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CHAPTER 16

FOREIGN-CURRENCY OPTIONS

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A foreign-currency option is the right, but not the obligation, to buy or sell a specified foreign-currency contract. This could take the form of a spot, a futures, or even a forward contract.

Foreign-currency options, first introduced in 1982, are relatively new financial instruments. Since then, the trading of these instruments has grown dramatically. The demand for foreign-currency options by corporations and financial institutions is based on their desire to hedge financial and economic risks given the increased uncertainty about foreign-exchange rates and the inability to forecast them.

The Philadelphia Stock Exchange was the first exchange to introduce currency options trading. Options on the Australian dollar, British pound, Canadian dollar, German mark, Japanese yen, and the Swiss franc are traded on its floor. Options on futures contracts for these currencies are traded on the Chicago Mercantile Exchange. Foreign-currency options are also traded on the European Options Exchange in Amsterdam, the Montreal Exchange, the London International Financial Futures Exchange, and the London Stock Exchange. The contracts traded on these exchanges are standardized. Since, however, many corporate hedgers desire tailor-made contracts, an over-the-counter foreign-exchange options market also exists.

This chapter presents a general overview of foreign-currency options. We first review some basic concepts and definitions relevant to the foreign-currency options market. Second, we discuss the pricing of options. Finally, we describe some basic currency-option strategies for speculators and hedgers.

Basic Concepts

A call (put) option gives its owner (holder) the right to buy (sell) a specified financial instrument at a fixed price (exercise or strike price) before or at a certain future date (maturity or expiration). The buyer of the option pays the option price (premium) to the seller (writer, grantor).

A call or put option whose exercise price is the same as the spot price is termed *at-the-money*. A call (put) whose exercise price is below (above) the underlying spot price is termed *in-the-money*. A call (put) whose exercise price is above (below) the underlying spot price is termed *out-of-the-money*. An option owner only exercises an option if it is in-the-money.

Profit profiles at expiration of buying call and put options are given in Figure 16–1. The profit profiles of selling options are the mirror images, around the horizontal axis, of those for buying options. Put differently, the profits earned by the buyer of an option equal the losses for the seller, and vice versa.

At maturity, options are usually settled physically. That is, the grantor of the option delivers or receives delivery of the underlying financial instrument. Some over-the-counter options, however, are cash settled. No delivery of the underlying instrument takes place. Instead, the cash value of the option contract equaling the difference between the exercise price and the spot price is remitted.

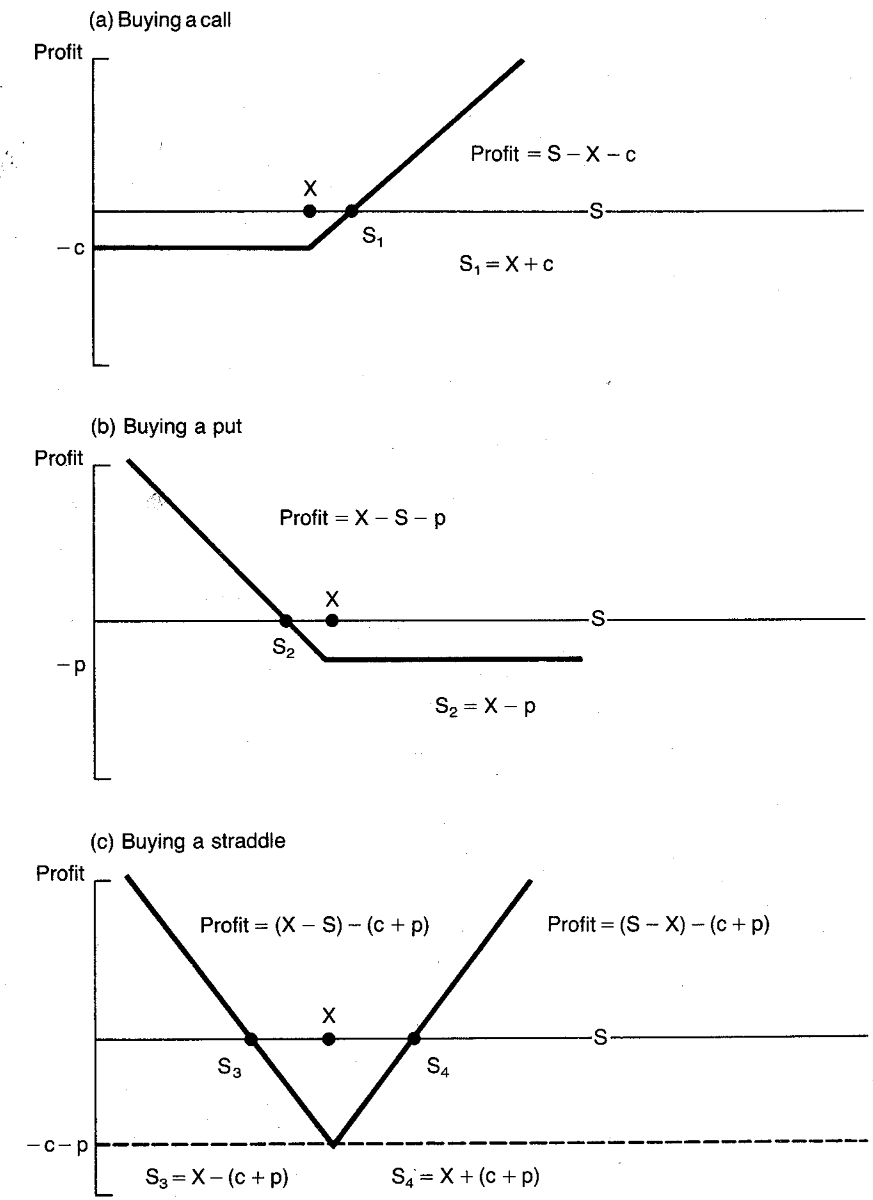
The option premium is a function of the option's strike price, the spot exchange rate, the domestic and foreign interest rates, and the expected volatility of the relevant exchange rate. The following glossary reviews and expands on the preceding concepts.

Glossary

American option Any option that can be exercised on or before the expiration date.

arbitrage Taking advantage of a temporary price disparity between different options or between options and the underlying currency.

FIGURE 16–1
Profit Profile of Buying a Straddle



at-the-money An option is at-the-money if the underlying currency is selling for the option's exercise price. The intrinsic value of the option is exactly equal to zero.

call option A contract granting the right to buy a given underlying currency or currency-futures contract at a specific price for a stated period of time or at a stated point in time.

covered call writer A covered call writer owns the underlying currency on which the option is written. Also considered covered is a call writer who has purchased a call option on the same currency as the call sold. The exercise price of the purchased call is equal to, or less than, the exercise price of the written call.

covered put writer A covered put writer is short (owes) the underlying currency on which the option is written. Strictly speaking, the definition only applies to a put option writer who also bought put options that have an exercise price equal to or higher than that of the written put options.

curvature A characteristic of an option or option spread position describing how rapidly the delta of an option or a spread changes when the spot rate changes. Also called gamma.

deliverable currency The specific underlying currency that is actually deliverable upon the exercise of a particular option contract.

delta The change in the theoretical value of an option due to an infinitesimal change in the spot rate, expressed as a percentage or in natural numbers. A deep in-the-money call (put) option has a delta close to 100 percent (−100 percent). Its value changes almost one for one (−1) with the spot rate. A far out-of-the-money option has a delta close to zero. A change of the spot rate has little or no effect on the value of the option. An at-the-money call (put) option has a delta near 50 percent (−50 percent).

delta long position A position in options and/or underlying currency in which a small appreciation of the currency theoretically increases the net value of the position.

delta short position A position in options and/or underlying currency in which a small depreciation of the currency theoretically increases the net value of the position.

European option An option that can be exercised only on the expiration date and not before.

exercise A right held by an option buyer. The buyer requests the call option writer to deliver the foreign currency at the stated price or requests the put writer to pay the exercise price for the delivered foreign currency.

exercise price The price at which the call option buyer may purchase or the put option buyer may sell the underlying currency. Also called the strike price.

expiration date The final date on which an option may be exercised. After the expiration date the option is worthless.

forecast volatility A forecast of the volatility which an underlying currency spot, futures, or forward rate will exhibit in the future.

gamma See curvature.

historic volatility The observed volatility that an underlying currency spot, futures, or forward rate has exhibited.

implied volatility The volatility that must be attributed to the underlying currency to equate the theoretical value of an option with its current market price.

in-the-money An option is in-the-money when it has intrinsic value. A call option is in-the-money if the underlying currency's spot price is greater than the option's exercise price. A put option is in-the-money if the underlying currency's price is lower than the option's exercise price.

intrinsic value For a call option the intrinsic value is the difference between the underlying currency's spot value and the exercise price. For a put option the intrinsic value is the difference between the exercise price and the underlying currency's spot value. Because options convey a right, but not an obligation, intrinsic value is always greater or equal to zero. Note, however, that the theoretical as well as the actual value of a European option can lie below its intrinsic value.

long option An option that has been purchased.

option buyer The purchaser of a call or put option.

option valuation model The model is based on variables including the underlying currency's spot or futures rate, time to expiration, domestic and foreign interest rates, the exercise price, and the forecast volatility. The model develops theoretical valuations for individual options and provides information necessary to determine proper ratios for hedge positions. Typically, for European options the Black-Scholes model or modified versions are used. For American options, a modified binomial option pricing model of Cox, Ross, and Rubinstein is used.

