9
Introduction to options

9.1 Option terminology

Options are a unique type of financial contract that have a throwaway feature. They give you the right but not the obligation to do something. You only use the contract if you want to. This contrasts with forward contracts, which oblige you to make a transaction at the pre-agreed price even if the market has changed and you would rather not. The fact that options provide a right but not an obligation means that users are able to obtain insurance against an adverse movement in the price of an asset rate, while still retaining the opportunity to benefit from a favourable price movement. At the same time, the maximum risk to the buyer of an option is the actual cost of the option.

An American call option is an asset that gives its owner the right to purchase a given “asset” (e.g. some shares or a quantity of currency):

- at a predetermined price (the exercise or strike price)
- on, or before, a stated date (the expiration or maturity date).

An American put option is similar except that it gives the right to sell the “asset”:

- at a predetermined price (the exercise or strike price)
- on, or before, a stated date (the expiration or maturity date).

In each option transaction there are two parties. The buyer of the option holds all the power and decides whether to buy, in the case of a call option, or to sell, in the case of a put option,
the asset contained in the option contract. In contrast, the writer of the option stands ready to sell (if a call is exercised) or to buy (if a put is exercised). The maximum upside to the writer of the option is the premium received, and if they are forced to buy/sell it will only be because it is financially advantageous to the buyer.

The table below illustrates a typical equity option quotation:

<table>
<thead>
<tr>
<th>Strike</th>
<th>Call T = 3 months</th>
<th>Call T = 6 months</th>
<th>Call T = 12 months</th>
<th>Put T = 3 months</th>
<th>Put T = 6 months</th>
<th>Put T = 12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>$21.1</td>
<td>$22.5</td>
<td>$25.4</td>
<td>$0.1</td>
<td>$0.6</td>
<td>$1.5</td>
</tr>
<tr>
<td>85</td>
<td>$16.5</td>
<td>$18.3</td>
<td>$21.6</td>
<td>$0.4</td>
<td>$1.2</td>
<td>$2.5</td>
</tr>
<tr>
<td>90</td>
<td>$12.2</td>
<td>$14.4</td>
<td>$18.1</td>
<td>$1.1</td>
<td>$2.2</td>
<td>$3.8</td>
</tr>
<tr>
<td>95</td>
<td>$8.5</td>
<td>$11.1</td>
<td>$15.0</td>
<td>$2.4</td>
<td>$3.7</td>
<td>$5.4</td>
</tr>
<tr>
<td>100</td>
<td>$5.6</td>
<td>$8.3</td>
<td>$12.3</td>
<td>$4.4</td>
<td>$5.8</td>
<td>$7.5</td>
</tr>
<tr>
<td>105</td>
<td>$3.4</td>
<td>$6.0</td>
<td>$10.0</td>
<td>$7.1</td>
<td>$8.4</td>
<td>$9.9</td>
</tr>
<tr>
<td>110</td>
<td>$2.0</td>
<td>$4.2</td>
<td>$8.0</td>
<td>$10.6</td>
<td>$11.5</td>
<td>$12.7</td>
</tr>
<tr>
<td>115</td>
<td>$1.1</td>
<td>$2.9</td>
<td>$6.4</td>
<td>$14.6</td>
<td>$15.1</td>
<td>$15.8</td>
</tr>
<tr>
<td>120</td>
<td>$0.5</td>
<td>$2.0</td>
<td>$5.0</td>
<td>$19.1</td>
<td>$19.0</td>
<td>$19.2</td>
</tr>
</tbody>
</table>

These prices are generated using an asset price of $100, a standard deviation of 25% and interest rate of 5%, though what follows would apply regardless of the underlying assumptions.

It is evident that the further away the expiration of the option, the greater the option premium for both calls and puts. For example, the right to buy at $100 in 3 months’ time is priced at $5.6, whereas the right to buy in 12 months’ time is priced at $12.3. Similarly, the right to sell at $100 in 3 months’ time is priced at $4.4, whereas the right to sell in 12 months’ time is priced at $7.5.

