# 2022 CFA®
Exam Prep

# SchweserNotes™
Derivatives and Currency Management

LEVEL III BOOK 2

KAPLAN® SCHWESER

# Book 2: Derivatives and Currency Management

## SchweserNotes™ 2022

Level III CFA®

SCHWESERNOTES™ 2022 LEVEL III CFA® BOOK 2: DERIVATIVES AND CURRENCY MANAGEMENT



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# LEARNING OUTCOME STATEMENTS (LOS)

## STUDY SESSION 4

*The topical coverage corresponds with the following CFA Institute assigned reading:*

### 8. Option Strategies

The candidate should be able to:

a. demonstrate how an asset's returns may be replicated by using options.
b. discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a covered call position.
c. discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a protective put position.
d. compare the delta of covered call and protective put positions with the position of being long an asset and short a forward on the underlying asset.
e. compare the effect of buying a call on a short underlying position with the effect of selling a put on a short underlying position.
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*The topical coverage corresponds with the following CFA Institute assigned reading:*

### 9. Swaps, Forwards, and Futures Strategies

The candidate should be able to:

a. demonstrate how interest rate swaps, forwards, and futures can be used to modify a portfolio's risk and return.
b. demonstrate how currency swaps, forwards, and futures can be used to modify a portfolio's risk and return.
c. demonstrate how equity swaps, forwards, and futures can be used to modify a portfolio's risk and return.
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*The topical coverage corresponds with the following CFA Institute assigned reading:*

### 10. Currency Management: An Introduction

The candidate should be able to:

a. analyze the effects of currency movements on portfolio risk and return.
b. discuss strategic choices in currency management.

c. formulate an appropriate currency management program given financial market conditions and portfolio objectives and constraints.
d. compare active currency trading strategies based on economic fundamentals, technical analysis, carry-trade, and volatility trading.
e. describe how changes in factors underlying active trading strategies affect tactical trading decisions.
f. describe how forward contracts and FX (foreign exchange) swaps are used to adjust hedge ratios.
g. describe trading strategies used to reduce hedging costs and modify the risk–return characteristics of a foreign-currency portfolio.
h. describe the use of cross-hedges, macro-hedges, and minimum-variance-hedge ratios in portfolios exposed to multiple foreign currencies.
i. discuss challenges for managing emerging market currency exposures.

The following is a review of the Derivatives and Currency Management principles designed to address the learning outcome statements set forth by CFA Institute. Cross-Reference to CFA Institute Assigned Reading #8.

# READING 8: OPTION STRATEGIES

**Study Session 4**

## EXAM FOCUS

The primary focus of this Study Session is on the ways in which derivative contracts (instruments whose values derive from the economic performance of underlying securities, currencies, or other instruments or factors) may be used to hedge, or change the degree of exposure to, existing positions (for example a holding of a stock, or the exposure to a foreign currency caused by the ownership of an asset or liability in that currency). We will also see how derivatives, particularly options, can be used to obtain exposures to instruments and factors that cannot be obtained directly from the instruments and factors themselves (strategies such as straddles and spreads, for instance).

Reading 8 deals with options, mainly focusing on options on individual stocks, although the principles apply equally well to options on any other instruments. Reading 9 looks at the principles and uses of futures and forward contracts, while Reading 10 is concerned with currency management, beginning with the various approaches to currency along the passive-active spectrum, moving on to active currency strategies (including volatility trading via options), before considering currency hedging using futures and forwards (mainly the latter), and options.

The sequence of topics in our coverage of Reading 8 differs from the LOS order. We start by looking at the payoffs and profits associated with holding option positions to expiration. Since value at expiration is purely reflective of intrinsic value, the calculations involved are simple (but highly examinable, so worth getting clear before the complicating issue of time value is addressed). Only then do we move on to the more theory-heavy areas associated with time value—the option “Greeks” and strategies derived from them.

## MODULE 8.1: OPTIONS BASICS—VALUE AT EXPIRATION AND PROFIT AT EXPIRATION

Video covering this content is available online.

*Options have already been met at the previous levels, of course, so the material in this first module is largely revision. However, we recommend that you don’t skip it, since it is vital to everything that follows.*

*In particular, distinguishing between option value and profit (respectively pre- and post-initial premium), and the graphical representation of how they vary with differing values of the underlying price, is very helpful when we move on to analyze more complex strategies.*

### A Refresher on Options Terminology

- A **call** is a right to **buy**
- A **put** is a right to **sell**

Each option contract will specify the **underlying** to which the right relates.

- Underlyings include stocks and stock indices, bonds and bond futures, currencies, commodities, and more abstract factors such as stock volatility.

The contract will specify the **exercise** (**strike**) price at which the right can be exercised, and the **expiration** (**expiry**) date (and time) at which the right can be exercised (or not).

- **European-style options** may only be exercised at the point of expiration, while **American-style options** may be exercised on any trading day up to and including the point of expiration.
  - Note that European- and American-style are just labels for the two main styles of option, and are nothing to do with where the options are traded (there are other, more exotic, styles, such as Bermudan, but the details of such exotics are beyond the scope of the syllabus).

The buyer of an option pays a **premium** (the value of the option) to the seller.

- The **buyer** (who takes the **long** position in the option) has the right.
- The **seller** (taking the **short** position) receives the premium as payment for taking on the contingent liability associated with the buyer's right:
  - In the case of a **call** option, the short has undertaken to deliver the underlying if the buyer chooses to exercise (receiving the strike price in exchange).
  - In the case of a **put** option, the short has undertaken to take delivery of the underlying if the buyer chooses to exercise (paying the strike price).

## Symbols and Formulas

*We must minimize the use of formulas, where possible. The curriculum text does include some formulas and, if they help your understanding, by all means learn and use them, but our experience is that it is more reliable to focus on the underlying principles embedded in the formulas. None of the strategies tested are greatly complex, and in all cases, answers can be determined from the basic principles of in/out the moneyness that follow in the next section.*

When symbols are used, we will follow the notation in the curriculum:

- X = the e**x**ercise (strike) price.
- S = the underlying (**s**tock) price.
- p and c = the prices (premiums) of the **p**ut and **c**all options.
- Subscripts on S, p, and c will stand for time, with 0 = the point at which the position is entered and T = option expiration.

## Intrinsic Value and Time Value

At any point in time any given option will have a value. This is set, as are all values, by supply and demand but is likely to be determined by reference to one of the many option pricing models, of which the Black-Scholes-Merton (BSM) was the first (introduced in 1973), and is still widely used.

The key determinants of an option's value are:

- The strike price.
- The current level of the underlying (e.g., stock price, currency rate, etc.).
- The remaining time to expiration.
- The volatility of the underlying (the **expected** annualized standard deviation of the underlying over the period to option expiration).
- The annualized risk-free interest rate over the period to expiration.
- The annualized yield expected from the underlying (if any) over the period to expiration.
- Whether it is European- or American-style (in principle the latter might be worth more because they give the right to exercise before expiration, in addition to at expiration).

Market participants may not agree on what an option is worth—most likely because they disagree on the appropriate figure to use for volatility. However, note that all options that trade on exchanges will have a value, which is reflective of the consensus at that point in time. The current value of an option can be used to infer the consensus estimate of volatility for the underlying, known as **implied volatility**. This is done by working backwards through a pricing model, given the other factors can be directly observed.

Note that **implied volatility** is not the same as **historical (realized) volatility**, which is the square root of the **actual** realized variance of returns to date.

It is important to note that the volatility that is used to determine the option value is an estimate of the volatility **looking forward**, which is not the same as actual movement in the stock price. For example, the implied volatility for a stock option could well rise, even though the stock price is currently stable, if the consensus view changes on the potential for price moves during the period to expiration.

The value of an option can be decomposed into its intrinsic value and its time value, the total premium being the sum of these two.

- **Intrinsic value** is the value of immediate exercise[1]. It reflects the degree to which the option is in the money (ITM).
- **Time value** is the additional value reflective of *what might happen* between now and the point of expiration (i.e. over the option's remaining life).

An option is ITM if the long would derive a benefit from immediate exercise.

- **A call option is ITM if the current price of the underlying > strike price**, so the long has the right to pay less than the current market price for the underlying.

  The intrinsic value in such a case equals the underlying price minus the strike price (the extent to which the underlying price exceeds the strike price, which is the amount the long could gain by exercising their right, then immediately selling the underlying in the market). Note that here, and throughout, we will ignore transaction costs.

- **A put option is ITM if the current price of the underlying < strike price**, so the long has the right to receive more than the current market price for the underlying.

The intrinsic value in such a case equals the strike price minus the underlying price (the extent to which the strike price exceeds the underlying price, which is the amount the long could gain by buying the underlying in the market, then immediately exercising their right to sell at the strike price).

Note that the intrinsic value is not the same as the profit to the long, which would have to factor in the premium that the long originally paid for the option. This means that it is perfectly possible for an option to be ITM, but for exercise to result in a loss to the long (if the intrinsic value < initial premium paid).

Note also that we are not saying that the long will *choose* to exercise, just that (ignoring premium paid) exercise would lead to a gain.

An option that is not ITM will have zero intrinsic value. It could be at the money (ATM), with the underlying = strike price, or out of the money (OTM):

- **A call option is OTM if current price of the underlying < strike price.**
- **A put option is OTM if current price of the underlying > strike price.**

At any point before expiration an option also has time value, which reflects what might happen over its remaining life. This is a much more complex concept, which explains why the first option pricing formula only appeared in 1973. Time to expiry, volatility, the risk-free rate, and the yield on the underlying all have a part to play, in addition to the underlying price and the strike price.

The details of pricing models are beyond the scope of the Level III curriculum—you will not be plugging figures into the BSM model, for example—but a couple of general principles are worth remembering, namely that with **all other factors held constant:**

- **Higher** volatility means **higher** option premiums (both for calls and puts).
- **Less** time to expiry means **lower** option premiums (both for calls and puts).

## Data for Examples

For most of the examples in this reading we will use the following options on XYZ stock (current stock price = $52.14). The premiums are quoted as of "now" (assumed to be 20 March), and the April, May, and June expiration dates are respectively 31, 61, and 91 days in the future. The risk-free interest rate is 3%, and volatility has been assumed to be a constant 60% (we will see later that this is unrealistic, but this is not in itself a problem). The XYZ stock pays no dividends.

Each option contract is a right over 100 shares, but this table shows prices per share (in $), and we will work in per-share terms, unless otherwise stated:

| Call Price | | | Strike | Put Price | | |
|---|---|---|---|---|---|---|
| APR | MAY | JUN | Price | APR | MAY | JUN |
| 4.80 | 6.26 | 7.40 | **50** | 2.53 | 3.87 | 4.88 |
| 3.53 | 5.05 | 6.22 | **52.5** | 3.75 | 5.14 | 6.19 |
| 2.52 | 4.02 | 5.20 | **55** | 5.24 | 6.61 | 7.65 |

We refer to the May expiry call with a strike price of 50 as the MAY 50 call, for instance.

***We will initially be limiting ourselves to evaluating values and profits at expiration. This simplifies things since at expiration there will be no time value—only intrinsic value (which may be referred to as the option's payoff).***

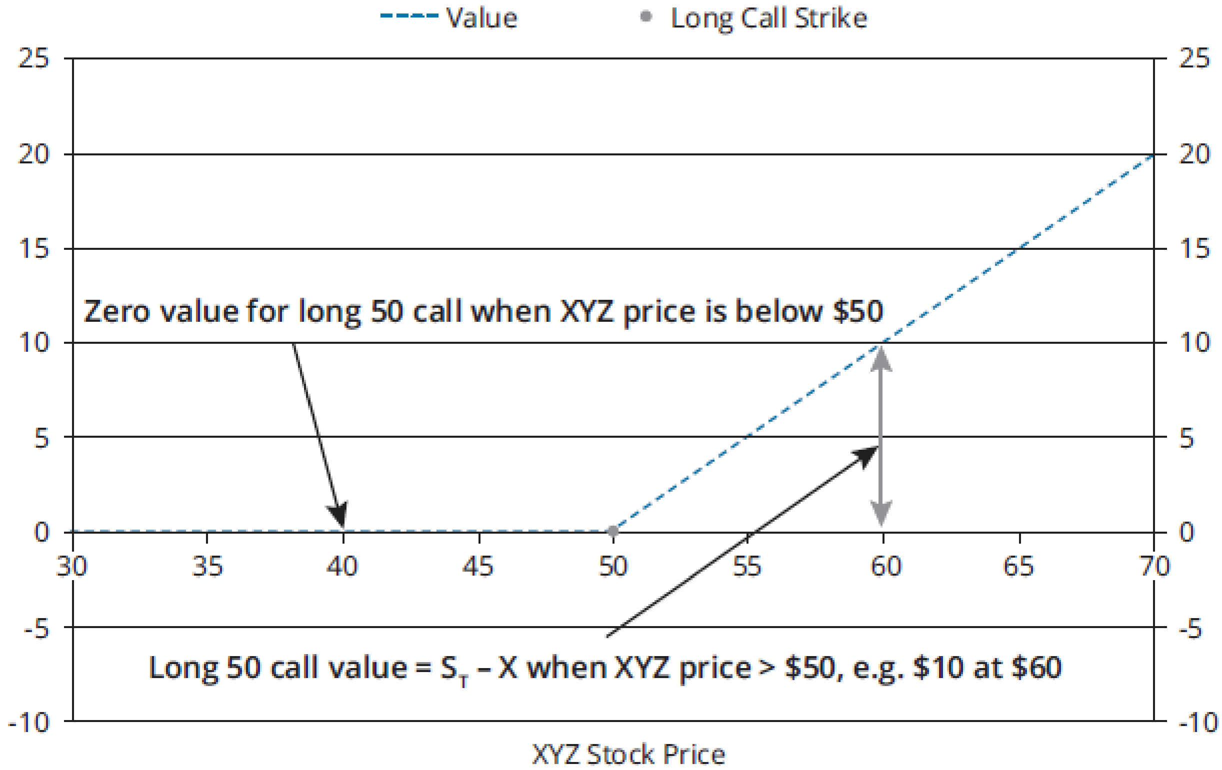
## Basic At-Expiration Payoff Diagrams for Calls and Puts

### *Calls*

Let us use the example of a long call to illustrate the way in which option values and profits can be depicted graphically.

Consider an investor who buys (goes long) an XYZ MAY 50 call, paying the $6.26 premium.

At the May expiration the option will either be ITM or OTM, dependent on whether the stock price then is above or below $50. Below $50 it will be OTM, with no (intrinsic) value, while above $50 the intrinsic value will equal stock price—$50:




In all such diagrams, the horizontal axis represents the value of the underlying, while the vertical axis represents the value or profit of the position [which it is will be clear from the labelling of the line(s)] corresponding to that underlying value.

For example, if the XYZ stock price at expiry is $40 then the 50 call will expire OTM, with zero value, while if the stock price at expiry is $60 then the 50 call will expire ITM, with a value of $60 – $50 = $10.

The initial cost of the option was $6.26 (per the table), so the profit at expiration will equal the value of the call minus $6.26, implying:

- If XYZ stock price = $40, profit = $0 – $6.26 = loss of $6.26.
- If XYZ stock price = $60, profit = $10 – $6.26 = $3.74.

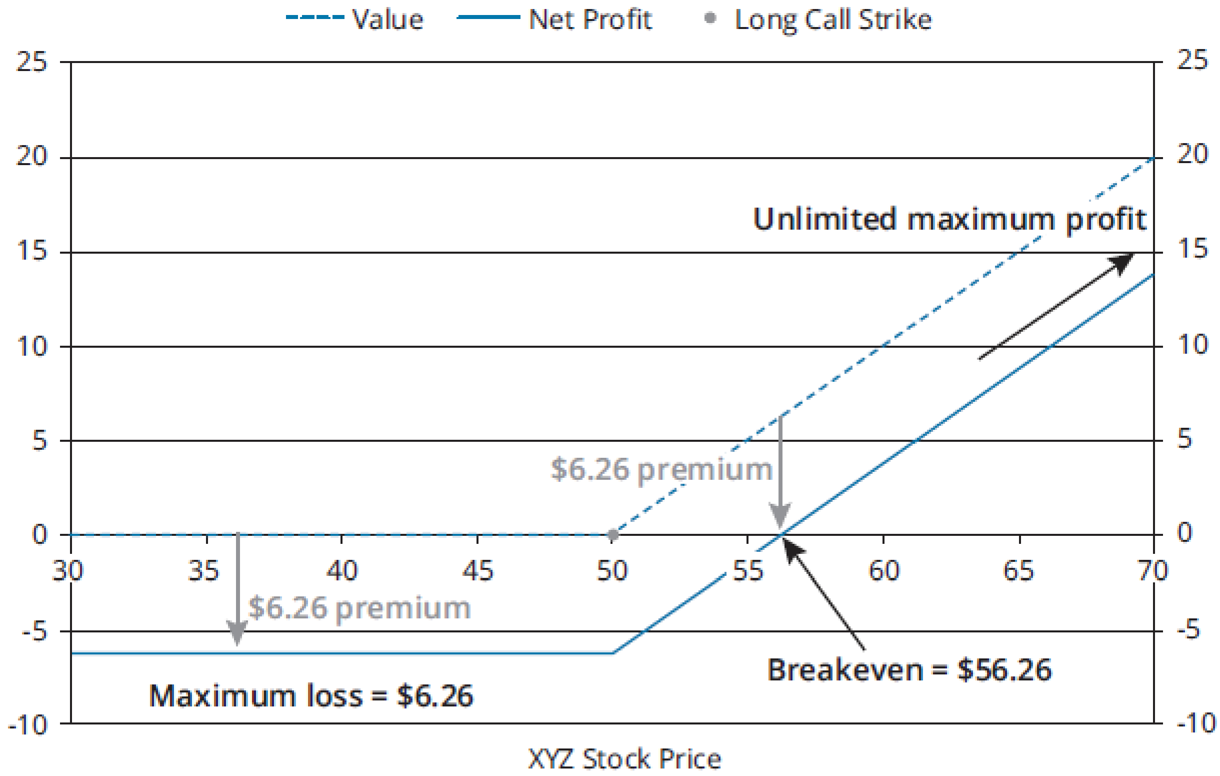
Overall, the profit line will be the value line shifted downwards uniformly by the $6.26 initial premium.

As a rule, for each and every strategy we consider, the profit line will be the value line shifted:

- **Downwards** by the amount of the (net) initial premium – if the (net) initial premium is an outflow (as here).
- **Upwards** by the amount of the (net) initial premium – if the (net) initial premium is an inflow.

This means that if we know the shape of the value line for a strategy, the profit line will have exactly the same shape.

For the long XYZ MAY 50 call:




It is clear that the maximum loss from a long call occurs when the option expires OTM with zero value, thus equals the premium paid.

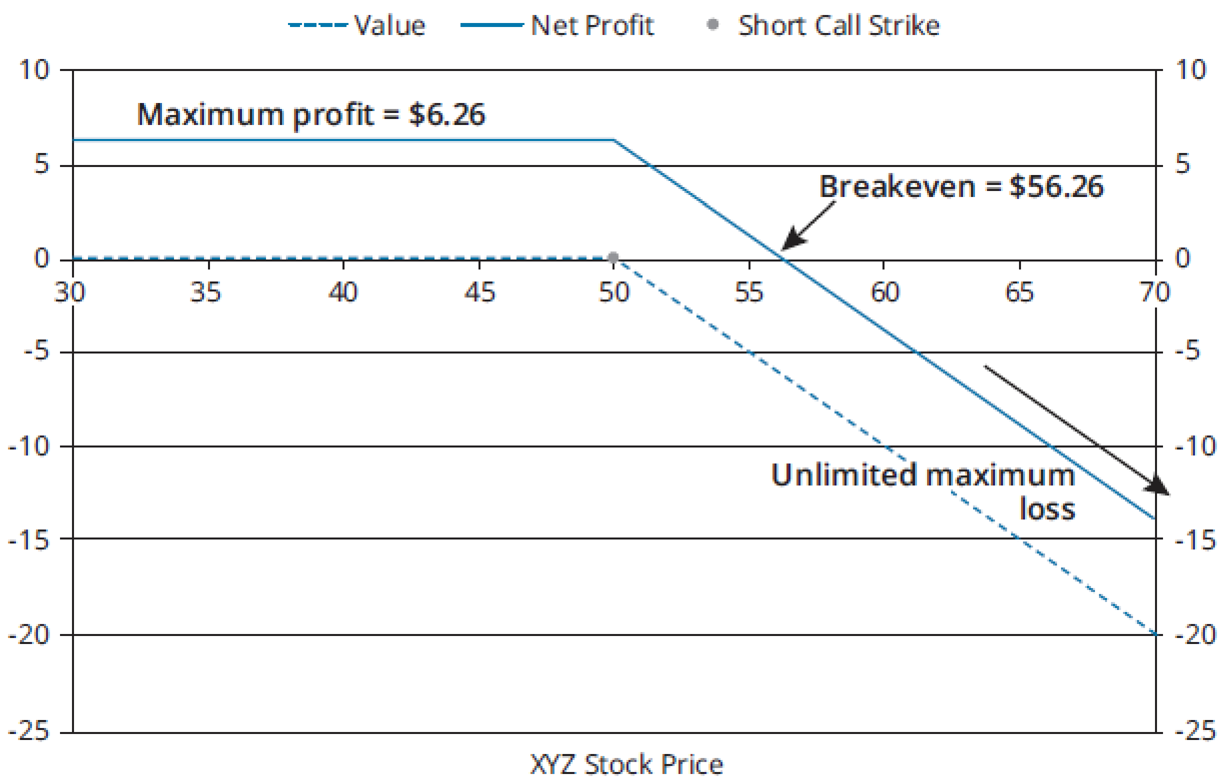
The long call position will break even at expiration if the value at expiration is exactly equal to the premium paid. This will happen when the stock price expires at the sum of the strike and the premium, $50 + $6.26 = $56.26 as shown on the previous diagram.

A long call has no maximum profit—the higher the stock price at expiry, the higher the profit on the call, with no upper limit.

The diagrams for a short call are identical, except that plus values, vertically, become minus, and vice-versa (since, in the absence of transaction costs, a positive result for the long is a negative result for the short, and vice-versa (in the jargon, it is a zero-sum game).

This means that equivalent long and short positions will have identical breakeven values for the underlying, while their maximum losses and profits will just swap around.

The short XYZ MAY 50 call has value and profit at expiration as here:



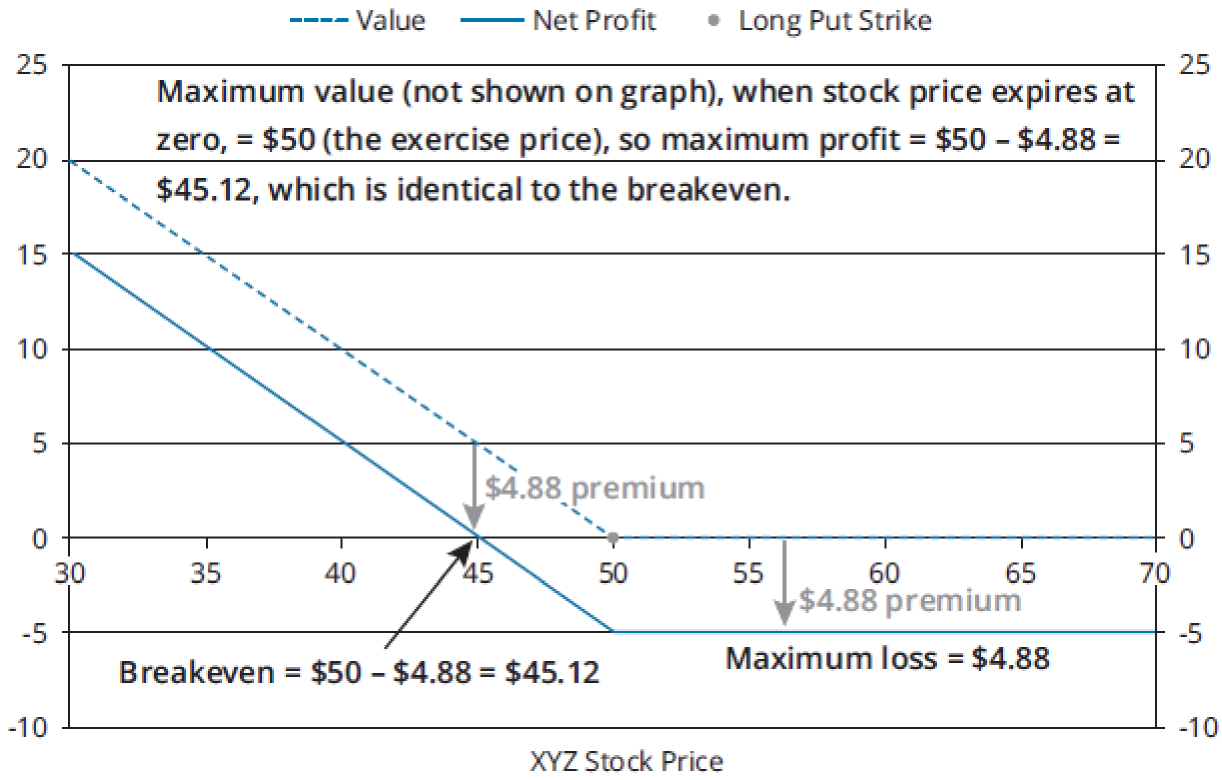

The basic motivation for buying a call is to profit from a rise in the underlying price, while limiting the downside.

When a call is sold (without any hedging position in place) then the position is described as a **naked** (uncovered) **call**, and limited upside from falls in the underlying price is balanced against unlimited potential losses from the underlying rising.

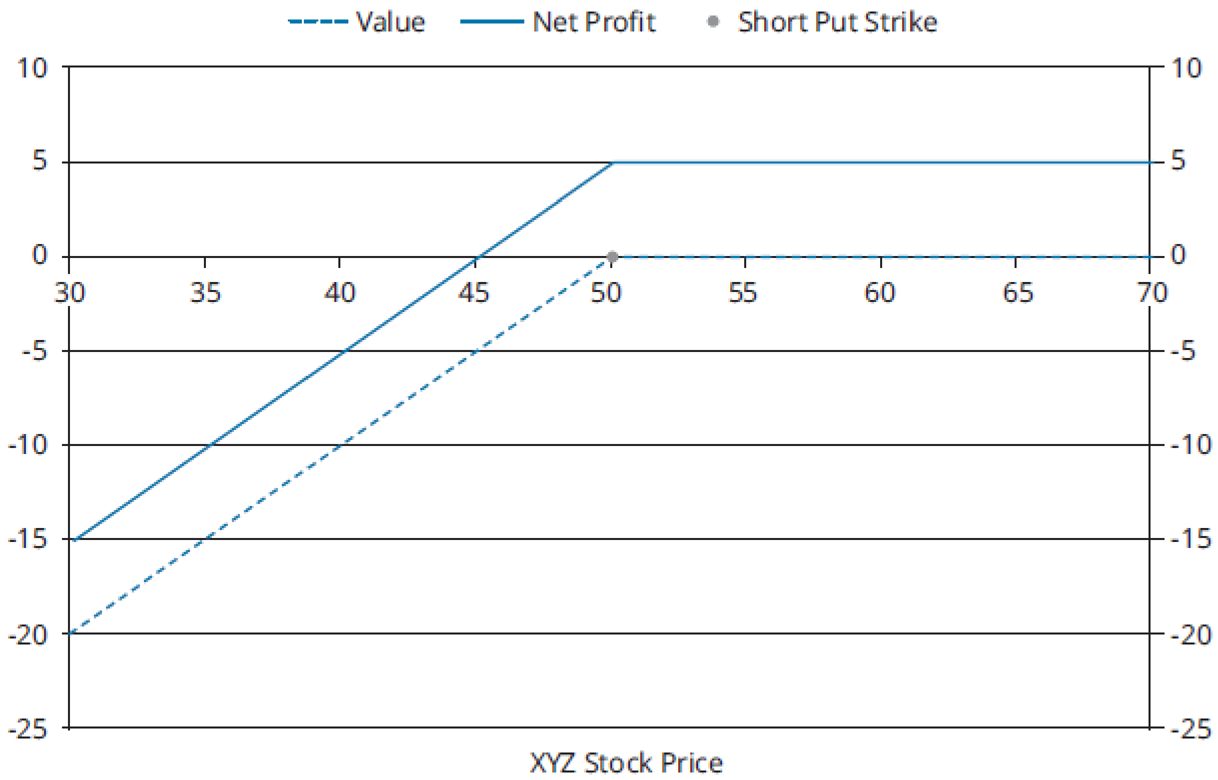
## *Puts*

Puts are ITM on expiry when the underlying value ends below the strike price. This means that the graph for a put exposure will look like the call graph with left and right reversed.

For example, a long XYZ JUN 50 put (initial premium = $4.88) at expiration:




Here is the corresponding short XYZ JUN 50 put at expiration:




Confirm that you understand why the short XYZ JUN 50 put has maximum profit at expiration of $4.88, and breakeven = maximum loss = $45.12.

The basic motivation for buying a put is to profit from a fall in the underlying price, while limiting the downside.

When a put is **sold**[2] limited upside from rises in the underlying price is balanced against large (although limited) potential losses from the underlying falling.

# MODULE 8.2: SYNTHETIC POSITIONS USING OPTIONS

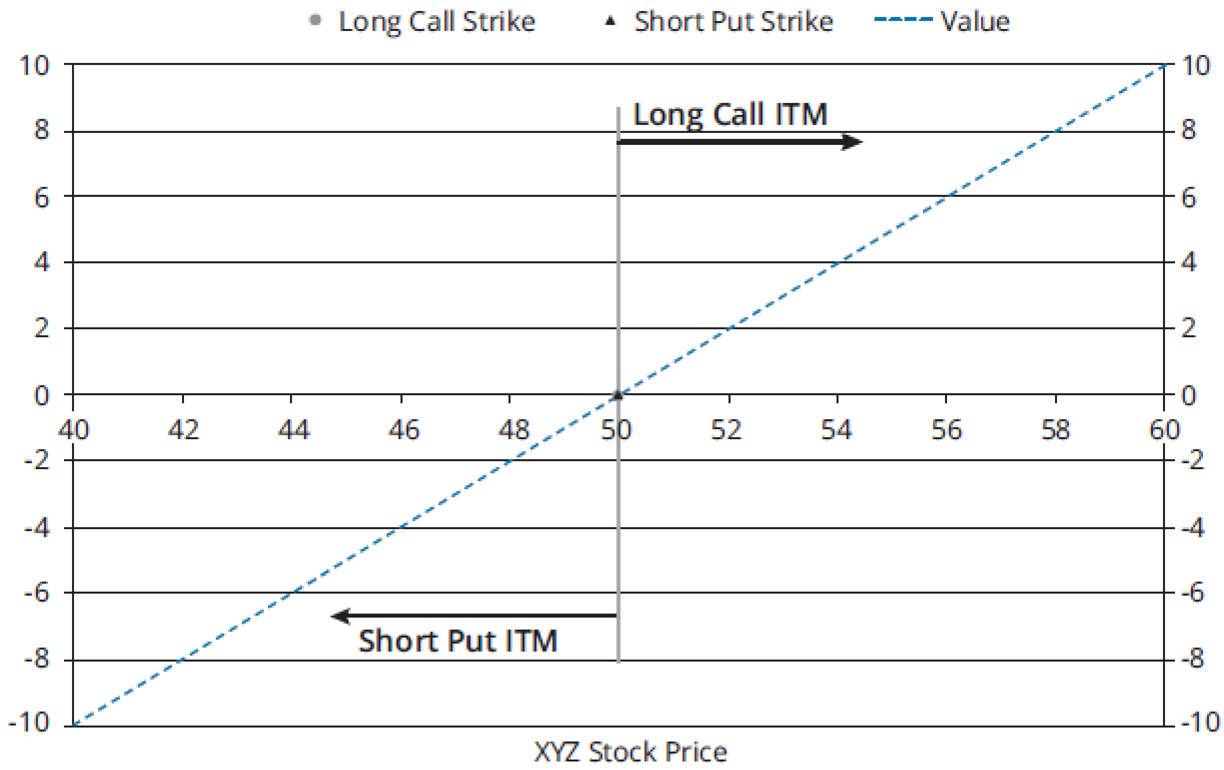
Video covering this content is available online.

**LOS 8.a: Demonstrate how an asset's returns may be replicated by using options.**

*CFA® Program Curriculum, Volume 2, page 6*

If we combine a long call with a short put (both on the same underlying, with the same strike price and expiration) then we create a synthetic long forward position.

For example, here are the values at expiration from being long an XYZ 50 call and short an XYZ 50 put:




For values of the underlying above 50 the long call expires ITM (while the put is OTM), giving positive value, while if the underlying is below 50 the short put expires ITM (the call is OTM), giving negative value (it is exercised by the counterparty). Whatever happens to the stock price this position gives the same payoff at expiration as does an identical-maturity long forward contract on XYZ at 50—both result in buying the stock for 50.

- In symbols the value at expiration = $S_T - X$.

Suppose both options were for May expiration, then the premium paid for the call would have been \$6.26, while the premium received on the put would have been \$3.87, for a net initial payment of \$6.26 – \$3.87 = \$2.39. The profit line would thus be \$2.39 below the value line. The breakeven at expiration for the position is \$50 + \$2.39 = \$52.39 (the call would be \$2.39 ITM at this stock price, just covering the net premium paid).

This profit calculation has ignored the time value of money, as we do throughout this topic review when we calculate net profits, but in this section let us be a bit more accurate. The premiums are paid "now" (assumed to be 20 March), whereas the value at expiration is in May, 61 days later, so we should not really just net them off.