option writer The seller of an option who grants option privileges to the buyer in exchange for receiving the premium.

out-of-the-money An option that has no intrinsic value. A call option is out-of-the-money when the exercise price is higher than the underlying currency's price. A put option is out-of-the-money when the exercise price is lower than the underlying currency's price.

parity A call option is said to be at parity when the price of the option equals the current market price minus the exercise price. A put option is at parity when the price of the option equals the exercise price minus the current price of the underlying currency.

premium The price of an option agreed upon by the buyer and seller. The premium is paid by an option buyer to the seller.

put option A contract granting the right to sell a given underlying currency or currency-futures contract at a specific price for a stated period of time or at a stated point in time.

short option An option that has been sold.

strike price See exercise price.

theoretical value The value of an option as given by an option valuation model.

time decay Options are described as wasting assets. In most cases, the value of an option decreases as expiration approaches, all other variables remaining constant. Under some circumstances, characterized by low volatilities and large interest-rate differentials, the value of European-style currency options can increase as expiration approaches.

time value The component of the option premium that reflects the remaining life of the option. The time value component is defined as the difference between the option premium and the option's intrinsic value.

uncovered call writer A call writer is uncovered (naked) when the writer does not own the underlying currency on which the option is written or does not own a long call on the same currency with an equal or lower exercise price.

uncovered put writer A put writer is uncovered (naked) when the writer does not hold a put on the same underlying currency with an equal or higher exercise price.

underlying currency A spot, forward, or futures position/contract that underlies a particular option or option position.

volatility A measure of actual or expected price movement in an underlying currency over a specific time period. Volatility is expressed as the annualized standard deviation of daily exchange-rate changes.

PRICING

Options are viewed by the majority of the public as exotic and speculative instruments. This can partially be attributed to the pricing formula for options. The formula involves rather complex mathematics and is usually not well understood. In this section, we attempt to erase the myth about options by explaining the pricing mechanism on intuitive rather than rigorous mathematical levels. First, we discuss how currency option prices are quoted in the market and interpret these quotes. Second, we analyze the value and, therefore, the prices of options at expiration. For hedgers, the value of options at expiration is of greatest concern. Third, we attempt to describe the value of options before expiration on an intuitive level. Last, we discuss several propositions to clarify the relationship among prices for puts, calls, and the underlying currency as well as the price relationships among options with different exercise prices and expiration dates.

Quotations

In the United States option premiums are most often expressed as U.S. dollars or cents per unit of foreign currency (American terms). This is in contrast to the interbank spot and forward markets where most major currencies (except the British pound) are quoted in foreign currency units per U.S. dollar (European terms).

Quotation in American terms is standard in the major foreign-currency futures market—the International Money Market of the Chicago Mercantile Exchange (CME). The tradition has spilled over to the major foreign-currency option markets both within and outside of the United States.

Tailor-made foreign-exchange options are also traded in the interbank market. Prices for these options are usually quoted in

European terms. A user should double-check pricing conventions, especially when using the over-the-counter market or dealing in cross-currency options.

Exhibit 16–1 illustrates how *The Wall Street Journal* displays foreign-currency option prices. The table lists horizontally different expiration dates for calls and puts, and vertically different strike prices. The quotes refer to prices of the last transactions of the day. The letters "r" and "s" indicate options not traded and options not offered, respectively.

Though option premiums are usually quoted as described, traders in the interbank market also quote options in implied

EXHIBIT 16–1
Foreign Currency Options

Philadelphia Exchange

Wed., Apr. 19

Option & Underlying	Strike Price	Calls—Last			Puts—Last		
		Apr	May	Jun	Apr	May	Jun
50,000 Australian Dollars-cents per unit.							
ADollr	...78	s	r	r	s	r	0.90
80.11	...79	s	r	1.62	s	r	1.33
80.11	...80	s	0.80	1.22	s	r	r
80.11	...81	s	0.41	0.78	s	r	r
80.11	...82	s	0.18	r	s	2.55	r
31,250 British Pounds-cents per unit.							
BPound	167½	s	r	r	s	0.44	1.17
171.14	.170	s	r	r	s	1.15	r
171.14	172½	s	0.84	r	s	r	r
171.14	.175	s	0.29	0.80	s	r	r
50,000 Canadian Dollars-cents per unit.							
CDollr	...83	s	1.25	1.30	s	r	r
84.31	.83½	s	r	r	s	r	0.47
84.31	...84	s	0.49	0.69	s	0.33	r
84.31	...85	s	0.13	0.31	s	r	r
62,500 West German Marks-cents per unit.							
DMark	.. 50	s	r	r	s	r	0.03
53.73	...52	s	r	r	s	r	0.10
53.73	...53	s	r	r	s	0.14	0.30
53.73	...54	s	0.37	0.77	s	r	0.71
53.73	...55	s	0.10	0.35	s	r	r
53.73	...56	s	r	0.16	s	r	r
53.73	...57	s	r	r	s	r	3.19
250,000 French Francs-10ths of a cent per unit.							
FFranc	..16	s	0.78	r	s	r	r
6,250,000 Japanese Yen-100ths of a cent per unit.							
JYen	... 73	s	r	r	s	r	0.11
75.53	...74	s	r	r	s	0.07	r
75.53	...75	s	r	r	s	0.24	0.48
75.53	...76	s	0.45	r	s	0.55	r
75.53	...77	s	0.15	0.59	s	r	r
75.53	...78	s	0.06	0.34	s	r	2.40
75.53	...79	s	r	0.15	s	r	r
75.53	...80	s	r	0.10	s	r	r
75.53	...81	s	r	0.04	s	r	r
62,500 Swiss Francs-cents per unit.							
SFranc	..60	s	r	r	s	0.15	r
61.15	...61	s	r	r	s	r	0.67
61.15	...62	s	0.30	0.75	s	r	1.15

Total call vol. 20,827 Call open int. 320,485
Total put vol. 7,351 Put open int. 353,287
r—Not traded. s—No option offered.
Last is premium (purchase price).

Source: Reprinted by permission of *The Wall Street Journal*.

volatilities. A typical quote for a three-month U.S. dollar option against the German mark might be: 11.5–11.8. This means that the dealer is willing to buy the option if its premium translates into an implied volatility of 11.5 percent. The dealer is willing to sell the option if the premium translates into an implied volatility of 11.8 percent.

Value at Expiration

At expiration, the value of any currency option is determined solely by the difference between the spot exchange rate and the exercise price. Because options entail the right, but not the obligation, to buy or sell a given amount of foreign currency, option values can never be negative. This holds not only at expiration, but also for the entire life of the option.

At expiration, a call option only has value if the spot exchange rate is higher than the exercise price. When this is the case, the holder exercises the option. The exerciser buys the foreign currency at the exercise price and sells the received foreign currency at the prevailing spot exchange rate. The call option holder's profit from this transaction equals the difference between the spot exchange rate and the exercise price. Therefore, the value of the call option at expiration must also equal the difference between the spot rate and the exercise price. Similarly, the value of a put option at expiration equals the greater of zero or the exercise price minus the spot price. The following table shows the expiration values as a function of the spot exchange rate for call and put options on the DM with an exercise price of $0.50/DM.

Spot Rate ($/DM) at Expiration	*Expiration Value in $*	
	Call	*Put*
.30	.00	.20
.35	.00	.15
.40	.00	.10
.45	.00	.05
.50	.00	.00
.55	.05	.00
.60	.10	.00
.65	.15	.00
.70	.20	.00

Suppose the spot rate at expiration is $0.35/DM. The call option buyer can purchase DM cheaper in the spot market than through the exercise of the option. The value of the option at expiration cannot be greater than zero. Suppose the spot exchange rate at expiration is $0.65/DM. The call option holder exercises the option and buys DM for $0.50 and then sells DM for $0.65, pocketing a profit of $0.15/DM. The call option cannot be priced less than $0.15/DM, otherwise arbitrage opportunities exist. Because the option is at its expiration, no one would be willing to pay more than $0.15/DM. The call option price at expiration equals exactly the greater of zero or the difference between the spot exchange rate and the exercise price.

Assume the spot rate at expiration is $0.35/DM. The put option holder exercises the option by selling DM for $0.50 and then buys the DM back in the spot market for $0.35/DM, pocketing a profit of $0.15/DM. The put option cannot be priced less than $0.15/DM, otherwise arbitrage opportunities exist. Because the option is at its expiration, no one would be willing to pay more than $0.15/DM. Suppose the spot rate at expiration is $0.65/DM. The put option buyer can sell DM at a higher price in the spot market than through the exercise of the option. The value of the option cannot be greater than zero. The value of the put option at expiration equals exactly the greater of zero or the difference between the exercise price and the spot exchange rate.

Once the option value at expiration is known, the profit on any option position can be calculated by accounting for the initial investment for option buyers or cash receipts for option writers. Ignoring the time value of money, the profit at expiration for options buyers is the option value at expiration minus the option purchase price. The profit at expiration for the option seller is the option selling price minus the option value at expiration. Typical option profit profiles are given in parts (a) and (b) of Figure 16–1.

