6. Foreign Currency Options

So far, we have studied contracts whose payoffs are contingent on the spot rate (foreign currency forward and foreign currency futures). The payoffs from these instruments are linear in the future spot rate. That is, if you buy any of these instruments and the underlying exchange rate increases, you gain proportionally, and when the rate decreases, you lose money proportionally. In other words, the payoff of these instruments is symmetric.

Foreign currency options, however, are instruments that permit investors to achieve asymmetric or linear payoffs. Options are instruments that are much more flexible for hedging and for speculating.

A foreign currency option is a contract giving the option purchaser (the buyer) the right, but not the obligation, to buy or sell a fixed amount of foreign exchange at a fixed price per unit for a specified time period.

6.1 Options Vocabulary

**Holder**: The buyer of an option is called the holder.

**Writer**: The seller of an option is called a writer or a grantor.

**Call**: A call is an option to buy foreign currency.

**Put**: A put is an option to sell foreign currency.

**Strike Price**: The strike price or exercise price is the price at which the foreign currency can be purchased or sold.

**Premium**: The premium or option price is the cost, price, or value of the option.

**American Option**: An American option gives the holder the right to exercise the option at any time between the date of writing and the expiration or maturity date.

**European Option**: A European option gives the holder the right to exercise the option only at the expiration date.

**At-the-Money (ATM)**: An option whose exercise price is the same as the spot price of the underlying currency is said to be at-the-money.
**In-the-Money (ITM):** An option that would be profitable if exercised immediately is said to be in-the-money.

**Out-of-the-Money (OTM):** An option that would not be profitable to exercise immediately is said to be out-of-the-money.

**Exchange-Traded Options:** Options traded in organized exchanges.

### 6.2 Foreign Currency Options Markets

Foreign currency options are available on the over-the-counter market and on organized exchanges.

**Over-the-Counter (OTC) Market:**
Over-the-counter options are written by financial institutions. These OTC options are more liquid than forward contracts. At any moment, the holder can sell them back to the original writer, who quotes tow-say prices.

The main advantage of OTC options is that they are tailored to the specific needs of the firm: Financial institutions are willing to write or buy options that vary by contract size, maturity, and strike price. As a consequence, the bid-ask spread in the OTC market is higher than in the traded-options market.

Firms buying and selling currency options as part of their risk management program do so primarily in the OTC market.

In OTC market, most of the options are written at a strike price equal to the spot price of that moment (at-the-money options).

A firm wishing to purchase an option in the OTC market normally places a call to the currency option desk of a major money center bank, specifies the currencies, maturity, strike price(s), and asks for an indication (a bid-ask quote). The bank normally takes a few minutes to a few hours to price the option and return the call.

**Exchange Trade Options:**
Options on the underlying currency are traded on a number of organized exchanges worldwide, including the Philadelphia Stock Exchange (PHLX) and the London International Financial Futures Exchange (LIFFE).

An organized option exchange, like a futures market, has an organized secondary market, with a clearing-house as a guarantor. That is, exchange traded options are settled through
a clearing-house, so buyers do not deal directly with sellers. The clearing-house is the counterpart to every option contract and it guarantees fulfillment. In the case of the Philadelphia Stock Exchange, the clearing-house is the Options Clearing Corporation (OCC).

Another idea that options exchanges have borrowed from futures markets is standardization. For example, on the Philadelphia Stock Exchange, the following features are standardized:

**Contract Sizes:** For example, a DEM option contract gives the right to buy or sell DEM 62,500.

**Expiration Date:** All options contracts expire on the third Wednesday of March, June, September, and December. Only the three nearest expiration dates are traded.

**Strike Price:** For example, the strike price must be multiples of one USD cent for DEM and CAD options, 5 USD cents for GBP options, and multiples of 0.01 USD cent for JPY options.

### 6.3 Currency Options Quotations

Following is a quote from the *Wall Street Journal* on DEM option contracts.