As an alternative to buying the call and selling the put, consider buying the underlying XYZ stock in March (for $52.14) and holding it to the May expiration date. If we simultaneously borrow the PV of the strike price then at the May expiration date we will end up with a position with a net value exactly the same as the value of the long call + short put position we just examined: we will be able to sell the stock for the stock price at expiration and will have repay the borrowing (the amount to repay will be the strike price, since the amount borrowed was its present value), leaving us with $S_T - X$, as before.

Since these two positions end up with identical values, irrespective of the stock price at expiration, they must cost the same, so:

- Call premium (paid initially) – put premium (received initially) = initial stock price paid – PV(X) received
- In symbols, $\mathbf{c_0 - p_0 = S_0 - PV(X)}$, which can be rearranged to $\mathbf{S_0 + p_0 = c_0 + PV(X)}$.

This, of course, you will recognize as the **put-call parity** relationship. Note that this version of the put-call parity formula assumes that the underlying pays no yield (during the period to expiry).

In this case, we have $c_0 - p_0$ = \$6.26 – \$3.87 = \$2.39. The risk-free interest rate is 3%,

so PV(\$50) = $\$50/(1.03)^{61/365}$ = \$49.75, and the equation works, since $S_0 - PV(X)$ = \$52.14 – \$49.75 = \$2.39.

Were PV(X) exactly equal to $S_0$ then put-call parity tells us that the call and put should have identical premiums (because $c_0 - p_0$ would equal zero). X in that situation would be the fair price for a forward contract.

**Put-call forward parity** substitutes $\mathbf{PV(F_0(T))}$ in place of $S_0$, where $F_0(T)$ is the forward price for a contract that matures at the same time as the options expire, giving $\mathbf{PV(F_0(T)) + p_0 = c_0 + PV(X)}$. Given that cash-and-carry arbitrage means that the fair forward price for an underlying that pays no yield equals $FV(S_0)$, and $PV(FV(S_0)) = S_0$, this is just a restatement of standard put-call parity.

EXAMPLE: **Synthetic Long Forward Position**

Gavin Ennis is a dealer who has just sold a four-month forward contract on AlphaCo Stock to a client who will thereby purchase 1,000 shares of the stock for 179.59. AlphaCo's current share price is 179, and AlphaCo will not be paying a dividend during the next four months. The annualized interest rate is 1%, and AlphaCo 179.59 calls and puts are both currently trading at 16.34 per share.

Explain how Ennis could hedge his short forward position using a synthetic long forward position, and explain what happens at expiry if the AlphaCo share price is above or below 179.59.

**Answer:**

Ennis should purchase a 179.59 call and sell a 179.59 put (both on 1,000 shares) with expiration matching the maturity of the forward contract. The net premium for these options will be zero.

At forward contract maturity, whatever happens, Ennis will have to sell the 1,000 shares to his client and receive 179.59 × 1,000. This is also the expiry point of the options.

If the share price is above 179.59 then Ennis will exercise the call, which is ITM, and purchase 1,000 shares, whereas if the share price is below 179.59 then the put counterparty will exercise the put (ITM) and sell 1,000 shares to Ennis. In either case Ennis buys 1,000 shares for 179.59 per share, which precisely offsets his obligation under the forward contract.

# MODULE 8.3: COVERED CALLS

**LOS 8.b: Discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a covered call position.**

Video covering this content is available online.

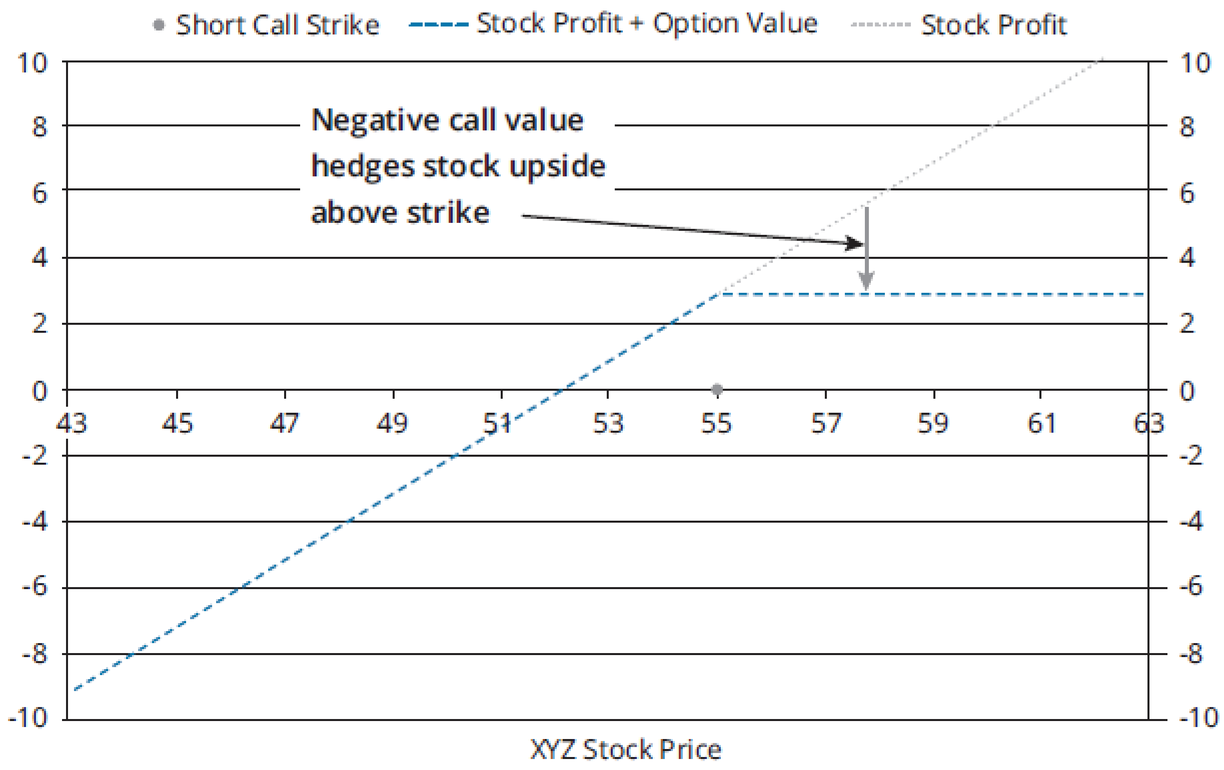
*CFA® Program Curriculum, Volume 2, page 11*

## Covered Calls with Extra Yield the Main Focus

Suppose an investor has a long position in XYZ stock on 20 March. They think that the stock has limited upside over the next month, and are prepared to sell off upside above $55 ($2.86 above the 20 March stock price of $52.14).

The classic way of doing this is to sell a call (a **covered call**, because the risk of the short option position is hedged by ownership of the stock), in this case an XYZ APR 55 call. This will give premium income of $2.52 (per share) in March.

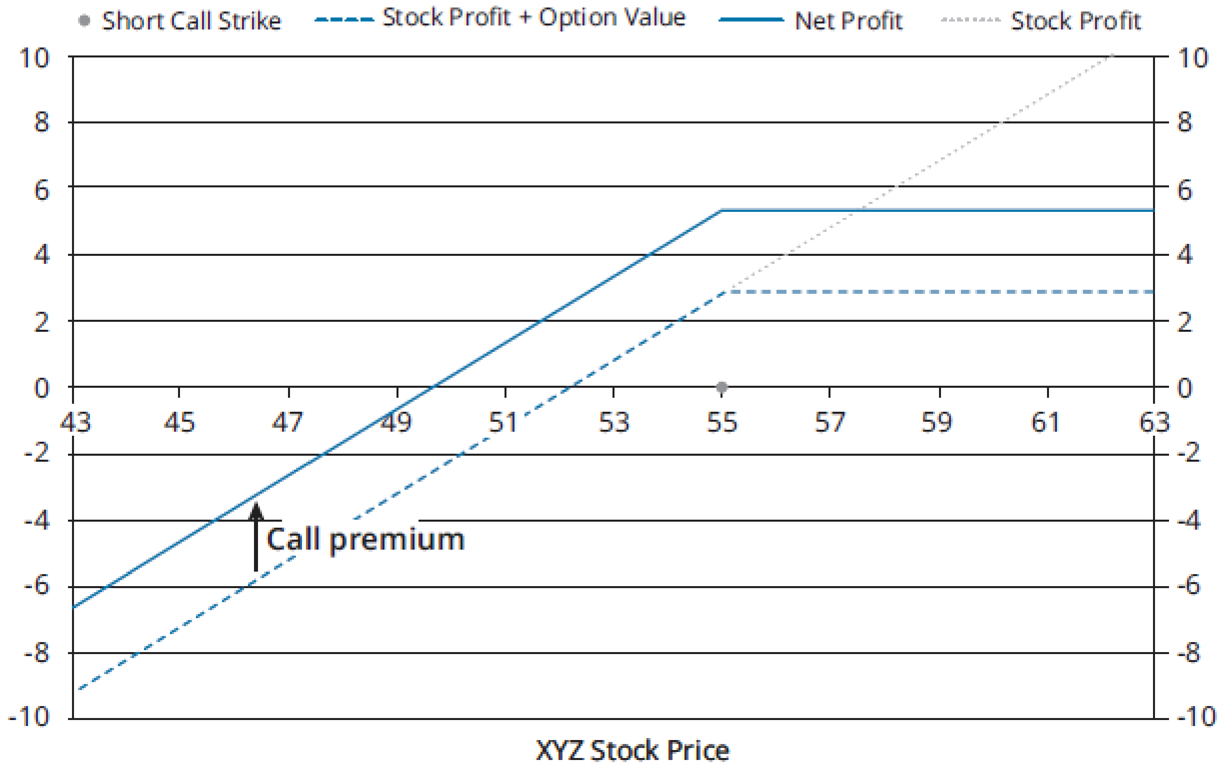
At expiration, if the XYZ stock price is above $55 then the call will be exercised by the counterparty and the investor will be obliged to sell the stock to them for $55. If the stock price is below $55 the call will expire OTM and unexercised, so the investor continues to hold the stock. Ignoring the call premium received, this means the gain/loss associated with holding the stock is capped for stock prices above $55:




An equivalent way of thinking about it is that below $55 the call has zero intrinsic value, so adding this to the original stock gain/loss leaves us as we were, whereas above $55 the call's intrinsic value is the stock price minus the strike price (with a minus sign in front, since it is short), thus any gain on the stock above $55 is precisely offset by the increasing negative value of the short call.

At $55 the stock has risen by $2.86, and this is thus the maximum gain (ignoring the call premium). Note also that, ignoring the call premium, the breakeven point is the original stock price of $52.14.

Taking account of the $2.52 call premium received takes us to the overall net profit/loss line:




The net profit line is the stock gain/loss (as modified by the call intrinsic value) shifted uniformly upwards by the call premium received.

The maximum profit equals $2.86 + $2.52 = $5.38, while the breakeven is $2.52 lower than it was without the premium received, which is at $52.14 – $2.52 = $49.62 (up to a $2.52 fall in the stock price is cushioned by the call premium).

Notice that the profit line has the same general shape as a short put and, as for a short put, the maximum loss is the same as the breakeven (since the loss increases one-for-one below breakeven, but the stock price cannot fall below zero). Thus maximum loss = $49.62.

Since the investor holding the stock believed the stock had limited upside over the month, they have turned upside potential (which they did not need) into cash in hand. They will only end up worse off if the stock price at expiry exceeds $55 + $2.52 = $57.52, which is the level at which the original stock gain/loss line cuts through the net profit line.

In general, for a covered call:

- maximum profit at expiry = $X - S_0 + c_0$
- breakeven stock price at expiry = maximum loss at expiry = $S_0 - c_0$

The motivation in the previous example of a covered call was earning extra yield (the focus was on the premium income).

There are two other likely motivations: reducing a position at a favorable price, and target price realization. Let us look at each in turn.

## Reducing a Position at a Favorable Price

A second scenario where covered calls might be written is when an investor holds a position in a stock and intends to reduce that holding in the near future. For example Jenkins might hold 5,000 shares in XYZ on 20 March (share price = $52.14), but plans to dispose of 1,500 of these. She might simply sell 1,500 shares at $52.14, realizing $78,210, but instead could write 15 exchange-traded XYZ April 50 call contracts (on 1,500 shares), receiving a total premium of 1,500 × $4.80 = $7,200. Note that the options are currently ITM.

Provided the share price at the April expiry is no lower than $50, the options will get exercised, and Jenkins will be obliged to deliver 1,500 shares for 1,500 × $50 = $75,000. Adding the premium already received to this brings the total proceeds to $75,000 + $7,200 = $82,200, which exceeds the proceeds had she simply sold at the market price on 20 March.

However, there is a risk: if the XYZ price at expiration is lower than $50 then the calls will not be exercised and the shares will not be sold—the opportunity to sell at the current favorable price will have been missed.[3]

## Target Price Realization

A third motivation is realizing a target price. In this case calls are written with a strike just above the current market price. The idea is that the investor believes the stock should be worth a bit more than its current price, and would be happy to sell it at that slightly-higher price. For example Perkins holds XYZ shares at $52.14 and writes APR 52.5 calls, receiving $3.53 per share. If the calls are exercised in April, then the shares are sold at the $52.50 strike price, so a total per share of $52.50 + $3.53 = $56.03 has been realized.

The dangers are twofold. First, the stock price may rise substantially, in which case Perkins would regret having to sell at $52.50, rather than the higher market price. Second, the stock price might decline, and the opportunity to sell at the current level will have been missed.

Note that this use of covered calls is best seen as a hybrid of the previous two.

The observable difference between these three uses of covered calls is the value of the strike relative to the current stock price:

- For yield enhancement, the calls are OTM (possibly substantially so).
- For reducing a position at a favorable price, the calls are ITM.
- For target price realization, the calls are marginally OTM.

### MODULE QUIZ 8.1, 8.2, 8.3

*To best evaluate your performance, enter your quiz answers online.*

1. Which of the following trades would create a synthetic short exposure to PQR stock? The options expire in 6 months, and the risk-free interest rate is 2%.
   A. Borrow 99, buy a PQR 100 put and sell a PQR 100 call.
   B. Borrow 101, buy a PQR 100 put and buy a PQR 100 call.
   C. Buy a PQR 100 call and sell a PQR 100 put, simultaneously selling a six-month forward contract on PQR at 100.
2. An investor purchases a stock for $43 and sells a call for $2.10 with a strike price of $45. At expiration of the call:

a) compute the maximum profit and loss and the breakeven price.

b) compute the profit or loss when the stock price is \$0, \$35, \$40, \$45, \$50.

## MODULE 8.4: PROTECTIVE PUTS

Video covering this content is available online.

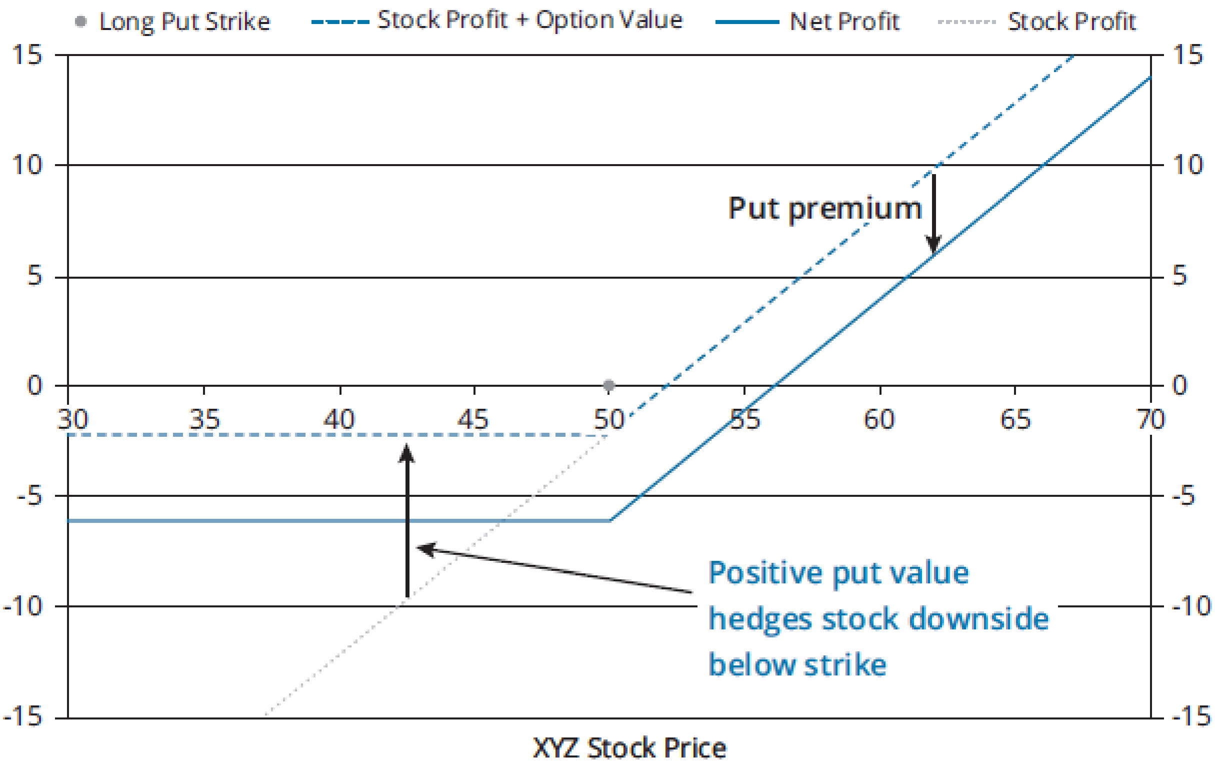
**LOS 8.c: Discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a protective put position.**

*CFA® Program Curriculum, Volume 2, page 20*

For an investor who has a long position in an underlying, the classic options-based hedge is the protective put – buying a put option to protect against the underlying falling in value, while retaining upside.

Suppose that an investor has a holding of XYZ stock on 20 March, and purchases XYZ May 50 puts on an equal number of shares as a hedge. The puts will cost \$3.87 per share, and the share price is \$52.14.

The position at May expiry is as shown on the next graph (in per-share terms, as always):




As with the covered call, when the initial option premium cost is ignored the breakeven is the same as for the unhedged stock, but this time we see that the stock loss is limited to the distance of the strike below the initial stock price (\$52.14 – \$50 = \$2.14). Factoring in the initial premium, the net maximum loss is \$2.14 + \$3.87 = \$6.01, while the breakeven is the premium added to the unhedged breakeven of \$52.14, so \$52.14 + \$3.87 = \$56.01. This breakeven can also be inferred from the fact that at 50 there is a loss of \$6.01, so the underlying needs to expire \$6.01 above that, at \$56.01, to break even.

In general, for a protective put:

- Maximum loss at expiry = $S_0 - X + p_0$

- Breakeven stock price at expiry = $S_0 + p_0$
- Maximum profit = unlimited

# MODULE 8.5: OPTIONS AS A HEDGE OF A SHORT POSITION

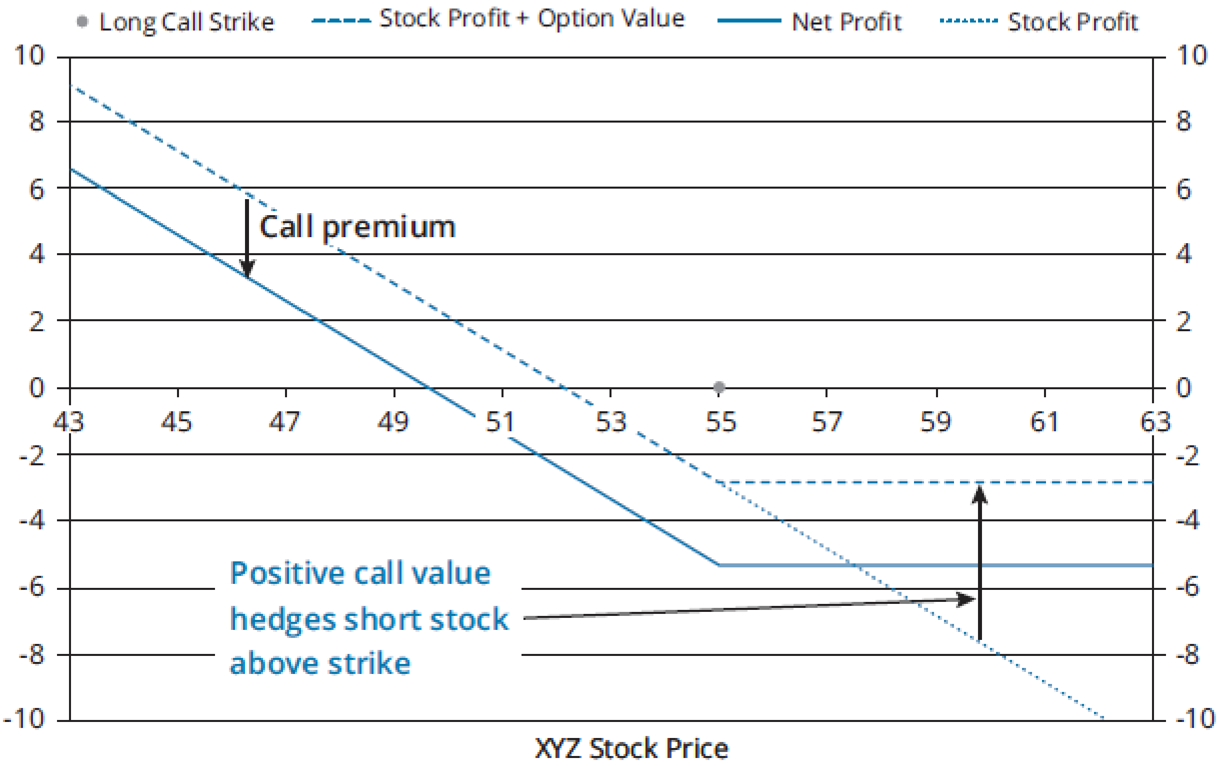
Video covering this content is available online.

**LOS 8.e: Compare the effect of buying a call on a short underlying position with the effect of selling a put on a short underlying position.**

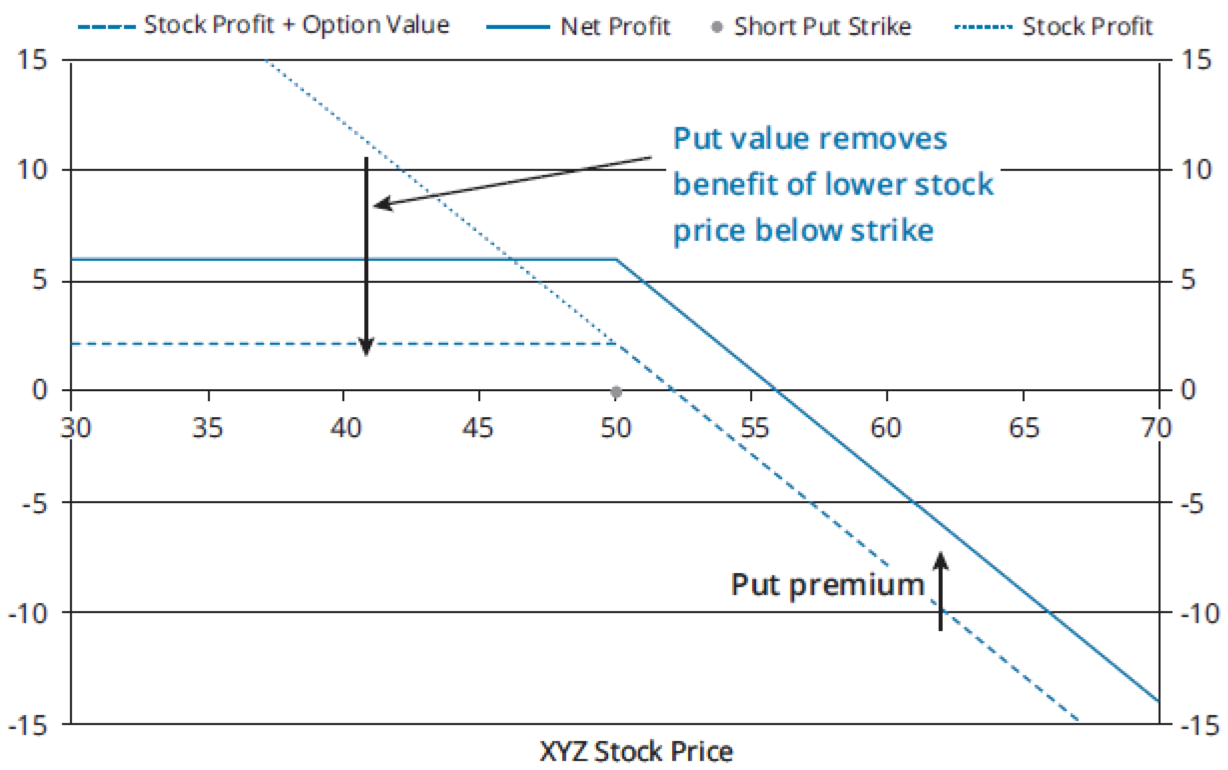
*CFA® Program Curriculum, Volume 2, page 28*

If an investor starts with a short position in the underlying, they will gain if the price falls and lose if the price rises.

Buying a call (probably above the current stock price) would provide a hedge against the stock rising. This is analogous to the way a protective *put* hedges a *long* stock position against a *fall* in the price:




Similarly, the sale of a put (probably below the current stock price) sells off (part of) the benefit of the stock falling, in the same way a **covered *call*** sells off the upside of a ***long* stock** position:




## MODULE QUIZ 8.4, 8.5

*To best evaluate your performance, enter your quiz answers online.*

1. An investor purchases a stock for \$37.50 and buys a put for \$1.40 with a strike price of \$35. At expiration of the put:

   a) compute the maximum profit, maximum loss, and breakeven price.

   b) compute the profit or loss for when the stock price is \$30, \$35, \$40, and \$50.

2. It is September, and Jones has a short position in Alphacorp stock. The share price is currently 220 and Jones anticipates little movement in the price over the next month, although his long-term view is bearish. To increase his yield from the holding Jones would *most likely* sell:
   A. October 240 calls.
   B. October 240 puts.
   C. October 200 puts.

# MODULE 8.6: COLLARS

Video covering this content is available online.

**LOS 8.f: Discuss the investment objective(s), structure, payoffs, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of the following option strategies: bull spread, bear spread, straddle, and collar.**

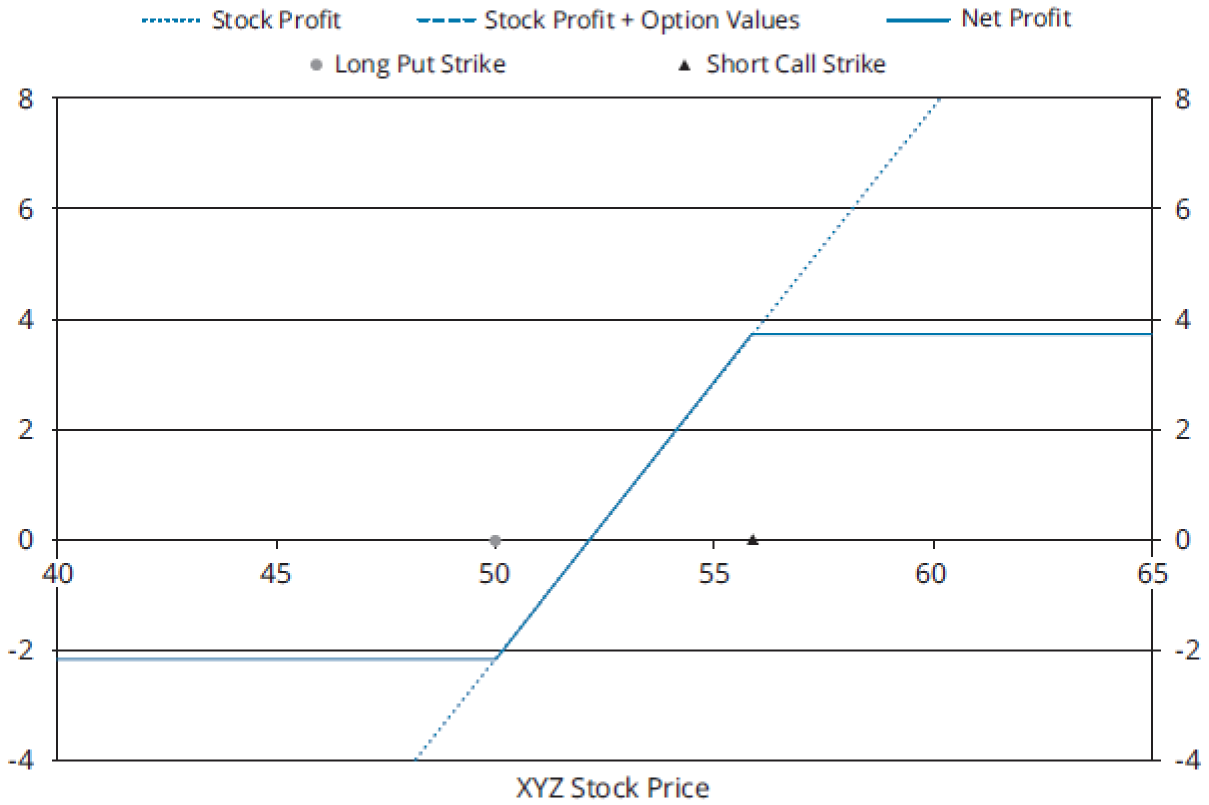
*CFA® Program Curriculum, Volume 2, page 40*

The **collar**[4] is probably best thought of as combination of protective put and covered call.

An investor who is long the underlying could buy a put (most likely OTM) to hedge the stock's downside, while at the same time selling a call (also most likely OTM) to sell off the upside and subsidize the cost of the put.

Usually the put strike is set, then an appropriate call strike is determined such that the call and put have the same premium. If the options are over-the-counter, rather than exchange-traded, this will be easy to do. In this case there will be no net inflow or outflow at initiation and the investor will have constructed a **zero-cost collar**.

For example, consider an investor with a holding of XYZ stock on 20 March (price = $52.14). They buy a June 50 put (premium = $4.88) and sell a June 55.87 call (premium = $4.88). At the June expiration:




Notice, in this case, that the line for stock profit + option values is the same as the net profit line because of the zero net initial premium.

The stock value is hedged beyond the strikes, with a maximum profit equal to the rise from the initial stock price up to the call strike ($55.87 – $52.14 = $3.73) and a maximum loss equal to the fall from the initial stock price down to the put strike ($52.14 – $50 = $2.14). The breakeven stock price is simply the initial stock price of $52.14, as when it was unhedged.

## MODULE 8.7: STRADDLES

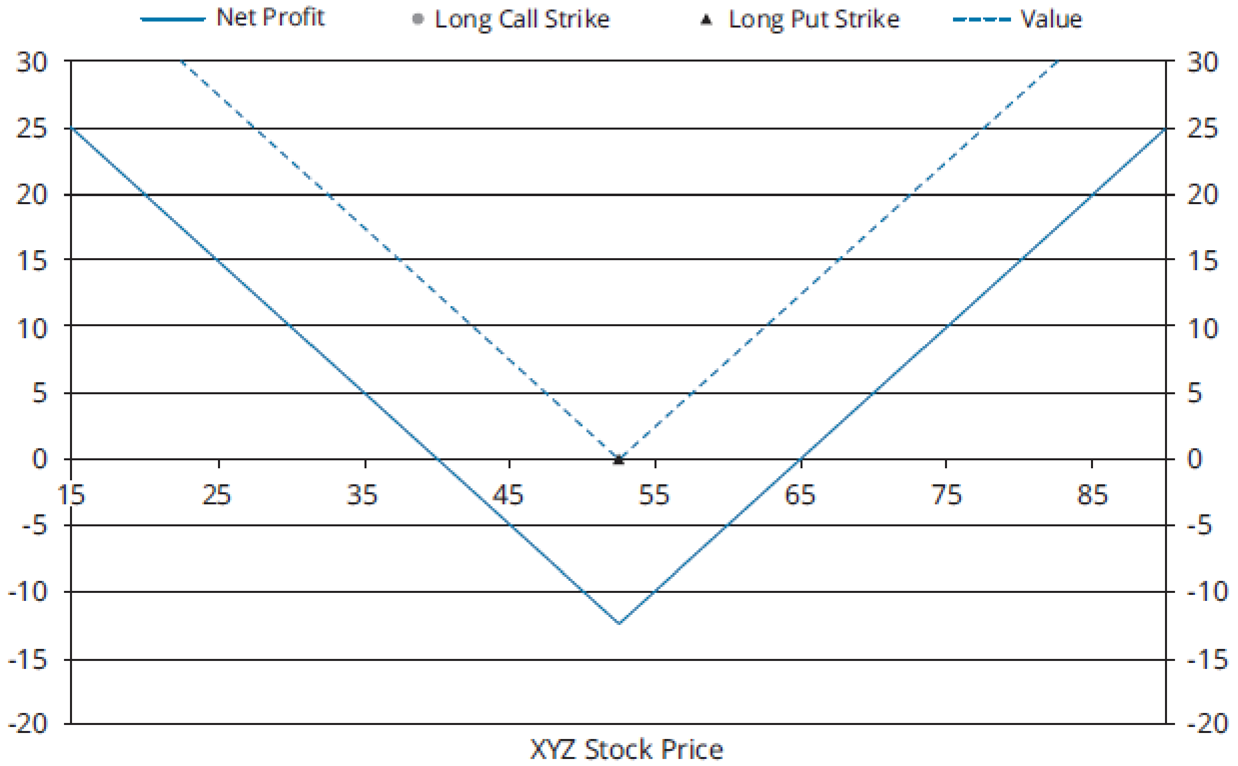
Video covering this content is available online.