Value before Expiration

To calculate the value of a call or put option at expiration is easy. Before maturity, however, we do not know what the spot price will be at expiration. We can, nevertheless, assign probabilities to various possible maturity spot prices, compute the corresponding call values, and then discount these values to the present. That is, we can compute the value of a call or put option before expiration as the probabilistically discounted net present value of its future value. Complex as this might seem, most of the widely used option-pricing models simulate this procedure.

Of these, the Black-Scholes (B-S) options pricing model is the most commonly used. This model was originally developed for pricing European options on nondividend paying stocks. It can be extended to apply to stocks continuously paying dividends, foreign exchange, commodities such as oil and gold, and even debt instruments—albeit crudely.

First, we attempt to demystify the B-S model by stressing the intuition behind its derivation. Though we do present the B-S formula, we do not use mathematical concepts more sophisticated than simple algebra. Second, by using the B-S formula and intuitive arguments we discuss how various input parameters affect foreign-currency option prices.

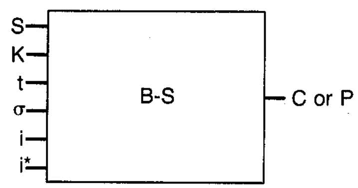
The Black-Scholes Currency Options Pricing Model

The basic idea behind the Black-Scholes approach to pricing options is that option portfolios can be replicated by buying or selling a certain proportion of the underlying instrument and by borrowing or lending money. If the replicating portfolio is identical to the desired option portfolio, and one can price the replicating portfolio, then one can also price the option portfolio.

Specifically, buying a call option is identical to buying a certain proportion of the underlying instrument (the delta) and borrowing money to finance the transaction. Analogously, buying a put is identical to selling a proportion of the underlying instrument and lending the proceeds.

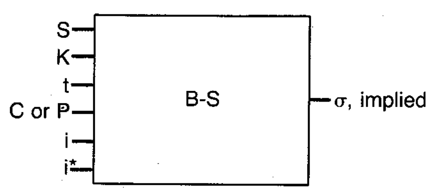
The mathematical derivation of the preceding is beyond the scope of this chapter. The intuition, however, is fairly straightforward. If an investor is long a call option, the return on the investment increases drastically as the underlying instrument appreciates. Put differently, a call option holder's returns resemble the returns of a leveraged portfolio.

The value of any currency option depends on six variables: domestic interest rate (i), foreign interest rate (i*), time to expiration (t), current spot rate (S), exercise price (K), and expected volatility (σ). These six variables are the inputs to the B-S currency options pricing model. In theory, the domestic interest rate is the risk-free rate, and the foreign rate is the Eurodeposit rate. In practice, both the domestic and foreign rates are given by the corresponding Eurorates. Of the six price-determining variables, five are readily observable. Only expected volatility is unknown and has to be estimated. The output of this model can be either the price of a European call (C), or the price of a European put (P). Put differently, the B-S model can be thought of as a black box:



where the input variables are on the left side of the box and the output variable (the option price) is on the right side.

Interestingly, the box is frequently used in a mode where one of the input variables, σ, changes places with the output, C or P:



In this mode, the output is referred to as the implied volatility, as opposed to the expected volatility, which is an input variable to the first mode. Options traders use implied volatilities to devise hedging, speculative, and trading strategies. Implied volatility is a quantification of the market's estimate of the underlying currency's future price movements.[1]

[1] To pick a simple example, let the DM/$ rate be DM 2.00/$, and the implied volatility be 10 percent. Assuming that the logs of exchange rates behave as a random-walk model, the market's 68 percent and 95 percent confidence levels for the DM/$ rate one year out are DM 1.90–2.10/$, and DM 1.80–2.20/$, respectively.

If the world were deterministic, the value of the call would be the greater of zero or:

$$C = Fe^{-it} - Ke^{-it} \qquad (1)$$

where F is the forward rate in domestic currency units per foreign currency and e represents the natural number such that e^{-it} (e^{it}) stands for continuous discounting (compounding). Because of the interest-rate parity theorem, the forward rate is a function of the spot rate and the domestic and foreign interest rates:

$$F = Se^{(i - i^*)t} \qquad (2)$$

Rewriting Equation 1, we have:

$$C = Se^{-i^*t} - Ke^{-it} \qquad (1^*)$$

Similarly, if the world were deterministic, the value of the put would be the greater of zero or:

$$P = Ke^{-it} - Fe^{-it} \qquad (3)$$

Rewriting Equation 3 we have:

$$P = Ke^{-it} - Se^{-i^*t} \qquad (4)$$

So, in a deterministic world, the value of the call is the greater of zero, or the discounted value of the forward price minus the strike price. Similarly, the value of the put is the greater of zero, or the discounted value of the strike price minus the forward price.

The B-S model is a modified version of this formula. The modification is there because the world is not deterministic, and adjustments for probabilistic outcomes must be made. These adjustments lead to the B-S foreign-currency option pricing formula:

$$C = Fe^{-it}\,N(d_1) - Ke^{-it}N(d_2) \qquad (5)$$

where:

$$d_1 = (\ln (F/K) + (\sigma^2/2)t)/\sigma t^{0.5}, \text{ and}$$

$$d_2 = d_1 - \sigma t^{0.5}$$

N is the cumulative distribution of the stardard normal probability distribution function and ln is the natural logarithm. Note that i and i* are continuously compounded interest rates.

The formula for put options can be derived using the formula for call options and the option parity theorem (see the upcoming section on put-call price relationships for more details):

$$P = Ke^{-it} N(d_3) - Fe^{-it}N(d_4) \quad (6)$$

where:

$$d_3 = (\ln (F/K) + (\sigma^2/2)t)/\sigma t^{0.5}, \text{ and}$$

$$d_4 = d_3 - \sigma t^{0.5}$$

The Sensitivity of Option Prices to Changes in Input Variables

The best way to understand option pricing and the B-S formula is to examine what happens to C and P as S (or F), K, t, σ, i, and i* change in value one at a time.

Underlying Foreign-Currency Price. The higher the underlying foreign-currency price (S or F), the higher (lower) the value of the call (put). This can be easily seen from the deterministic formulations 1* and 4, and also holds for the B-S formula. As S or F approach zero, C approaches zero, and P approaches the present value of the exercise price. As S or F approach infinity, C approaches infinity and P approaches zero.

The magnitude of the effect of changes in exchange rates on option prices depends to a large extent on the level of the spot rate relative to the exercise price. The price effect of a given change in the spot rate for (far) out-of-the-money options is (very) small. Prices of deep in-the-money options change by nearly the same amount as the spot rate. For at-the-money options, prices tend to change by one unit for every two unit change in the spot rate.

The sensitivity of option prices to changes in the spot rate (the delta) is not only a function of the level of the spot rate relative to the exercise price but also a function of the volatility level. As a general rule, the following holds: For out-of-the-money options, the option price sensitivity with respect to changes in the spot rate increases as volatility increases. For in-the-money options, the option price sensitivity decreases as volatility increases. Intuitively, the delta can be interpreted as the probability that the options will be in-the-money at expiration. Assume a far-out-of-the-money option. If volatility is low, the probability for this option to be in-the-money at expiration approaches zero. If volatility is high, the out-of-the-money option has a greater chance of being in-the-money at expiration. Thus, the price sensitivity of out-of-the-money options increases as volatility increases. For deep in-the-money options, the opposite holds. If volatility is low, the option has a very high probability of staying in-the-money throughout its life. On the other hand, if volatility is high, the probability of being in-the-money at expiration is lower. Thus, the price sensitivity of in-the-money options decreases as volatility increases.

Strike Price. The higher the strike price, the lower (higher) the value of the call (put). Again, this can be readily seen from the deterministic formulations. As K approaches zero, C approaches S, and P approaches zero. Intuitively, a call with a zero strike price is like the underlying instrument.

An option's price sensitivity with respect to the exercise price depends on how far in- or out-of-the-money the option is and also on the volatility level. The arguments here are virtually identical to those discussed in the preceding section.

Expected Volatility. The expected volatility of future spot price changes is an important variable in option pricing. It is the only variable which is unknown and has to be estimated. If currency prices were fixed, all (European-style) currency options would be either worthless if out-of-the-money or would be priced at the discounted value of the difference between the forward price and exercise price for calls or between the exercise price and forward price for puts. It is volatility which gives options the additional value. The higher the volatility of the spot exchange rate, the greater the uncertainty, and as a result the higher the prices for puts and calls. In addition, as explained earlier, the price sensitivity of options with respect to changes in volatility is also dependent on the time to maturity and the relative position of the spot exchange rate to the exercise price.

Domestic Interest Rate. Assume that the spot rate and the foreign interest rate do not change with a change in the domestic interest rate. As domestic interest rates rise, the value of a call (put) increases (decreases). This can be readily seen from the deterministic formulations 1* and 4. This is the pure interest-rate effect.

As i rises, the present value of K declines so that the call price increases. The value of the call is equivalent to the cost of maintaining the hedge portfolio which consists of delta units of the underlying currency and borrowed money. As interest rates rise, the cost of maintaining the hedge portfolio rises, leading to a rise in the call price.

The value of a put decreases as i increases because the cost of the hedge portfolio of a put which shorts the underlying currency decreases. That is, the hedge portfolio on a put earns more interest as i increases, lowering its overall cost.

A change in the domestic interest rate, however, usually influences both the spot and the forward-exchange rate. These changes lead to a change in the option price. The effect on option prices depends not only on the extent of the change in the domestic interest rate but also on the change's relative impact on the spot and forward rates.