<table>
<thead>
<tr>
<th>Underlying Price</th>
<th>Strike</th>
<th>Calls—Last</th>
<th>Puts—Last</th>
</tr>
</thead>
<tbody>
<tr>
<td>62,500 German Marks—cents per unit</td>
<td></td>
<td>Aug</td>
<td>Sep</td>
</tr>
<tr>
<td>58.51</td>
<td>58 1/2</td>
<td>0.50</td>
<td>r</td>
</tr>
<tr>
<td>58.51</td>
<td>59</td>
<td>0.30</td>
<td>0.66</td>
</tr>
<tr>
<td>58.51</td>
<td>59 1/2</td>
<td>0.15</td>
<td>0.40</td>
</tr>
<tr>
<td>58.51</td>
<td>60</td>
<td>r</td>
<td>0.31</td>
</tr>
</tbody>
</table>

r—not traded, s—no option offered. Last is premium (purchase price)

The first line indicates that the contract size is DEM 62,500 and that prices are expressed in USD cents per unit of DEM. The last line indicates that market prices refer to the last trade (at the close). The different headers are:

**Option and Underlying:** Shows the spot price of the underlying currency (here USD 58.51/DEM) at the close of trading on the preceding day.

**Strike Price:** The exercise price, or strike price, means the price per DEM that must be paid if the option is exercised.
Calls—Last: Shows the premium that must be paid to purchase a call option contract by maturity.

Puts—Last: Shows the premium that must be paid to purchase a put option contract by maturity.

6.4 Options Premiums and Option Writing

Buying a call is like buying an insurance contract against the risk of high exchange rates. For example, a firm that faces a future outflow of CAD might buy a call option on CAD at strike price X. The ensuing right to buy CAD at X means that this firm will pay no more than X per CAD.

Similarly, buying a put is like buying an insurance contract against the risk of low exchange rates. For example, a firm that faces a future inflow of CAD might buy a put option on CAD at strike price X. The ensuing right to sell CAD at X means that this firm will get no less than X per CAD.

Like in any insurance contract, the insured party will pay an insurance premium to the insurer (the writer). The price of an option is, not coincidentally, often called the option premium and acquiring an option contract is called buying an option.

Insurance companies are willing to sell insurance policies because they receive a premium that covers the discounted expected costs and because they can diversify most of the risks. Likewise, option writers sell options because they receive a premium that covers the discounted expected exercise value of the claim and because they can diversify or hedge most of the risks.
6.5 A Graphical Analysis of European Options

The put call parity is a relation between the value of a forward contract and a portfolio of put and all options.

**Forward Payoffs:**
As we have seen, values for forward purchases and sales at expiration are:

\[
V^b_T = S_T - F_{0,T} \\
V^s_T = F_{0,T} - S_T
\]

These payoffs have a graphical representation (see payoff chart with short and long positions).

**Call Options Payoffs:**
A call option is a contract that gives the holder the right to buy a stated number of units of the underlying asset (currency) at a given price (the strike price).

A call option allows you to obtain only the nice part of the forward purchase. Rather than paying X for the foreign currency (as in the forward purchase), you pay no more than X, and possibly less than X. Denoting the strike price by X, we formally state this as follows. On the expiration day, a call option on one unit of foreign currency is worth:

\[
C_T = MAX (S_T - X, 0)
\]

It has a simple graphical representation (see payoff chart with short and long positions).

A European call option can only be exercised on the expiration day, such that the current market price is based solely on that final payoff.

An American call option can be exercised up to the expiration day, which makes its valuation more complicated. For early exercise to be rations, two conditions must be met:

- The holder will not exercise early if the payoff is not positive
- The holder will not exercise when the option's market value exceeds its immediate exercise value because, under these circumstances, it would be better to sell the option than to exercise it.

**Put Options Payoffs:**
A put option is a contract that gives the holder the right to sell a stated number of units of the underlying asset (currency) at a given price (the strike price).
A put option allows you to obtain only the nice part of the forward sale. Rather than getting X for the foreign currency (as in the forward sale), you get no less than X, and possibly more than X. Denoting the strike price by X, we formally state this as follows. On the expiration day, a call option on one unit of foreign currency is worth:

\[ P_t = \text{MAX}(X - S_t, 0) \]

It has a simple graphical representation (see payoff charts with short and long positions).

A European put option can only be exercised on the expiration day, such that the current market price is based solely on that final payoff.

An American put option can be exercised up to the expiration day, which makes its valuation more complicated. For early exercise to be rational, two conditions must be met:

- The holder will not exercise early if the payoff is not positive
- The holder will not exercise when the option's market value exceeds its immediate exercise value because, under these circumstances, it would be better to sell the option than to exercise it.