The **straddle** is the classic volatility play. A **long straddle** involves the purchase of an equal number of calls and puts on a given underlying. The options all have the same expiry date and strike[5].

Notice that, unlike the strategies we have considered up to now, the straddle (and the spreads that follow) do not involve a position in the underlying—they just use options.

Keeping it simple, let us consider the purchase of a call and a put on one share of XYZ on 20 March. Typically the strike would be close to ATM, so given the stock price is $52.14, let us go long both the June 52.5 call and the June 52.5 put.

At expiration *either* the call *or* the put will be ITM, but not both. The call is ITM for stock prices above 52.50, while the put is ITM for stock prices below 52.50:




The value line for a long straddle is always V-shaped, centered on the strike, where both options expire worthless, so the total value is 0.

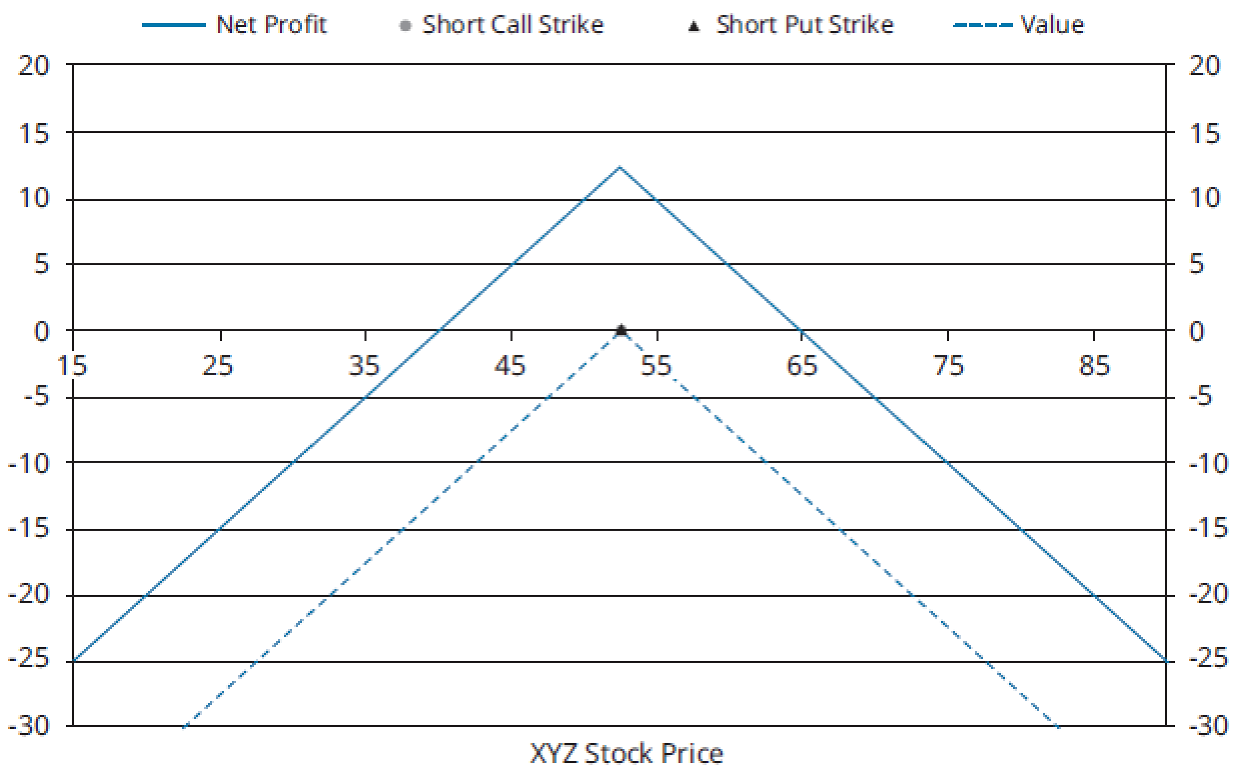
In this case, the premium for the call was \$6.22, while the premium for the put was \$6.19. Both were paid at initiation, so there was a total outlay of \$6.22 + \$6.19 = \$12.41. This is thus the maximum loss (at the strike). The strategy breaks even at expiration when:

- either the call is \$12.41 ITM at \$52.50 + \$12.41 = \$64.91
- or the put is \$12.41 ITM at \$52.50 – \$12.41 = \$40.09

The strategy, if held to expiration, makes larger profits, the further from the strike the underlying ends up (i.e. the more the underlying moves, either way). There is no maximum profit.

A **short straddle** involves selling, instead of buying, and is a neutrality play. It makes more profit the closer to the strike the underlying ends up, with no limit on potential loss.

The at-expiration value and profit for the short XYZ June straddle is shown here:




### MODULE QUIZ 8.6, 8.7

*To best evaluate your performance, enter your quiz answers online.*

1. An investor purchases a stock for $29 and a put for $0.20 with a strike price of $27.50. The investor also sells a call with the same expiration date for $0.20 with a strike price of $30. At expiration of the options:

   a) Calculate the maximum profit and loss and the breakeven price.

   b) Calculate the profit or loss when the price is $20, $25, $28.50, $30, and $100.

2. An investor purchases a call on a stock, with an exercise price of $45 and premium of $3, and a put option with the same maturity that has an exercise price of $45 and premium of $2. At expiration of the options:

   a) Compute the maximum profit, maximum loss, and breakeven price.

   b) Compute the profit or loss when the price is $0, $35, $40, $45, $47, $55, and $100.

3. The EUR is trading at USD 1.035. A trader expects the EUR to become much more volatile than is reflected in current option prices. Puts and calls on the EUR are available. Puts with a strike of USD 0.98 are trading at USD 0.005 and with a strike of USD 1.04 are trading at USD 0.017. Calls with a strike of USD 0.98 are trading at USD 0.068 and with a strike of USD 1.04 are trading at USD 0.004. Compute the at-expiry breakeven price or prices of the correct option strategy.

# MODULE 8.8: SPREADS

Video covering this content is available online.

Bull and bear spreads are positions that have equal numbers of long options on one strike and short options on a second strike. A spread will *either* be constructed using calls *or* using puts.

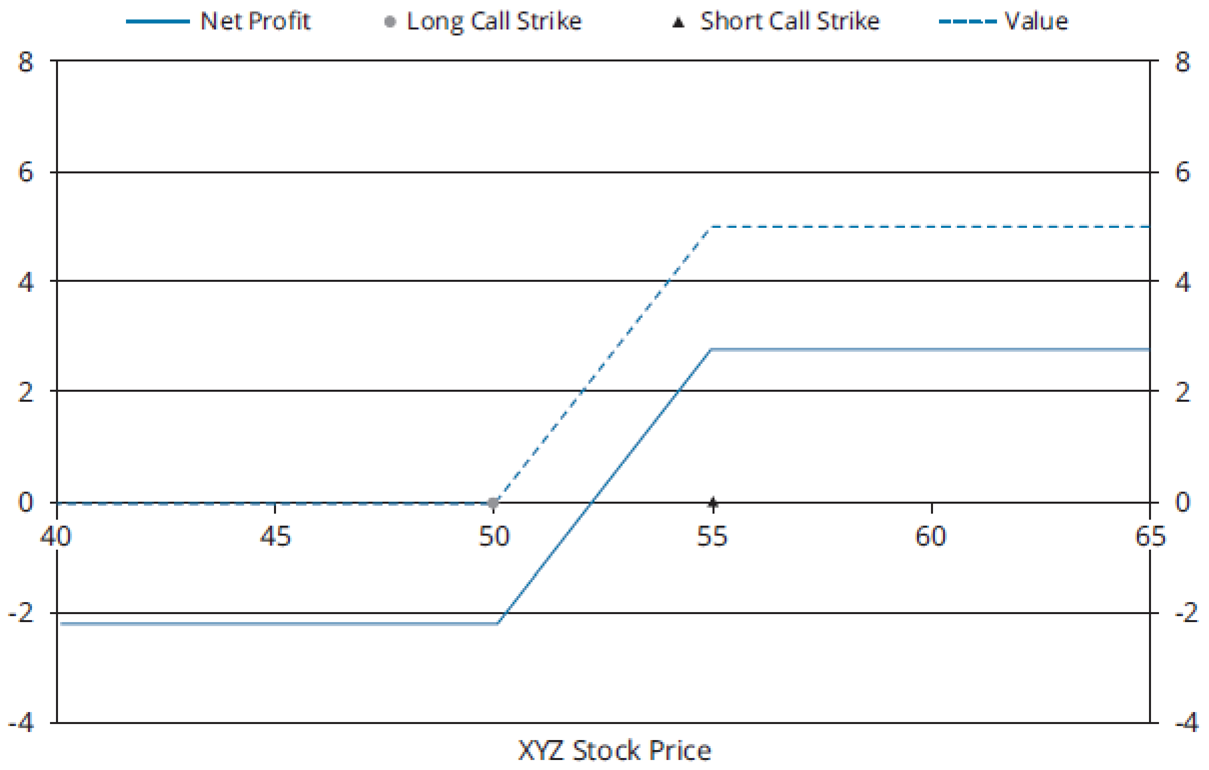
- **Bull** spreads use **long** options on the **lower** strike (**Bul**l = **Buy** **L**ow) and **short** options on the **higher** strike.
- **Bear** spreads use **short** options on the **lower** strike and **long** options on the **higher** strike.

Bear spreads are just short bull spreads, in fact.

## Bull Call Spread

Suppose that on 20 March an investor buys an XYZ June 50 call for $7.40 and sells an XYZ June 55 call for $5.20. This will involve a net outlay of $7.40 – $5.20 = $2.20.

The following diagram shows the value of the position, and the net profit, for a range of stock prices at expiration:




It is clear that the exposure is bullish, but limited, compared to just having a long call at 50.

We can think of the bull call spread as similar to a covered call, but with a long call taking the place of the stock.

Below the lower strike the position has zero value, since both options expire OTM.

Between the strikes only the long call expires ITM, so the value is equal to the difference between the stock price and the lower strike.

At 55 the value will equal 5, the difference between the strikes. This is also the maximum value, since any further upside to the long call is hedged away by the short call, which goes ITM above 55.

The maximum loss (when value = 0) is the net premium paid, $2.20.

Breakeven occurs when the value of the long call exactly compensates for the net premium paid. This will be $2.20 above the lower strike, at $50 + $2.20 = $52.20.

The maximum profit is the maximum value of $5 less the net premium, thus $5 – $2.20 = $2.80.

In general, for a bull call spread:

- Maximum loss = net premium paid

- Breakeven = lower strike + net premium paid
- Maximum profit = difference between strikes – net premium paid

The bull call spread is an example of a **debit spread** since it entails a net outlay: the bought call, with a lower strike, is more valuable than the sold call.

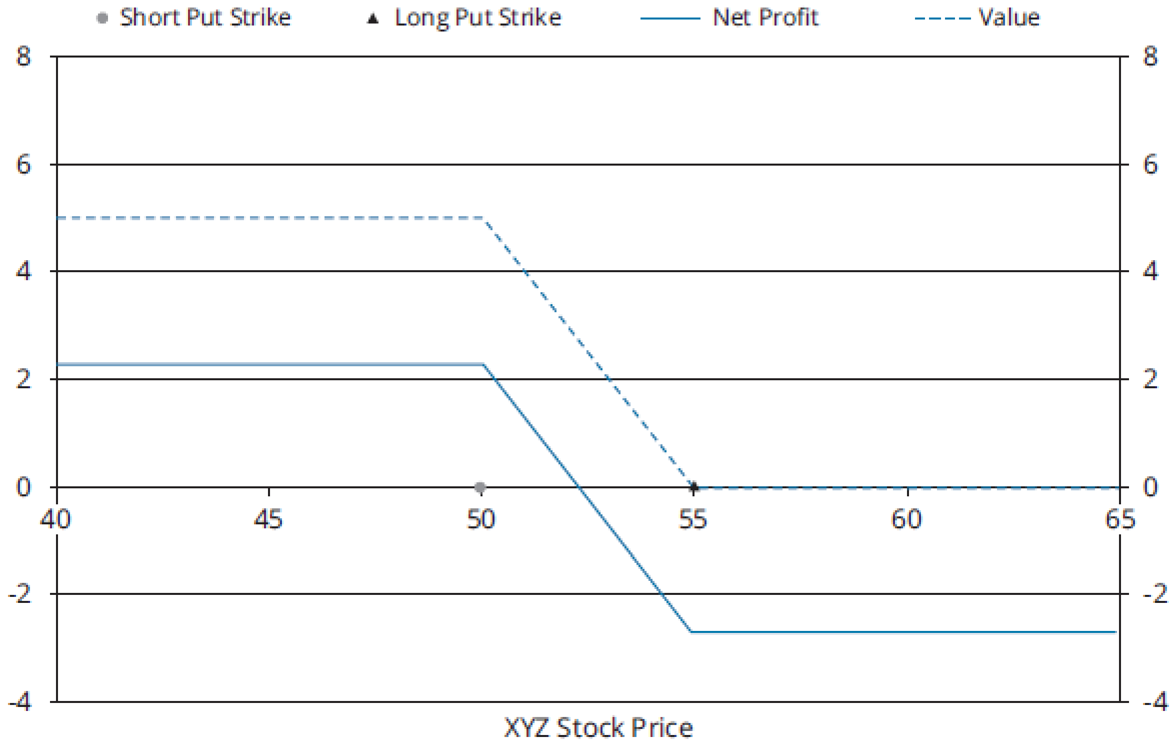
The other debit spread is the bear put spread.

## Bear Put Spread

Here we sell a lower strike put and buy a higher strike put.

Suppose that on 20 March an investor buys an XYZ May 55 put for $6.61 and sells an XYZ May 50 put for $3.87. This will involve a net outlay of $6.61 – $3.87 = $2.74.

Value and profit at May expiration:




It is clear that the exposure is bearish, but limited, compared to just having a long put at 55.

Both options are OTM above the higher strike, for zero value.

Between the strikes the value reflects the moneyness of the long 55 put (how far the stock price is below the upper strike).

At the lower strike, the value is maximized and is hedged at that level for any lower stock price.

For a bear put spread:

- Maximum loss = net premium paid ($2.74 in this case)
- Breakeven = higher strike – net premium paid ($55 – $2.74 = $52.26)
- Maximum profit = difference between strikes – net premium paid ($5 – $2.74 = $2.26)

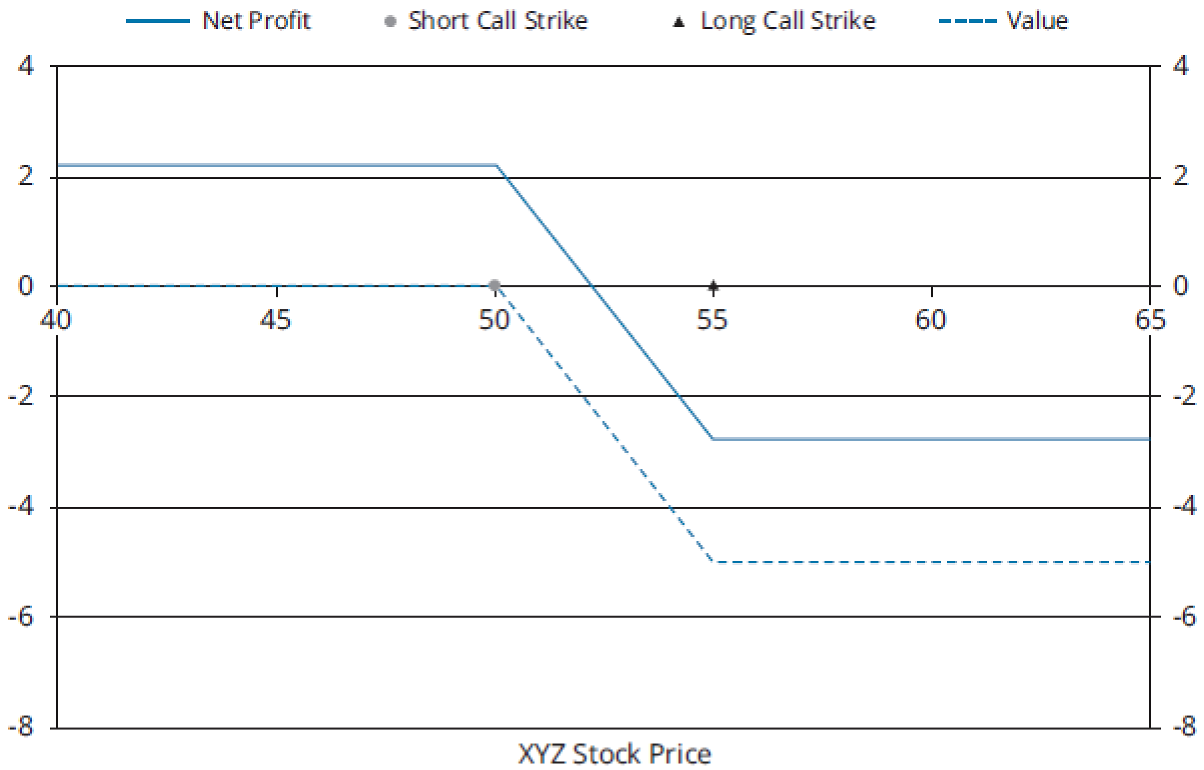
## Bear Call and Bull Put Spreads

It is also possible, of course, to use calls to create a bear spread, or puts to create a bull spread. In both cases there would be a net inflow of premium (since the relatively more valuable option is sold) and they are referred to as **credit spreads**.

### PROFESSOR'S NOTE

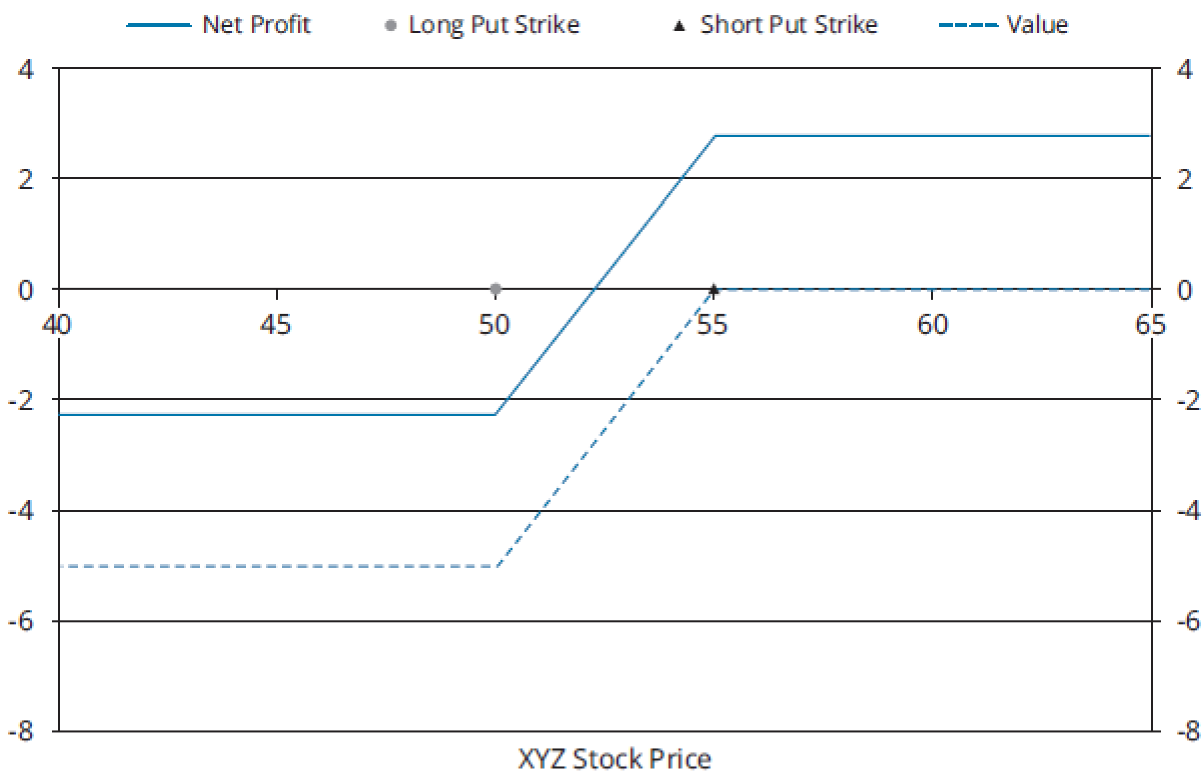
As a general rule, assume that a bull spread would be constructed using calls and that a bear spread would be constructed using puts (i.e. that debit spreads are to be preferred over credit spreads) unless a question states otherwise.

For example, a bear call spread could use a short XYZ June 50 call ($7.40) plus a long XYZ June 55 call ($5.20), with a net initial inflow of $7.40 – $5.20 = $2.20, which is the maximum profit at 50 and below. At 55 and above, the net intrinsic value is –$5, resulting in a maximum loss of $2.80.




- Maximum profit = net premium received
- Breakeven = lower strike + net premium received
- Maximum loss = difference between strikes – net premium received

Similarly, a **bull put spread** is the reverse of a bear put spread, in this case a short XYZ May 55 put ($6.61) and a long XYZ May 50 put ($3.87). At expiration:




- Maximum profit = net premium received
- Breakeven = higher strike – net premium received
- Maximum loss = difference between strikes – net premium received

Beware of credit spreads using American-style options, where there is the possibility of the short option going ITM, while the long option is still OTM, in which case the counterparty might choose to exercise early, which would disrupt the strategy.

## Adding a Short Leg to a Long Position

Both legs of the spread do not necessarily have to be established at the same time, or held for the same length of time. For instance, a trader might have gone long an October 30 call in August, when the stock price was 28, and by September the stock may have risen to 38.5, so that he is already sitting on a potential profit. If at that point he thinks it unlikely that the stock price will rise further, he might sell an October 40 call, effectively cashing in the upside potential he does not think he needs. This is similar to the motivation behind a covered call.

## Generalized At-Expiration Formulas for Spreads

In these formulas, net premium means the absolute value of the difference between the premiums.

For **debit spreads** (bull call and bear put):

- Maximum loss = net premium paid
- Maximum profit = difference between strikes – net premium paid

For **credit spreads** (bear call and bull put):

- Maximum profit = net premium received
- Maximum loss = difference between strikes – net premium received

For **call spreads**, breakeven = lower strike + net premium

For **put spreads**, breakeven = higher strike – net premium

## MODULE QUIZ 8.8

*To best evaluate your performance, enter your quiz answers online.*

1. An investor purchases a call for $2.10 with a strike price of $45 and sells a call for $0.50 with a strike price of $50. At expiration of the options:

   a) Compute the maximum profit and loss and the breakeven price.

   b) Compute the profit or loss when the price is $35, $45, $48, $50, and $55.

2. An investor purchases a put for $4.00 with a strike price of $25.00 and sells a put for $1.80 with a strike price of $20.00. At expiration of the puts:

   a) Compute the maximum profit and loss and the breakeven price.

   b) Calculate the profit or loss when the price is $15, $20, $23.50, $25, and $30.

3. A stock trades at 51. Calls with strike prices of 47 and 53 are priced at 5.25 and 0.75, respectively. Compute the initial investment for a bear spread and the breakeven price or prices of the spread at options expiration.

# MODULE 8.9: DELTA AND GAMMA

Video covering this content is available online.

So far, we have only considered values and profits at the point of option expiration; in so doing, we only had to worry about intrinsic value (thus simple one-for-one relationships).

During their lives, the way in which options respond to changes in the value of the underlying (and other factors) is more complicated, and we will now look at some aspects of this.

## The Greeks

As you should recall, each is a ratio of absolute changes (in each case assuming only the named factor changes):

- **Delta** (Δ) = change in option **price** per +1 change in **stock price**.

  Delta is positive for (long) calls and negative for (long) puts.

- **Gamma** (Γ) = change in option **delta** per +1 change in **stock price.**

  Gamma is positive for (long) calls and for (long) puts.

- **Theta** (θ) = daily change in option **price** (effect of **time passing**).

  Theta is negative for (long) calls and (long) puts.

- **Vega** (ν) = change in option **price** per +1% change in **volatility.**

  Vega is positive for (long) calls and for (long) puts.

Like option premiums, you will not be asked to calculate the values of the Greeks—if needed in a question they would be provided. What is important is an appreciation of the meaning and significance of each one. We will see they help us more fully understand some of the options strategies met in the last few sections.

Recall that **delta** measures the change in the price of an option for a +1 change in the price of the underlying (all other factors held constant).

Taking the XYZ stock options as an example, below is the table of option premiums on 20 March (when the stock price was $52.14) as seen before, together with a table of deltas at the same point in time:

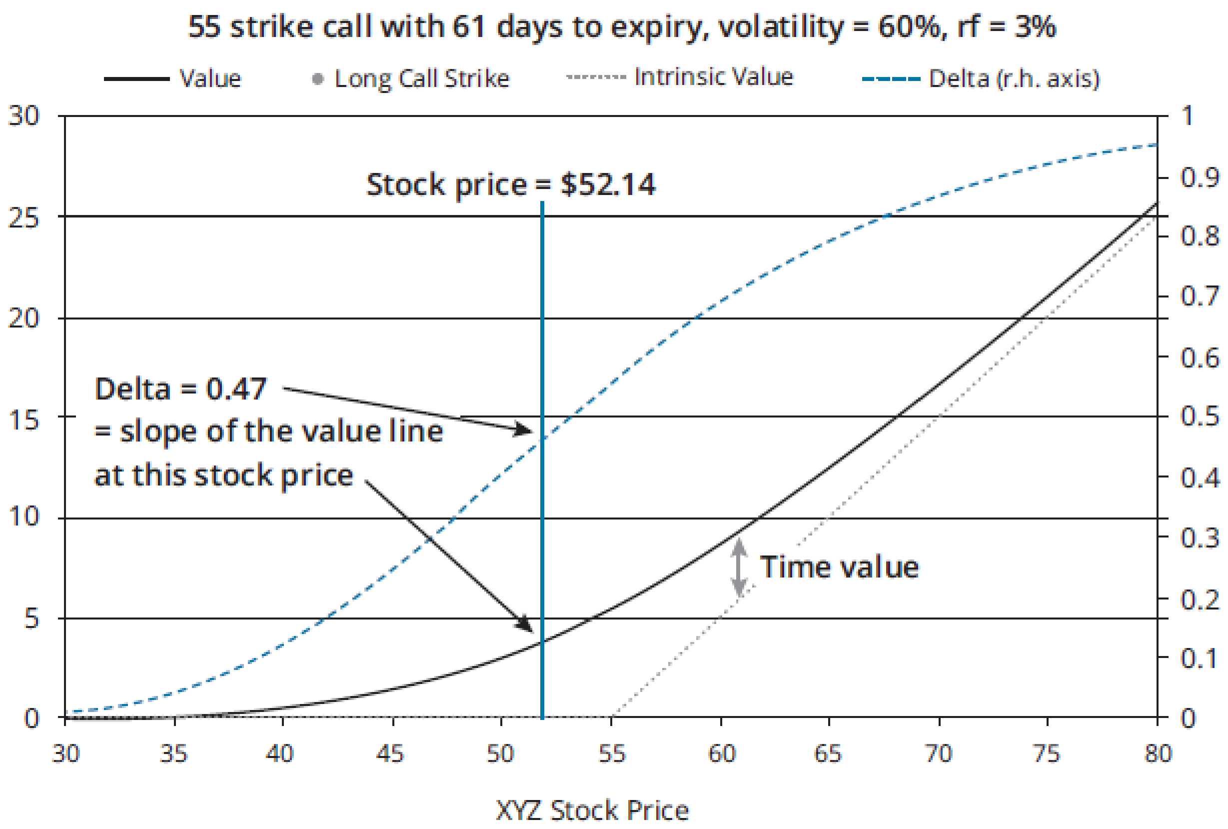
| Call Price | | | Strike | Put Price | | |
|---|---|---|---|---|---|---|
| APR | MAY | JUN | Price | APR | MAY | JUN |
| 4.80 | 6.26 | 7.40 | **50** | 2.53 | 3.87 | 4.88 |
| 3.53 | 5.05 | 6.22 | **52.5** | 3.75 | 5.14 | 6.19 |
| 2.52 | 4.02 | 5.20 | **55** | 5.24 | 6.61 | 7.65 |

| Call Delta | | | Strike | Put Delta | | |
|---|---|---|---|---|---|---|
| APR | MAY | JUN | Price | APR | MAY | JUN |
| 0.634 | 0.623 | 0.623 | **50** | –0.366 | –0.377 | –0.377 |
| 0.525 | 0.546 | 0.560 | **52.5** | –0.475 | –0.454 | –0.440 |
| 0.419 | 0.470 | 0.499 | **55** | –0.581 | –0.530 | –0.501 |

For example, the MAY 55 call has a delta of 0.47, meaning that if the stock price rose by $1 to $53.14 then the MAY 55 call would rise, in principle, by $0.47, to $4.02 + $0.47 = $4.49. Note that all other factors are assumed held constant, in particular, time, so the change has to be *instantaneous*.

In fact, if we recompute the MAY 55 call premium for the $53.14 stock price, the pricing model gives us a figure of $4.51, slightly higher than the $4.49 predicted by delta. This is because the option price line is not a straight line (other than at expiration), with a curvature measured by **gamma**, so delta itself varies with the underlying.

The vertical distance between the (total) value line and the intrinsic value line corresponds to the time value, which is at its greatest around ATM, and diminishes the more the option is ITM or OTM[6]:




Here is the corresponding table for the option gammas on 20 March (at the original stock price of $52.14):

| Call Gamma | | | Strike | Put Gamma | | |
|---|---|---|---|---|---|---|
| APR | MAY | JUN | Price | APR | MAY | JUN |
| 0.041 | 0.030 | 0.024 | **50** | 0.041 | 0.030 | 0.024 |
| 0.044 | 0.031 | 0.025 | **52.5** | 0.044 | 0.031 | 0.025 |
| 0.043 | 0.031 | 0.026 | **55** | 0.043 | 0.031 | 0.026 |

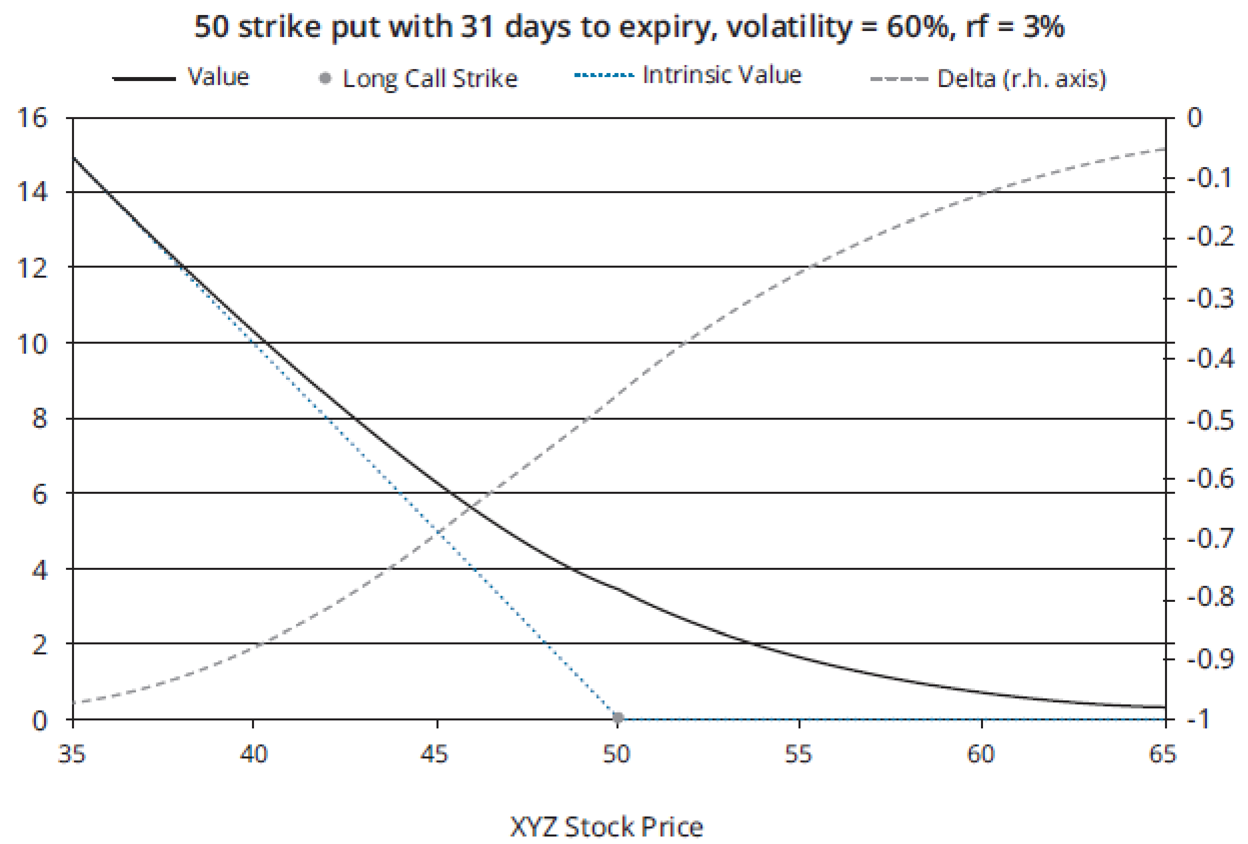
For example, the MAY 55 call has a gamma of 0.031, meaning if the share price were $1 higher, the call's delta would be 0.031 higher: 0.470 + 0.031 = 0.501.