Suppose that a change in the domestic interest rate does not alter the current spot rate. This implies that an increase in the domestic interest rate either increases the forward premium or decreases the forward discount of the foreign currency. Given a constant spot rate, an increase in domestic interest rates leads to an increase in call option prices and a decrease in the prices of put options on the foreign currency. Similarly, a decrease in domestic interest rates decreases call option and increases put option prices on the foreign currency.

An investor may view a long foreign-currency position and a call-option position as alternatives to profit from anticipated appreciations of the foreign currency. An increase in the domestic interest rate increases the carrying costs of holding the foreign currency more than the carrying costs for the call option. This increases the attractiveness of call options and thus their value. A similar argument holds for put options. An investor may view a short foreign-currency (long domestic-currency) position and a put-option position as alternatives to profit from anticipated depreciations of the foreign currency. An increase in the domestic interest rate increases the opportunity costs of carrying a put option because the investor does not earn the higher interest on the

domestic currency. Thus, the price of put options falls with an increase in domestic interest rates and rises with a decrease in these rates.

Suppose, now, that changes in domestic interest rates leave the forward rate constant. If so, increases (decreases) in domestic interest rates lead to spot depreciations (appreciations) of the foreign currency. The effect on call and put prices is undetermined. If the call option is in-the-money, an increase (decrease) in the domestic interest rate will lead to decline (increase) in call prices. The same holds for the price of put options.

As changes in domestic interest rates usually affect both spot and forward rates simultaneously, the preceding effects offset each other, at least partially. Hence, the pure interest effect usually dominates. The effect of changes in interest rates on option prices is positively correlated to the length of the options life.

Foreign Interest Rate. According to Formulations 1* and 4 an increase in foreign interest rates, given a constant spot rate, decreases (increases) call (put) option prices. For a constant forward rate, Equations 1 and 3 indicate that a change in the foreign interest rate does not affect call and put option prices. In particular, any news such as a change in foreign interest rates affects both spot and forward rates simultaneously and in the same direction. Therefore, in all likelihood, a change in foreign interest rates affects option prices only to the extent that the underlying currency's value changes.

Time to Expiration. Everything else constant, option values usually decline as time passes. The holder of an American option with a longer time to maturity has all the rights that a holder of an option with a shorter time to maturity has. In addition, he has the rights for a longer period. Therefore, the price of an American option with longer maturity has to be greater than the price of an option with shorter maturity. This, however, is not always true for European options.

The longer the time to expiration, the higher the value of a call on nondividend paying stock. A European call with a longer time to maturity offers everything that a European call with a shorter time to maturity offers. Hence, it should be more expensive.

The above holds because an investor would not want to prematurely exercise a European call on nondividend paying stock. An investor exercising such a call prematurely would lose the option's time value. To avoid this loss, the investor would rather sell the call in the open market. If the stock pays dividends, however, the situation might be different. On the ex-dividend date, the call option holder not only loses time value, but also intrinsic value. If the expected loss in intrinsic value is larger than the loss in time value, a dividend-paying stock's call should be exercised prematurely.

The change in the value of a European put on nondividend-paying stock with respect to a change in time to expiration is ambiguous. Two opposing effects are at work. Because of the time value of money, it is better to early exercise a put. This leads to the conclusion that the longer the time to expiration, the less valuable the put. On the other hand, as it increases, the likelihood of the put price ending in-the-money increases, raising the value of the put. Because these two effects operate in opposite directions, the overall effect of a change in t on the put price is ambiguous.

Options on foreign currencies are like options on stocks which pay dividends continuously. In a deterministic world, the effects of changes in time to maturity on option prices are mostly ambiguous. As time to expiration increases, the value of a call (put) on a foreign currency trading at a discount decreases (increases) or stays at zero. The same effect would lead to ambiguous results for options on currencies trading at a forward premium.

Time decay of an option is, in addition, a function of the volatility level and the ratio between the current spot rate and the exercise price. In general, time decay for deep in-the-money options is small. Time decay for at-the-money options increases as expiration approaches. The time decay for out-of-the-money options is most severe in the beginning of their lives and decreases as expiration approaches. Absolute time decay (and correspondingly the total time value) increases with an increase in volatility. However, in relative terms (ratio of time value of total premium), distinctions have to be made about whether the option is out-of-the-money or in-the-money. In relative terms, time decay decreases for out-of-the-money options as volatility increases. On the other hand, time decay increases in relative terms for in-the-money options as volatility increases.

Put - Call Price Relationships

Though an option buyer has the right, but not the obligation, to deliver or receive foreign exchange and a forward contract must be delivered or reversed, the two contracts are linked in many ways. Various combinations of puts, calls, forward (or futures) contracts, and lending or borrowing can substitute for one another. Thus, some basic relationships between prices for options and forward exchange contracts can be established. Strictly speaking, these relationships only hold for European options. However, for most practical purposes, few American options are exercised before the expiration date. American options are almost always more valuable "alive" than "dead" and thus are kept alive. To the extent that the premature exercise right of American options is not used and is hence worthless, the following relationships also apply to American options.

1. A position of buying a call option (C) with an exercise price of K and selling a put option (P) with an identical exercise price and expiration date is equivalent to buying a forward contract at a forward-exchange rate K:

$$C(K) - P(K) = \text{Forward contract } (K)$$

As the spot-exchange rate is above K on the expiration date, the gains on the long call position match those on the forward contract. The put expires worthless. As the spot-exchange rate is below K on the expiration date, the losses on the short put position match those on the forward contract. The call expires worthless.

2. The difference between the value of a call and a put option with the same expiration date and identical exercise prices K equals the discounted value of the difference between the forward/futures rate (F) and the exercise price (put-call parity):

$$C(K) - P(K) = (F - K)/(1 + r)^t$$

Traders regard the preceding as a result of two arbitrage transactions. The reversal combines buying a call and selling a put option with identical strike prices and selling the foreign currency forward for the same expiration date. The conversion combines buying a put and selling a call option with identical strike prices and buying the foreign currency forward for the same expiration date.

3. The prices for put and call options with identical expiration dates and exercise prices equal to the forward/futures rates (F) are the same:

$$C\ (F) = P\ (F)$$

This follows immediately from the previous proposition, since:

$$F - K = 0$$

4. Prices of call and put options with the same expirations but different exercise prices are related to the discounted value of the exercise prices' difference:

$$C\ (K_1) - P\ (K_1) + P\ (K_2) - C\ (K_2) = (K_2 - K_1)/(1 + r)^t$$

This can simply be derived by summing up two put-call parity equations. The correct relative pricing of call and put options with different exercise prices is maintained by boxes. Boxes contain positions of long call/short put at a given exercise price and short call/long put at a different exercise price.

5. At any date before maturity, an American call option (C_A) must sell for at least the difference between the spot rate (S) and the exercise price. An American put option (P_A) must sell for at least the difference between the exercise price and the spot rate:

$$C_A\ (K) \geqslant S - K, \text{ and}$$
$$P_A\ (K) \geqslant K - S$$

If the call options sell for less, an investor could buy the option, immediately exercise the option, receive the foreign currency, and sell it in the spot market to earn a riskless profit.

6. A European call or put option may be priced below the intrinsic value ($S - K$ for calls, $K - S$ for puts). The longer the time to maturity, the larger the difference between domestic and foreign interest rates, and the lower the volatility, the more likely that European options are valued below their intrinsic value. European put options on foreign currencies trading at a forward premium and European call options on foreign currencies trading at a forward discount can be priced below intrinsic value.

7. At any time before maturity, an in-the-money call option (put option) must be priced at least at the discounted value of the difference between the forward price and the exercise price (the exercise price and the forward price):

$$C\ (K) \geqslant (F - K)/(1 + r)^t, \text{ and}$$
$$P\ (K) \geqslant (K - F)/(1 + r)^t$$

If the call is underpriced, an investor can buy the call, sell the currency forward at F, and exercise the call option if in-the-money at expiration. This arbitrage transaction increases the value of the call option.

The possibility for combining put and call positions, having different exercise prices and expiration dates, with forward/futures contracts and lending or borrowing is almost endless. For each of these possibilities, an arbitrage equation and lower and upper bounds for prices could be formulated. For most practical purposes, the preceding relationships suffice.

CURRENCY-OPTION STRATEGIES

A foreign-currency option is a powerful tool for managing risk in today's volatile foreign-exchange market. It can be used by participants in an almost unlimited number of ways. The existence of calls and puts and a wide array of exercise prices and maturity dates allows a versatility unequaled by other financial instruments. Currency options enable international firms and investors to hedge contingent and noncontingent foreign-exchange exposures, to tailor international portfolio results in new ways, and to take a view on the direction and volatility of exchange-rate movements. This section describes some of the most often used currency-option strategies.

Speculation

Options are versatile tools not only for the purpose of hedging foreign-currency exposures but also for speculation. Options allow investors to speculate both on directional moves in exchange rates and on exchange-rate volatilities.

Suppose an investor expects the British pound to appreciate or depreciate against the U.S. dollar. Conventional strategies such as buying or selling the British pound in the spot, forward, or futures market expose the investor to large potential losses in case of an unfavorable movement in the exchange rate. Because options give the holder the right, but not the obligation, to buy or sell foreign exchange, the potential loss of a long option position is limited to the premium paid. On the other hand, the profit potential is unlimited and reduced only by the premium paid.