**Put Call Parity:**

A summary comparison of the forward payoff and the put and call payoffs suggests that it is possible to replicate a forward contract using options. For example, the payoff from a forward sale is identical to the payoffs from buying a put and selling a call, when the forward sale is executed at a price equal to the option portfolio's strike price:

\[ P_t - C_t = X - S_t = F_{0,T} - S_t \]

Since the future payoffs are the same, the law of one price suggests that the present values of the option portfolio and the forward sale must be the same also. From the equivalence at time \( T \), it follows that there must also be equivalence in terms of present values or current values in equilibrium. That is, the current market value of the option portfolio must be equal to the market value of the forward contract (\( F=X \)):

\[ P_t - C_t = \frac{X - F_{i,T}}{1+r_{i,T}} \]

This relationship is called the Put Call Parity (for European currency options).
For at-the-money options, the put call parity is:

\[ P_t - C_t = \frac{S_t - F_{t,T}}{1 + r_{t,T}} \]

This expression states that \( P > C \) when \( S > F \). That is, a bet on a decrease of the spot rate (the ATM put) is worth more than a bet on an increase of the spot rate (the ATM call) if the forward rate is at a discount. Recall that the forward rate should be an unbiased predictor of the future spot rate.

### 6.6 Foreign Currency Speculation

Speculation is an attempt to profit by trading on expectations about prices in the future. In the foreign exchange markets, one speculates by taking an open (unhedged) position in a foreign currency and then closing that position after the exchange rate has moved in the expected direction.

**Speculating on the Spot Market:**

Speculation on the spot market requires only that the speculator believe the foreign currency will appreciate in value. It is a bet that a currency will appreciate.

Example: You have USD 1m with which to speculate on the CAD, and the market is currently quoting a spot rate of USD 0.6500/CAD. You use your USD 1m to purchase CAD at a price of USD 0.6500/CAD, and hold on to it over that year. In a year, you sell the CAD when the spot, hopefully, reaches your forecasted price of USD 0.6600/CAD and make a profit of USD 0.01 for each CAD you purchased.

The potential maximum gain is unlimited, especially if the currency appreciates a lot. The maximum loss is the value of your initial purchase (USD 1m in the example), which occurs only when the currency you purchased drops in value to 0.

**Speculating on the Forward Market:**

Speculation on the forward market occurs when the speculator believes the spot price at some future date will differ from today’s forward price for that same date. Success does not depend on the movement of the spot rate itself, but on the relative position of the future spot rate and the current forward rate.
Example: You have USD 1m with which to speculate on the CAD, and the market is currently quoting a one-year forward rate of USD 0.6500/CAD. You believe however that the spot rate in a year will be USD 0.6600/CAD. You purchase CAD forward at a price of USD 0.6500/CAD with no cash outlays. In a year, you fulfill the forward contract and pay USD 0.6500 for every CAD you purchased. Simultaneously, you sell the CAD on the spot market at the spot price of USD 0.6600/CAD. This earns you a profit of USD 0.01 for each CAD you purchased.

The potential gain is unlimited. The maximum loss is the value of your forward purchase (USD 1m in the example), which occurs only when the currency you purchased drops in value to 0.

**Speculating on the Option Markets:**

As we have seen, options produce asymmetric payoffs and provide insurance to the holder. That is, the option owner has the choice of exercising the option or allowing it to expire unused. The holder will exercise it only when exercising is profitable, which means when the option is in the money. In the case of a call option, as the spot price of the underlying currency moves up, the holder has the possibility of unlimited profit. On the downside, however, the holder can abandon the option and walk away with loss never greater than the premium paid.

**BUYER OF A CALL: (LONG CALL)**

This is a bet that the spot rate at maturity is above the strike price (you are purchasing foreign currencies).

Example: You can purchase a call option contract on the CAD at a strike price of USD 0.6500/CAD (ATM) and a premium of USD 0.005/CAD. At maturity, you do not exercise if the spot rate is below USD 0.6500/CAD. You do exercise if the spot rate is above USD 0.6500/CAD. The break-even point is at the spot rate of USD 0.6550/CAD. If the spot rate is USD 0.6650/CAD, you purchase the CAD at the strike price of USD 0.6500/CAD and sell them on the current spot market at a rate of USD 0.6650/CAD. Because you paid a premium of USD 0.005/CAD, you earn a profit of USD 0.01 per CAD purchased.

In this particular case, the profits can be computed as:

\[
\text{Profit} = \text{Spot Rate} - (\text{Strike Price} + \text{Premium})
\]

The potential gain is unlimited. The maximum loss is the premium paid.