## PROFESSOR'S NOTE

The gamma adjustment is an approximation, in that same way that delta is. They are both only accurate for infinitesimal changes in the underlying price. Delta is the slope of the option price line at the current underlying price (think of it as the slope of the tangent to the line at that point)—as soon as the underlying moves at all, the delta changes. Similarly Gamma is the slope of the line representing delta, and this changes with the underlying, too.

*Don't worry about having to do this calculation, but if Delta at the $52.14 stock price is 0.470, while it is 0.501 at the $53.14 price, then the average delta between those stock prices is (0.470 + 0.501)/2 = 0.486, so we could predict that the call value $1 above $52.14 would be $4.02 + $0.486 = $4.506, which is much closer than when we just used the initial value of delta.*

The same principles apply to puts, of course. The following graph shows value and delta for the XYZ APR 50 (long) put (also on 20 March):

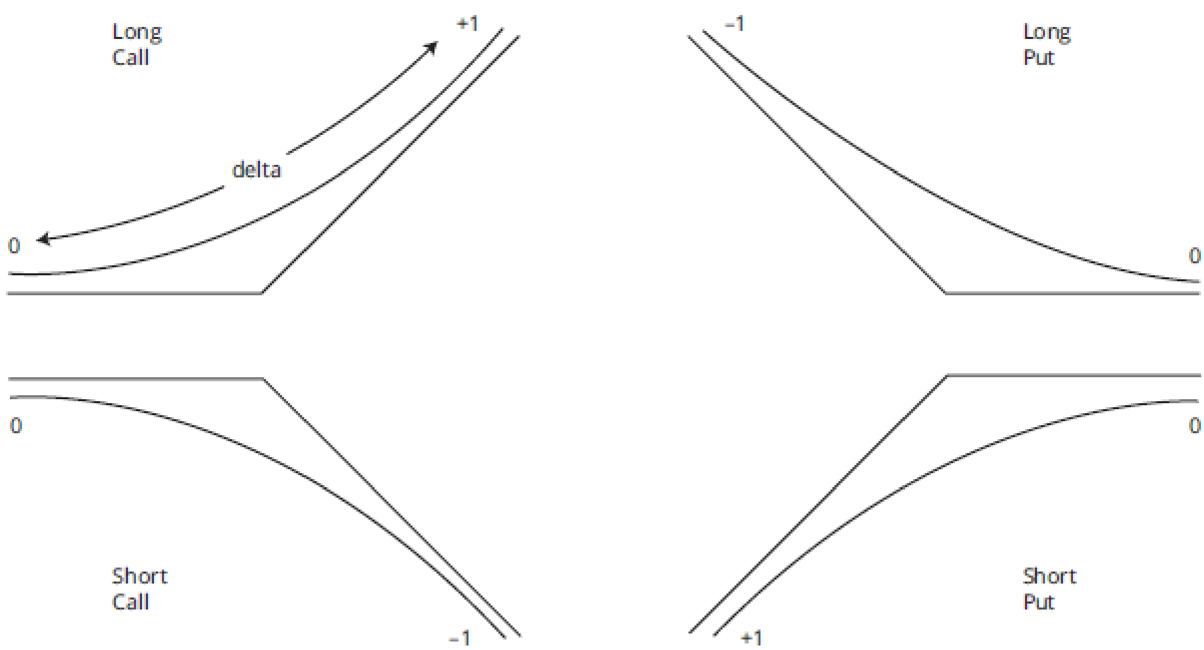



Puts (long) have negative delta, since the line slopes downwards, but there is a simple rule that applies to both calls and puts regarding the absolute size of delta (i.e. ignoring the sign):

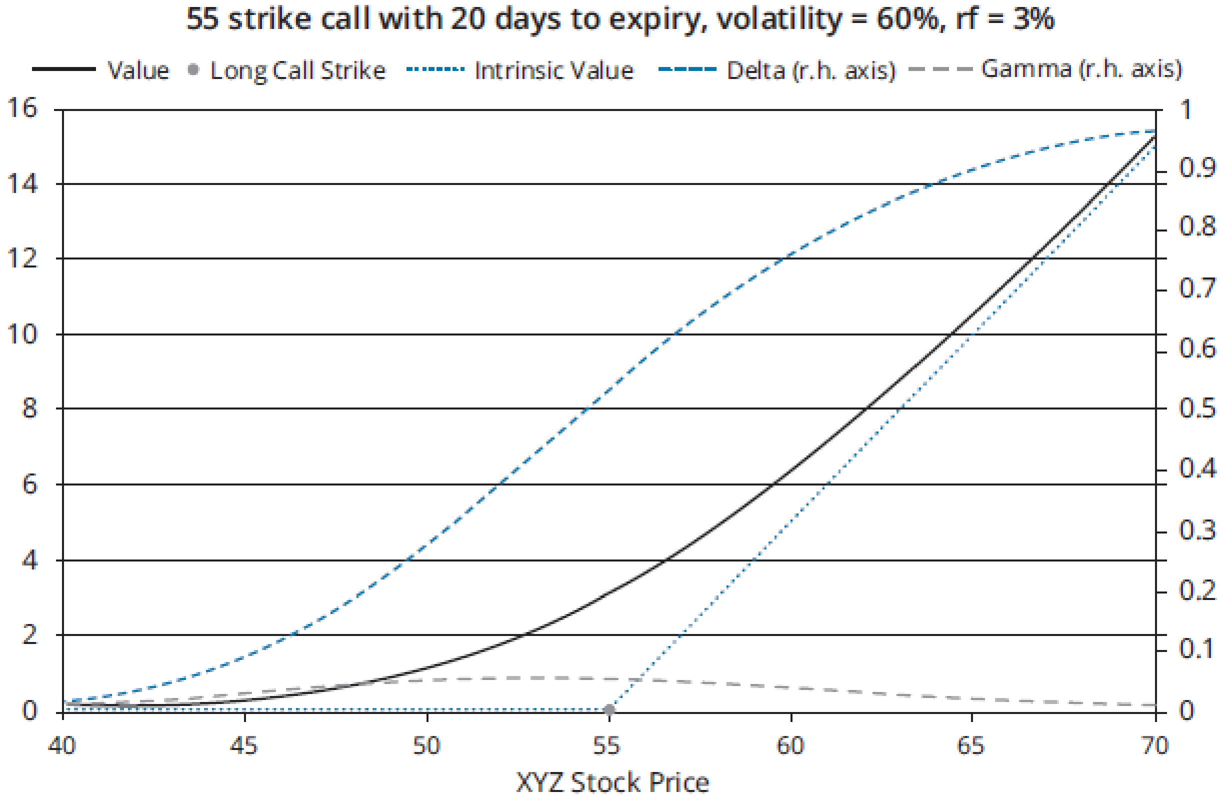
All other factors held constant:

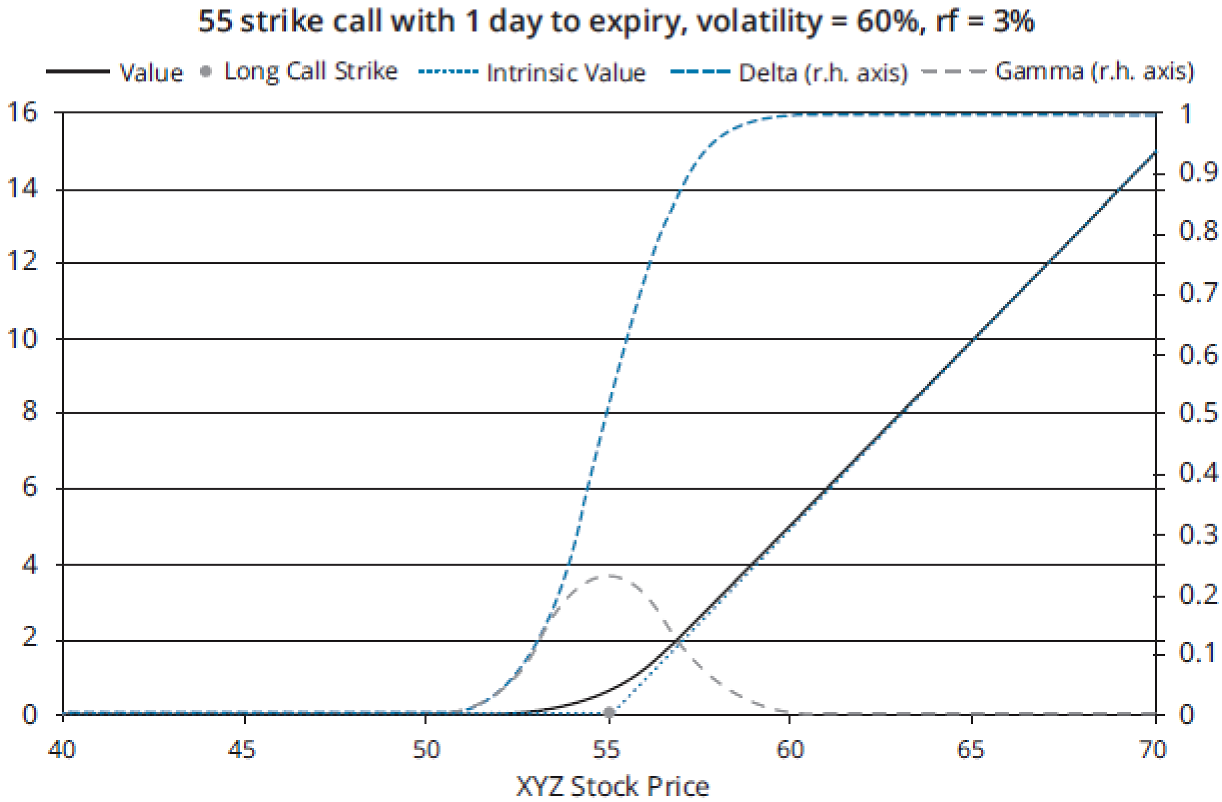
- The **more ITM** is an option, the **higher** is its (absolute) delta (closer to 1).
- The **more OTM** is an option, the **lower** is its (absolute) delta (closer to 0).

The following diagram summarizes the ranges of values of delta for long and short calls and puts:



Gamma is trickier to generalize, but it tends to be higher the closer to ATM an option, **and is at its greatest for ATM options that are close to expiration**. For instance, the following graphs illustrate the same call, first with 20 days to expiration and then with one day to expiration when, with much less time remaining (so much less time value), the option premium line is crammed into a narrow range either side of the strike price, so gamma is highest over that range:



## Deltas for the Underlying and for Futures and Forwards on the Underlying

It follows directly from the definition of delta that:

- The delta of a **long** position in one unit of the underlying is **+1**.
- The delta of a **short** position in one unit of the underlying is **–1**.

Futures and forwards on underlyings that pay no yield (e.g. nondividend paying stocks) are essentially proxies for the underlying, so they also have deltas of +1 (if long) and –1 (if short). All the examples we consider in this reading use underlyings of this sort.

## Position Deltas

**LOS 8.d: Compare the delta of covered call and protective put positions with the position of being long an asset and short a forward on the underlying asset.**

*CFA® Program Curriculum, Volume 2, page 24*

The overall (or portfolio) delta for a combination of options and positions in the underlying is computed by adding up the individual deltas (being careful with the signs).

For example, a holding of 100 shares in XYZ will have a delta of 100 × +1 = +100. That is, if the stock price rises $1 then the position value will rise by $100.

### PROFESSOR'S NOTE

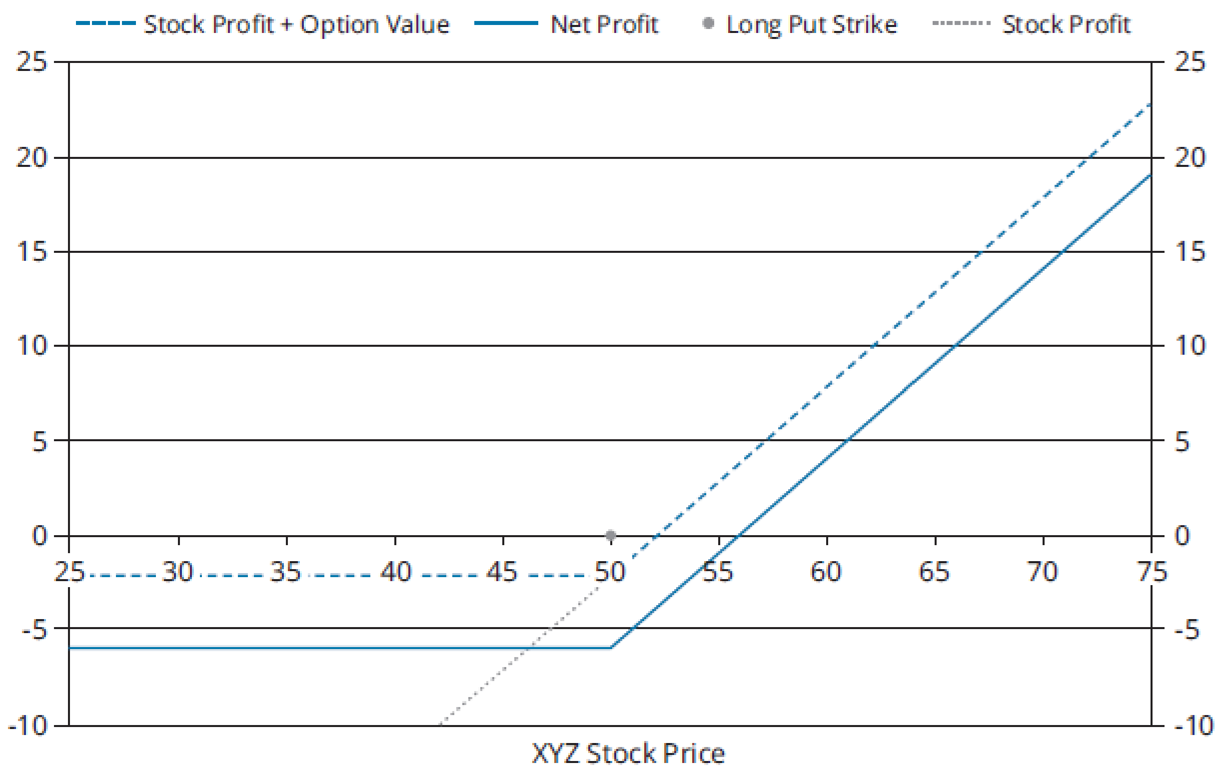
Unless told otherwise, assume that a traded stock option contract is a right over 100 shares. So a long position in an XYZ call option contract, where the option delta is +0.65, would have a position delta of 100 × +0.65 = +65.

A holding of 1,000 shares in XYZ, plus a long position in 10 XYZ put contracts (delta = –0.6), has a position delta of (1,000 × +1) + (10 × 100 × –0.6) = 1,000 – 600 = 400. Some of the stock's exposure is being offset by the negative exposure given by the puts.

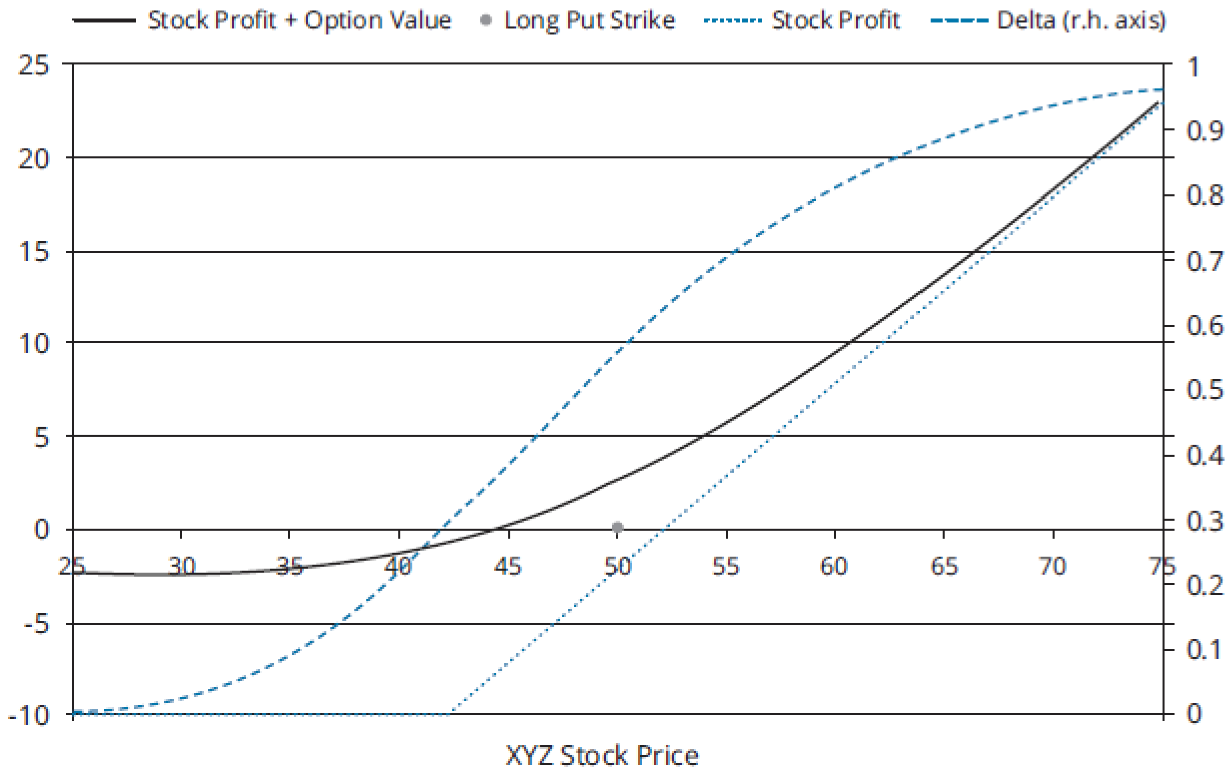
If the stock price falls $1, then the shares lose $1,000, but the net position value will only fall $400.

## Protective Put Pre-Expiry

In the earlier section, where we concentrated on value at expiration, we thought of a protective put as a strategy that retains the full stock exposure above the strike price, but completely hedges below the strike price. For example a protective put on the XYZ stock, using the May 50 put (premium = $3.87), looks like this at expiration (assuming one share plus a long put on one share):




However, before expiration, the protective put is better thought of as modifying the delta of the long stock from its unhedged value of +1:

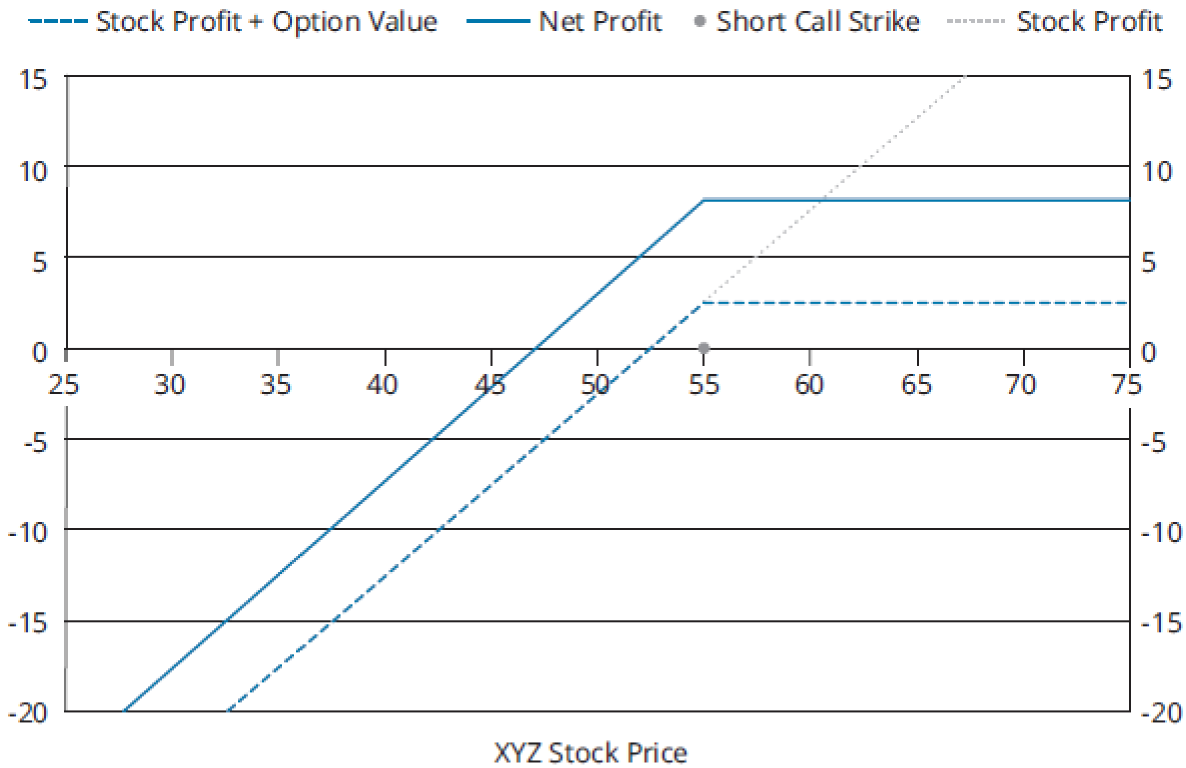


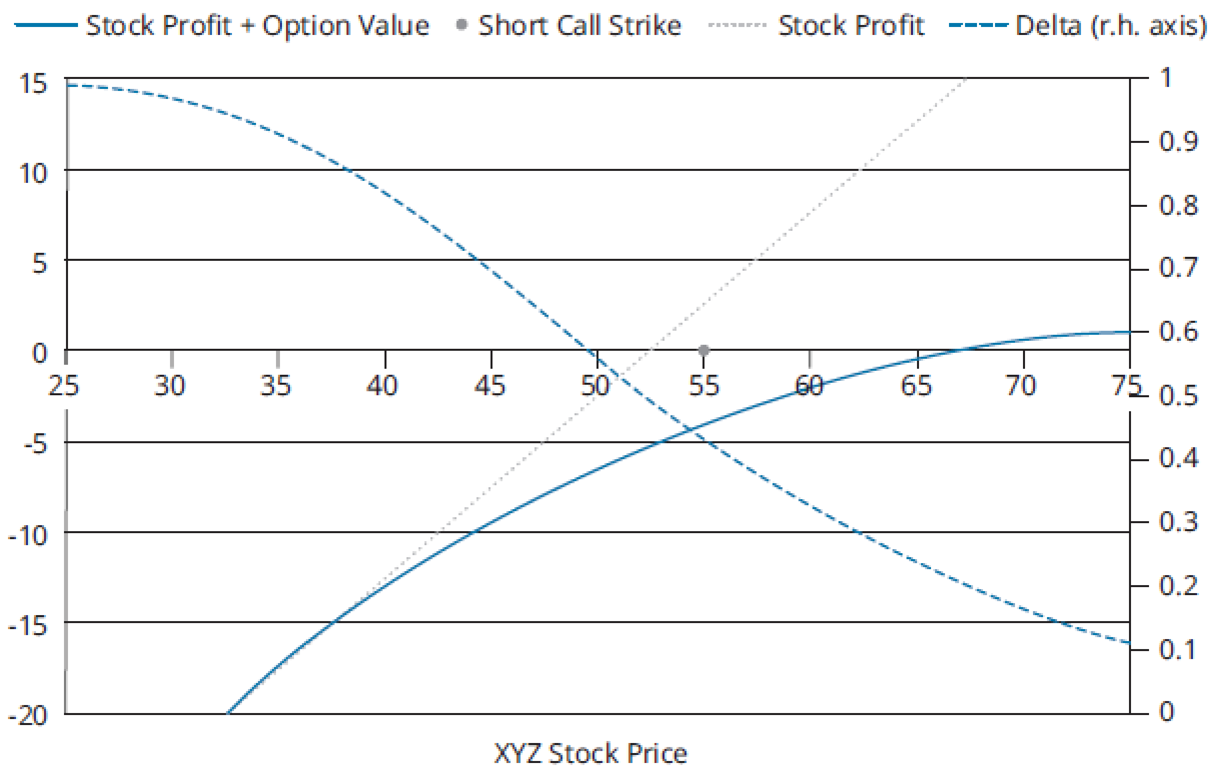

This graph shows the impact of the option value (ignoring the premium paid) on the gain/loss position for the stock at the point the option position was set up on 20 March. The net effect is that for large rises in the stock, the option moves substantially OTM, and the position delta tends towards +1 (so we have almost the same exposure as from the unhedged stock), whereas for large falls in the stock the option moves to being substantially ITM, and the delta tends towards 0 (protecting against the stock's downside). Notice that the stock plus the protective put has a net exposure equivalent to a long call.

Had we, instead, undertaken a forward contract-based hedge of the stock (selling forward against the long stock position) then, given that our forward position would be on exactly the same number of shares as we were holding, we would obtain a position delta of *number of shares × (delta of long stock + delta of short forward) = number of shares × (+1 + −1) = 0*, and would be completely hedged against price movements.

## Covered Call Pre-Expiry

Similarly, we can compare a covered call (XYZ June 55) at expiration and earlier in the option's life:

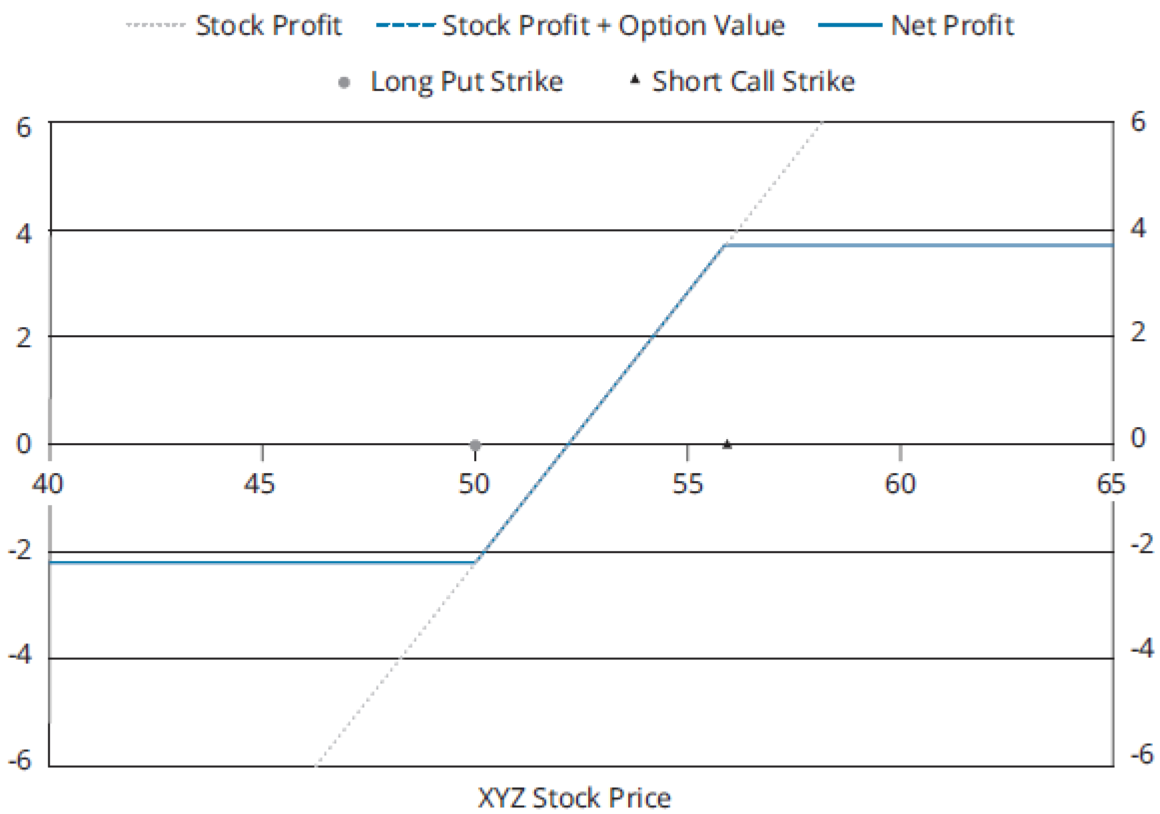


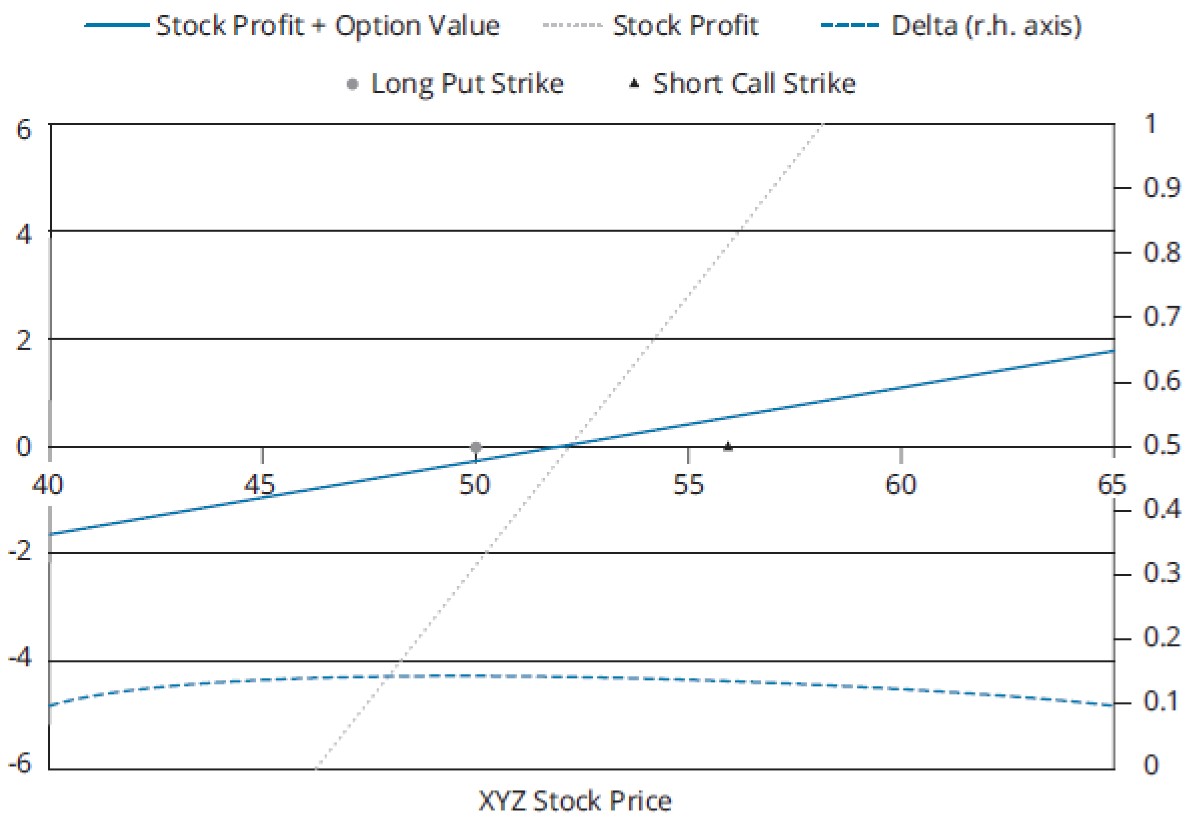



As with the protective put, the position delta varies from close to +1 (when the call is deeply OTM) to close to 0 (when the call is deeply ITM, and virtually all of the stock's upside is hedged away).

## Collar Pre-Expiry

Here is a collar [XYZ stock, long June 50 put (premium = $4.88), short June 55.87 call (premium = $4.88)] shown in the same way, at expiration, and at initiation (91 days before expiration):

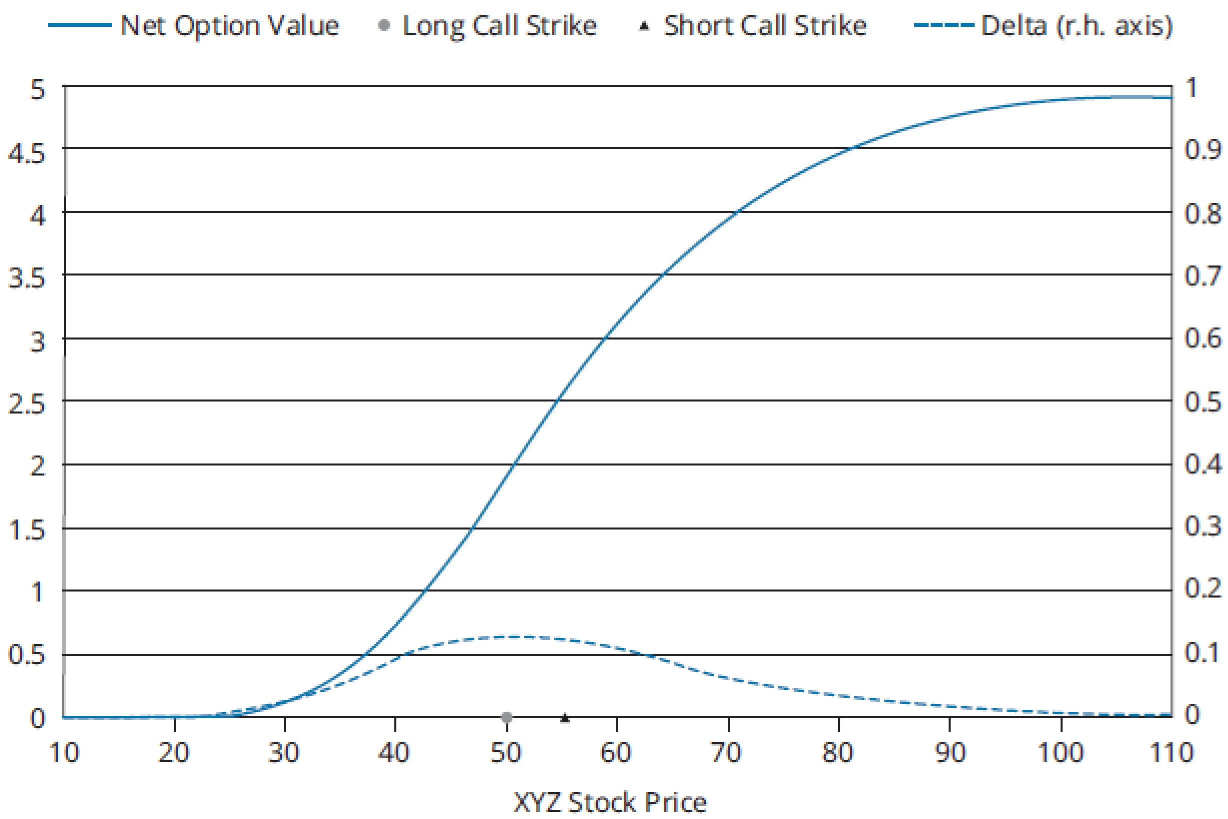





Pre-expiry the impact of the collar is to considerably dampen down the variability of the position (to about 15–20% of its unhedged level, in this case).