Regardless of the maturity, it is clear from the table above that there is a positive relationship between put premiums and strike prices but a negative relationship between call premiums and strike prices. In Chapter 7 you were introduced to forward contracts, where there is one forward rate for each maturity. With options there is a “menu” to choose from, and as with all menus, the more attractive the offering, the more expensive it is. For example, it is clearly more attractive for an investor to buy at $80 in one year than at $120 in one year, and the premium ($25.4 versus $5) reflects this. Likewise, it is more attractive to sell at $120 in one year’s time than at $80 in one year’s time. Again, the premium reflects this ($19.2 versus $1.5).

The buyer of an option pays the premium of the option up front, and subsequently has the right to exercise or not exercise the option. Options can be purchased on an exchange (exchange-traded options) or direct from a bank (over-the-counter options, OTCs). Exchange-traded options are standardised in terms of expiration date and contract size. OTCs can be
“tailor made” to suit your needs. For example, you can choose the expiration date, the amount to be bought or sold and the strike price.

9.2 Option strategies

Many types of option strategies exist, with exotic names such as straddles, strangles, butterflies, strips and straps. Strategies that combine options of the same type (i.e. all calls or all puts), but different strike prices and/or maturity dates, are referred to as spreads. Strategies that combine options of different type are referred to as combinations. All these strategies can be understood easily once you grasp the features of four fundamental option strategies:

- call and put purchases
- call and put writes

To best understand the features of these strategies, it is appropriate to examine the relationship between the price of the underlying asset, at expiration, and the net profit/loss.

9.3 Long call purchase

Consider an investor who buys a call option on ABC stock with an exercise price (X) of $100 at a call premium (C) of $6.25. In simple terms, this option gives the holder the right, but not the obligation, to buy ABC stock for $100. What we have to determine is what factors will lead to the option being exercised or thrown away.

If the stock price is $70 on the expiration date, will the investor exercise their call option? Of course not! Why would they buy the stock for $100 in the option market if they could buy it for $70 in the cash market? If the stock price is $80 on the expiration date will the investor exercise their call option? Again of course not. And so on for $81, $82 ... $99.

Note that, regardless of whether the option is exercised or not, the investor must still pay the premium of $6.25. However, if the stock price is $100 the investor is indifferent between buying the stock in the cash market and the options market.

What about stock prices above $100? At stock prices above $100, it is advantageous for the investor to buy the stock from the options contract rather than buying it in the cash market. However, as the investor paid $6.25 for the option, they are effectively paying $106.25 for the stock. So, although it is advantageous for the investor to exercise their option, in reality it would have been better not to have purchased the option at all. But if the stock price is above $106.25 at expiration, not only is it advantageous for the option to be exercised, it is in fact profitable. For example, if the stock price is $110 the investor could purchase the stock for $100 by the terms of the option contract, then sell the stock in the cash market for $110, thus making a
profit of $10. The profit, net of the premium, is then $3.75. Following this logic, it is possible to map out a relationship between the stock price and profit/loss from exercising the option.

<table>
<thead>
<tr>
<th>Terminal stock price</th>
<th>Exercise?</th>
<th>Premium</th>
<th>Profit from exercising</th>
<th>Net profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>No</td>
<td>$6.75</td>
<td>$0.00</td>
<td>–$6.75</td>
</tr>
<tr>
<td>85</td>
<td>No</td>
<td>$6.75</td>
<td>$0.00</td>
<td>–$6.75</td>
</tr>
<tr>
<td>90</td>
<td>No</td>
<td>$6.75</td>
<td>$0.00</td>
<td>–$6.75</td>
</tr>
<tr>
<td>95</td>
<td>No</td>
<td>$6.75</td>
<td>$0.00</td>
<td>–$6.75</td>
</tr>
<tr>
<td>100</td>
<td>Yes/No</td>
<td>$6.75</td>
<td>$0.00</td>
<td>–$6.75</td>
</tr>
<tr>
<td>105</td>
<td>Yes</td>
<td>$6.75</td>
<td>$5.00</td>
<td>–$1.75</td>
</tr>
<tr>
<td>110</td>
<td>Yes</td>
<td>$6.75</td>
<td>$10.00</td>
<td>$3.25</td>
</tr>
<tr>
<td>115</td>
<td>Yes</td>
<td>$6.75</td>
<td>$15.00</td>
<td>$8.25</td>
</tr>
<tr>
<td>120</td>
<td>Yes</td>
<td>$6.75</td>
<td>$20.00</td>
<td>$13.25</td>
</tr>
<tr>
<td>125</td>
<td>Yes</td>
<td>$6.75</td>
<td>$25.00</td>
<td>$18.25</td>
</tr>
<tr>
<td>130</td>
<td>Yes</td>
<td>$6.75</td>
<td>$30.00</td>
<td>$23.25</td>
</tr>
</tbody>
</table>