**WRITER OF A CALL: (SHORT CALL)**

This is a bet that the spot rate at maturity is below the strike price.
As we have seen, the payoffs to the writer are the opposite of the payoff to the holder. That is,

\[ \text{Profit} = \text{Premium} - (\text{Spot Rate} - \text{Strike Price}) \]

The potential is gain is limited to the premium. The maximum loss is infinite.

**BUYER OF A PUT: (LONG PUT)**
This is a bet that the spot rate at maturity is below the strike price (you are selling foreign currencies).

Example: You can purchase a put option contract on the CAD at a strike price of USD 0.6500/CAD (ATM) and a premium of USD 0.005/CAD. At maturity, you do not exercise if the spot rate is below USD 0.6500/CAD. You do exercise if the spot rate is above USD 0.6500/CAD. The break-even point is at the spot rate of USD 0.6550/CAD. If the spot rate is USD 0.6450/CAD, you buy the CAD on the current spot market at the rate of USD 0.6450/CAD and sell them at the strike price of USD 0.6500/CAD. Because you paid a premium of USD 0.005/CAD, you earn a profit of USD 0.01 per CAD sold.

In this particular case, the profits can be computed as:

\[ \text{Profit} = \text{Strike Price} - (\text{Spot Rate} + \text{Premium}) \]

The potential gain is unlimited. The maximum loss is the premium paid.

**WRITER OF A PUT: (SHORT PUT)**
This is a bet that the spot rate at maturity is above the strike price.

As we have seen, the payoffs to the writer are the opposite of the payoff to the holder. That is,

\[ \text{Profit} = \text{Premium} - (\text{Strike Price} - \text{Spot Rate}) \]

The potential is gain is limited to the premium. The maximum loss is infinite.
6.7 Option Pricing and Valuation

The value of an option is the sum of two components:

\[
\text{Option value} = \text{Intrinsic value} + \text{Time value}
\]

The Intrinsic value is the financial gain if the option is exercised immediately. It is zero for out-of-the-money and at-the-money options, as no gain can be derived from exercising the option. It becomes positive for in-the-money options.

The Time value of an option exists because the price of the underlying currency, the spot rate, can potentially move further in the money between the present time and the option's expiration date. An investor will pay something for an out-of-the-money option on the chance that the spot rate will move far enough before maturity to move the option in the money. Consequently, the price of an option is always somewhat greater than its intrinsic value prior to maturity. On the date of maturity, an option will have a value equal to its intrinsic value (zero time remaining means zero time value).

Note that for identical maturity and strike price, an American option is more valuable, since it can be exercised up to maturity while the European option can only be exercised at maturity.

The pricing of a currency option combines 6 elements. The premium is based on
1. The forward rate
2. The current spot rate
3. The time to maturity
4. The volatility of the underlying asset
5. The home and foreign interest rates
6. The strike price

If currency options are to be used effectively, the individual trader needs to know how option values—premium—react to their various components.

**Forward Rate Sensitivity:**
Standard foreign currency options are priced around the forward rate because the current spot rate and both the domestic and foreign interest rates are included in the option premium calculation. Regardless of the specific strike rate, the forward rate is central to valuation.

**Spot Rate Sensitivity (Delta):**
As long as the option has time remaining before expiration, the option will possess this time value element. This characteristic is one of the primary reasons why an American option, which can be exercised on any day up to and including the expiration date, is
seldom actually exercised prior to expiration. If the option holder wishes to liquidate if for its value, it would normally be sold, not exercised, so that the holder can capture the remaining time value.

The further the option's strike price is out-of-the-money, the lower the value or premium of the option. This situation arises because the market believes the probability of this option actually moving into the exercise range prior to expiration is significantly less than one that is already at-the-money.

The expected change in the option premium for a small change in the spot exchange rate is called the \textit{delta}:

\[ Delta = \frac{\Delta \text{ Premium}}{\Delta \text{ Spot Rate}} \]

If the \textit{delta} of the specific option is known, it is easy to determine how the option's value will change as the spot rate changes.

Traders in options categorize individual options by their \textit{delta} rather than in-the-money, at-the-money, or out-of-the-money. As an option moves further in the money, \textit{delta} rises toward 1. As an option moves further out-of-the-money, \textit{delta} falls toward 0.

\textbf{Rule of Thumb:} The higher the \textit{delta} (deltas of .7 or .8 and up are considered high), the greater the probability of the option expiring in the money.