## Bull Call Spread Pre-Expiry

Here is the value and delta for the XYZ bull call spread (long 50 call and short 55 call) at the point the strategy is initiated, 91 days pre-expiration:



It is still clear why it is bullish in outlook, but the exposure is highly muted, compared to the position at expiration (look at the values for delta). Notice the resemblance to the position for the collared stock. Something very similar would be seen for the other bull and bear spreads.

### PROFESSOR'S NOTE

Detailed calculation questions are extremely unlikely for pre-expiry scenarios such as these, given how complex is the behavior of the options during their lives, in contrast to the relatively simple at-expiration scenarios.

### MODULE QUIZ 8.9

*To best evaluate your performance, enter your quiz answers online.*

1. Which of the following would most likely be possible deltas for covered call and protective put positions, just after they were established with three months to expiration?
    A. Both have deltas of zero.
    B. The covered call has a delta of 0.4, and the protective put has a delta of 0.45.
    C. The covered call has a delta of 0.35, while the protective put has a delta of –0.4.

## MODULE 8.10: THETA AND VEGA

Video covering this content is available online.

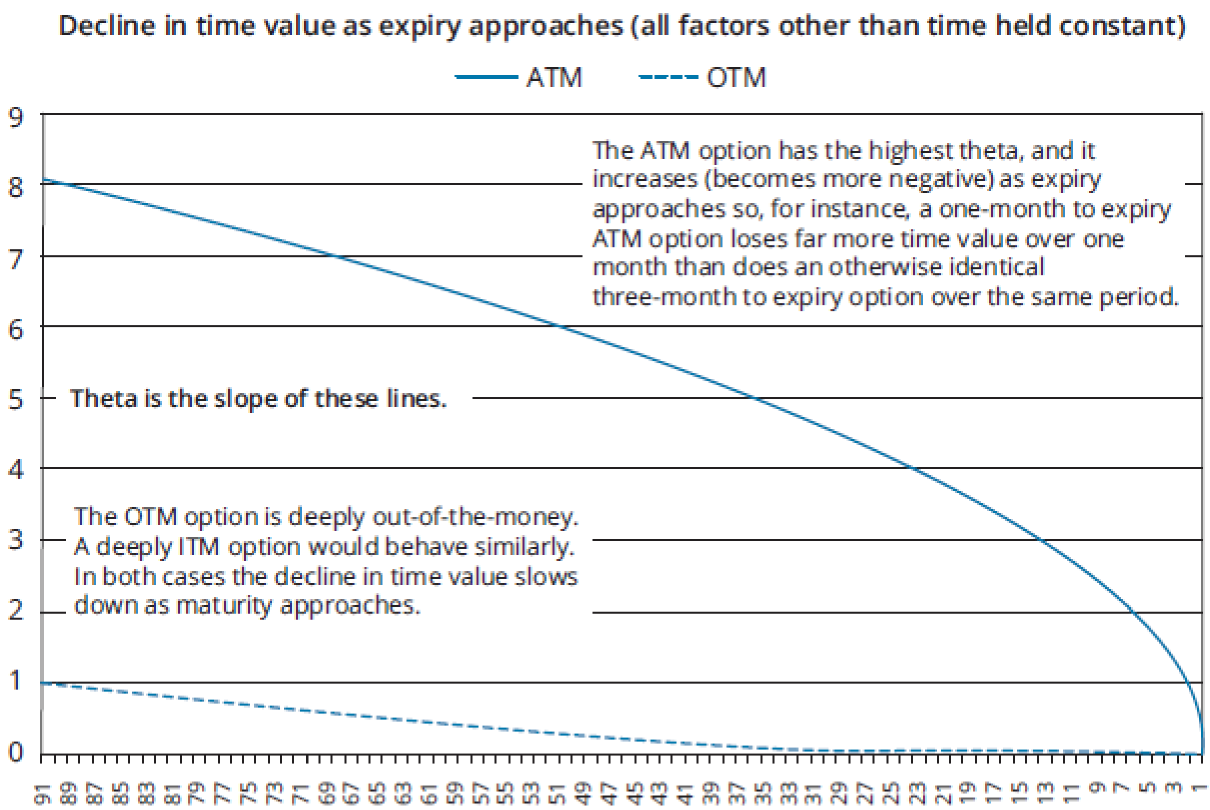
### Theta

Theta measures how quickly an option loses value as time passes. For our old friends the XYZ stock options on 20 March the thetas are:

| Call Theta | | | Strike | Put Theta | | |
|---|---|---|---|---|---|---|
| APR | MAY | JUN | Price | APR | MAY | JUN |
| –0.058 | –0.042 | –0.035 | **50** | –0.054 | –0.038 | –0.031 |
| –0.061 | –0.043 | –0.036 | **52.5** | –0.056 | –0.039 | –0.031 |
| –0.059 | –0.043 | –0.036 | **55** | –0.055 | –0.039 | –0.031 |

Notice that they are all negative: all other factors equal, less time to expiration means less time value.

Theta changes as the time passes. Options that are close to ATM have the highest thetas (in absolute terms), and these increase as expiration approaches (all other factors being held constant). In other words ATM options lose time value at an increasing rate as they mature. Here is an illustration, the horizontal axis is number of days to expiry, and the vertical axis is time value:




## Calendar Spreads

### LOS 8.g: Describe uses of calendar spreads.

*CFA® Program Curriculum, Volume 2, page 46*

In the spreads we have looked at so far, the options all expired at the same point (as well as being on the same underlying). **Calendar spreads** are the only examples we consider of option strategies where the options have different expirations.

The basic motivation with calendar spreads is to exploit the difference in **theta** between close-to-expiry and more-distant-from-expiry options.

For options that are near to ATM, the nearer-dated options will have a higher absolute value of theta (more negative) than longer-dated options.

A long calendar spread entails buying longer-dated options and selling shorter-dated options with the same strike and underlying. In principle the premium on the shorter-dated should fall faster than the premium on the longer-dated. Thus more value is gained on the short position than is lost on the long position, and a net profit is realized.

The options need to be close to ATM so the thetas are the right way around, and little movement should be anticipated in the underlying over the period to expiry of the nearer-dated option (large movement might undermine the profit from the strategy). Both options will either be calls or puts, and the choice between calls and puts will reflect the investor's view on the longer-term prospects for the stock (calls if bullish, puts if bearish).

EXAMPLE: **Long calendar spread**

Suppose that on 20 March, when the XYZ stock price is $52.14 Jenkins has a long-term bullish view on the XYZ stock price, but that over the next month he anticipates very little price movement.

He buys 4 XYZ June 52.5 call contracts (on 100 shares) at 6.22, and sells 4 XYZ April 52.5 call contracts for \$3.53. The net premium outlay is \$2.69 × 4 × 100 = \$1,076.

If at the April call's expiry the stock price is still \$52.14, both calls will be OTM and the April call will expire worthless. Assuming all other factors are unchanged, the June call will now be worth \$5.00 (this is derived from the pricing model and, if needed, would be given in a question).

Jenkins will now have a position worth \$5 × 400 = \$2,000, having paid only \$1,076 a month earlier. The profit would be even higher if implied volatility rose, since that would drive the June call value higher.

A short calendar spread entails selling longer-dated options and buying shorter-dated options with the same strike and underlying. When options are sufficiently ITM or OTM the thetas are relatively higher for the longer-dated options, so this time the belief is that the longer-dated options will lose time value relatively more rapidly, thus the position as a whole should gain.

The short calendar spread strategy is vulnerable, however, to the underlying moving so the options end up ATM when the shorter-dated option expires (so the longer-dated option premiums rise, unless implied volatility also falls, and overall there is a loss since we are short). If the stock moves at all during the period of the strategy, it would be better for it to move a lot.

In both cases, the strategy is fundamentally the same: to sell the options that are expected to fall relatively faster as time passes.

In general:

- A long calendar spread will benefit from a stable market or an increase in implied volatility.
- A short calendar spread will benefit from a big move in the underlying market or a decrease in implied volatility.

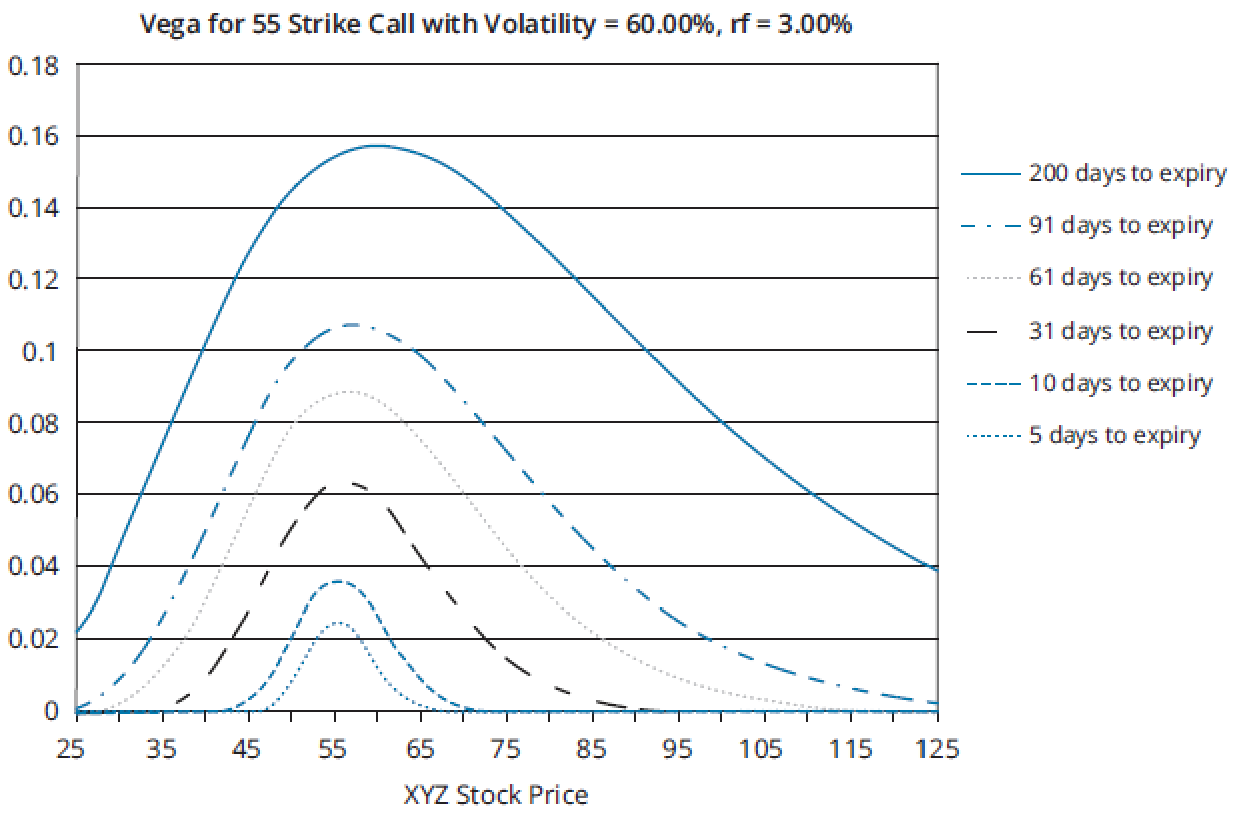
## Vega

Vega measures the effect of a 1% increase in volatility on the value of the option. The vegas for the XYZ stock options on 20 March are:

| Call Vega | | | Strike | Put Vega | | |
|---|---|---|---|---|---|---|
| APR | MAY | JUN | Price | APR | MAY | JUN |
| 0.057 | 0.081 | 0.098 | **50** | 0.057 | 0.081 | 0.098 |
| 0.060 | 0.084 | 0.102 | **52.5** | 0.060 | 0.084 | 0.102 |
| 0.059 | 0.084 | 0.103 | **55** | 0.059 | 0.084 | 0.103 |

Vegas are always positive: a more volatile underlying makes all the options on it more valuable (because there is more uncertainly about how things will turn out at expiration, thus more time value).

All other factors constant, vega is higher the more time there is to expiry, but it diminishes the further ITM or OTM the option is. For example:



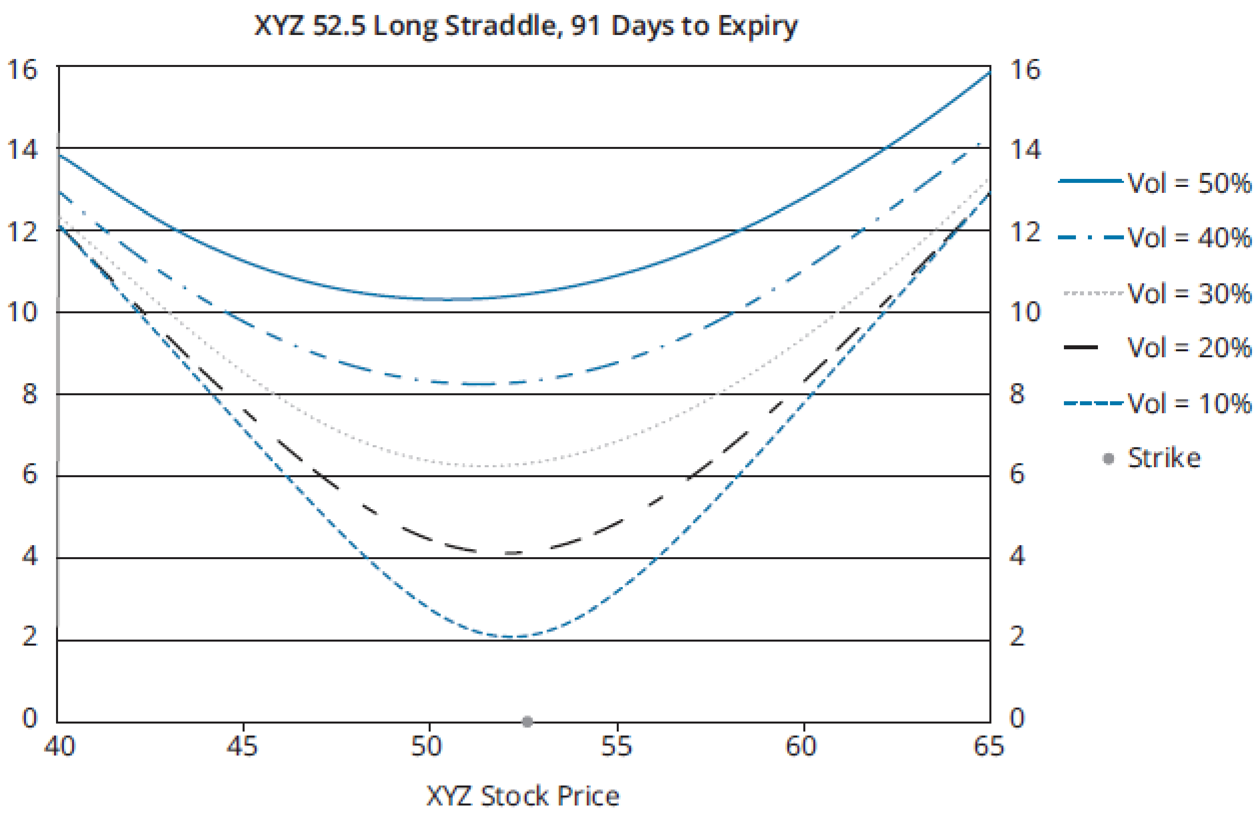

## An Aside on Calculating Volatility

In converting between volatility (standard deviation) values for different time periods we multiply the volatility number by the **square root** of the ratio between the period lengths. For example, if we have used our pricing model to compute an annualized implied volatility of 57% from the value of an option expiring in two months (of, say, 42 trading days), then assuming a 252-day trading year we could derive an expected two-monthly volatility of $57\% \times \sqrt{\frac{42}{252}} = 23.27\%$.

Converting from monthly (21 days) to annual, on the other hand, would entail multiplying by $\sqrt{\frac{252}{21}}$.

## Straddle Pre-Expiry

Earlier on we looked at the values and profits for long and short straddles at expiration. Let us now briefly look at the behavior of the value of a (long) straddle pre-expiration. We see that, at a given level of volatility the value varies with the underlying in a more subtle way than the V-shape we saw at expiry. It is still the case that value increases the further the underlying price is from the strike price, but the slope of the line (i.e., the delta) near the strike is close to zero, tending towards +1 as the underlying increases, and towards −1 as the underlying decreases. In particular note how, at a given point in the option's life, the level of volatility can have a dramatic effect on the value of the position:




In particular this means that if a straddle is bought, and then volatility increases, the position is likely to rise in value, even if nothing happens to the price of the underlying. This is the real reason why we refer to a long straddle as going long volatility.

Having both a call (with positive delta) and a put (with negative delta) means that we can have a position with a delta close to zero (**delta-neutral**, so we do not care what happens to the underlying price, within reason) but with positive vega.

Beware, however, that with two long options we will have negative theta, which means that the value will fall over time. The volatility must rise quickly enough to compensate for this.

Similarly, a short straddle, where both options are sold, can be delta-neutral but vega-negative, which would be a bet on falling volatility.

## MODULE 8.11: VOLATILITY SKEW AND SMILE

Video covering this content is available online.

**LOS 8.h: Discuss volatility skew and smile.**

*CFA® Program Curriculum, Volume 2, page 48*

The option prices that we have been using for the XYZ options were calculated assuming a volatility of 30% for all the expirations and strike prices. This was for simplicity.

In practice, if implied volatility is computed for actual traded options on a particular underlying (e.g. a stock) the option prices for different expirations and strike prices are likely to imply differing values of volatility (and implied volatilities likely differ between calls and puts, too).

Holding expiration date constant, there are two often-observed patterns in the relationship between implied volatility and strike price:

- A **volatility smile** is where the further-from-ATM options have higher implied volatilities, so we would see a U-shaped (smiling) curve if implied volatility were plotted against strike.

  This is less common, however, than volatility skew.

- A **volatility skew** is where implied volatility increases for more OTM puts, and decreases for more OTM calls. This is explained by OTM puts being desirable as insurance against market declines (so their values are bid up by higher demand, and higher values imply higher volatility), while the demand for OTM calls is low.

Deviations in the skew from historical levels can be used to draw conclusions about market sentiment:

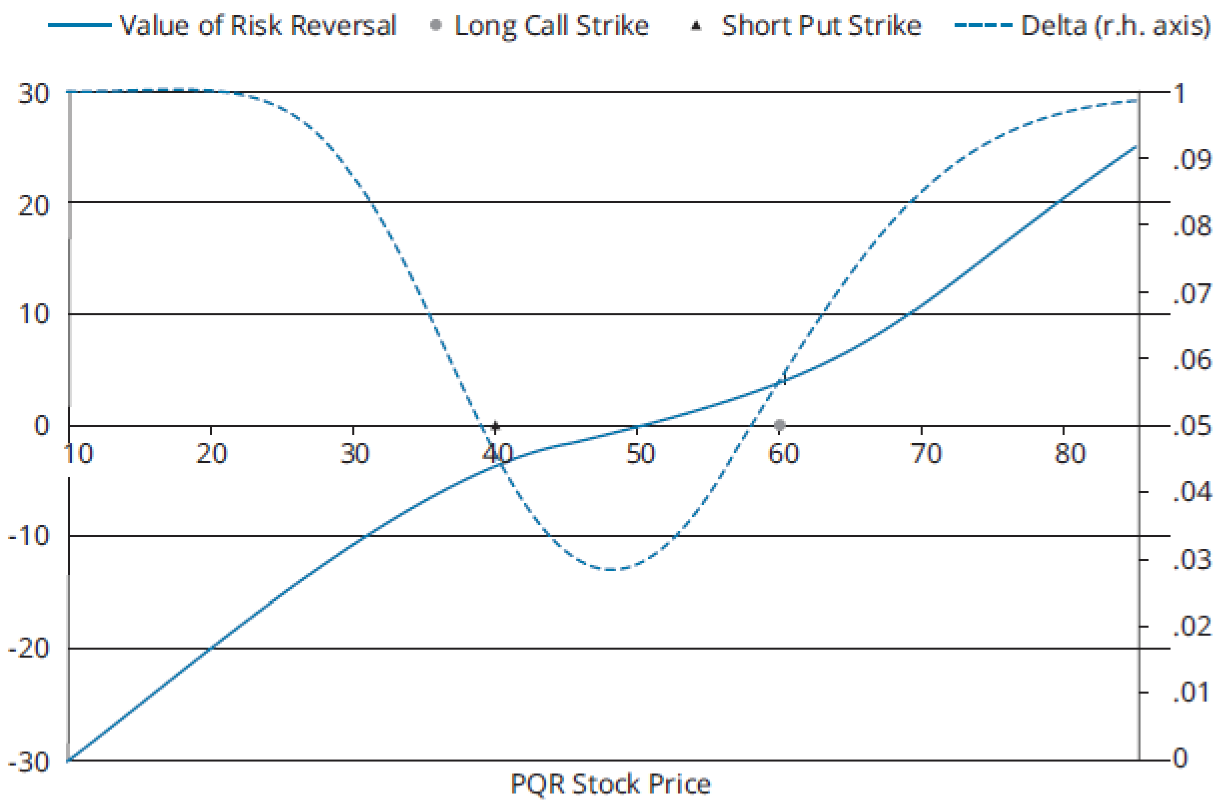
- A sharp increase in the level of the skew, plus a surge in the absolute level of implied volatility, is an indicator that market sentiment is turning bearish.
- Higher implied volatilities (relative to historical levels) for OTM calls indicate that investors are bullish, so the demand for OTM calls to take on upside exposure is strong.

Deviations that are expected to correct could form the basis of trading strategies, which might involve the use of risk reversals.

A long (short) **risk reversal** combines long (short) calls and short (long) puts on the same underlying.

For example, if a trader believes that put implied volatility is relatively too high, compared to that for calls, a long risk reversal could be created by buying the OTM call (seen as relatively underpriced) and selling the OTM put (seen as relatively overpriced) for the same expiration. This would create a broadly long exposure to the underlying, which could be problematic.

The following diagram shows values and deltas for a risk reversal on PQR stock. The PQR price is currently 50 and the call is bought at a strike of 60, while the put is sold at 40. The call's implied volatility is 50%, while the put's implied volatility is 70%. Suppose that this differential is substantially greater than we have seen in the past.




Do not worry about the precise details here, but notice that, at the current stock price of 50, the risk reversal has a delta considerably less than one. Suppose it equals 0.3, and the strategy involves 10 call contracts and 10 put contracts (each on 1,000 shares). For each $1 fall in the stock price the risk reversal will lose roughly $1 × 0.3 × 1,000 = $300.

The aim of the strategy is to make money if the anomalous relationship among the implied volatilities corrects (we went long the options that should gain value and short the options that should lose value if this happens). We were not aiming to bet on the stock price moving, but we have a net long exposure to the stock. To remove this exposure to the stock one further trade is necessary: the sale of 300 shares.

Why 300 shares? Because such a short position will experience equal and opposite gains/losses to the risk reversal, and will thus hedge the exposure to the stock price. This kind of hedge is called a **delta hedge** because the size of the position on one side of the hedge is adjusted to compensate for the delta of the position on the other side. 1,000 shares' worth of options with a delta of 0.3 are delta-hedged by 1,000 × 0.3 = 300 shares.

Note that the delta of the risk reversal will not stay constant (for example it changes as the stock price changes, and as time passes) and the size of the delta-hedge position will need to be adjusted (this is typical of delta hedges; they are **dynamic hedges** and require periodic rebalancing).

Finally, be aware of two further pieces of terminology:

- There is a **term structure of volatility**, where implied volatilities differ across option maturities (*contango* is quite common, with longer-dated options having higher implied volatilities).
- An **implied volatility surface** uses a three-dimensional graph, with implied volatility on the z-axis, to examine the joint influence of maturity (x-axis) and strike price (y-axis).

## MODULE QUIZ 8.10, 8.11

*To best evaluate your performance, enter your quiz answers online.*

1. An investor has a long-term bearish view on the Acme stock price, but over the next two months he anticipates very little price movement. An appropriate strategy to benefit from this view would be to:
   A. buy ATM calls on Acme with two months to expiry and simultaneously sell ATM calls on Acme with five months to expiry.
   B. sell ATM puts on Acme with two months to expiry and simultaneously buy ATM puts on Acme with five months to expiry.
   C. buy OTM calls on Acme with two months to expiry and sell OTM puts on Acme with two months to expiry.
2. Which of the following statements is *most correct*?
   A. A long straddle is a strategy based on the implied volatility smile, since the further the underlying moves from the strike by the expiration of the options, the greater the profit from the strategy.
   B. Volatility skew describes the empirical situation where implied volatility increases for more OTM calls, and decreases for more OTM puts.
   C. Volatility skew describes the empirical situation where implied volatility increases for more OTM puts, and decreases for more OTM calls.

# MODULE 8.12: APPLICATIONS

Video covering this content is available online.

**LOS 8.i: Identify and evaluate appropriate option strategies consistent with given investment objectives.**

**LOS 8.j: Demonstrate the use of options to achieve targeted equity risk exposures.**

*CFA® Program Curriculum, Volume 2, pages 52 and 55*

### PROFESSOR'S NOTE

In the final section of the curriculum reading a sequence of scenarios are described, each of which illustrates a use of a particular option strategy. The following outlines each scenario, and explains the choice of strategy, highlighting key issues in each case.

## Covered Call

SCENARIO

A client needs cash. Within their portfolio is a stock (current price = 169) that they are considering selling in the near future and on which their advisor has a bearish outlook over the next six months. Information is provided on 44-day exchange-listed options (calls and put premiums and deltas, plus vegas).

**Solution**

Sell calls on the stock to generate premium income (provides the required cash) and reduce delta of stock holding (reduce exposure given bearish outlook).

**Considerations**

The premium on chosen option must be high enough to meet cash target (assumes 50 contracts sold to match 5,000 shares held): ITM call would generate the most cash, but there is a danger of shares being called away, so choose 170 calls (just OTM). More OTM calls raise too little cash.

**Risks**

Stock may rise. If it is above 170 at expiry then sell at 170 and lose further gain.

Stock may fall over period to expiry, giving loss on long stock position (but cushioned by premium).

**Other points**

Position delta is calculated for covered call at point options written, but otherwise the focus is on at-expiry outcomes. Vegas are ignored.

## Put Writing

SCENARIO

Investor OQ wants to purchase shares, but considers them too expensive at 169. OQ is prepared to pay no more than 165.

**Solution**

Write OTM puts (165 strike), and effectively gets paid to buy the stock.

If the stock is less than 165 at expiry then the put is exercised (by the counterparty) and OQ has to buy at 165.

**Risks**

Shares may fall below $X - p_0$ by expiry, in which case would have been better off buying them outright (cheaper than 165 by more than the premium).

The stock may rise to point where $S_T - 169 > p_0$. At that point it would have been better off buying shares at 169 since the rise in value since would exceed the premium received.

## Long Straddle

SCENARIO

KH believes a stock price is about to rise or fall dramatically (at least ±10%), and considers a straddle.

Before KH makes the trade, a news story breaks that increases volatility, making the same straddle more expensive.

**Solution**

The straddle is no longer worthwhile, since to reach new breakeven points stock needs to move > ±12%.

**Other points**

KH uses vega of the straddle before the news story broke to predict the effect of the story on the price of the straddle (sum of put and call premiums). The implied volatility is higher by 15 percentage points × initial vega of 0.468 (given) = 7.02 ($) increase in straddle value. This is very close to actual rise in price of straddle, given earlier in the solution.

## Collar

SCENARIO

A client has a long position in a low cost basis stock, which means that selling is ruled out. Need to protect against a decline in price.

**Solution**

Use a zero-cost collar. Short calls sell off right tail of return distribution (potential large gains) and subsidize the purchase of puts that eliminate the left tail (potential large losses).

## Calendar Spread

SCENARIO

ID expects little price movement in Euro Stoxx 50 index over next month from the current level of 3,500, but has a bearish long-term view. The consensus is for a flat market. ATM options are available.

**Solution**

Sell a three-month 3,500 put option and buy a six-month 3,500 put option (a **long** calendar spread, since they are long the options with more time to expiry).

This requires a net initial payment because the longer-dated put is more valuable (€173 – €119 = €54).

If ID's expectation is correct, and the stock index is unchanged at the expiry of the short (so the options are still ATM) then the following is true:

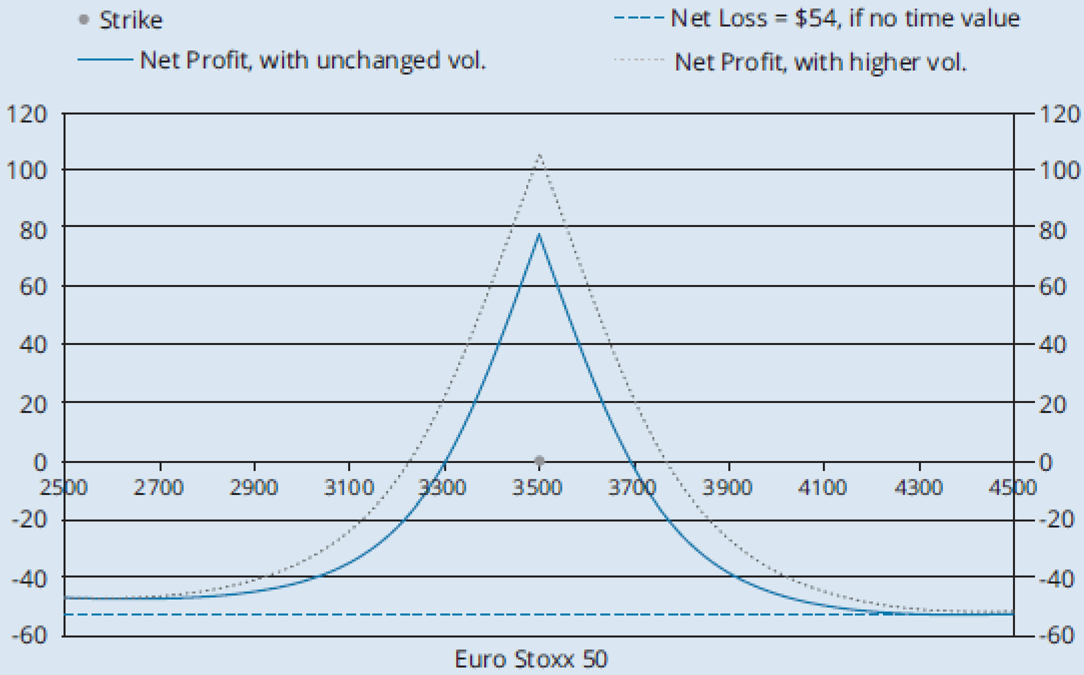
- The short put expires worthless. The long put (which now has three months to expiry) will be worth less than when it was bought (less time value), but its value will be higher than the net premium paid initially.
- This is because the three-month put had higher (more negative) theta, so it fell in value by more. ID was short this put and long the other, so makes a net profit.
- ID could either sell the long put at this point, realizing the net profit, or keep it as a bet on the index subsequently falling (having paid less, net, compared to solely going long).

**Considerations**

A calendar spread could use calls or puts, so why puts in this case? Because once the near-dated option expires ID wants to be left with a bearish exposure to the index – hence long puts.

**Risks**

At the short put's expiry it will only have intrinsic value, whereas the long put will have both intrinsic and time value. At any expiry level of the index the two options will have identical (absolute) intrinsic values (same strike), and these will cancel out, but the long put will also have time value, which is thus the net value of the position. Subtracting the net premium from the time value gives us the net profit:




A rise or fall in the index would reduce the (time) value of the long put, reducing the profit. A sufficiently large move, either way, could lead to a loss.

The worst outcome would be the entire net premium being lost.

A rise in implied volatility could increase profit/reduce loss, by pumping-up the long put's time value. Vice-versa a fall in implied volatility would decrease profit/increase loss.

## Hedging an Expected Increase in Equity Market Volatility

SCENARIO

JW has a stock portfolio and fears the market is due a correction (a fall), which will be accompanied by a rise in short-term volatility. He wants to set up a position that will benefit from higher volatility, while lowering the cost of this hedge.

**Solution**

Buy an ATM call on volatility index (VIX) futures (futures which rise or fall with an index of market volatility). If volatility rises then the call will expire ITM and he will receive a payoff.

However, such a call could be expensive, so he simultaneously sells an OTM put on VIX futures—selling off the benefit of a fall in volatility.

**Considerations**

A regression of the portfolio's historic profits/losses versus changes in volatility could be used to determine what value of options to trade (to balance the hedge).

Buying VIX futures would be an alternative, less flexible, hedge.