The spreadsheet for this exercise can be found [here](#). Please ensure you click on Section 9 and the 9.3 tab at the bottom of the spreadsheet.

This relationship can best be described graphically. We refer to this relationship as a profit profile.
The profit profile highlights two important features of call purchases:

- The position provides an investor with unlimited profit potential.
- Losses are limited to an amount equal to the call premium.

These two features help explain why speculators prefer to buy a call rather than the stock itself. In addition, options are highly leveraged. In our example above, we have assumed that the price of ABC stock could range from $80 to $130 at expiration. If an investor purchased the stock for $100, the profit from the stock would range from –$20 to +$30, or in percentage terms from –20% to +30%. On the other hand, the return from the option would range from +344% to –100%. Thus, the potential reward to the speculator from buying a call instead of a stock can be substantial, 344% compared to 30%; but the potential loss is also large, –100% vs –20%. Note the profit of 344% is based on an investment in the option of $6.75 and the stock price rising to $130, earning a net profit of $23.25. As a long call is profitable following a price rise it is attractive to investors with a bullish view of the underlying asset.
9.4 Naked call write

The second fundamental option strategy involves the sale of a call in which the seller does not own the underlying stock. Such a position is known as a naked call write.

Again, assume that the exercise price on the call option on ABC stock is $100 and the call premium is $6.75. The profits/losses associated with each stock price from selling the call are depicted in the following table.

<table>
<thead>
<tr>
<th>Terminal stock price</th>
<th>Exercise?</th>
<th>Premium received</th>
<th>Action from writer</th>
<th>Net profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>No</td>
<td>$6.75</td>
<td>Do nothing</td>
<td>$6.75</td>
</tr>
<tr>
<td>85</td>
<td>No</td>
<td>$6.75</td>
<td>Do nothing</td>
<td>$6.75</td>
</tr>
<tr>
<td>90</td>
<td>No</td>
<td>$6.75</td>
<td>Do nothing</td>
<td>$6.75</td>
</tr>
<tr>
<td>95</td>
<td>No</td>
<td>$6.75</td>
<td>Do nothing</td>
<td>$6.75</td>
</tr>
<tr>
<td>100</td>
<td>Yes/No</td>
<td>$6.75</td>
<td>Do nothing</td>
<td>$6.75</td>
</tr>
<tr>
<td>105</td>
<td>Yes</td>
<td>$6.75</td>
<td>Buy ABC at prevailing stock price, sell at $100</td>
<td>$1.75</td>
</tr>
<tr>
<td>110</td>
<td>Yes</td>
<td>$6.75</td>
<td>Buy ABC at prevailing stock price, sell at $100</td>
<td>–$3.25</td>
</tr>
<tr>
<td>115</td>
<td>Yes</td>
<td>$6.75</td>
<td>Buy ABC at prevailing stock price, sell at $100</td>
<td>–$8.25</td>
</tr>
<tr>
<td>120</td>
<td>Yes</td>
<td>$6.75</td>
<td>Buy ABC at prevailing stock price, sell at $100</td>
<td>–$13.25</td>
</tr>
<tr>
<td>125</td>
<td>Yes</td>
<td>$6.75</td>
<td>Buy ABC at prevailing stock price, sell at $100</td>
<td>–$18.25</td>
</tr>
</tbody>
</table>
The spreadsheet for this exercise can be found here. Please ensure you click on Section 9 and the 9.4 tab at the bottom of the spreadsheet.

The payoff profile to the writer of a call option is the mirror image to that of the buyer of a call option. The maximum upside is limited to the premium received, whereas the downside is unlimited as potentially the underlying asset price could rise to infinity. This trade-off of limited reward versus unlimited risk may seem unattractive, but the cash received may be attractive to some investors with a particularly high-risk appetite.