\textit{Time to Maturity Sensitivity (Theta):} Option values increase with the length of time to maturity.

The expected change in the option premium from a small change in the time to expiration is termed \textit{theta}:

\[ Theta = \frac{\Delta \text{ Premium}}{\Delta \text{ Time}} \]

As any specific option ages, moving continually toward expiration, the time value will constantly decrease. Option premiums deteriorate at an increasing rate as they approach expiration. In fact, the majority of the option premium, depending on the individual option, is lost in the final 30 days prior to expiration.

\textbf{Rule of Thumb:} A trader will normally find longer maturity options to be better values, giving the trader the ability to alter an option position without suffering significant time value deterioration.

\textit{Volatility Sensitivity (Lambda):} Option volatility is defined as the standard deviation of daily percentage changes in the underlying exchange rate. Volatility is important to option value because of an exchange
rate perceived likelihood to move either into or out of the range in which the option would be exercised. If the exchange rate's volatility is rising, and therefore the risk of the option being exercised is also increasing, then the option premium would be increasing.

The expected change in the option premium for a small change in volatility is termed \( \lambda \):

\[
\lambda = \frac{\Delta \text{Premium}}{\Delta \text{Volatility}}
\]

The primary problem with volatility is that it is unobservable; it is the only input in the option pricing formula that is judgmentally based by the trader pricing the option.

Like all futures markets, option volatility reacts instantaneously and negatively to unsettling economic and political events. Most currency option traders focus their activities on predicting movements of currency volatility in the short run, for they will move price the most.

**Rule of Thumb:** Traders who believe volatility will fall significantly in the near future will sell (write) options now, hoping to buy them back for a profit immediately after volatility falls, causing the option premium to fall.

**Interest Rate Differentials Sensitivity (Rho and Phi):**

Interest rate changes in either currency will alter the forward rate, which in turn will alter the option's premium or value.

The expected change in the option premium for a small change in the domestic interest rate is termed \( \rho \):

\[
\rho = \frac{\Delta \text{Premium}}{\Delta \text{USD Interest Rate}}
\]

The expected change in the premium for a small change in the foreign interest rate is termed \( \phi \):

\[
\phi = \frac{\Delta \text{Premium}}{\Delta \text{Foreign Interest Rate}}
\]

For the option trader, an expectation on the differential between interest rates can help in the evaluation of where the option value is headed. For example, when foreign interest rates are higher than domestic interest rates, the foreign currency sells forward at a discount. The trader can then forecast that the foreign currency will be depreciating. This lowers the premium for call options and increases it for put options.

**Rule of Thumb:** A trader who is purchasing a call option on foreign currency should do so before the domestic interest rate rises. This would allow the trader to purchase the option before its price increases.
**Alternative Strike Prices:**
Finally, options that are in-the-money are more valuable than options that are out-of-the-money. Thus, an increase in the strike price reduces the option premium for call options and increases it for put options.

### 6.8 Summary

- Foreign currency options, however, are instruments that permit investors to achieve asymmetric or linear payoffs.

- A foreign currency option is a contract giving the option purchaser (the buyer) the right, but not the obligation, to buy or sell a fixed amount of foreign exchange at a fixed price per unit for a specified time period. A call is an option to purchase foreign currencies and a put option is an option to sell foreign currencies.

- Foreign currency options can be purchased over-the-counter (flexible) or on an organized exchange (standardized). They specify a strike or exercise price and a premium.

- A European option can only be exercised on the expiration day, while an American option can be exercised up to the expiration day. In general, the holder will not exercise early if the payoff is not positive and will not exercise when the option's market value exceeds its immediate exercise value because, under these circumstances, it would be better to sell the option than to exercise it.

- Buying a call is like placing a bet that the spot rate at maturity is above the strike price. Buying a put is like placing a bet that the spot rate will be below the strike price.

- Purchasing a premium is like purchasing insurance against adverse realizations. For speculation, the potential gains are unlimited, while the maximum losses are the premiums paid.

- The value of an option is the sum of its intrinsic value and its time value. The Intrinsic value is the financial gain if the option is exercised immediately. The Time value of an option exists because the price of the underlying currency, the spot rate, can potentially move further in the money between the present time and the option's expiration date.

- The pricing of a currency option combines 6 elements. The premium is based on: the forward rate, the current spot rate, the time to maturity, the volatility of the underlying asset, the home and foreign interest rates, and the strike price.