**Other points**

Given the apparent negative correlation between volatility and the level of the market JW is in effect short volatility, and the hedge can be seen as equivalent to a collar, but against a short, rather than a long exposure.

## Long Calls as a Proxy for the Underlying

SCENARIO

AS anticipates a rise in a share's price from £60 to £70 over the next three months, with no change in the implied volatility of the associated stock options. He wants to recommend the three-month (long) call that will maximize profits if this happens.

**Solution**

Choose the call which maximizes the ratio of expected profit to cost (assuming the stock rises to £70):

$$\frac{\text{profit at expiration if stock } = \text{ £70}}{\text{premium}} = \frac{70 - (X + c_0)}{c_0}$$

Note that we can automatically rule out any call where the breakeven ($X + c_0$) is above £70.

They also comment on delta, presumably because they are implicitly assuming that the position may not be held to call expiration, but could be closed out by selling the call once the rise in share price has happened. In that case the key issue is how the call value will change if the share price rises. The call that has the highest value for the profit to cost ratio has a lower (absolute) value of delta, suggesting that it is less responsive to rises in the underlying share price (bad), but it does have a higher gamma which, the answer claims, will more than compensate.

**Risks**

Not covered within the solution, but the obvious risk is that the share ends at a price other than £70, in which case a different call could have been preferable.

## Protective Put

SCENARIO

EM holds shares that he expects will suffer a decline of up to 10% in one week. This would take the price down from €42 to €37.80. He wants to protect the position, while keeping the cost of the protection to a minimum. A range of one-month puts are presented.

**Solution**

Similarly to the previous example, they identify the put that maximizes the ratio of expected profit to cost (assuming the stock falls to €37.80):

$$\frac{\text{profit at expiration if stock } = \text{€}37.80}{\text{premium}} = \frac{(X - p_0) - 37.8}{p_0}$$

Note that we can automatically rule out any put with breakeven ($X - p_0$) below €37.80.

Since the put will not be held to expiration this breakeven calculation (based on intrinsic value) is not definitive (although it could be seen as providing a worst-case estimate, ignoring time value). In practice the hedge will be closed out by selling the put once the period in which the decline is likely has passed, thus the hedge is really based on how the premium on the put will change over the holding period.

They thus go on to discuss delta, since the key issue is how the put value will change if the share price falls. The put that has the highest value for the profit to cost ratio has a lower (absolute) value of delta, suggesting that it is less responsive to falls in the underlying share price, but it does have a higher gamma which, the answer claims, will more than compensate.

For the following table, we suggest that you work out why the particular strategy is chosen in each case, given what you have read so far. Explanations are given below the exhibit on that same page if you want to check your conclusions:

**Choosing Options Strategies Based on Direction and Volatility of the Underlying Asset**

| | | Outlook on the Trend of Underlying Asset | | |
|---|---|---|---|---|
| | | Bearish | Trading Range/ Neutral View | Bullish |
| Expected Move in Implied Volatility | Decrease | *Write calls* | *Write straddle* | *Write puts* |
| | Remain Unchanged | *Write calls and buy puts* | *Calendar spread* | *Buy calls and write puts* |
| | Increase | *Buy puts* | *Buy straddle* | *Buy calls* |

*Reproduced from CFA Institute, page 273

## MODULE QUIZ 8.12

*To best evaluate your performance, enter your quiz answers online.*

**Use the following information to answer Questions 1 and 2.**

Dennis Austin works for O'Reilly Capital Management and manages endowments and trusts for large clients. The fund invests most of its portfolio in S&P 500 stocks, keeping some cash to facilitate purchases and withdrawals. The fund's performance has been quite volatile, losing over 20% last year but reporting gains ranging from 5% to 35% over the previous five years. O'Reilly's clients have many needs, goals, and objectives, and Austin is called upon to design investment strategies for their clients. Austin is convinced that the best way to deliver performance is to, whenever possible, combine the fund's stock portfolio with option positions on equity.

1. Given the following scenario:
   - Performance to date: Up 3%
   - Client objective: To maintain a positive stock position and retain upside potential
   - Austin's scenario: Expect low stock price volatility between now and the end of year.

   Which is the *best* option strategy to meet the client's objective?

   A. Bull call.
   B. Protective put.

C. Long butterfly.

2. Given the following scenario:
   - Performance to date: Up 16%
   - Client objective: Earn at least 15%
   - Austin's scenario: Good chance of large gains or large losses between now and end of year.

   Which is the *best* option strategy to meet the client's objective?

   A. Long straddle.
   B. Long butterfly.
   C. Short straddle.

3. An investor believes that a stock they own will continue to oscillate in price and may trend downward in price. The *best* course of action for them to take would be to:

   A. sell call options on the stock.
   B. buy put options on the stock.
   C. enter into both a covered call and protective put strategy.

4. A short position in naked calls on an asset can be hedged by:

   A. buying a put.
   B. buying the underlying asset.
   C. shorting the underlying asset.

# KEY CONCEPTS

## LOS 8.a

Options can be used to replicate an asset's returns, or the returns from a forward contract.

- A long call plus a short put, with the same strikes and expiration, gives a synthetic long forward—equivalent to a long position in the underlying financed by borrowing at the risk-free rate.
- A short call plus a long put, same strikes and expiration, gives a synthetic short forward, which is equivalent to a short position in the underlying plus a long bond paying Rf.
- Put-call parity links all these positions together: $c_0 - p_0 = S_0 - PV(X)$ or $S_0 + p_0 = c_0 + PV(X)$.

## LOS 8.b

An investor creates a covered call position by buying the underlying security and selling a call option.

- Covered call writing strategies can be used to generate additional portfolio income when the investor believes that the underlying stock price will remain unchanged over the short term. The calls are likely to be written OTM.
- ITM calls could be written when the investor aims to reduce a position at a favorable price.
- Marginally OTM calls could be used if the aim is to realize a target price.

## LOS 8.c

A protective put is constructed by holding a long position in the underlying security and buying a put option (usually ATM, or somewhat OTM). You can use a protective put to limit the downside risk at the cost of the put premium.

- The purchase of the put provides a lower limit to the position at a cost of lowering the possible profit (i.e., the gain is reduced by the cost of the insurance). It is an ideal strategy for an investor who thinks the stock may go down in the near future, yet who wants to preserve upside potential.

## LOS 8.d

The delta of a long (short) position in one unit of the underlying is +1 (−1). If a long position in an asset is hedged by a short forward, then the delta will be reduced to zero, whereas both covered call and protective put positions have (positive) deltas that are different than zero.

- In other words, the effect of the covered call and protective put, during the option's life, is to reduce the asset's delta, but not eliminate it.

## LOS 8.e

If an investor has a short position in the underlying then they could:

- Hedge their exposure to the underlying *rising* by buying a call (analogous to hedging a long position with a protective put).
- Sell off some of the benefit from the underlying *falling* by selling a put (analogous to a covered call).

## LOS 8.f

There are many strategies that combine option positions, all on a single underlying, having the same expiration date:

- A bull call spread strategy comprises a long call and a short call. The short call has a higher exercise price, and its (lower) premium subsidizes the long call. A bull spread offers gains if the underlying asset's price goes up, but the upside is limited.
- A bear put spread strategy comprises a long put and a short put. The short put has a lower exercise price, and its (lower) premium subsidizes the long put. A bear spread offers gains if the underlying asset's price goes down, but the upside is limited.
- Both bull call and bear put spreads are known as *debit* spreads, because they involve an initial net premium payment. Particularly with American-style options, where early exercise is possible, they are the most common bull and bear spreads.
- Bull put and bear call spreads are also possible, however. These are *credit* spreads, and are the short versions of the other two spreads.
- Before expiration, bull (bear) spreads are best seen as positions giving long (short) exposure to the underlying, but with a reduced level of (absolute) delta.
- A long straddle is a long call plus long put with the same exercise price. The greater the move in the stock price, the greater the payoff from a straddle at expiration (with no upper limit on profit). Before expiration, the prime focus is on volatility increasing, since a long straddle will have positive vega (but low delta, when ATM).
- A short straddle is a short call plus short put with the same exercise price. The closer the stock price ends to the strike the greater is the payoff from a short straddle at expiration (this is limited to the sum of the premiums). Before expiration, as with a long straddle, the prime focus is on volatility, this time falling—a short straddle has negative vega (but low delta, when ATM).

The spreads and straddles only use options, whereas the collar combines options with the underlying:

- A collar strategy is simply a covered call and protective put combined to limit the downside and upside values of the position at expiration. Before expiration the collar can be seen as a way of reducing delta.

### LOS 8.g

A long calendar spread involves the sale of a shorter-dated ATM (or near-ATM) call and the purchase of a longer-dated call with the same strike (or both could be puts). The basic motivation is to profit from the higher theta of the closer-to-expiry ATM option. At expiration the position will have a net value equal to the long put's time value. If the options are still ATM this will exceed the net premium paid initially.

- The danger is that the underlying could have moved away from its initial level, and the long put's time value is below the initial premium, although an increase in implied volatility could offset this.
- A short calendar spread buys the shorter-dated and sells the longer-dated options. The options are either ITM or OTM, and now a large move in the underlying (so it ends up well away from the strike) is needed (and/or a decrease in implied volatility).

### LOS 8.h

A volatility smile is where further-from-ATM options have higher implied volatilities.

The relatively more common situation is volatility skew, where implied volatility increases for more OTM puts, and decreases for more OTM calls.

- The skew is explained by OTM puts being desirable as insurance against market declines, while the demand for OTM calls is low.
- Deviations of the skew from historical levels could form the basis of trading strategies, e.g., a long (short) risk reversal combines long (short) OTM calls and short (long) OTM puts on the same underlying, delta-hedged using the underlying stock. A long risk reversal assumes the OTM calls are relatively underpriced (their implied volatility is relatively too low, compared to OTM puts).

### LOS 8.i, LOS 8.j

See the examples towards the end of this reading for illustrations of the uses of the various strategies that have been covered in the reading.

## ANSWER KEY FOR MODULE QUIZZES

### Module Quiz 8.1, 8.2, 8.3

1. **A** Remember put-call parity: $\mathbf{c_0 - p_0 = S_0 - PV(X)}$, which can be rearranged to $\mathbf{-S_0 = p_0 - c_0 - PV(X)}$.

   This means that short stock equals long put plus short call plus borrowing at $r_f$.

   Given that X = 100, $r_f$ = 2% and T = 0.5, we have PV(X) = $100/(1.02)^{0.5}$ = 99.01 ≈ 99.

The options position in B is a long straddle, whose profile is nothing like a short position in the stock.

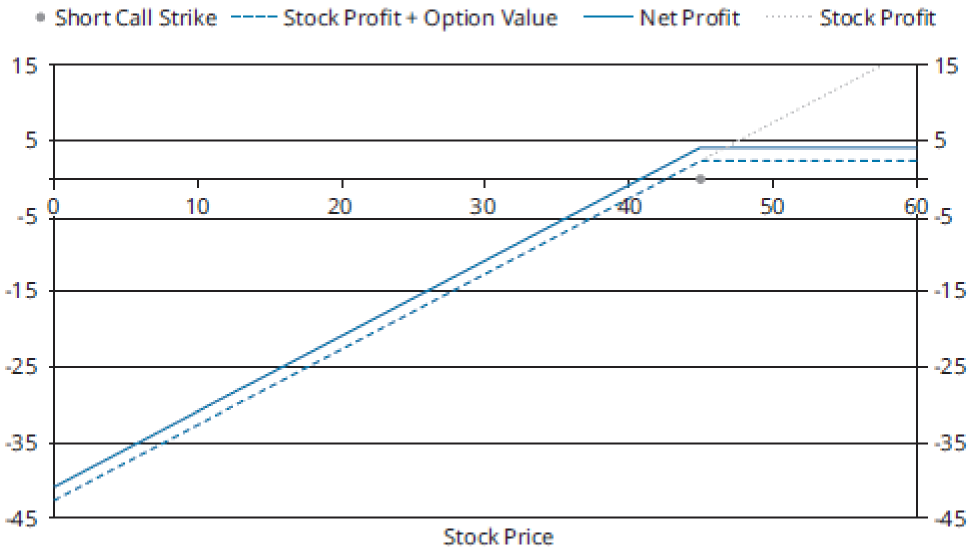
The options in C would create a synthetic long forward. (Module 8.2, LOS 8.a)

2. a) **Maximum profit** occurs at the strike, and above.

Rise in stock value at strike = \$45 – \$43 = \$2, plus the premium received of \$2.10 = \$4.10

**Breakeven price** = premium below the initial stock price = $X - c_0$ = \$43 – \$2.10 = \$40.90

**Maximum loss** = breakeven = \$40.90




b) Given breakeven = \$40.90, while maximum profit = \$4.10 at the \$45 strike and above:

- Profit at \$0 (\$40.90 below breakeven) = loss of \$40.90 (= maximum loss)
- Profit at \$35 (\$40.90 – \$35 = \$5.90 below breakeven) = loss of \$5.90
- Profit at \$40 (\$0.90 below breakeven) = loss of \$0.90
- Profit at \$45 = Profit at \$50 = maximum profit = \$4.10

(Module 8.3, LOS 8.b)

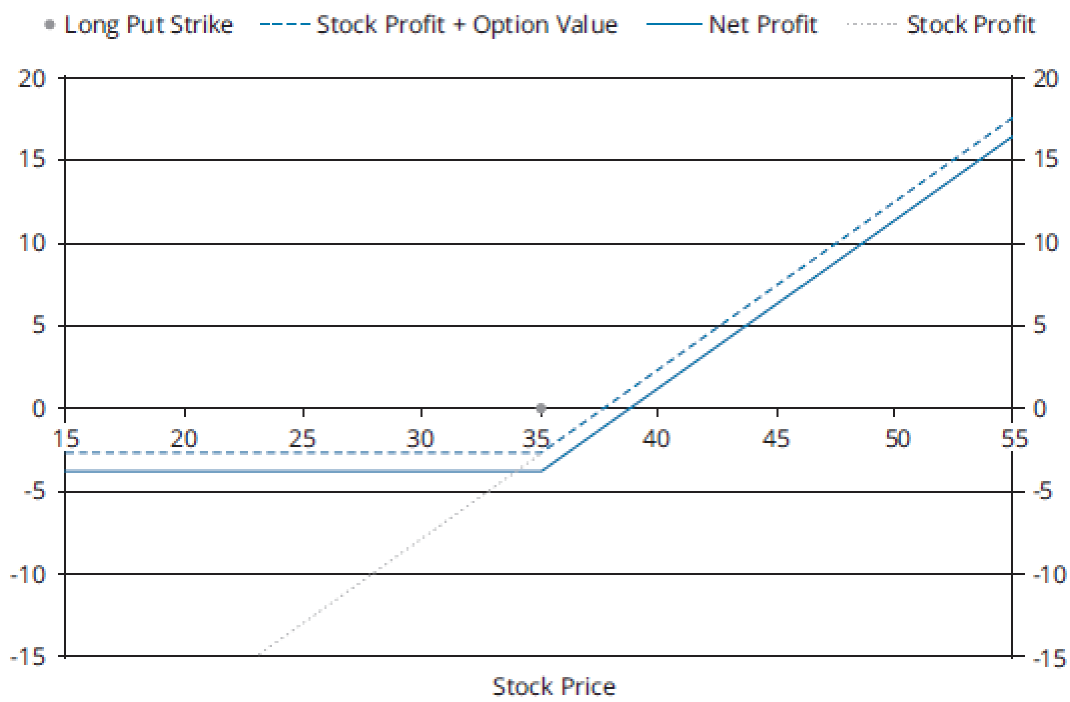
## Module Quiz 8.4, 8.5

1. a) **Maximum profit** = unlimited

**Maximum loss** occurs at the strike, and below

Fall in stock value to strike = \$37.50 – \$35 = \$2.50, plus the premium paid of \$1.40 = \$3.90

**Breakeven price** = premium above the initial stock price = $X + p_0$ = \$37.50 + \$1.40 = \$38.90




b) Given breakeven = $38.90, while maximum loss = $3.90 at the $35 strike and below:

Profit at $30 = Profit at $35 = loss of $3.90

Profit at $40 ($40 – $38.90 = $1.10 above breakeven) = $1.10

Profit at $50 = $50 – $38.90 = $11.10

(Module 8.4, LOS 8.c)

2. **C** Jones has a short exposure to Alphacorp. Selling an OTM put is the best choice to enhance yield.

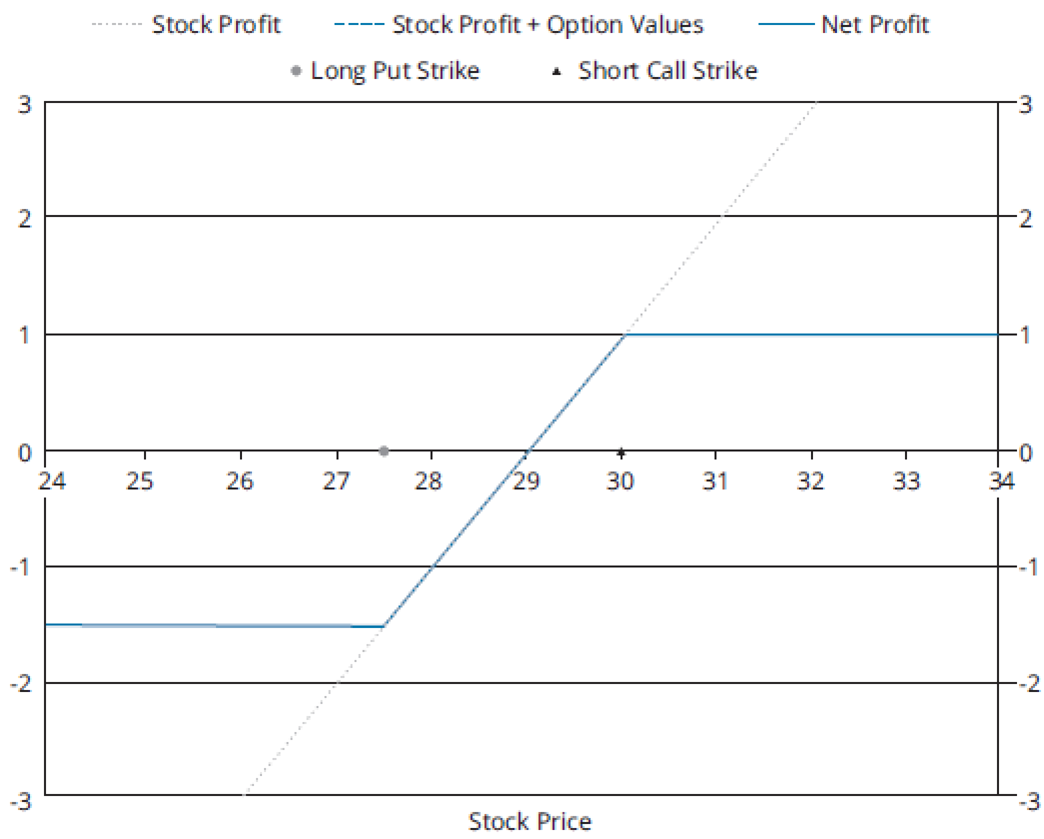
   October 240 calls would only be appropriate were his exposure long. October 240 puts is an ITM put, which would likely get exercised by the counterparty unless the share price rises, which Jones does not anticipate happening. Selling the 200 puts is a better choice than the 240 calls because the puts result in limited risk exposure whereas selling uncovered calls results in unlimited risk exposure if the stock price goes up. (Module 8.5, LOS 8.e)

## Module Quiz 8.6, 8.7

1. a) Call and put premiums are identical, so this is a **zero-cost collar**. Between strikes the profit/loss is the same as for the stock alone, and **breakeven** = initial stock price = $29

   **Maximum profit** at call strike = gain on stock at $30 = $30 – $29 = $1

   **Maximum loss** at put strike = loss on stock at $27.50 = $29 – $27.50 = $1.50




b) \$20 and \$25 are both below put strike, so profit at \$20 = profit at \$25 = loss of \$1.50 (= maximum loss)

Profit at \$28.50: between strikes, so the same as for stock alone. \$0.50 below breakeven, so loss = \$0.50

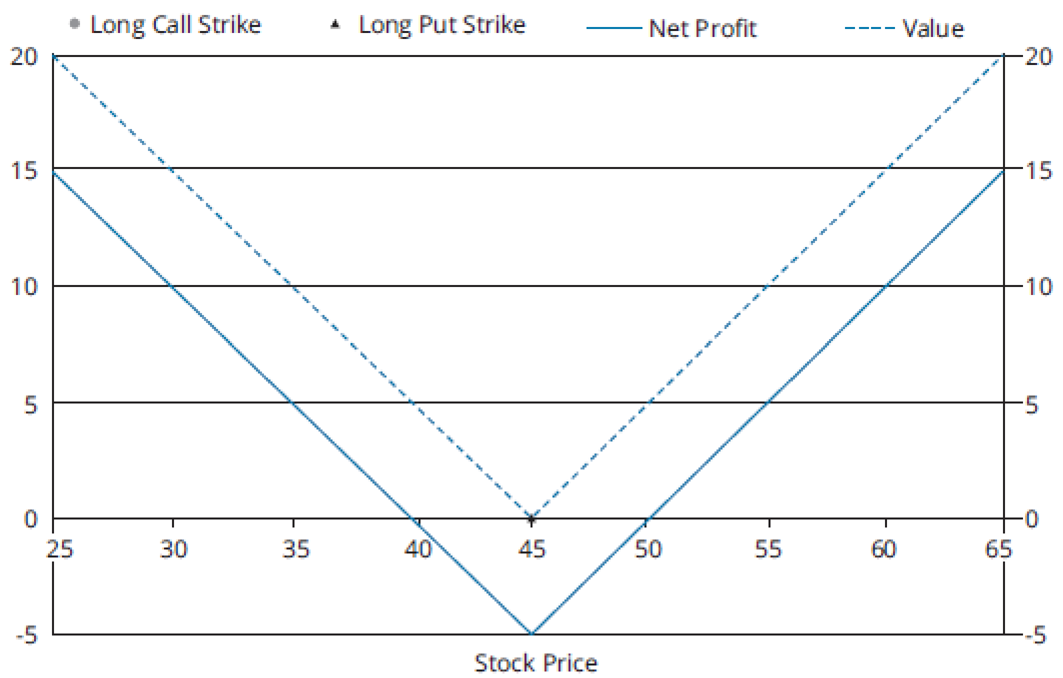
Profit at \$30 = profit at \$100 = \$1 (= maximum profit)

(Module 8.6, LOS 8.f)

2. a) **Maximum profit** = unlimited

   **Maximum loss** occurs at the strike and equals the total premium paid = \$3 + \$2 = \$5

   **Breakeven prices** = total premium below and above the strike = \$45 ± \$5 = \$40 and \$50




b) Profit at \$0: long put is \$45 ITM, so profit = \$45 – total premium = \$45 – \$5 = \$40 (= lower b/even)

Profit at \$35: long put is \$45 – \$35 = \$10 ITM, so profit = \$10 – \$5 = \$5

Profit at \$40 = \$0 (breakeven)

Profit at \$45 = loss of \$5 (maximum loss at strike)

Profit at \$47: long call is \$47 – \$45 = \$2 ITM, so profit = \$2 – \$5 = loss of \$3

Profit at \$55: long call is \$55 – \$45 = \$10 ITM, so profit = \$10 – \$5 = \$5

Profit at \$100: long call is \$100 – \$45 = \$55 ITM, so profit = \$55 – \$5 = \$50

(Module 8.7, LOS 8.f)

3. Buy ATM puts and calls on the EUR. The 1.04 strike price is the closest to ATM. Buying the call and put will cost: 0.004 + 0.017 = 0.021. This is the max loss and occurs if the EUR closes at 1.04. For breakeven prices, the EUR must decrease or increase 0.021 to USD 1.019 or 1.061. (Module 8.7, LOS 8.f)

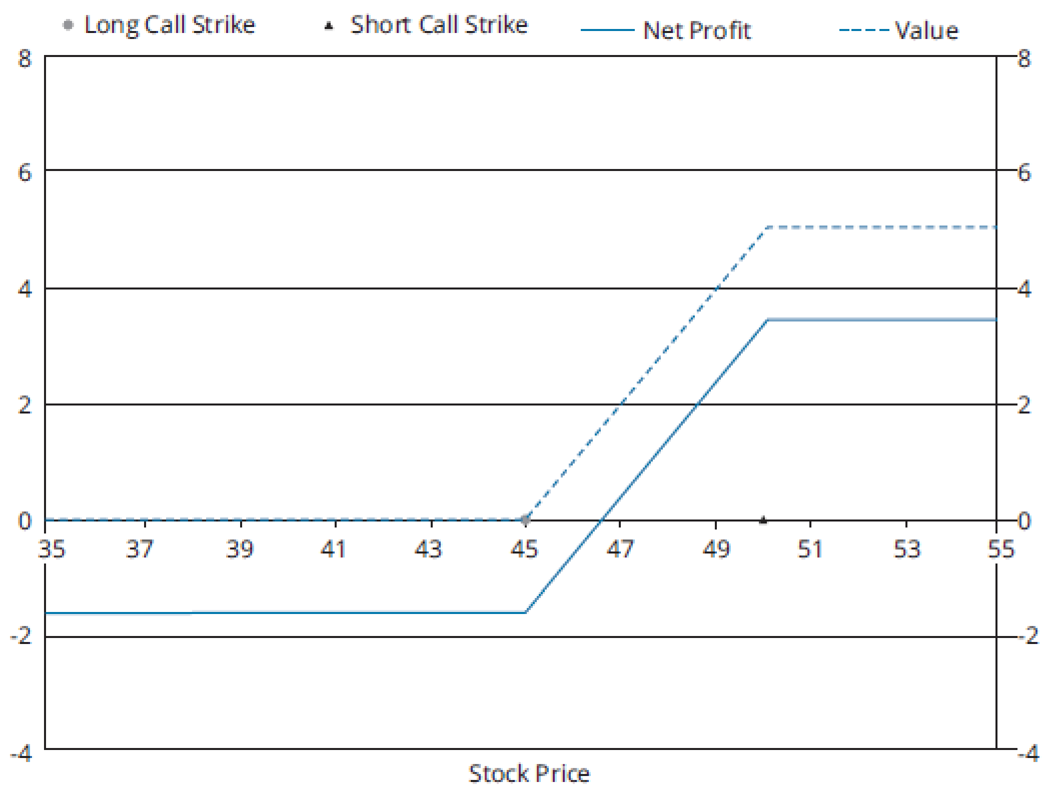
## Module Quiz 8.8

1. a) This is a bull call spread, which is a debit spread (net initial outlay).

   For debit spreads, the **maximum loss** = net premium paid = \$2.10 – \$0.50 = \$1.60.

   The difference between the maximum loss and the maximum profit is equal to the difference between the strikes, which is \$50 – \$45 = \$5, so the **maximum profit** = \$5 – \$1.60 = \$3.40.

   Maximum loss occurs at lower strike (and below), so **breakeven price** = lower strike + net premium = \$45 + \$1.60 = \$46.60




b) Given breakeven = \$46.60, maximum loss = \$1.60 at \$45 and below, while maximum profit = \$3.40 at \$50 and above:

Profit at \$35 = profit at \$45 = loss of \$1.60 (= maximum loss)

Profit at \$48 (\$48 – \$46.60 = \$1.40 above breakeven) = \$1.40

Profit at \$50 = profit at \$55 = \$3.40 (= maximum profit)

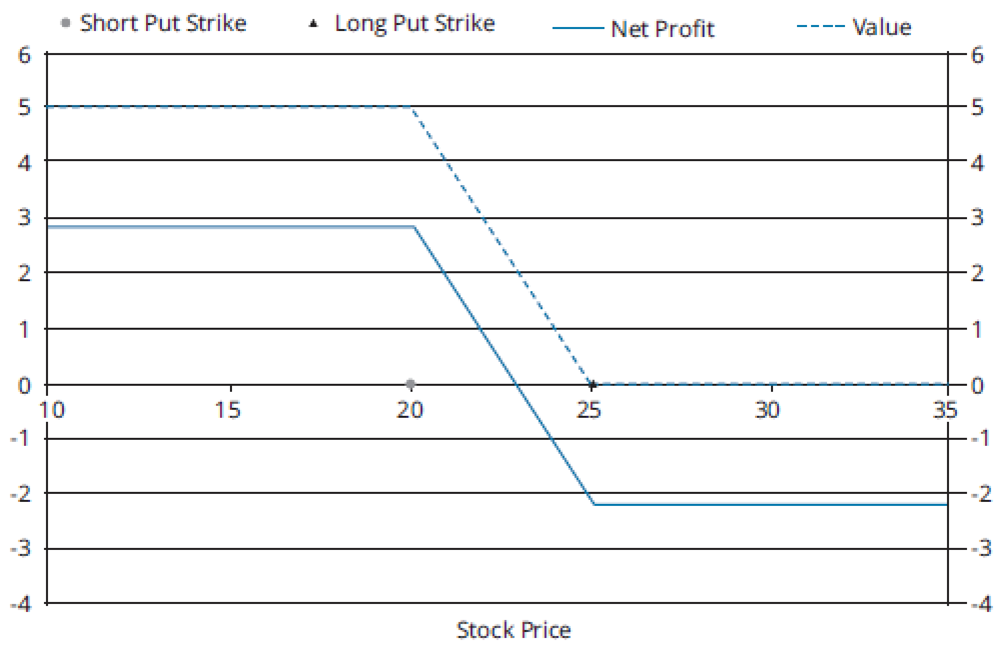
(LOS 8.f)

2. a) This is a bear put spread, which is a debit spread (net initial outlay).

For debit spreads the maximum loss = net premium paid = \$4.00 – \$1.80 = \$2.20.

The difference between the **maximum loss** and the maximum profit is equal to the difference between the strikes, which is \$25 – \$20 = \$5, so the **maximum profit** = \$5 – \$2.20 = \$2.80.

Maximum loss occurs at upper strike (and above), so **breakeven price** = upper strike – net premium = \$25 – \$2.20 = \$22.80.




b) Given breakeven = $22.80, maximum loss = $2.20 at $25 and above, while maximum profit = $2.80 at $20 and below:

Profit at $15 = profit at $20 = $2.80 (= maximum profit)

Profit at $23.50 ($23.50 – $22.80 = $0.70 above breakeven) = loss of $0.70

Profit at $25 = profit at $35 = loss of $2.20 (= maximum loss)

(LOS 8.f)

3. In a bear spread the lower strike option is sold and the higher strike option is bought. Using calls this is a credit spread, since there is a net initial inflow of premium of 5.25 – 0.75 = 4.50.

   Initial investment = –4.50 (per share).

   The initial investment is also the maximum profit from the strategy. This occurs at and below the lower strike of 47, above which the profit falls one-for-one with rises in the underlying stock. Thus breakeven is 4.50 above the lower strike, at 47 + 4.50 = 51.50. (LOS 8.f)

## Module Quiz 8.9

1. **B** Before expiration both covered calls and protective puts have positive deltas (short calls and long puts both have negative deltas, with absolute values less than 1, so they partially, but not fully, hedge the +1 delta of the long underlying). Neither fully eliminate the delta of the underlying. (LOS 8.d)

## Module Quiz 8.10, 8.11

1. **B** An appropriate strategy in such a situation would be a long calendar spread, where close-to-ATM options with the same strikes but different expirations are traded. The longer-dated is bought and the shorter-dated is sold, to exploit the higher theta of the shorter-dated.

A is a short calendar spread, whereas C is a risk reversal, which is a strategy to exploit implied volatility skews that differ from historical levels. (Module 8.10, LOS 8.g)

2. **C** A is incorrect because the straddle has little to do with the volatility smile, and B has calls and puts the wrong way around. (Module 8.11, LOS 8.g)

## Module Quiz 8.12

1. **B** The client wants to stay positive on the stock and a protective put will retain the stock upside with limited down side risk. In addition volatility is low which will make option prices low. Both of the other strategies will compromise stock upside potential and involve selling options to reduce initial investment cost. Lowering initial investment was not a specific goal and it makes little sense to do so while option prices are low. (LOS 8.i)
2. **A** Long straddle produces gains if prices move up or down, and limited losses if prices do not move. Short straddle produces significant losses if prices move significantly up or down. Long Butterfly also produces losses should prices move either up or down. The condor is similar to the long butterfly, although the gains for no movement are not as great. (LOS 8.i)
3. **C** With a stock that is oscillating in price in which it is not trending upward, a covered call strategy is appropriate in which the investor owns the underlying asset and sells call options to enhance income. This strategy will work as long as the stock price does not go above the call strike price. In a downward trending market in which the investor believes the stock price will decrease, a protective put is appropriate in which they purchase a put on the underlying stock. The combination of the covered call and protective put is a collar. (LOS 8.i)
4. **B** Hedging a naked call can be accomplished by owning the underlying asset called a covered call strategy. (LOS 8.i)

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1. This can be computed for both European and American-style options, even though the former can only be exercised at expiration. It can be thought of as the base level for the option's value.

2. Writing a put option and simultaneously depositing the exercise price into a designated account is called writing a **cash-secured** put, thereby the long is assured that the put writer would be able to purchase the stock, if called on to do so. Simply writing a put without doing this is called a **naked** put.

3. If the strategy does work as intended, however, Jenkins will have captured the time value embedded in the option price (in this case $4.80 – ($52.14 – $50) = $2.66 per share, which corresponds to 1,500 × $2.66 = $3,990 (= $82,200 – $78,210).

4. Also known as a *fence* or a *hedge wrapper.*

5. **Strangles**, which we encounter in the currency reading, are like straddles, but the calls and puts have different strikes.

6. Time value is a reflection of the relative difficulty of hedging an option, and options are harder to hedge when it is unclear whether they are going to **expire** ITM or OTM. If they are already deeply ITM or OTM there is less uncertainty about this.

