A swap is basically a bilateral agreement to a sequence of exchange of one currency for another currency or a sequence of interest payment or a cocktail of the two. An option is the right offered to the holder of those derivative assets for a premium paid by the holder to the issuer in case of needed contingency claims. Many synthetic varieties with two basic types—a *call option* and a *put option*—can create a network of instruments that an investor can play with in the market. There are instruments such as options on futures, options on swaps (swaptions), and so on, to color the landscape of strategic instruments in the foreign exchange market. In the following chapters, we expound and explore these items in the arsenal of the market.

REFERENCES

Clark, E. (1998). *International Finance.* London: Thompson Publishing.
Ghosh, D.K. (1997). "Arbitrage with Hedging: Exploited and Exploitable Profits," *The European Journal of Finance* (November). Vol. 3, 349–361.
Ghosh, D.K., and E. Ortiz. (1994). *Changing Environment of International Financial Markets: Issues and Analysis.* London: Macmillan.
Ghosh, D.K., and E. Ortiz. (1997). *The Global Structure of Financial Markets.* London: Routledge.
Grabbe, J.O. (1991). *International Financial Markets,* 2nd ed. New York: Elsevier Science Publishing.
Levi, M. (1997). *International Finance.* New York: McGraw-Hill.
Neihans, J. (1984). *International Monetary Economics.* Baltimore: Johns Hopkins University Press.
Sercu, P., and R. Uppal. (1995). *International Financial Markets and the Firm.* Cincinnati, Ohio: South-Western College Publishing.

Chapter 2

Currency Futures, Swaps, and Hedging

Currency risk, or foreign exchange risk as it is often called, refers to the fluctuations in domestic currency value of assets, liabilities, income, or expenditure due to unanticipated changes in exchange rates. Many techniques are available to cover, or hedge, exposure to risk of this kind. The simplest and most common technique involves using a forward contract. However, forward contracts are relatively costly and lack a liquid secondary market where positions can be taken and undone cheaply and swiftly. Currency futures contracts traded on organized exchanges overcome these shortcomings but in so doing, they create problems of their own. Judging the relative merits of hedging with forwards or futures requires a firm grasp of the characteristics of each type of instrument. In chapter 1, we outlined the characteristics of the forward contract. In this chapter, we begin with a detailed presentation of the currency futures contract and its relation to the forward contract. We then establish the principles of hedging with the futures contract. In the last two sections, we look at currency hedging in more detail, including the role of discounts and premiums as well as long-term hedging with forwards and currency swaps.

MECHANICS OF CURRENCY FUTURES MARKETS

The Difference between Forwards and Futures

As discussed in chapter 1, a forward contract is an agreement to buy or sell an asset at a certain future time for a certain future price, whereas a spot contract is an agreement to buy or sell an asset on that day. Forward contracts are traded in the over-the-counter market and usually involve a financial institution on one side of the deal and either a client or another financial institution on the other side of the deal. One party to the deal