Direction. Assume an investor expects an appreciation of the British pound against the U.S. dollar. The investor could buy British pounds in the spot or forward/futures market. The final outcomes for all these alternatives will be identical if the interest-rate parity condition holds. With a long position in the British pound, profits materialize if the British pound appreciates as anticipated. On the other hand, losses are realized if the British pound depreciates.

The investor can use at least two options strategies. First, the investor can sell a put option on the British pound, receiving a premium. If the pound appreciates, the put option expires worthless and the investor's profits are limited to the premium received. If the pound depreciates, the holder of the put exercises it and the investor delivers U.S. dollars (buys British pounds) at the stated exercise price. The received premium (partially) cushions the investor's losses. Second, the investor can buy a call option on the British pound, paying a premium. If the British pound appreciates, the investor profits. However, profits are reduced by the initial premium paid, compared to a spot, forward, or futures position. If the pound depreciates, losses are limited to the premium paid.

Options are analogous to insurance contracts. Call options used as uncovered (naked) long positions in foreign currencies protect the holder from large losses if the value of the underlying currency decreases. Put options used as uncovered (naked) short positions in foreign currencies protect the holder from large losses if the value of the underlying currency increases.

To demonstrate this principle, consider the following scenario and prices:

$$S = \$1.4000/£$$
$$F_{90} = \$1.3880/£$$
$$\text{90 day 1.4000 Call} = .0280$$
$$\text{90 day 1.4500 Put} = .0714$$

The investor expects an appreciation of the British pound and is willing to take a long position of £1 million. The total premium to be paid for the call option is $28,000 ($.028/£ premium), and the premium received for the in-the-money put option is $71,400 ($.0714/£ premium). Because spot, forward, and futures positions give identical outcomes, we assume that the investor buys £1 million forward for 90 days at the prevailing forward rate of $1.3880/£. The following table shows profits and losses as a function of the spot rate on maturity date for the three investment alternatives.

Profit/Loss Comparison (in U.S. dollars)

Future Spot Rate ($/£)	*Forward Contract 1.3880/£*	*Sell in-the-Money Put–Premium: $71,400*	*Buy at-the-Money Call–Premium: ($28,000)*
$1.2000	−$188,000	−$178,600	−$ 28,000
1.3000	− 88,000	− 78,000	− 28,000
1.3500	− 38,000	− 28,600	− 28,000
1.3880	0	+ 9,400	− 28,000
1.4000	+ 12,000	+ 21,400	− 28,000
1.4500	+ 62,000	+ 71,400	+ 22,000
1.5000	+ 112,000	+ 71,400	+ 72,000
1.6000	+ 212,000	+ 71,400	+ 172,000

Interest income earned on the premium received is not considered. Thus, the outcomes for the short-put option position are downward biased, whereas, the results for the long-call option position are upward biased.

The insurance characteristics of the long-call option position is obvious. The maximum loss is limited to the total premium paid. The flexibility of using any exercise price for the call and put position gives the investor a large variety of possibilities. Also note that none of the alternatives is dominant. Each has a unique profit-loss profile. The forward strategy is preferred for large appreciations of the British pound, while the call-buying strategy is superior for large depreciations. The put-selling strategy is the best for in-between outcomes.

For obvious reasons, an investor expecting a depreciation of the British pound would compare these strategies: selling forward, buying puts, and selling calls.

Volatility. Options also can be used to profit from anticipated exchange-rate volatilities, independent of the direction of exchange-rate movements. We discuss some of these strategies next.

Straddles

A straddle is formed by simultaneously buying or selling puts and calls. The purchase of a straddle is equivalent to buying both a put and call with identical strike prices and expiration dates. The sale of a straddle is equivalent to selling both a put and a call.

Straddles are bought or sold when management has specific expectations about the future variability of exchange rates, but not about the direction of those movements. Specifically, management buys a straddle when it believes a currency will either appreciate or depreciate beyond a specific point.[2]

Similarly, a straddle is sold if management thinks that currency movements will be limited within a specific range. For example, management may sell a straddle if it thinks that the volatility of a certain currency will drop below market expectations, possibly because of expected central bank intervention. Conversely, management may buy a straddle if it expects volatility to rise above market expectations—as the result, for example, of expected increases or decreases in money supply growth.

Figure 16–1 shows the profit profile of a long straddle position. To see why a straddle provides this payoff profile, remember that the purchase of a straddle is equivalent to the simultaneous purchase of a call option and a put option with identical terms. The profit profile of buying a call option at exercise price X is illustrated

[2]As shown later, this point is a function of the exercise prices of the individual options in the straddle, and the option premiums.

by part A in Figure 16–1. At spot-exchange rates X and lower, the call is not exercised. The loss of this position equals the price of the option. At spot-exchange rates above S_1, the option is sufficiently in-the-money to more than cover its cost. Between X and S_1, the option is in-the-money, though not by enough to cover its cost. Similarly, part B illustrates the profit profile of buying a put option.

Part C in Figure 16–1 illustrates the profit profile of a straddle purchase. It is constructed as the vertical sum of parts A and B. The price of the straddle incorporates the market's assessment of the variability of the exchange rate. The buyer of the straddle thus profits only if the exchange rate moves plus or minus a certain percentage, $[(S-X)(100)/X]$, or $[(X-S)(100)/X]$ beyond X. The seller of the straddle accepts that risk for a lump sum.

The profit profile of selling a straddle is the mirror image of part C around the horizontal axis. Writing a straddle is quite risky because the investor is writing both a naked call and a naked put. The investor has no protection against large moves in the value of the currency in either direction, thus exposing himself to potentially large losses.

As Figure 16–1 suggests, buying a straddle is equivalent to buying insurance, with a deductible, against large movements either up or down in the value of the underlying instrument. Profit opportunities or bargains exist, however, only if this insurance (1) can be bought for less than its fair actuarial value, or (2) can be sold for more than its fair actuarial value.

The most important determinant of the fair actuarial value of this insurance is the expected volatility of the underlying currency. If one's expectation of this volatility is higher than the market's, one buys this insurance. But, if one's expectation of this volatility is lower than the market's, one sells this insurance.

Spreads

A spread is the simultaneous purchase of one option and sale of another on the same underlying instrument in which the two options differ only in time to expiration and/or in strike price. Vertical spreads are formed by varying only the strike price; horizontal spreads (also called time or calendar spreads) are formed by varying the time to maturity. These spreads are so named because quotes for options differing in exercise prices are listed vertically and quotes for options differing in maturities are listed horizontally.

When traders think that certain options are mispriced, they try to make a profit by establishing a spread—that is, by buying the low-priced option and selling the relatively high-priced one. The following example, using three-month and six-month foreign-exchange options (FXO), illustrates how traders detect arbitrage opportunities.

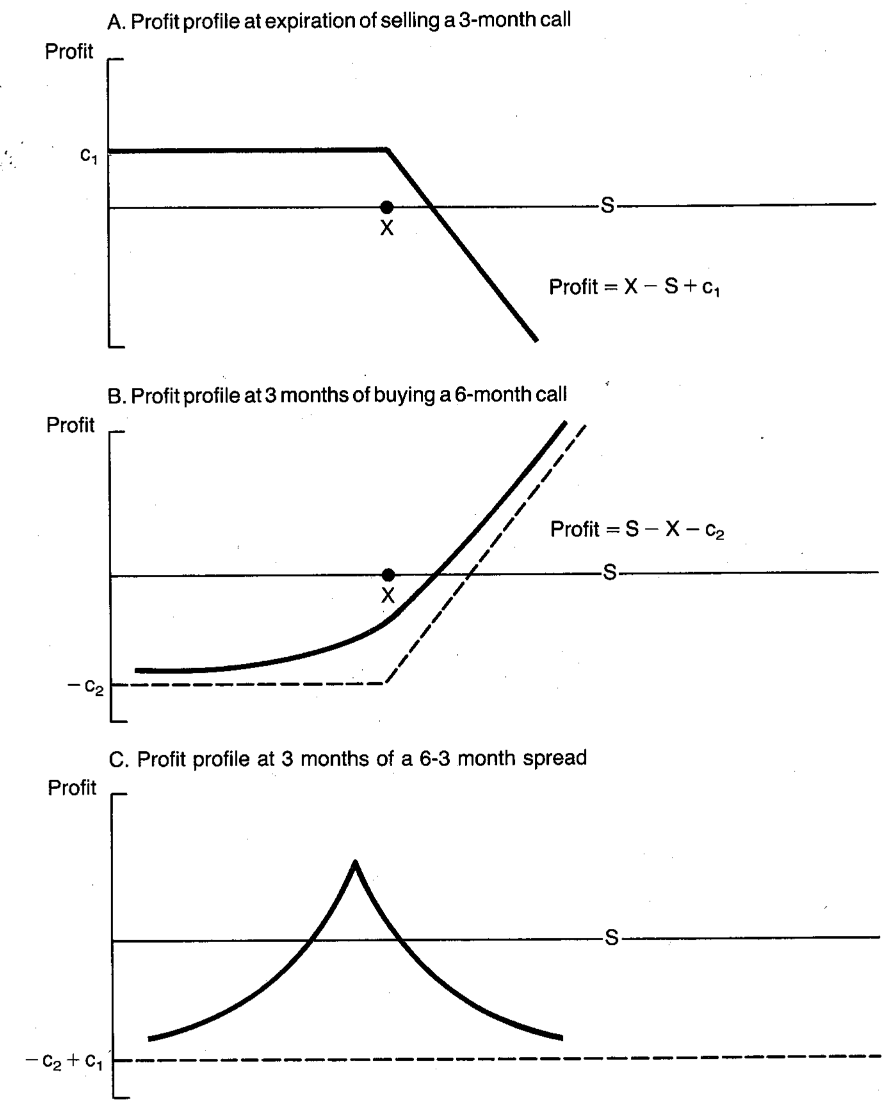
First, the implied volitilities of three-month and six-month FXOs are calculated by using the option-pricing models together with current market prices to "back-out" the market's implicit estimate of expected volitility. Second, the implied volitility of three-month FXOs is used to compute the theoretical value of six-month FXOs. If the theoretical value of six-month FXOs is higher than the current market value, then six-month FXOs must be relatively underpriced compared to three-month FXOs, at least theoretically. The trader thus buys six-month FXOs and sells three-month FXOs.