The following is a review of the Derivatives and Currency Management principles designed to address the learning outcome statements set forth by CFA Institute. Cross-Reference to CFA Institute Assigned Reading #9.

# READING 9: SWAPS, FORWARDS, AND FUTURES STRATEGIES

**Study Session 4**

## EXAM FOCUS

The primary focus here is understanding how to use derivatives to (1) change the beta of an equity portfolio, (2) change the duration of a bond portfolio, (3) change portfolio exposure to various asset classes, (4) create synthetic positions, and (5) lock in an interest rate for anticipated future borrowing or lending. Understand how the risks of various derivative contracts offset existing portfolio risks. This material may be tested with either a constructed response question on the morning exam or an item set on the afternoon exam.

## MODULE 9.1: MANAGING INTEREST RATE RISK—INTEREST RATE SWAPS, FORWARD RATE AGREEMENT, AND INTEREST RATE FUTURES

Video covering this content is available online.

**LOS 9.a: Demonstrate how interest rate swaps, forwards, and futures can be used to modify a portfolio's risk and return.**

*CFA® Program Curriculum, Volume 2, page 83*

Interest rate swaps can be used to alter the duration of a fixed-income portfolio by changing a fixed-rate exposure to a floating-rate exposure, or vice versa.

### Interest Rate Swaps

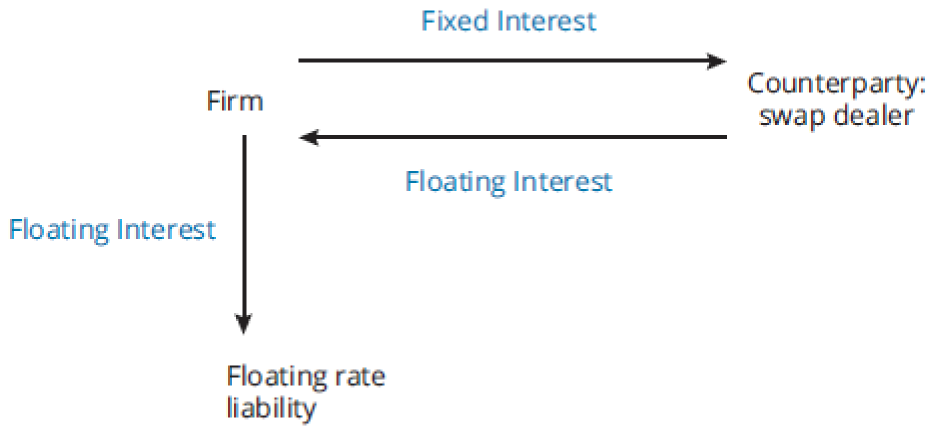
A *payer swap* is a contract to make a series of fixed-rate payments and receive a series of floating-rate payments, both based on a specified *notional principal* (amount). If future floating rates are higher than rates expected at the initiation of a swap, a payer swap will increase in value. A payer swap will decrease in value if future floating rates are less than expected. The counterparty to a payer swap has a *receiver swap* and will receive the fixed-rate payments and make the floating-rate payments. In practice, the payments from each party to a swap are netted (the party that owes the larger amount pays the difference) to reduce credit risk.

The floating-rate payment for the first *settlement date* is known at contract initiation, but the floating-rate payments for future settlement dates are not. A quarterly pay swap, for example, has quarterly settlement dates with floating-rate payments based on a quarterly reference rate such as 90-day LIBOR. The risk-return characteristics of a swap can be replicated with a capital market trade. For example, issuing a fixed-rate bond and buying an otherwise identical floating-rate bond would generate the same payments as a payer swap.

## Converting a Floating-Rate Exposure to a Fixed-Rate Exposure

A company with a floating-rate exposure can use a payer swap (pay fixed, receive floating) to change it into a fixed-rate exposure. The swap must have settlement dates that match the payment dates on the floating-rate liability.

Figure 9.1: Converting Floating to Fixed Using a Payer Swap




Note that the firm's floating-rate payments from the swap will just offset its floating-rate payments on the liability, so the firm has only its fixed-rate liability from the swap.

Figure 9.2: Converting Fixed-Rate and Floating-Rate Exposures

| Existing Exposure | Converting | Interest Rate Swap Required | Beneficial When |
|---|---|---|---|
| Floating-rate liability | Floating to fixed | Payer swap | Floating rates expected to rise |
| Fixed-rate liability | Fixed to floating | Receiver swap | Floating rates expected to fall |
| Floating-rate asset | Floating to fixed | Receiver swap | Floating rates expected to fall |
| Fixed-rate asset | Fixed to floating | Payer swap | Floating rates expected to rise |

EXAMPLE: **Converting a floating-rate liability to a fixed-rate liability**

ABC, Inc., has issued $30 million four-year, semiannual-pay, floating-rate notes (FRNs) with coupons equal to 180-day LIBOR plus a 25 basis point margin. After one year, the firm expects interest rates to rise. ABC enters into a three-year payer swap with a fixed rate of 2%, semiannual payments, and a notional principal of $30 million. At initiation of the swap, 180-day LIBOR was 1.5%. The FRN and the swap have the same settlement dates.

Settlement date 1 (180 days after swap initiation):

Swap: fixed payment = \$30 million × 2% × 180 / 360 = \$300,000

floating payment = \$30 million × 1.5% × 180 / 360 = \$225,000

net cash flow = \$225,000 – \$300,000 = –\$75,000

FRN: floating payment = \$30 million × (1.5% + 0.25%) × 180 / 360 = \$262,500

ABC, Inc.: total payment = \$262,500 + \$75,000 = \$337,500

180-day LIBOR at settlement date 1 = 3%

Settlement date 2 (360 days after swap initiation):

Swap: fixed payment = \$30 million × 2% × 180 / 360 = \$300,000

floating payment = \$30 million × 3% × 180 / 360 = \$450,000

net cash flow = \$450,000 – \$300,000 = \$150,000

FRN: floating payment = \$30 million × (3% + 0.25%) × 180 / 360 = \$487,500

ABC, Inc.: total payment = \$487,500 – \$150,000 = \$337,500

Note that, regardless of realized LIBOR at the remaining settlement dates, the cash payments from ABC, Inc., will be \$337,500—the fixed rate on the swap plus the margin above the reference rate on the FRN:

\$30 million × (2% + 0.25%) × 180 / 360 = \$337,500

The floating-rate payments of the FRN and the floating-rate payments from the payer swap just offset each other.

For the issuer of an FRN, the payer swap has converted the floating exposure to a fixed-rate exposure. This strategy eliminates both the downside and upside of exposure to floating rates.

## Using Interest Rate Swaps to Alter Portfolio Duration

The cash flows on a payer swap can be replicated with two capital markets transactions: issuing a fixed-rate note and purchasing a floating-rate note (FRN). A receiver swap is equivalent to issuing an FRN and buying a fixed-rate note.

Because a fixed-rate note has a greater modified duration than an otherwise identical FRN, a payer swap has a negative duration (increasing in value when interest rates increase) and a receiver swap has a positive duration (decreasing in value when interest rates increase). Adding a payer swap to a fixed-income portfolio will reduce portfolio duration, while adding a receiver swap to a fixed-income portfolio will increase portfolio duration.

### PROFESSOR'S NOTE

The analysis presented here is based on modified duration, one of several available measures of price sensitivity to changes in interest rates. Using modified duration implicitly assumes that the yield curve is flat and shifts in the yield curve are parallel.

The notional principal of the interest rate swap to increase (or reduce) portfolio duration (target duration) can be calculated as follows:

$$NP_s = \left(\frac{MD_T - MD_P}{MD_s}\right)(MV_P)$$

where:

$NP_S$ = notional swap principal

$MD_T$ = target modified duration

$MD_P$ = current portfolio modified duration

$MD_S$ = modified duration of swap

$MV_P$ = market value of portfolio

EXAMPLE: **Using an interest rate swap to alter portfolio duration**

A fund manager has a portfolio of £120 million fixed-rate U.K. bonds. The fund manager believes that interest rates will fall over the next three years and wishes to increase the portfolio's modified duration (exposure to changes in interest rates). She decides to increase portfolio duration from 4.5 to 6. A payer swap has a modified duration of –2 and a receiver swap has a modified duration of +2.

What type of swap will achieve the desired portfolio duration, and what is the required notional principal of the swap?

**Answer:**

The fund manager wishes to increase duration, so she should add a receiver swap with a notional principal of:

$$NP_s = \left(\frac{6 - 4.5}{2}\right) \times £120 \text{ million} = £90 \text{ million}$$

# Interest Rate Forwards and Futures

## *Forward Rate Agreements (FRAs)*

FRAs are typically used to hedge the uncertainty about a future short-term borrowing or lending rate. Consider a firm that anticipates borrowing a lump sum for 60 days, 30 days from now. The 60-day interest rate 30 days from now is uncertain. To hedge this uncertainty, the firm could take a long position in an FRA.

The long position in an FRA will receive a payment at settlement if the market rate of interest rate is higher than the (forward) rate specified in the FRA. Thus, if the 60-day rate 30 days from now is greater than the forward rate, the firm receives a payment from the FRA (with notional principal equal to the anticipated loan amount) that offsets the firm's higher borrowing costs. If the 60-day rate 30 days from now is less than the forward rate, the firm must make a payment to settle the FRA. This payment offsets the decrease in the firm's borrowing costs. Thus, the firm's borrowing costs in the future are essentially fixed by the FRA hedge. A firm that anticipates lending in the future could hedge the uncertainty about the market interest rate of the loan by taking a short position in an FRA. The key point is that long FRA positions will increase in value when future interest rates rise, and short positions will increase in value when interest rates fall.

Figure 9.3: FRA Diagram

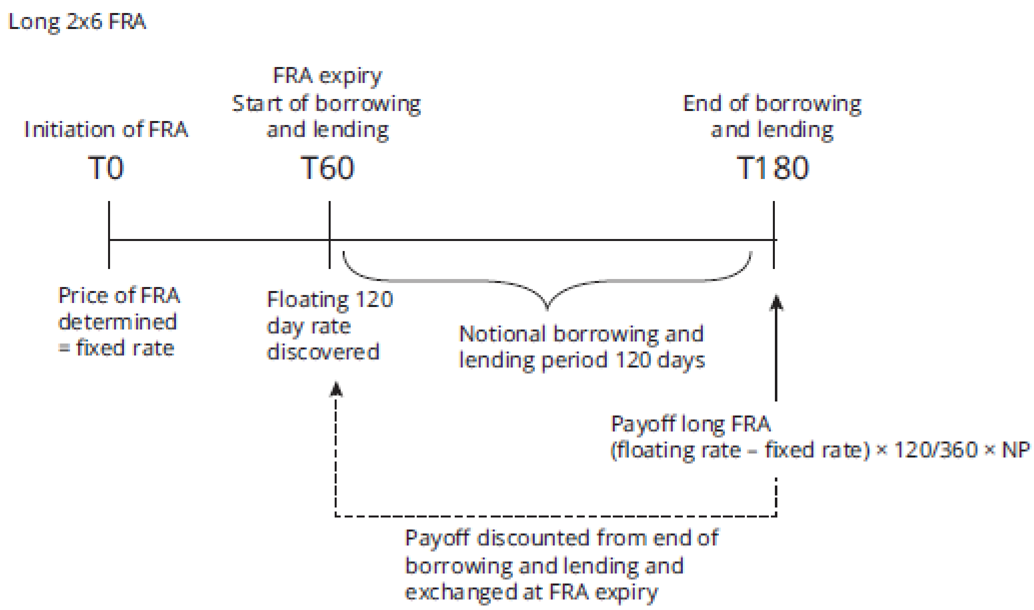



Figure 9.3 illustrates an FRA based on the future 120-day borrowing rate that settles 60 days from initiation. Note that the payment is made at the future borrowing or lending date and is equal to the present value of the difference in interest between a market-rate loan and a loan at the forward rate (rate specified in the FRA).

EXAMPLE: **Using an FRA to hedge short-term future borrowing**

Smithies Plc needs to borrow £1,000,000 for 180 days, 90 days from now, at LIBOR + 50 basis points (bp). The company is concerned that interest rates will rise over the 90-day period, increasing the cost of the 180-day loan. Smithies takes a long position in an FRA on 180-day LIBOR, 90 days in the future with a forward rate of 5% (annualized) and a notional principal of £1,000,000.

**Calculate** the firm's borrowing costs on the loan net of the FRA payment for realized 180-day LIBOR values, 90 days from now of 7% and 3%.

**Answer:**

*LIBOR 7% at FRA expiry:*

Cost of loan: (7% + 0.5%) × 180 / 360 × £1,000,000 = £37,500

Long FRA receipt: (7% – 5%) × 180 / 360 × £1,000,000 = £10,000*

Net cost: £37,500 – £10,000 = £27,500

*LIBOR 3% at FRA expiry:*

Cost of loan: (3% + 0.5%) × 180 / 360 × £1,000,000 = £17,500

Long FRA payment: (3% – 5%) × 180 / 360 × £1,000,000 = –£10,000*

Net cost: £17,500 + £10,000 = £27,500

The total cost is fixed at 5% + 50 bp regardless of the direction of interest rates:

5.5% × 180 / 360 × £1,000,000 = £27,500

*Note this is the payoff at the end of the borrowing and lending period; it is typically discounted and exchanged between FRA counterparties at settlement at day 90.

The firm has effectively hedged its future borrowing costs.

## *Short-Term Interest Rate (STIR) Futures*

STIR futures are conceptually very similar to FRAs. The futures price is forward interest rate on deposits starting at the expiry of the future and lasting for 90 days. The standardization of futures means that contracts are only available on specific maturities (typically quarterly). Users that are hedging interest rate risk will often need to enter an offsetting transaction to close their futures position out when the hedge is no longer needed.

Eurodollar futures ($-based STIR futures) are based on deposits of $1 million and are priced using the IMM Index convention (i.e., 100 − annualized forward rate). The pricing convention means that futures prices will rise when forward rates fall. The forward interest rate is calculated from current spot LIBOR rates in the same way the forward price of an FRA is established. One basis point change in the forward rate will cause the contract's value to change by $25 ($1 million × 0.0001 × 90 / 360 = $25).

Using this pricing convention, a long Eurodollar futures position will increase in value as forward rates decrease and decrease in value as forward rates increase. Note that this differs from a long FRA position, which increases in value as forward rates increase and decreases in value as forward rates decrease.

EXAMPLE: **Using Eurodollar futures to hedge short-term future investing**

Allan Luard is expecting to receive a $20 million inheritance in 120 days. Allan intends to invest the $20 million in a 90-day deposit account at LIBOR –25 bp. Currently, Eurodollar futures expiring in 120 days are trading at 95. Allan is concerned that short-term rates may fall before he makes his deposit and would like to lock in a guaranteed interest rate today. He takes a long position in 20 Eurodollar futures contracts.

A. After 120 days, 90-day LIBOR is quoted at 3.5%. Allan closes out his future position and invests his inheritance in a 90-day deposit account at LIBOR – 25 bp. What is Allan's $ return from depositing his inheritance combined with his futures position?

**Answer:**

Interest received on deposit: $20 million × (3.5% − 0.25%) × 90 / 360 = $162,500

Number of futures contracts: $20 million / $1 million = 20

Futures price at settlement: 100 − 3.5 = 96.5

Profit on futures: 96.5 − 95 = 150 bp; 150 bp × $25 × 20 contracts = $75,000

Total return: $162,500 + $75,000 = $237,500

Allan has locked in the 90-day forward rate of 5% − 25 bp:

$20 million × (5% − 0.25%) × 90 / 360 = $237,500

B. If 3-month LIBOR is 6.5% in 120 days, what is Allan's $ return from depositing his inheritance combined with his futures position?

**Answer:**

Interest received on deposit: $20 million × (6.5% − 0.25%) × 90 / 360 = $312,500

Futures price: 100 − 6.5 = 93.5

Loss on futures: 93.5 − 95 = −150 bp; −150 bp × $25 × 20 contracts = −$75,000

Total return: $312,500 − $75,000 = $237,500

Both Eurodollar futures and FRA agreements allow lenders and borrowers to lock in rates for future borrowing and lending. While the pricing mechanisms are different, in both contracts, forward price is a forward rate of interest derived from current LIBOR rates. The FRA forward price (based on a 90-day loan period) should be the same as the forward reference rate used to price the Eurodollar futures in order to prevent arbitrage between futures and an equivalent FRA. The major differences between the two, besides their pricing conventions, are that futures are standardized, exchange traded, and require a margin deposit that is marked to market, while FRAs are customized contracts, created by dealers so that they are not liquid, and subject to counterparty risk.

Interest rate futures are available for many currencies. Euro interest rate futures, for example, are based on Euribor.

## Fixed-Income Futures

Interest rate futures can be used to hedge the interest rate risk of short-maturity bonds (2–3 years), but this requires the estimation of the sensitivity of the value of each of the bond's cash flows to changes in the corresponding forward rate. Liquidity of interest rate futures decreases for forward rates further in the future. Longer-maturity bonds are most often hedged with fixed-income futures (bond futures), which have very good liquidity.

Treasury futures are available on T-bills, Treasury notes and Treasury bonds and are traded on the CBOT (Chicago Board of Trade) and CME (Chicago Mercantile Exchange). In Europe, government bond futures are traded on the Eurex and ICE exchanges and are available for bonds of various maturities.

## Mechanics of Fixed-Income Futures

In practice, the majority of bond futures are closed out prior to settlement (the delivery date) by entering an offsetting trade. For futures held until settlement, bond futures include delivery options for the short party. For example, with U.S. Treasury bond futures, the short party may deliver any U.S. Treasury bond with a maturity between 15 and 25 years at contract maturity. This practice ensures availability of government bonds for the short to deliver.

The price of Treasury bond futures is based on a notional government bond. The notional government bond is assumed to have a coupon rate of 6%. Each eligible bond that can be delivered by the short party is assigned a **conversion factor** (CF) to reflect its value relative to the notional bond in the contract.

CFs for eligible Treasury bonds are computed as the clean price of $1 face value of the eligible bond discounted at a yield to maturity of 6%. Note that bonds with a 6% coupon will automatically have a CF of one. Bonds with coupons higher than 6% will have CFs greater than one, and bonds with coupon rates less than 6% will have CFs less than one.

The short party will receive the principal invoice price on delivery:

principal invoice price = (futures settlement price / 100) × $100,000 × CF

Settlement price is quoted with a par of $100. $100,000 is the face value of Treasury bond futures.

In practice, the bond delivered may be between coupon dates at the delivery date, so the short party will also receive any accrued interest on the bond delivered:

total invoice amount = principal invoice price + accrued interest

The process to compute the CF is imperfect largely because it assumes a flat interest rate term structure at 6%. The deliverable bonds have different coupons and maturities and, therefore, different durations. As a result, the shape of the term structure of interest rates does have an effect on the bond's value, which is ignored by the computation. If CFs were perfect, the short party would be indifferent between which of the eligible bonds to deliver. The bias in the computation of CFs means that one of the eligible bonds will generate the greatest gain (or smallest loss) to the short party at delivery. This bond is known as the **cheapest-to-deliver (CTD) bond**.

The cash-and-carry model is still used to price the future. The bond selected to price the future is the CTD. There are two methods to identify the CTD bond. The first method identifies the eligible bond that generates the highest return (implied repo rate) on a cash-and-carry trade. The second method is to find the eligible bond with the lowest basis. Basis is defined as the spot price minus the futures price.

The Treasury bond with the lowest basis will typically have the highest implied repo rate and be the cheapest to deliver.

### PROFESSOR'S NOTE

Due to the mark-to-market feature in futures contracts, the short party does not receive the initial futures price at contract expiry. Daily futures settlement prices are used to compute the daily profit or loss on the futures contact with gains being added to the counterparties' margin accounts and losses being deducted. Daily profit or loss is calculated as $FP_t - FP_{t-1}$. To avoid double-counting profits and losses, the short party will receive the final settlement price multiplied by the CF at the maturity of the futures contract.

At delivery, the short party will deliver the CTD bond—with a value equal to the clean price plus accrued interest (the dirty or invoice price)—to the long party at the delivery date and receive the settlement price multiplied by the CF plus accrued interest. The CTD bond will be the bond that generates the greatest profit or lowest loss on delivery.

$$\text{profit/(loss) on delivery} = [(\text{settlement price} \times \text{CF}) + AI_T] - (\text{CTD clean price} + AI_T)$$

EXAMPLE: **Identifying the CTD bond at delivery**

| | Bond 1 | Bond 2 |
|---|---|---|
| Coupon | 5.5% | 5.75% |
| Time to maturity | 20 years | 19 years |
| Bond price | $141.13 | $145.10 |
| Accrued interest at delivery | $0 | $0 |
| CF | 0.9422 | 0.9719 |
| Futures settlement price | $148.75 | $148.75 |

**Answer:**

| | Bond 1 | Bond 2 |
|---|---|---|
| Settlement price × CF | \$148.75 × 0.9422 | \$148.75 × 0.9719 |
| = principal invoice amount | \$140.15 | \$144.57 |
| + $AI_T$ | \$0 | \$0 |
| = total invoice amount | \$140.15 | \$144.57 |
| Per \$100,000 par | \$140,150 | \$144,570 |
| | | |
| CTD clean price | \$141.13 | \$145.10 |
| + $AI_T$ | \$0 | \$0 |
| = CTD dirty price | \$141.13 | \$145.10 |
| Per \$100,000 | \$141,130 | \$145,100 |
| | | |
| Delivery loss | –\$980 | –\$530 |

Note that this example has assumed that delivery is immediately after a coupon payment and, therefore, accrued interest at delivery is zero. This is a simplifying assumption.

Bond 2 is the cheapest to deliver as it results in the smallest loss on delivery. Due to bias in the computation of CFs if yields are lower than 6%, there is a bias to short-duration (high coupon, low maturity) securities. If yields are greater than 6%, there is a bias to long-duration securities.

## *Hedging Interest Rate Risk Using Treasury Futures*

To hedge the interest rate risk of a long bond portfolio, the fund manager will sell Treasury bond futures. As interest rates rise, bond prices fall and the futures price decreases, increasing the value of a short futures position. Futures contracts are typically used by portfolio managers to achieve a target duration. Short futures positions reduce portfolio duration, while long futures positions increase portfolio duration.

The starting point when hedging interest rate risk with Treasury futures is to identify the futures contract CTD security. Treasury futures prices will tend to correlate most closely with the CTD bond because the CTD has the lowest basis of any deliverable bond. The implication of this is that the change in the futures price will equal the change in the value of the CTD adjusted by its CF (i.e., the CTD and futures contract have the same duration).

$$\Delta \text{ futures price} = \frac{\Delta \text{CTD}}{\text{CF}}$$

To fully hedge (immunize) a portfolio's value against interest rate changes, the change in portfolio value must be offset by the change in the futures value:

$\Delta P = HR \times \Delta$ futures price

where:
$\Delta P$ = change in portfolio's value
HR = hedge ratio = Number of futures contracts

$$\Delta P = HR \times \frac{\Delta \text{CTD}}{\text{CF}}$$

$$HR = \frac{\Delta P}{\Delta \text{CTD}} \times \text{CF}$$

In practice, the CTD bond and the bonds in an investor's portfolio are unlikely to be perfect substitutes. The mismatch between the change in value of an asset or portfolio and the change in value of the derivative used to hedge it is referred to as basis risk or spread risk. The hedge ratio mentioned previously will be effective if the portfolio only contains the CTD bond. If the portfolio does not consist solely of the CTD bond, a duration-based hedge ratio (BPVHR) is calculated to determine the number of futures contracts required for a hedge:

$$BPVHR = \frac{-BPV_{portfolio}}{BPV_{CTD}} \times CF$$

Basis point value (BPV) is the expected change in value of a security or portfolio given a one basis point (0.01%) change in yield.

BPVHR = number of short futures

$BPV_{portfolio} = MD_{portfolio} \times 0.01\% \times MV_{portfolio}$

MD = modified duration

$BPV_{CTD} = MD_{CTD} \times 0.01\% \times MV_{CTD}$

$MV_{CTD}$ = CTD price / 100 × $100,000

To achieve a target duration, the formula can be amended to:

$$BPVHR = \frac{BPV_{target} - BPV_{portfolio}}{BPV_{CTD}} \times CF$$

$BPV_{target} = MD_{target} \times 0.0001 \times MV_{portfolio}$

The original formula is a special case where the $BPV_{target}$ equals zero.

EXAMPLE: **Immunizing a bond portfolio from interest rate risk**

A fixed-income portfolio manager is holding a portfolio with a market value of £60 million and wants to fully hedge the portfolio value against parallel movements in the yield curve. The portfolio has a modified duration of 10.75. The portfolio manager will sell U.K. Government Long Gilt futures to hedge the portfolio.

| U.K. Government Long Gilt Futures Specifications | |
|---|---|
| Futures price | £130.21 |
| Futures contract size | £100,000 |
| CTD | 4.75% coupon, 12 years to redemption |
| CTD price | £139.56 |
| CTD CF | 1.0709 |
| CTD modified duration | 9.7 |

1. **Compute** the number of U.K. Government Long Gilt futures to be sold to immunize the portfolio.
2. **Compute** the number of Gilt futures that need to be sold to achieve a target duration of 8.7.

**Answer:**

1. *Step 1*: Compute the BPV of the portfolio ($BPV_{portfolio}$):

   $BPV_{portfolio}$ = 10.75 × 0.0001 × £60 million = £64,500

   *Step 2*:

Compute the BPV of the CTD ($BPV_{CTD}$):

$$BPV_{CTD} = 9.7 \times 0.0001 \times [(£139.56 / 100) \times £100{,}000]$$

$$= £135.37$$

*Step 3*:

Compute the BPV hedge ratio:

$$\text{BPVHR} = \frac{-\text{BPV}_{\text{portfolio}}}{\text{BPV}_{\text{CTD}}} \times \text{CF} = \frac{-£64{,}500}{135.37} \times 1.0709$$

$$= -510.25 \approx -510$$

The fund manager will need to sell 510 Long Gilt futures to fully hedge the portfolio.

2. $BPV_{target} = MD_{target} \times 0.0001 \times MV_{portfolio} = 8.7 \times 0.0001 \times £60 \text{ million} = £52{,}200$

$$\text{BPVHR} = \frac{\text{BPV}_{\text{target}} - \text{BPV}_{\text{portfolio}}}{\text{BPV}_{\text{CTD}}} \times \text{CF}$$

$$= \frac{£52{,}200 - £64{,}500}{£135.37} \times 1.0709 = -97.30 \approx -97$$

Selling 97 Long Gilt futures will achieve the portfolio's target modified duration of 8.7.

In practice, hedging results are not perfect due to three main factors:

1. The hedge was constructed using the CTD bond. If the level or slope of the term structure of interest rates changes significantly, the eligible bond, which is the CTD bond, may change. If the CTD bond changes, the duration of the Treasury bond future will also change.
2. Duration is not a perfect measure of how bond prices react to interest rate changes. Duration ignores the convexity of the bonds.
3. Modified duration only captures the impact of parallel movements in the term structure of interest rates. Shaping risk refers to nonparallel changes in the term structure, such as steepening, flattening, and changes in curvature.

## MODULE QUIZ 9.1

*To best evaluate your performance, enter your quiz answers online.*

1. Ben Root holds an interest rate swap with a tenor of one year and quarterly settlement dates. The variable reference rate is LIBOR. The variable payment/receipt on day 270 will be determined by:
   A. 270-day LIBOR at initiation.
   B. 90-day LIBOR at day 270.
   C. 90-day LIBOR at day 180.
2. Virat Sharma, a high-net-worth individual, holds a four-year floating-rate note (FRN) with semiannual coupons at 180-day $LIBOR + 40 bp and a par value of $4 million. Sharma is concerned about falling interest rates and would like to hedge this risk.

   Four-year semiannual swaps are quoted at a swap rate of 4%; 180-day LIBOR at initiation is 3.5% and 180-day LIBOR at the first settlement date is 2.5%.

   What type of swap should Sharma use? **Compute** the net cash flow on the swap at the first and second settlement dates. **Compute** the net return on Sharma's combined positions.

3. Adalene Bisset has agreed to purchase a new house for €8 million. Bisset expects to close the transaction in six months. She does not expect to close on the sale of her current house for nine months. Bisset needs to arrange three-month bridge financing for €8 million commencing six months from now and is concerned interest rates may have risen by then. She decides to sell three-month Euribor futures to hedge her risk.

| Euribor Futures Contract Details | |
|---|---|
| Contract size | €1 million |
| Tick size 0.0001 × 90 / 360 × €1 million | €25 |
| Futures price | 98 |

In six months, three-month interest rates are quoted at 2.5%, Bisset unwinds the hedge, and futures are trading at 97.5. What is the effective interest rate on Bisset's loan?

A. 0.5%.
B. 2.0%.
C. 2.5%.

4. Carlos Hendricks is a fixed-income fund manager. Hendricks is running a fund with a modified duration of 12 and a market value of $200 million. He is concerned that interest rates will increase and wants to reduce the duration of his portfolio to 8 using U.S. Treasury futures.

| U.S. Treasury Future | |
|---|---|
| Futures price | $164.20 |
| Contract size | $100,000 |
| CTD | 4%, 20 years to maturity |
| CTD price | $126.39 |
| CF | 0.7689 |
| CTD modified duration | 14.54 |

What Treasury future position is required to achieve a portfolio duration of eight?

A. Sell 335 contracts.
B. Sell 435 contracts.
C. Sell 1,004 contracts.

# MODULE 9.2: MANAGING CURRENCY EXPOSURE

Video covering this content is available online.

**LOS 9.b: Demonstrate how currency swaps, forwards, and futures can be used to modify a portfolio's risk and return.**

*CFA® Program Curriculum, Volume 2, page 95*

Many investors have assets and liabilities denominated in foreign currencies (not their domestic, or local, currency). When exchange rates change, the domestic-currency value of assets and liabilities denominated in a foreign currency will change. The exposure of foreign-currency denominated assets and liabilities to changes in exchange rates is termed currency risk.

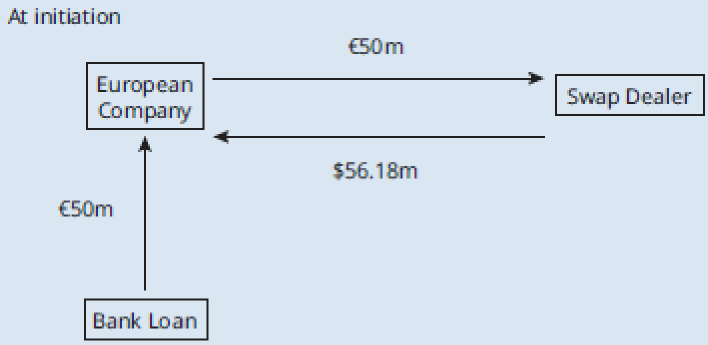
## Currency Swaps

In a **currency swap**, one party agrees to make periodic interest rate payments on a notional amount in one currency, while the other party agrees to make period interest payments on a notional amount in another currency. The notional amounts are equivalent based on the exchange rate at the inception of the swap. Currency swaps allow borrowers requiring foreign currency to effectively borrow in a foreign currency. This may be advantageous to a company that will invest in a foreign asset that will generate foreign currency cash flows. The firm may not have good access to capital markets in the foreign country. A currency swap will allow the firm to hedge its currency risk from the foreign-currency cash flows. This is known as synthetic borrowing.

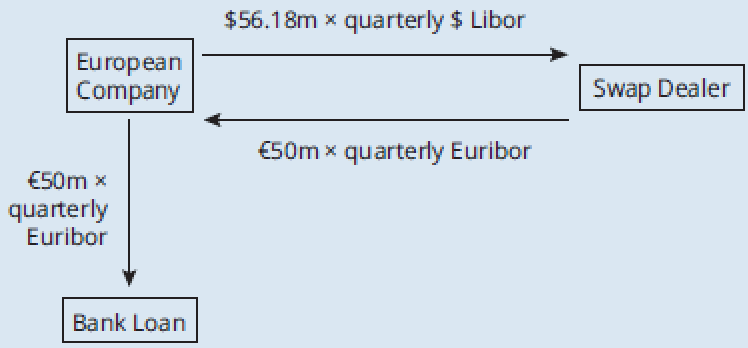
The parties to a currency swap may exchange only interest payments, but they may also exchange the notional amounts of each currency at the beginning and the end of the swap. This second case is known as a **cross-currency basis swap**. The periodic payments on a currency swap may be fixed or floating, but the typical swap is floating for floating.

EXAMPLE: **Cross-currency basis swap**

A euro-based company requires USD but does not have access to direct USD borrowing or finds it prohibitively expensive. The company decides to borrow in euros at 90-day Euribor and enter into a cross-currency basis swap to USD based on 90-day USD LIBOR (a floating-for-floating swap). The swap has a tenor of two years with quarterly settlement. The principal on the euro loan is €50 million and the $/€ exchange rate at initiation of the swap is $1.1236.

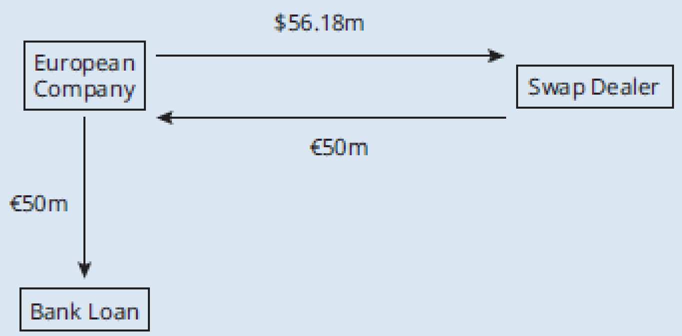



The euro-based company borrows €50 million and exchanges it for €50 million × 1.1236 = $56.18 million.