**9.5 Long put purchase**

Suppose an investor buys a put option on ABC stock with an exercise price (X) of $100 at a put premium (P) of $3.79. In simple terms, this option gives the holder the right, but not the obligation, to sell ABC stock for $100. What we have to determine is what factors will lead to the option being exercised or thrown away.
Put premium = $3.79
Put strike = $100

<table>
<thead>
<tr>
<th>Terminal stock price</th>
<th>Exercise?</th>
<th>Premium</th>
<th>Profit from exercising</th>
<th>Net profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>Yes</td>
<td>$3.79</td>
<td>$20.00</td>
<td>$16.21</td>
</tr>
<tr>
<td>85</td>
<td>Yes</td>
<td>$3.79</td>
<td>$15.00</td>
<td>$11.21</td>
</tr>
<tr>
<td>90</td>
<td>Yes</td>
<td>$3.79</td>
<td>$10.00</td>
<td>$6.21</td>
</tr>
<tr>
<td>95</td>
<td>Yes</td>
<td>$3.79</td>
<td>$5.00</td>
<td>$1.21</td>
</tr>
<tr>
<td>100</td>
<td>Yes/No</td>
<td>$3.79</td>
<td>$0.00</td>
<td>–$3.79</td>
</tr>
<tr>
<td>105</td>
<td>No</td>
<td>$3.79</td>
<td>$0.00</td>
<td>–$3.79</td>
</tr>
<tr>
<td>110</td>
<td>No</td>
<td>$3.79</td>
<td>$0.00</td>
<td>–$3.79</td>
</tr>
<tr>
<td>115</td>
<td>No</td>
<td>$3.79</td>
<td>$0.00</td>
<td>–$3.79</td>
</tr>
<tr>
<td>120</td>
<td>No</td>
<td>$3.79</td>
<td>$0.00</td>
<td>–$3.79</td>
</tr>
<tr>
<td>125</td>
<td>No</td>
<td>$3.79</td>
<td>$0.00</td>
<td>–$3.79</td>
</tr>
<tr>
<td>130</td>
<td>No</td>
<td>$3.79</td>
<td>$0.00</td>
<td>–$3.79</td>
</tr>
</tbody>
</table>

The spreadsheet for this exercise can be found [here](#). Please ensure you click on Section 9 and the 9.5 tab at the bottom of the spreadsheet.

If the stock price is $120 on the expiration date will the investor exercise their put option? Of course not! Why would they sell the stock for $100 in the option market if they could sell it for $120 in the cash market? If the stock price is $110 on the expiration date will the investor exercise their put option? Again of course not. And so on for $109, $108 ... $101. Note that regardless of whether the option is exercised or not the investor must still pay the premium, $3.79.

However, if the stock price is $100 the investor is indifferent between selling the stock in the cash market and the options market. What about stock prices below $100? At stock prices below $100 such as $99 and $98 it is advantageous for the investor to sell the stock in the options contract rather than selling it in the cash market. But the investor paid $3.79 for the option, so they are effectively receiving $96.21 (i.e. $100 – $3.79) for the stock. So although it is advantageous for the investor to exercise their option, in reality it would have been better not to have purchased the option at all. If the stock price is below $96.21 on expiration, not only is it advantageous for the option to be exercised, it is in fact profitable. For example, if the stock price is $90 the investor could buy the stock in the cash market for $90, then sell the stock for $100 by the terms of the option contract. The profit, net of the premium, is then $7.21. Following this logic, it is possible to map out a relationship between the stock price and profit/loss from exercising the option.
The profit facing the buyer of a put option is potentially large, though not unlimited, as the underlying asset price can never fall below zero. Like the call purchase, the maximum loss equals the premium paid. As a long put is profitable following a price decline, it is attractive to investors with a bearish view of the underlying asset.