But this is not an entirely riskless activity. First, a spread might incur a loss. The maximum loss is called the basis of the spread, and is discussed in further detail later. Second, volatility may not be a stationary process—that is, the relationship between the volatility of three-month and six-month FXOs may change over time—creating potential losses for spread positions.

Horizontal Spreads

Figure 16–2 shows the profit of a horizontal spread formed by selling a three-month call and by buying a six-month call, both at the same exercise price. The profit profile, at expiration, of selling a three-month call is straightforward and is presented in part A. The profit profile, at three months, of buying a six-month call is given in part B. (The broken lines are the asymptotes of the profit profile.) The solid line represents the actual profit profile, reflecting the fact that options command a time premium. The profit profile of the spread, at three months, is the vertical sum of parts A and B. The maximum loss of the spread equals the premium of the six-month call minus the premium of the three-month call. This is called the basis of the spread.

FIGURE 16–2
Profit Profile of a 6–3 Month Spread



The Simple Vertical Spread

The simple vertical spread is formed by buying an option with one exercise price (X_1) and selling another option with the same maturity date as the first, but a different exercise price (X_2). Figure 16–3 depicts the profit profile of buying a call at X_1, and selling a call at X_2 (X_2 greater than X_1). The profit profile from selling a call at X_1 and buying a call at X_2 is the negative counterpart of Figure 16–3. When referring to spreads, the first quantity represents the option in which one is long.

The Butterfly Spread

This spread is formed by selling two options, one with a high exercise price and one with a low exercise price, and buying two options at an exercise price in between the two. Figure 16–4 illustrates the profit profile of a butterfly spread formed by selling two calls at X_1 and X_3, and by buying two calls at X_2 ($X_1 > X_2 > X_3$; $X_2 = (X_1 + X_3/2)$.

The Sandwich Spread

A sandwich spread is the opposite of a butterfly spread. It is formed by buying two options, one with a high exercise price and one with a low exercise price, and selling two options at the exercise price in between the two. The profit profile of a sandwich spread formed by buying calls at X_1 and X_3, and selling two calls at X_2 is the negative of Figure 16–4 and is given in Figure 16–5.

FIGURE 16–3
Profit Profile of a Simple (X-X) Vertical Spread (also called a bull spread)

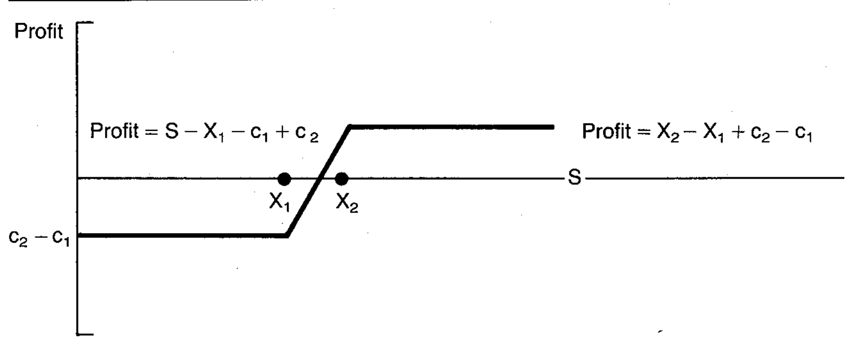
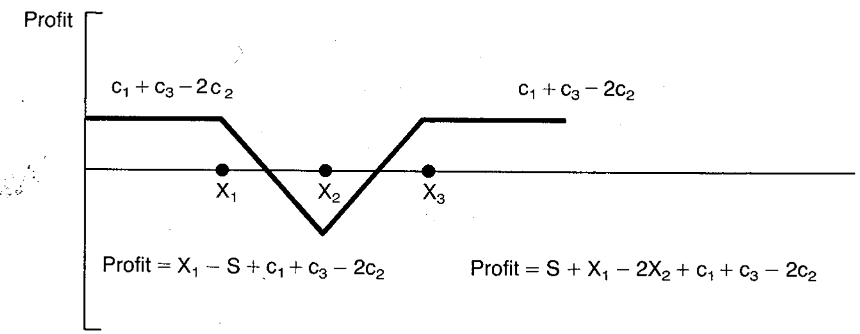


FIGURE 16–4
Profit Profile of a Butterfly Spread (a short butterfly position)

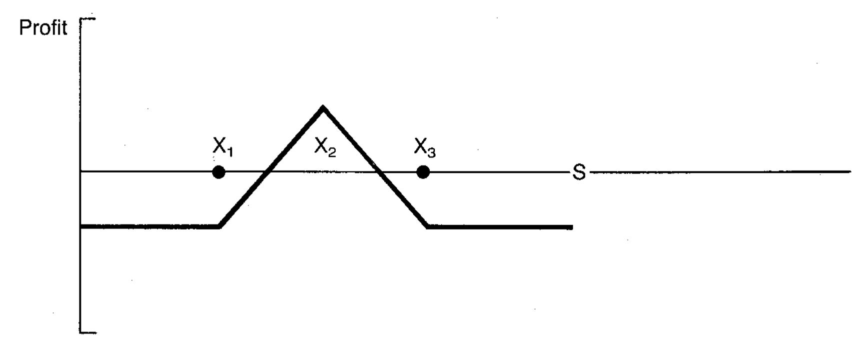


The profit profiles of sandwich and butterfly spreads somewhat resemble those of straddles. The difference is that, unlike straddles, sandwich and butterfly spreads limit the potential profits and losses. Like straddles, sandwich and butterfly spreads can be used to take positions when one's expectation of the future volatility of a currency's change is different from that of the market's.

Other Strategies

In addition to the preceding, there is a wide variety of option strategies, including diagonal spreads (a combination of vertical

FIGURE 16–5
Profit Profile of a Sandwich Spread (also called a long butterfly position)



and horizontal spreads), bull spreads, bear spreads, condors, strangles, call and put ratio spreads, and call and put ratio back spreads. Figures 16–6 through 16–10 highlight the characteristics of these various strategies. An investor uses these strategies to make directional, or volatility bets, or to exploit mispriced instruments. As each strategy has a different risk-return profile, an investor picks the one that best suits the economic outlook and the investor's particular risk-return preferences.

Hedging Contingent Payables/Receivables

Contingent foreign-currency receivables arise as the result of disposals of foreign subsidiaries, uncertain foreign sales, uncertain dividend remittances from abroad, and a host of other situations.

FIGURE 16–6
Profit Profile of a Bear Spread

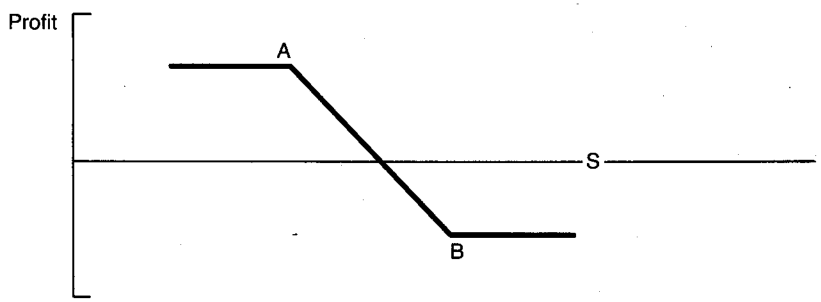


FIGURE 16–7
Profit Profile of a Long Condor

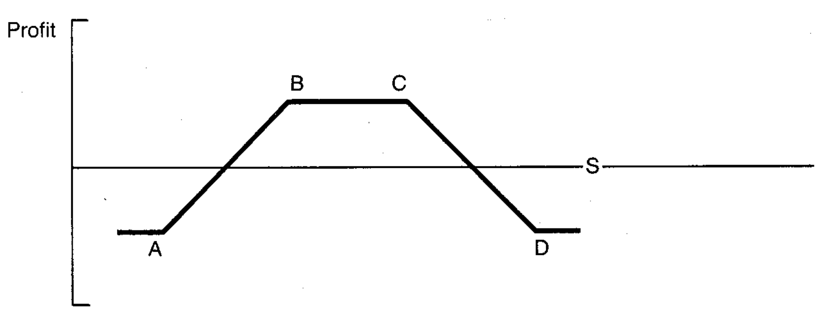


FIGURE 16–8
Profit Profile of a Long Strangle

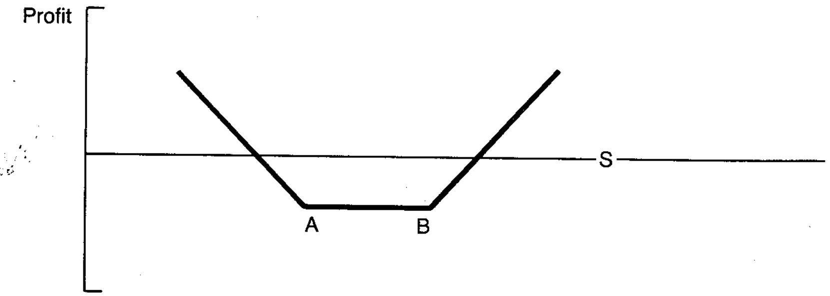


FIGURE 16–9
Profit Profile of a Call Ratio Spread (a call ratio backspread is the mirror image of this)

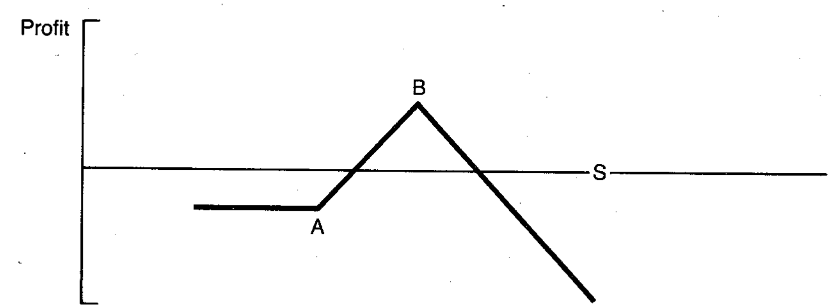
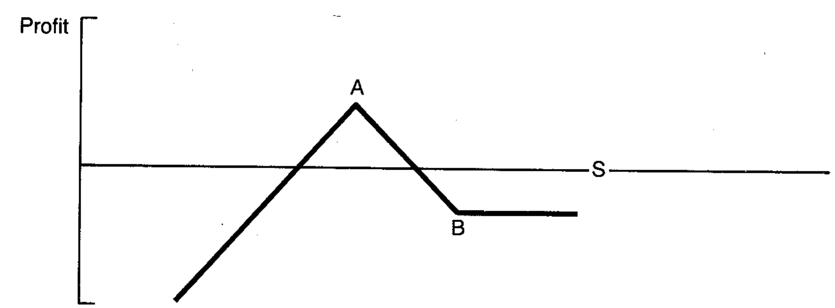


FIGURE 16–10
Profit Profile of a Put Ratio Spread (a put ratio backspread is the mirror image of this)



The most often used example for contingent receivables involves the case of a bidding firm. In hedging contingent receivables, the simple forward sale of foreign exchange equal to the sum of the bid is not a solution to the risk problem because the bidder's foreign-exchange exposure is contingent upon acceptance of the bid.

If the bid is accepted after the firm sells forward the foreign-exchange sum of the bid, the firm is hedged. If, however, the bid is not accepted and the firm has already sold forward the anticipated amount of foreign currency, the firm ends up with a short position in the foreign currency. Ex post the firm has taken a speculative rather than a hedged position. If the foreign currency appreciates, the firm takes a loss. Yet, if the firm does not sell forward the anticipated foreign currency and the bid is accepted, the firm finds itself with a long foreign-currency position. In this situation, it takes a loss if the foreign currency depreciates.

Options can solve these problems because the exercise of options is voluntary and contingent upon prevailing economic conditions. There are two methods of hedging receivables: buying a put option on the foreign currency, or selling the foreign currency forward and simultaneously buying a call option. Because of put-call parity, the methods generate identical results.

In the first case, buying a put option, the timing, quantity, and the exercise price of the option contract should correspond to the forward contract that would have been bought if the firm had a noncontingent foreign-currency receivable. But this is not always possible with respect to the timing. American options provide some flexibility only if the timing range—but not the exact date—of the contingent foreign-exchange receivables is known. The quantity and strike prices can take on a range of values depending on management's desired risk/return profile. Especially with respect to the quantity, some caution is in order. Firms bidding on a regular base know from experience that only a portion of the bids are accepted. Hedging each bid to the full amount is equivalent to "over-insurance." This can turn out to be costly for the bidding firm. Consequently, the firm should only cover a portion of the full bid. This portion should either approximate the average probability of bids being accepted or the expected probability of acceptance of the specific bid.

The premium on the put option is sometimes viewed as the cost of buying insurance against possible exchange-rate fluctuations in case the bid is accepted. If the bid is accepted and the foreign currency depreciates, the firm offsets the loss in the value of the foreign currency by exercising the put option.

In fact, however, the put option also provides additional profit opportunities. If the foreign currency depreciates and the bid is rejected, the hedger can exercise the option and profit by selling the foreign exchange for dollars. (Of course, if the foreign exchange appreciates, the firm lets the put option expire in either case.) So the option premium consists of an investment value and a hedging value. Only the hedging value of the option premium should be incorporated into the cost of submitting the bid—provided, of course, that this hedging value can be calculated.

As another hedging technique, the firm can sell the foreign currency forward and simultaneously buy a call option on the foreign currency. Obviously, the quantities, exercise prices, and maturity dates should match. If the bid is accepted and the foreign currency depreciates, the forward transaction hedges the firm, and the call expires worthless.

In the event that the foreign currency appreciates, the firm's forward contract covers its receipts, and it exercises the call option at a profit. If the bid is rejected and the foreign currency appreciates, the calls fully hedge the firm's short forward position. Should the foreign currency depreciate, the firm lets the call option expire and buys spot foreign currency to cover its forward position.

Contingent payables in foreign exchange come about through stock tender offers, merger and acquisition tenders to foreign companies, pending foreign law suits, anticipated foreign dividend payments, etc. These situations are properly hedged through the use of foreign-currency options, just as in hedging contingent receivables. Again, there are two corresponding techniques: buying a call option on foreign exchange, or simultaneously buying the foreign-currency forward and buying a put option. Our earlier comments on hedging contingent receivables apply correspondingly to the case of hedging contingent payables.

Hedging Payables and Receivables

The use of foreign-currency options to hedge noncontingent accounts payable and receivable creates outcomes that could not be constructed with more traditional instruments. The following section describes the use of five basic option strategies to hedge foreign-currency-denominated accounts payable.

Buy an at-the-money call option. This is the classic insurance policy for a company anticipating a foreign-currency-denominated payable. The chosen exercise price of the call option equals or approximates the current spot rate. This strategy protects the firm against any appreciation of the foreign currency as the call option provides the holder with the right to buy the foreign exchange at the exercise price. At the same time, the strategy allows the firm to participate in opportunity gains should the foreign currency depreciate. For this option, the firm pays a predetermined premium.

Many firms still view options differently from other insurance products. In general, premiums for automobile, health, or fire insurance are not viewed as wasted should the accidents not occur. On the other hand, firms continue to view an option premium as wasted should the foreign currency depreciate, that is, should the accident not occur. The firm, however, is always better off with a depreciated value of the foreign currency and a wasted option premium than with an appreciated value of the foreign currency and a nonwasted option premium.

Buy an out-of-the-money call option. Insurance premiums can be reduced by assuming some of the insurer's risks. This is the basic idea behind the deductible clause in property and health insurances. If a firm is willing to accept the risk of a limited adverse move in the exchange rate, it can buy a call option with an exercise price above the current spot rate at a lower premium. This out-of-the-money call option provides—depending on the exercise price—insurance against a large appreciation of the foreign currency. The higher the deductible, that is, the greater the difference between the exercise price and the current spot exchange rate, the lower the premium.

Buy a bull spread. Another way to reduce the net premium is to combine long and short option positions. For example, a firm that does not expect the foreign currency to appreciate sharply might want to buy a call option with an exercise price at or near the current spot rate and simultaneously sell a call option with a higher exercise price. The premium received for the sold call option reduces the net premium to be paid. With this strategy, the firm is protected against any appreciation of the foreign currency up to the exercise price of the written call. On the other hand, the position allows for full participation in opportunity gains should the foreign currency depreciate. The flexibility in the choice of exercise prices allows for a hedge which precisely reflects the exchange rate anticipations of the firm.

The described strategy is known as a 1:1 bull spread in the options industry. The strategy is directly comparable to any cap insurance contract.

Buy a fence. There is no real insurance analogy for this strategy. It is based again on the desire of a firm to lower the net premium to be paid by assuming some of the risk or by giving up some of the profit potential.

A firm that does not expect the foreign currency to depreciate sharply might consider buying a call option with an exercise price at or near the current spot exchange rate and simultaneously selling a put option with a lower exercise price. Again, the combination of a long and a short position reduces the net premium to be paid. The strategy protects the firm from any appreciation of the foreign currency. On the other hand, opportunity gains from a depreciating foreign currency are limited by the exercise price of the written put option. Any depreciation below the exercise price of the put option does not benefit the firm.

The preceding strategy is also known by other names such as a range forward. Variations on the basic fence strategy allow for choices of exercise prices or of ratios between bought calls and written puts.