9.6 Naked put write

The payoff profile to the writer of a put option is the mirror image to that of the buyer of a put option. A put option offers investors the right, but not the obligation, to sell a given asset at an agreed price on or before the expiry date. If the writer of such an option does not have a short position in the underlying asset, they are said to be naked. Hence, the fourth fundamental option strategy involves the sale of a put in which the seller does not have a short position in the underlying stock. Such a position is known as a naked put write. The profit and loss for a naked put write option position is detailed below:
<table>
<thead>
<tr>
<th>Terminal stock price</th>
<th>Exercise?</th>
<th>Premium received</th>
<th>Action by writer</th>
<th>Net profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>Yes</td>
<td>$3.79</td>
<td>Buy stock at $100, sell at the market price</td>
<td>−$16.21</td>
</tr>
<tr>
<td>85</td>
<td>Yes</td>
<td>$3.79</td>
<td>Buy stock at $100, sell at the market price</td>
<td>−$11.21</td>
</tr>
<tr>
<td>90</td>
<td>Yes</td>
<td>$3.79</td>
<td>Buy stock at $100, sell at the market price</td>
<td>−$6.21</td>
</tr>
<tr>
<td>95</td>
<td>Yes</td>
<td>$3.79</td>
<td>Buy stock at $100, sell at the market price</td>
<td>−$1.21</td>
</tr>
<tr>
<td>100</td>
<td>Yes/No</td>
<td>$3.79</td>
<td>Nothing</td>
<td>$3.79</td>
</tr>
<tr>
<td>105</td>
<td>No</td>
<td>$3.79</td>
<td>Nothing</td>
<td>$3.79</td>
</tr>
<tr>
<td>110</td>
<td>No</td>
<td>$3.79</td>
<td>Nothing</td>
<td>$3.79</td>
</tr>
<tr>
<td>115</td>
<td>No</td>
<td>$3.79</td>
<td>Nothing</td>
<td>$3.79</td>
</tr>
<tr>
<td>120</td>
<td>No</td>
<td>$3.79</td>
<td>Nothing</td>
<td>$3.79</td>
</tr>
<tr>
<td>125</td>
<td>No</td>
<td>$3.79</td>
<td>Nothing</td>
<td>$3.79</td>
</tr>
<tr>
<td>130</td>
<td>No</td>
<td>$3.79</td>
<td>Nothing</td>
<td>$3.79</td>
</tr>
</tbody>
</table>
The profit profile for this strategy is shown below:

![Net Profit vs. Terminal Stock Price for a Short Put](image)

The spreadsheet for this exercise can be found [here](#). Please ensure you click on Section 9 and the 9.6 tab at the bottom of the spreadsheet.

### 9.7 Long and short straddle strategies

In section 9.3 we introduced a long call strategy, whereby an investor with a bullish view of the market generates profit if the underlying asset price rises. In section 9.4 we introduced a long put strategy, where an investor with a bearish view of the market generates profit if the underlying asset price falls. What if an investor does not have a view on the direction of the market but is bullish on volatility? In this case, they could form a long call strategy and also a long put strategy with the same strike price and the same expiration date. This is referred to as a long straddle strategy.
The V-shaped line in the diagram above is referred to as a long straddle. The worst possible outcome is if the price does not move, and the maximum loss occurs if the underlying asset price, at expiry, equals the strike price. The straddle has two break-even points, $89.46 and $110.54, i.e. the strike price of $100 minus the combined premiums of $10.54, and $100 plus the combined premiums.

The spreadsheet for this exercise can be found [here](#). Please ensure you click on Section 9 and the 9.7 tab at the bottom of the spreadsheet.

An inverted V-shaped line can be created by selling a call and selling a put. An investor who forms such a strategy has a neutral view of market direction and a bearish view of future volatility. As this involves options being sold, the maximum profit is equal to the sum of the put and call premiums and is achieved when the underlying asset price, at expiry, equals the strike price. Sizeable, and potentially unlimited, losses occur if the underlying asset price moves significantly in either direction.
9.8 The Black–Scholes option pricing model

Up until now the premiums have been given and we have not questioned how they are calculated. To best understand how premiums are determined it is important to consider the profit profiles for the buyer and writer of options. In particular, it is important to note that the buyer of the option has all of the “power” and will ultimately decide to exercise or not exercise the option. The maximum gain, however, for the writer is the premium. The writer therefore hopes that the option is not exercised. In valuing the option, factors that would mean the option is more likely to be exercised, such as high volatility or a longer time to maturity, will be reflected in a higher premium. The position of the underlying asset price relative to the strike price is another important factor.