One version chooses the exercise prices for call and put options so that the net premium equals zero. This can be accomplished at an exercise price equal to the forward rate. However, this would just create a synthetic forward contract. In practice, exercise prices are chosen in such a way that both options are out-of-the-money and correspond to the risk/return trade-off for the client.

A second version is also constructed to end up with a net premium of zero. However, the firm pays for the protection against an appreciation of the foreign currency by giving up a certain proportion of the profit should the foreign currency depreciate. The strategy requires that the exercise prices for calls and puts are identical and that fewer puts are written than calls are bought. To end up with a net premium of zero, the bought call options must be out-of-the-money and, because of identical exercise prices, the puts must be in-the-money. The client either specifies the participation rate or the strike price for the call options.

Sell puts. If a firm believes that current option premium levels overestimate future exchange-rate volatilities, it might consider selling put options to cover its foreign-currency payables. This strategy provides fixed gains relative to a forward contract should the foreign currency depreciate. It protects the firm against any appreciation of the foreign currency only to the extent of the premium income received. However, should the foreign currency depreciate, losses on the put will offset gains on the payables.

To clarify the previously described strategies, consider the following example:

90 day account payable	= £1 million
S	= $1.4000/£
F_{90}	= $1.3880/£
90 day 1.40 call	= .0280
90 day 1.45 call	= .0105
90 day 1.50 call	= .0050
90 day 1.30 put	= .0060
90 day 1.45 put	= .0714

Table 16–1 summarizes the U.S. dollar outflows on expiration as a function of future spot rates. In addition to the five option strategies, results for a do-nothing strategy and a forward contract strategy are included.

These five strategies offer solutions to most foreign-currency exposure positions. The same principles apply for hedging foreign-currency-denominated receivables. The corresponding strategies are buy at-the-money puts, buy out-of-the-money puts, buy a bear spread, buy a fence, and sell calls. For hedging receivables, puts are used instead of calls and vice versa.

TABLE 16–1
U.S. Dollar Cash Outflows for £1 Million Payable

Future Spot Rate ($/£)	Open Position	Forward Position at 1.3880	Buy ATM £ Call: *Long 1.40 Call at .0280 Premium Paid: $28,000*	Buy OTM £ Call: *Long 1.45 Call at .0105 Premium Paid: $10,500*	Buy Bull Spread: *Long 1.40 Call at .0280 Short 1.50 Call at .0050 Net Premium Paid: $23,000*	Buy Fence: *Long 1.40 Call at .0280 Short 1.30 Put at .0060 Net Premium Paid: $22,000*	Sell Put: *Short 1.45 Put at .0714 Premium Received: $71,400*
1.25	$1,250,000	$1,388,000	$1,278,000	$1,260,500	$1,273,000	$1,322,000	$1,378,600
1.30	1,300,000	1,388,000	1,328,000	1,310,500	1,323,000	1,322,000	1,378,600
1.35	1,350,000	1,388,000	1,378,000	1,360,500	1,373,000	1,372,000	1,378,600
1.40	1,400,000	1,388,000	1,428,000	1,410,500	1,423,000	1,422,000	1,378,600
1.45	1,450,000	1,388,000	1,428,000	1,460,500	1,423,000	1,422,000	1,378,600
1.50	1,500,000	1,388,000	1,428,000	1,460,500	1,423,000	1,422,000	1,428,600
1.55	1,550,000	1,388,000	1,428,000	1,460,500	1,473,000	1,422,000	1,478,600

Interest income forgone or received due to option premiums is not considered.

Table 16–1 demonstrates that virtually every option recommendation is an in-between solution to a foreign-exchange exposure problem. For example, if the firm buys an at-the-money call it will be worse off compared to an open position if the foreign currency depreciates. It also will be worse off compared to a forward contract hedge if the foreign currency appreciates. So the option hedge is a compromise: not as good as the best scenario and not as bad as the worst scenario.

A second result worth emphasizing is the transaction nature of the option hedge: you get something and you give up something. Compared to other instruments, options do not create better or superior hedges under all circumstances. Options allow for hedges, with distinct risk/reward characteristics.

Hedging Noncash-Flow Exposures

Experience during the last decade has shown that sudden, unexpected large movements in exchange rates have significant and possibly devastating effects not only on the domestic currency value of foreign income streams but also on the domestic currency value of foreign-currency-denominated net asset or liability values. Treasurers of international firms and managers of international portfolios try to limit this foreign-exchange (translation) exposure through hedging. Hedging net asset or liability values with conventional instruments, however, can create very undesirable cash-flow positions.

Suppose a firm or a portfolio manager faces a foreign-currency net asset position. To cover the exposure, the manager sells the foreign currency forward at the current forward rate. Several scenarios are possible:

1. *Net asset value constant, foreign currency depreciates:* Assuming a relative long-term outlook, the foreign-currency-denominated net asset positions are not liquidated. The depreciation of the foreign currency leads to a reduction in the domestic value of of the foreign-currency net asset value. This is an unrealized (non-cash flow) book loss. This book loss is offset (partially or more than, depending on whether the foreign currency trades on a forward discount or premium) by gains in the forward contract. To fulfill the obligation of the forward contract, the manager buys the

foreign currency in the spot market. Thus a cash-flow gain is realized. The total position consists of a (non-cash flow) unrealized book loss which is offset by a realized (cash flow) gain.

2. *Net asset value constant, foreign currency appreciates:* The appreciation of the foreign currency leads to an increase in the domestic value of the foreign net asset position. The firm has an unrealized (non-cash flow) book gain. To fulfill the obligation of the forward contract, the firm buys the foreign currency in the spot market. Thus a cash-flow loss is realized. The total position consists of a (non-cash flow) unrealized book gain which is offset by a realized (cash flow) loss. From a cash-flow point of view, this outcome is highly undesirable.

3. *Net asset value declines, foreign currency appreciates:* Given the hedging strategy, this scenario leads to the worst outcome. Depending on the relative size of the currency appreciation versus the decline in the foreign-currency asset value, the domestic value of the foreign net asset value may decline, stay constant, or increase. If the percentage appreciation of the foreign-currency value is smaller than the percentage depreciation of the foreign-currency-denominated net asset value, the firm suffers an unrealized (non-cash flow) book loss. Again, the firm has to buy the foreign currency in the spot market to cover its obligations from the forward contract. The total position, therefore, might consist of an unrealized (non-cash flow) book loss and a realized (cash flow) loss. From a cash-flow point of view, this outcome is most undesirable.

The use of option strategies can diminish most of the problems associated with hedging net asset or liability positions denominated in foreign currencies. Each of the option strategies presented in the previous section can be employed.

In addition, the flexibility of exercise prices allows for specific custom tailoring. We use a hedge constructed with an at-the-money put option to point out the differences between a forward hedge and an option hedge. This is analyzed using the same scenarios.

1. *Net asset value constant, foreign currency depreciates:* The firm faces an unrealized (non-cash flow) book loss due to the decline in the domestic value of the foreign net asset position. Because the purchased put option is in-the-money at expiration, the firm realizes a cash-flow gain on the option position. This gain, though, is smaller than for the corresponding forward hedge because of the premium paid.

2. *Net asset value constant, foreign currency appreciates:* The firm has an unrealized (non-cash flow) book gain as the domestic value of the foreign net asset value increases. At expiration, the put option being out-of-the-money expires worthless. Except for the original cash outflow for the paid premium, there will be no potentially unlimited cash-flow losses as in the case of the forward hedge position. The main characteristic of an option—giving a right but not the obligation—makes this outcome possible.

3. *Net asset value declines, foreign currency appreciates:* Again the combination of both effects might lead to an increase, decrease, or constant domestic value of the foreign-asset position. The cash outflows on the hedge transaction are again limited to the original option premium paid. No further cash-flow losses are possible.

Aside from providing a multitude of possible risk/return characteristics, option strategies manage cash-flow problems associated with hedges for net asset and liability positions in a superior way.

Foreign-currency options are a potent instrument for coping with today's highly volatile financial environment. Options enable managers to (1) hedge contingent foreign-currency exposures; (2) take a view on the direction and volatility of exchange-rate movements while limiting downside risk; (3) tailor risk-return outcomes in ways previously impossible; and (4) fine-tune the level or currency risk one is willing to accept over a specific period of time. Options, though, are no substitute for omniscience. Trading spot or forward-outright positions with perfect knowledge and forecast will always outperform foreign-currency options as a hedge. The value of options to their users increases with the level of uncertainty.

Option strategies complete financial markets by allowing players to buy or sell contingent payoff streams. The quantity of possible variations in the structuring of option positions and hedges opens new possibilities for financial managers. Their flexibility, creativity, and potential to custom-tailor virtually any risk-return profile requires that financial managers study the instrument and use it when appropriate.

CHAPTER 17

CAPITAL INVESTMENT AND MANAGEMENT IN GLOBAL BUSINESSES

Christine R. Hekman

A handbook of international financial management can presumably be expected to prescribe financial solutions to global business management problems that do not arise in the management of domestic businesses. It follows that a handbook chapter describing investment acquisition and management should describe methods of analysis and investment selection in addressing such uniquely international challenges.

This chapter identifies and examines those uniquely international challenges and recommends a method for evaluating global investment opportunities. In sum, it addresses the following questions:

What distinguishes a global business from a domestic business?

How do global considerations change investment acquisition and management?

How can investment acquisition, divestiture, and restructuring opportunities be analyzed in a way that recognizes the importance of international factors?