The Black–Scholes¹ equation for valuing European call options, on non-dividend paying stocks, is:

\[ C = SN(d_1) - Xe^{-rT}N(d_2) \]

¹ Named after the developers of the model, Fisher Black and Myron Scholes.
\[
\begin{align*}
    d_1 &= \frac{\ln\left(\frac{S}{X}\right) + \left[r + \frac{1}{2} \sigma^2\right] T}{\sigma \sqrt{T}} \\
    d_2 &= d_1 - \sigma \sqrt{T}
\end{align*}
\]

where:

- \(T\) = time to expiration (years)
- \(N(.)\) = cumulative normal probability
- \(C\) = fair value of the option
- \(S\) = the current price of the stock
- \(r\) = the risk-free rate of interest
- \(X\) = exercise price of the option
- \(\sigma\) = annualised standard deviation of the stock return

Consider the case of an ABC 50 call that expires in three months (\(T = .25\)) in which ABC stocks are trading at $45 and have an estimated annualised standard deviation of 0.5, and in which the risk-free rate is 6%. Plugging the values into the Black–Scholes formulae:

\[
\begin{align*}
    r_1 &= \frac{\ln\left(\frac{45}{50}\right) + \left[0.06 + \frac{1}{2} 0.5^2\right] \times 0.25}{0.5\sqrt{0.25}} = -0.2364 \\
    r_2 &= r_1 - 0.5\sqrt{0.25} = -0.4864
\end{align*}
\]

From the normal distribution tables:

- \(N(-0.2364) = 0.4065\)
- \(N(-0.4864) = 0.3133\)

Putting all this together:

\[
C = 45 \times 0.4065 - 50e^{-0.05 \times 0.25} \times 0.3133 = 2.86
\]

The value of a corresponding put can be found using “put – call + parity”:

\[
P = C - S + X e^{-rT} = 2.86 - 45 + 50e^{-0.06 \times 0.25} = 7.12
\]

The spreadsheet for this exercise can be found [here](#). Please ensure you click on Section 9 and the 9.8 tab at the bottom of the spreadsheet.

Robert Merton extended the Black–Scholes model to incorporate the valuation of options on dividend paying stocks. In 1997 Robert Merton and Myron Scholes received the Nobel Prize in

9.9 FX options as foreign currency insurance

In Chapter 7 we used forward contracts to hedge against movements in the exchange rate. The examples taught us that if the exchange rate moves in an unfavourable direction, then we will, in hindsight, be glad we hedged the risk. However, if the exchange rate moves in a favourable direction, then we will wish, in hindsight, that we had not hedged, since it would have been preferable to have waited and bought (or sold) the currency at the prevailing market price.

Foreign currency options exist that provide the right, but not the obligation, to buy (an FX call option) or to sell (an FX put option) foreign currency at a pre-agreed price.

An individual with foreign currency to sell can use put options to establish a floor price on the domestic value of the foreign currency. A put option on £1 with an exercise price of $1.40/GBP will ensure that, in the event of the value of the GBP falling below $1.40, £1 can be sold for $1.40 anyway.

If the put option costs $0.01/GBP, this floor price can be approximated as:

\[ \text{Price} = \text{Strike Price} - \text{Premium} = $1.40/\text{GBP} - $0.01/\text{GBP} = $1.39/\text{GBP} \]

or the strike price minus the premium.

Similarly, an individual who has to buy foreign currency at some point in the future can use call options to establish a ceiling price on the domestic currency amount that will have to be paid to purchase the foreign currency. A call option on £1 with an exercise price of $1.40/GBP will ensure that, in the event that the value rises above $1.40/GBP, £1 can be bought for $1.40 anyway.

If the call option costs $0.01/GBP, this ceiling price can be approximated as:

\[ \text{Price} = \text{Strike Price} + \text{Premium} = $1.40/\text{GBP} + $0.01/\text{GBP} = $1.41/\text{GBP} \]

or the strike price plus the premium.

Example

A US company wants to lock in a maximum dollar value of €300m (i.e it wants to sell €300m and receive as many dollars as possible), and this amount is to be sold between 1 January and 30 June. What kind of option should the company buy? A put option on euros.
Suppose the company buys from its bank a June put option with a strike price of US$1.34/EUR. The put is American, so that it can be used at any time prior to expiration. How do we determine the premium?

There is a foreign currency equivalent of the Black–Scholes model with one additional input, the foreign interest rate.

Assuming that the maturity date is 6 months away, the strike price is US$1.34/EUR, the spot rate is US$1.34/EUR, the volatility is 10% p.a., the US interest rate is 0.5% p.a. and the euro interest rate is 0.5% p.a., then the put premium is US$0.0377/EUR or 3.77 cents per EUR.

The outcome is illustrated graphically below.

If the EUR depreciates (i.e. the spot rate drops below US$1.34/EUR), then the company will exercise its put option and receive US$402m:

€300m x US$1.34/EUR = $402m

However, it must pay the premium of €300m x US$0.0377/EUR = US$11.31m, to give a net revenue of US$390.69m.

This is represented by the flat component of the red bars.

This can also be expressed as USD per EUR:

US$390.69m/€300m = US$1.3023/EUR
Note this can also be expressed as:

\[
\text{strike price} - \text{premium} = \text{US$1.34/EUR} - \text{US$0.0377/EUR} = \text{US$1.3023/EUR}.
\]

When the EUR appreciates (i.e. the spot rate is above US$1.34/EUR) the put option is not exercised and the €300m is sold in the spot market instead. Note that the premium is paid whether the option is exercised or not.

As we go from the left-hand side to the right-hand side, the EUR appreciates against the USD and the unhedged revenue (blue bars) increases.

The spreadsheet for this exercise can be found [here](#). Please ensure you click on Section 9 and the 9.9a tab at the bottom of the spreadsheet.

**Example**

A US importer will have a net cash outflow of £5m in payment for goods bought. The payment date is not known with certainty, but should occur in late June. The importer locks into a ceiling price for pounds by buying calls on the pound, with a strike price of US$1.56/GBP and an expiration date in June. If the current spot rate is US$1.56/GBP, what is the US importer worried about?

Since it has to make a payment of £5m which it must obtain by selling dollars, it is worried that in the meantime the value of the GBP will appreciate so that it costs more dollars to buy the £5m.

Assuming that the maturity date is 6 months away, the strike price is US$1.56/GBP, the spot rate is US$1.56/GBP, the volatility is 10% p.a., the US interest rate is 0.5% p.a. and the GBP interest rate is 2%p.a., then the premium for a European call is US$0.0382/GBP or 3.82 cents per GBP.

The outcome is illustrated graphically below.
If the GBP appreciates (i.e. the spot rate goes above US$1.56/GBP), the company will exercise its option and pay US$7.8m. However, it must pay the premium of:

\[
\text{US$0.0382/GBP} \times £5m = \text{US$0.19m}
\]

to give a net cost of US$7.99m, which is represented by the flat component of the red bars.

This can also be expressed as USD per GBP:

\[
£5m/\text{US$7.99m} = \text{US$1.5982/GBP}
\]

Note this can also be expressed as:

\[
\text{strike price} + \text{premium} = \text{US$1.56/GBP} + \text{US$0.0382/GBP} = \text{US$1.5982/GBP}
\]

As we go from the left-hand side to the right-hand side, the GBP appreciates against the USD. This is represented by the blue bars increasing in size. When the GBP depreciates, the call option is not exercised and the £5m is purchased in the spot market instead. Note that the premium is paid whether the option is exercised or not.

The spreadsheet for this exercise can be found [here](#). Please ensure you click on Section 9 and the 9.9b tab at the bottom of the spreadsheet.
Activity 9.1

A US company faces a bill in three months’ time of £750,000. In order to hedge the exchange rate risk the company buys a call option on £750,000 with a strike price of US$1.53/GBP and a premium of 3.03 cents per GBP. To reduce the cost of the hedge, the company simultaneously sells a put option on £750,000 with a strike price of US$1.49/GBP and a premium of 2.95 cents per GBP.

Evaluate this hedge at the following exchange rates from US$1.45 per GBP through to US$0.57 per GBP in increments of 1 cent.