Each counterparty pays variable interest for the currency they initially received. The euro-based company will be paying USD interest to the swap dealer. The swap dealer will be paying the euro interest to the company, which will then use it to service the interest on its loan with the bank.

At swap maturity (2 years)




At the swap's expiration, the notional principal amounts are exchanged. The amounts are the same as those exchanged initially; changes in the exchange rate over the life of the swap do not affect these amounts, so there is no uncertainty (exchange rate risk) on the principal flows. The European company receives the €50 million and uses it to repay its bank loan.

In this swap, the European company is described as the dollar payer and the swap dealer as the euro payer (i.e., the description relates to the interest flows and final principal payment, not the swap of initial principal).

## Cross-Currency Basis

For the three decades leading up to the great financial crisis in 2008/2009, the **covered interest rate parity (CIRP)** relationship held quite well. When CIRP holds, borrowing directly in USD should have the same cost as borrowing in a foreign currency and hedging exchange rate risk with a currency swap.

When the CIRP relationship does not hold, arbitrage profits are theoretically possible, and exploitation of any arbitrage profits should result in zero basis over time. In a frictionless market, cross-currency basis should not exist.

Since the financial crisis, basis has not been zero, indicating a failure of CIRP. The failure of CIRP to hold results from frictions in the arbitrage market. The introduction of stricter capital adequacy requirements and rules since the financial crash has resulted in much higher costs for covered interest rate arbitrage transactions. Another factor is high demand for USD loans. Since the financial crisis, USD lending via swaps has attracted a premium.

Cross-currency basis represents the additional cost of borrowing dollars synthetically with a currency swap relative to the cost of borrowing directly in the USD cash market. Typically, when describing basis we view it from the foreign-currency perspective rather than the USD perspective. If the cost of borrowing dollars synthetically via a swap is greater than the cost of direct USD borrowing, the foreign currency is said to be exhibiting negative basis. Most currencies have shown a negative basis against the dollar since the financial crisis. The implication is that the USD borrower must accept a lower interest rate on the foreign-currency interest payments it receives.

USD fixed-income investors can benefit when foreign currencies have a negative basis versus the USD by swapping USD for foreign currency and investing in foreign-currency denominated bonds and using a currency swap to convert the returns back to USD. Using this strategy, a USD investor can earn a higher return than by simply investing in the USD denominated bonds.

EXAMPLE: **Cross-currency basis swap**

Boivis Patisseries Sarl is a French chain of patisseries that has an extensive network of shops in continental Europe. As part of their expansion strategy, they are looking to set up shops in the United States. Boivis estimates that it will initially require $50 million to set up shops and cover working capital requirements. The finance directors at Boivis have looked at directly borrowing in USD but have found that costs would be $LIBOR + 100 bp. The decision is made to borrow for four years in euros at a rate of Euribor + 60 bp with interest paid quarterly and enter a currency swap to exchange euros for dollars. Basis on the Eurodollar swap is being quoted at –20 basis points (–20 bp). The swap pays variable interest on both legs on a quarterly settlement basis. The current $/€ exchange rate is $1.1815.

Three-month Euribor is 1.5% and $LIBOR is 2.0% at swap initiation. Three months later at the first settlement date, three-month Euribor is 1.6% and $LIBOR is 1.9%.

**Compute** the principal flows exchanged at the start and end of the swap's tenor. **Compute** the interest payments at the first and second settlement dates on the swap and the cost to Boivis for its synthetic dollar loan.

**Answer:**

*Principal flows:*

$50,000,000 / $1.1815 = €42,319,086

Boivis will need to borrow €42,319,086 and exchange it for $50,000,000. These amounts will be swapped back at the maturity of the swap.

**Interest payment at first settlement date**

*Pays:*

€ interest on the loan: €42,319,086 × (0.015 + 0.006) × 90 / 360 = €222,175

$ interest on the swap: $50,000,000 × 0.02 × 90 / 360 = $250,000

*Receives:*

€ interest on the swap: €42,319,086 × (0.015 – 0.002) × 90 / 360 = €137,537

*Cost of $ financing:*

Cost of borrowing $ direct: $50,000,000 × (0.02 + 0.01) × 90 / 360 = $375,000 (LIBOR + 100 bp)

Cost of synthetic $ borrowing: $50,000,000 × (0.02 + 0.006 + 0.002) × 90 / 360 = $350,000 (LIBOR + 80 bp)

Net benefit of swap: $375,000 – $350,000 = $25,000

Net benefit of swap: $50,000,000 (1% – 0.8%) × 90 / 360 = $25,000

**Interest payment at second settlement date**

*Pays:*

€ interest on the loan: €42,319,086 × (0.016 + 0.006) × 90 / 360 = €232,755

$ interest on the swap: $50,000,000 × 0.019 × 90 / 360 = $237,500

*Receives:*

€ interest on the swap: €42,319,086 × (0.016 – 0.002) × 90 / 360 = €148,117

Cost of $ financing:

Cost of borrowing $ direct: $50,000,000 × (0.019 + 0.01) × 90 / 360 = $362,500 (LIBOR + 100 bp)

Cost of synthetic $ borrowing: $50,000,000 × (0.019 + 0.006 + 0.002) × 90 / 360 = $337,500 (LIBOR + 80 bp)

Net benefit of swap: $362,500 – $337,500 = $25,000

Net benefit of swap: $50,000,000 (1% – 0.8%) × 90 / 360 = $25,000

*Conclusion:*

By borrowing in euros and entering a currency swap, Boivis has locked into a cost of $LIBOR + 80 bp for their USD borrowing, reflecting the 60 bp spread above Euribor on the loan and the –20 bp on the swap.

## Currency Forwards and Futures

**Currency forwards and futures** allow users to exchange a specified amount of one currency for a specified amount of another currency on a future date. Forwards are customized, while futures are standardized contracts. Consider, for example, a U.K. company exporting goods to Canada that expects to receive a payment of 30 million Canadian dollars (CAD) in 90 days. The risk to the U.K. company is that the exchange rate may change over the next 90 days, so the amount received when converted to British pounds (GBP) is uncertain. A forward contract to purchase a specific number of GBP for 30 million CAD effectively guarantees the future exchange rate in 90 days. The customization of forward contracts allows the contract to be tailored to both the specific quantity of CAD to be received and the expected date of receipt.

Currency futures are standardized in terms of quantity of currency to be exchanged and delivery dates, so a futures hedge may not exactly match the requirements of a hedger. The range of currency pairs on which futures are available is limited, although they are available on most major currency pairs. The greater liquidity of currency futures is attractive to many investors and currency dealers.

The hedge ratio for futures can be calculated as:

$$\text{HR} = \frac{\text{amount of currency to be exchanged}}{\text{futures contract size}}$$

EXAMPLE: **Hedging exchange rate risk using futures**

A U.S. firm is due to receive €20 million in 90 days for goods they sold. The firm is seeking to hedge this risk by selling EUR futures contracts maturing closest to date the euros will be received. The EUR-USD FX future contract size is €125,000. The futures price is 1.3150 USD/EUR. The firm will sell futures contracts (promising to deliver euros at the rate of 1.3150 USD per EUR).

**Calculate** the number of futures contracts required to hedge the asset and the amount of USD to be received at contract settlement.

**Answer:**

$$\text{futures position HR} = \frac{€20{,}000{,}000}{€125{,}000} = 160 \text{ EUR-USD futures}$$

At contract settlement, the firm will deliver €20 million and receive 20 million × 1.3150 = $26,300,000.

If the settlement date of the futures does not match the date that euros will be received, the hedge will not be perfect. If the futures settlement is prior to the receipt of the euros, the firm will have exchange rate risk from the settlement date until the euros are received. If the futures settle after the euros are received, the futures position will be closed prior to the futures settlement. In this case, the futures price when the futures are purchased (to close out the short position) will likely not equal the spot price, so the firm has basis risk. This difference could lead to the receipt of either more or less USD than delivery at the settlement of the futures contract would.

## MODULE QUIZ 9.2

*To best evaluate your performance, enter your quiz answers online.*

1. The New Zealand dollar (NZD) is trading at a positive cross-currency basis against the U.S. dollar (USD). Sterling (GBP) is trading at a negative cross-currency basis to the USD. Which of the following strategies would generate the greatest return?
   A. Swapping USD for NZD and investing in New Zealand government securities.
   B. Swapping NZD for USD and investing in U.S. government securities.
   C. Swapping GBP for NZD and investing in New Zealand government securities.
2. Barney Wood imports goods to the U.K. from the Eurozone. He is due to make a payment in 30 days of €20 million. Wood is concerned that the pound will depreciate

against the euro over this period and would like to hedge his currency risk with futures. The current spot rate is £/€ = 0.8929.

| Cross-Currency EUR-GBP Future | |
|---|---|
| Futures price* £/€ | 0.8989 |
| Contract size | €125,000 |

*Expires in 40 days

**Calculate** the futures position needed to hedge Wood's liability.

In 30 days, the exchange rate is £/€ = 0.9034 and the futures price is £/€ 0.9054. **Calculate** the cost to Wood if he leaves his euro liability unhedged and if he hedges the position using the future.

3. ABC Robotics, Inc., a U.S. firm, will borrow £30 million to set up a subsidiary in the U.K. ABC can borrow GBP directly at a cost of £LIBOR + 50 bp. ABC Robotics can borrow in USD at $LIBOR + 40 bp. A GBP-USD swap is quoted at −15 bp. The spot exchange rate at swap initiation is quoted as $/£ = $1.2000. The swap is a four-year semiannual swap where both the USD and GBP reference rates are based on six-month LIBOR. Six-month $LIBOR is 2.5% and £LIBOR is 1.5% at initiation of the swap. At the first settlement date, six-month $LIBOR is 2.25% and £LIBOR is 1%. **Calculate** the interest payments at the first and second settlement dates. How much better off is ABC Robotics from using the cross-currency swap rather than directly borrowing GBP?

# MODULE 9.3: MANAGING EQUITY RISK

Video covering this content is available online.

**LOS 9.c: Demonstrate how equity swaps, forwards, and futures can be used to modify a portfolio's risk and return.**

*CFA® Program Curriculum, Volume 2, page 99*

## Equity Swaps

Equity swaps can be used to create a synthetic exposure to physical stocks, allowing market participants to increase or decrease their exposure to equity returns. Equity swaps enable users to achieve the economic benefits of share ownership without the cost and expense of ownership.

The three main types of swaps include the following:

1. Pay fixed, receive equity return.
2. Pay floating, receive equity return.
3. Pay another equity return, receive equity return.

An example of paying another equity return and receiving an equity return would be paying the return on the Nasdaq Composite Index and receiving the return on the S&P 500.

The equity return may be based on:

- A single stock.
- A basket of equities.
- An equity index.

The equity return may be price return (typical) or total return (price + dividends).

A typical equity swap will involve a series of payments at periodic settlement dates over the tenor of the swap. Some equity swaps require each party to make a single payment at the end of the swap's life.

Figure 9.4: Equity Swap vs. Physical Stock

| Advantages | Disadvantages |
|---|---|
| ■ Gain exposure to equity when participation in physical market is restricted<br>■ Avoid tax on physical ownership (i.e., stamp duty)<br>■ Avoid custody fees on physical ownership<br>■ Avoid the cost of monitoring physical positions, which may increase due to corporate actions (i.e., dividend payments, stock splits, buy-backs, M&A, etc.) | ■ Equity swaps typically require collateral<br>■ Swaps are illiquid<br>■ Swaps do not convey voting rights |

EXAMPLE: **Changing equity exposure using a swap**

A German pension fund manager holds a €200 million portfolio of domestic stocks passively tracking the DAX 30 stock market index. The pension fund expects the index to rise in the next year and wishes to increase its exposure by 40%. The fund manager enters an equity swap with a notional principal of €80 million, agreeing to pay floating interest at Euribor + 30 bp and receive the return on the equity index. The swap has a tenor of one year and semiannual settlements. The DAX 30 at the time of swap initiation is 12,400 points.

*Scenario 1:*

The reference rate relating to the first settlement date is six-month Euribor = 6%.

The DAX 30 at the first settlement date = 13,020.

*Scenario 2:*

The reference rate relating to the first settlement date is six-month Euribor = 6%.

The DAX 30 at the first settlement date = 11,780.

**Compute** the gain or loss on the portfolio, the cash flows on the swap, and the net position for the fund manager in both scenarios.

**Answer:**

*Scenario 1:*

Return on DAX 30 = (13,020 / 12,400) − 1 = 5%

Increase in portfolio value = €200 million × 0.05 = €10 million

Equity leg of swap = €80 million × 0.05 = €4 million

Euribor leg of swap = €80 million × (0.06 + 0.003) × 180 / 360 = €2.52 million

Net cash flow on swap = €4 million − €2.52 million = €1.48 million

This is the synthetic equivalent to borrowing €80 million in the money markets at Euribor + 30 bp and investing €80 million in an index-tracking portfolio:

€80 million × [0.05 − (0.063 × 180 / 360)] = €1.48 million

Fund manager's position = €10 million + €1.48 million = €11.48 million

*Scenario 2:*

Return on DAX 30 = (11,780 / 12,400) − 1 = −0.05

Decrease in portfolio value = €200 million × −0.05 = −€10 million

Equity leg of swap = €80 million × −0.05 = −€4 million

Floating leg of swap = €80 million × (0.06 + 0.003) × 180 / 360 = €2.52 million

Net cash flow on swap = −€4 million − €2.52 million = −€6.52 million

Note that the equity return receiver pays both the floating rate of interest and the negative return on the equity index.

This is the synthetic equivalent to borrowing €80 million in the money markets at Euribor + 30 bp and investing €80 million in an index-tracking portfolio:

€80 million × [−0.05 − (0.063 × 180 / 360)] = −€6.52 million

Fund manager's net position = −€10 million − €6.52 million = −€16.52 million

To reduce the exposure to equity, the fund manager would enter a swap to pay the equity return and receive a floating (or fixed) rate of interest. This synthetically creates a position equivalent to selling equity and investing the proceeds in the money markets.

## Equity Futures and Forwards

**Equity futures** are exchange traded, standardized, require margin, have low transaction costs, and are available on indexes and single stocks. They enable market participants to do the following:

- Implement tactical allocation decisions (alter the exposure to equity of a portfolio).
  - Selling futures (short position) reduces equity exposure.
  - Buying futures (long position) increases equity exposure.
- Achieve portfolio diversification.
- Gain exposure to international markets.
- Make directional bets on the direction of the market.

**Forwards** provide many of the same advantages but lack liquidity and are not subject to mark-to-market margin adjustments. Because there is no clearinghouse, the credit quality of the counterparties is a concern. The major advantage of forward contracts is they can be customized.

Index futures have a multiplier. The actual futures price is the quoted futures price (in points) × the multiplier. For S&P 500 Index futures, the multiplier is $250; for FTSE 100 Index futures, the multiplier is £10.

EXAMPLE: **Using index futures to hedge equity market exposure**

A fund manager holds a £200 million equity portfolio, which is passively tracking the FTSE 100 Index. The fund manager wishes to hedge 30% of the portfolio against equity market risk.

| Contract Details for FTSE 100 Index Futures | |
|---|---|
| Quotation | Index points |
| Multiplier | £10 per point |
| Tick size | 0.5 points |
| Delivery dates | March, June, September, December |
| Settlement price | FTSE 100 cash price on last day of trading |
| Futures price – September delivery | 7,300 |

**Compute** the number of contracts required to hedge 30% of the portfolio's equity position. **Compute** the profit or loss if the FTSE 100 increases by 5% and the futures price is 7,665. **Compute** the profit or loss if the FTSE 100 falls by 5% and the futures price changes to 6,935.

**Answer:**

number of futures contracts needed

$$= \frac{\text{monetary value of position to be hedged}}{\text{futures price} \times \text{multiplier}}$$

$$= \frac{-£60{,}000{,}000}{7{,}300 \times £10} = -821.9 = 822 \text{ short futures}$$

*FTSE 100 @ 7,665 at delivery (5% increase)*

Futures gain/(loss): 7,665 − 7,300 = 365 points ∴ 365 points × £10 × −822 = −£3,000,300

Portfolio value: (1 + 0.05) × £200,000,000 = £210,000,000

Net position: £210,000,000 − £3,000,300 = £206,999,700

| Impact of hedge | £ |
|---|---|
| Future position | −3,000,300 |
| Portfolio £60,000,000 × 0.05 | 3,000,000 |
| Net gain | −300 |

The imperfection in the hedge is the result of rounding the hedge ratio.

*FTSE 100 @ 6,935 at delivery*

Futures gain/(loss): 6,935 − 7,300 = −365 points ∴ −365 points × £10 × −822 = £3,000,300

Portfolio value: (1 − 0.05) × £200,000,000 = £190,000,000

Net position: £190,000,000 + £3,000,300 = £193,000,300

| Impact of hedge | £ |
|---|---|
| Future position | 3,000,300 |
| Portfolio £60,000,000 × −0.05 | −3,000,000 |
| Net gain | 300 |

## Achieving a Target Portfolio Beta

Short equity futures positions can be used to decrease the beta of a portfolio, and long positions can be used to increase the beta of a portfolio. A portfolio's beta is the weighted average of the betas of the portfolio stocks. The number of contracts required to change the beta of an existing portfolio can be calculated with the following formula:

$$\text{number of futures required} = \left(\frac{\beta_T - \beta_P}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$$

where:

$\beta_T$ = target portfolio beta

$\beta_P$ = current portfolio beta

$\beta_F$ = futures beta (beta of stock index)

$MV_P$ = market value of portfolio

F = futures contract value = futures price × multiplier

Note that to fully hedge the portfolio from market risk, $\beta_T = 0$.

EXAMPLE: **Achieving a target portfolio beta using index futures**

A fund manager has a $60 million portfolio of aggressive stocks with a portfolio beta of 1.2 relative to the S&P 500. The fund manager believes the market will decline over the next six months and wishes to reduce the beta of the portfolio to 0.8 using S&P 500 futures. S&P 500 futures currently have a contract price of 2,984 and a multiplier of $250. At the end of the six-month period, the S&P 500 Index has decreased by 1.5%. By definition, beta of the S&P 500 Index equals 1.

**Calculate** the number of futures contracts and **determine** whether they should be bought or sold to achieve the target portfolio beta. **Compute** the effectiveness of the strategy at the end of the six-month period.

**Answer:**

$$\text{number of futures required} = \left(\frac{0.8 - 1.2}{1}\right)\left(\frac{\$60{,}000{,}000}{\$746{,}000}\right) = -32.17$$

$$= -32 \text{ futures contracts}$$

futures contract value = 2,984 × $250 = $746,000

Because the calculated value of the number of futures contracts is negative, the futures contracts should be sold.

Value of portfolio in six months:

$60,000,000 × [1 − (0.015 × 1.2)] = $58,920,000

Note that if the market falls by 1.5%, the portfolio will fall by more than 1.5% because its beta is greater than 1.

Profit on futures contract:

Futures contract value in six months: 2,984 × (1 − 0.015) = 2,939.24 = 2,939 (rounded to the nearest 0.5 index point)

Futures profit: (2,984 − 2,939) × $250 × 32 = $360,000

Net position: $58,920,000 + $360,000 = $59,280,000

$$\text{return} = \frac{\$59{,}280{,}000}{\$60{,}000{,}000} - 1 = -0.012, \textit{ or} -1.2\%$$

$$\text{beta of portfolio} = \frac{\%\text{ change in portfolio}}{\%\text{ change in index}} = \frac{-0.012}{-0.015} = 0.8$$

# Cash Equitization

Holding cash balances will typically reduce the return on a portfolio because cash typically yields a lower rate of return than equity or fixed income. Holding cash balances will therefore increase the risk that the portfolios will underperform the benchmark. **Cash equitization** refers to purchasing index futures to replicate the returns that would have been earned by investing the cash in an index with risk and return characteristics similar to those of the portfolio. The major advantages of futures, in this application, are their liquidity and low transaction costs relative to direct investment in the equity markets. Cash equitization is also known as cash securitization or cash overlay.

An alternative to purchasing futures would be to buy call options and sell put options on the appropriate stock index with the same strike and expiry to create a synthetic forward position.

EXAMPLE: **Cash equitization**

A U.S. fund manager runs a passive fund, which tracks the S&P 500. Cash balances have built up in the portfolio and the fund manager is concerned that the cash drag will lead to portfolio underperformance relative to the S&P 500. The fund currently holds $8 million in cash. S&P 500 futures currently have a contract price of 2,780, a multiplier of $250, and a beta of 1.

**Calculate** the number of stock index futures needed to equitize the portfolio's excess cash.

**Answer:**

$$\text{number of futures required} = \left(\frac{\beta_T - \beta_P}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$$

where:

$\beta_P$ = current portfolio beta of cash position = 0 (note cash has a beta of 0)

$MV_P$ = cash position

$$\text{number of futures required} = \left(\frac{\beta_T}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$$

where:

$\beta_T$ = target portfolio beta (In this case, the target will be set to 1, as we want the beta of the synthetically invested cash to match the beta of the index.)

$$\text{number of futures required} = \left(\frac{1}{1}\right)\left(\frac{\$8{,}000{,}000}{\$695{,}000}\right)$$

F = 2,780 × $250 = $695,000

## MODULE QUIZ 9.3

*To best evaluate your performance, enter your quiz answers online.*

1. A U.K. fund manager has a defensive equity portfolio with a market value of £20 million and a beta equals 0.8 relative to the FTSE 100. The manager believes that U.K. equity will perform strongly over the next year and wishes to increase the portfolio beta to 1.4. FTSE 100 futures are currently trading at 7,425 points with a multiplier of £10. How many futures contracts are required to achieve the desired beta?
   A. 162 FTSE 100 futures.
   B. 377 FTSE 100 futures.
   C. 1,620 FTSE 100 futures.
2. Hideko Kobayashi is an active fund manager running an equity portfolio benchmarked against the Nikkei 225. The funds market value is ¥4,350,000,000. Due to recent sales, Hideko is worried that cash balances have built up to 5% of the fund's value. Hideko is worried about the cash drag affecting her performance fees and wishes to temporarily invest the surplus cash in the Nikkei 225. The Nikkei future she is considering has a price of 21,624 and a multiplier of ¥1,000. How many Nikkei 225 futures will she require for this cash overlay?
   A. 10 futures.
   B. 100 futures.
   C. 201 futures.

# MODULE 9.4: DERIVATIVES ON VOLATILITY

Video covering this content is available online.

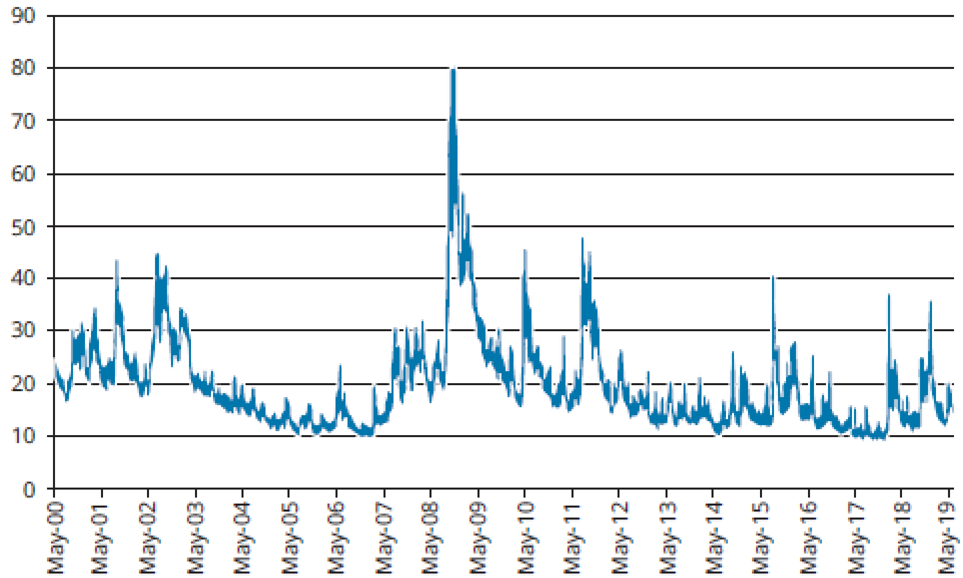
### LOS 9.d: Demonstrate the use of volatility derivatives and variance swaps.

*CFA® Program Curriculum, Volume 2, page 106*

Volatility is a measure of the magnitude of price movements over a certain period of time. The best known measure of market volatility is the CBOE Volatility Index (more commonly known as VIX). The VIX Index measures implied volatility in the S&P 500 Index over a forward period of 30 days. VIX computes a weighted average of implied volatility inferred from S&P 500 traded options (calls and puts) with an average expiration of 30 days. It is important to note that VIX is not a measure of actual volatility but rather the expected volatility that is priced into options. VIX is also known as the fear index or fear gauge as we can directly view the market's expectations of future volatility.

Specifically, the VIX Index value is the annualized standard deviation of the expected +/− percentage moves in the S&P 500 Index over the following 30 days. For example, if the VIX was at 20, we could interpret it as telling us that the market expects that the S&P will stay within a +/−20% range over one year with a 68% level of confidence. This implies a range +/− $+/-\frac{20}{\sqrt{12}} = 5.77\%$ over the next 30-day period.

VIX Index Level

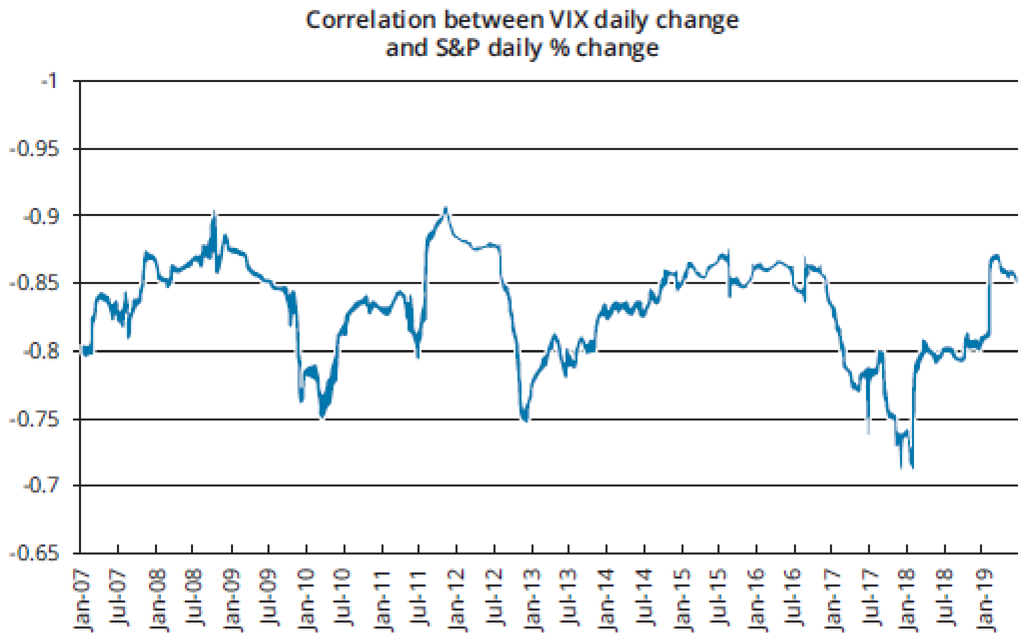



Source: CBOE

The graph of the VIX Index over the past 19 years shows large spikes in the index at times of great uncertainty—for example, in 2008 with the great financial crash, 2010 with the "flash crash" attributed to high-frequency traders, and 2011 with the S&P downgrade of U.S. sovereign debt. As a rule of thumb, a value lower than 20 represents a low-risk environment and values above 30 represent a high-risk environment. However, very low levels of the VIX Index can indicate an excessively bullish market, while very high levels can imply an excessively bearish market. The performance of VIX over this 19-year period also demonstrates the mean reversion of the index. Spikes in the index do not last, and the index reverts to more moderate levels soon after.

Importantly, empirical studies have shown a negative correlation between the VIX and stock returns, which becomes even more pronounced during downturns. This correlation allows derivatives based on the index to be used to offset the losses on an equity portfolio when volatility increases.

The following chart shows a rolling 252-day correlation between the VIX price and daily returns on the S&P 500.




Source: CBOE

While investors cannot directly invest in VIX, the CBOE introduced futures based on the VIX Index in 2004 and options in 2006. This has led to volatility being viewed as a separate asset class that can be bought and sold. VIX futures and options offer participants pure-play bets on market volatility.

## VIX Futures

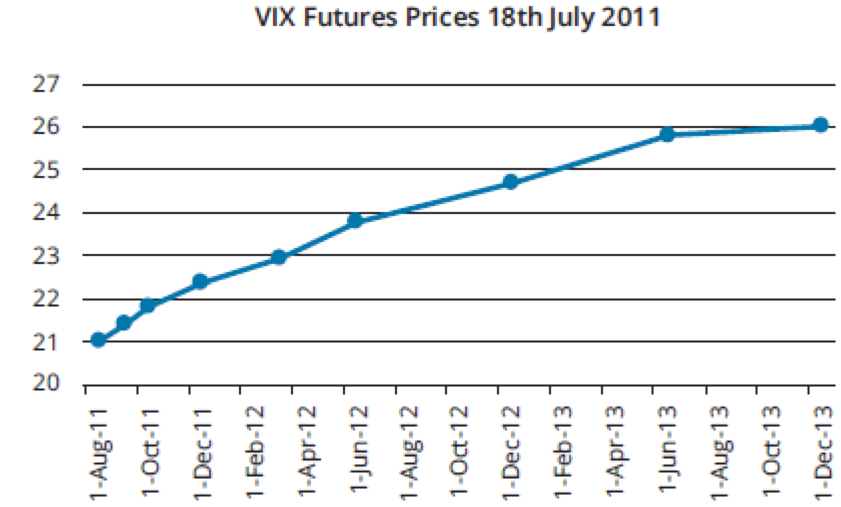
Unlike other futures contracts, the cost-of-carry model cannot be used to determine the fair value of the future because it is not possible to directly invest in spot VIX. The **VIX futures** price can be interpreted as the expected S&P 500 Index volatility in the 30-day period after the futures contract expiration date.

An equity holding can be protected from extreme downturns (tail risk) by buying VIX futures. Remember that VIX returns and equity returns are negatively correlated. If volatility increases, the equity portfolio will decline in value but VIX futures should increase in value. VIX futures will increase in value when the market's expectation of future volatility at contract maturity increases.

Selling VIX futures creates a short volatility position and captures the volatility risk premium embedded in S&P 500 options. Short volatility positions can result in large losses if expected volatility rises significantly.

The term structure of VIX futures can provide insights into the market's expectations of volatility over time. Contango and backwardation in the futures market are therefore driven by expected changes in volatility over time. The term structure of VIX futures is constantly changing, reflecting changes in expected 30-day volatility at future dates, current expected 30-day volatility, and VIX futures trading activity.

**Contango Market**

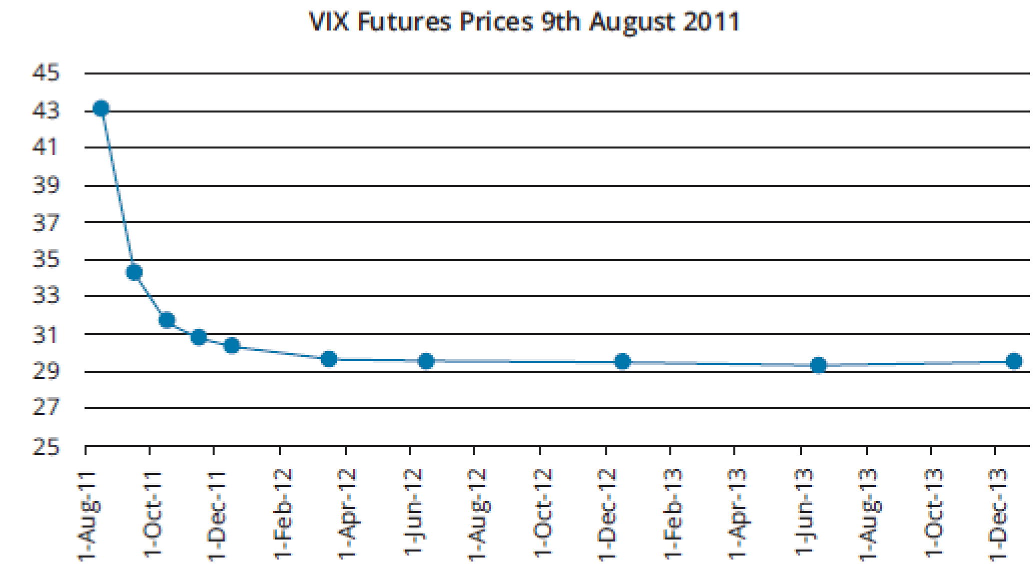



18 July, 2011; spot VIX = 20.95

Source: CBOE

The chart shows futures prices on the y-axis and futures expiration dates on the x-axis. Looking at the data on 18 July, 2011, the VIX futures market is in contango. Negative basis defines contango, where basis is computed as spot minus futures price. Longer-dated futures contracts have higher prices than short-dated futures contracts. We can interpret this as market participants expecting 30-day volatility to increase from August 2011 until December 2013. When levels of the VIX Index are low, it is common for the futures market to be in contango.

**Backwardation**




9 August, 2011; spot VIX = 35.06

Source: CBOE

Less than one month later, the term structure of VIX futures has completely changed and is now in backwardation. We can interpret this shape as the market expecting 30-day volatility to decrease over the period. The cause of the sudden change from contango to backwardation was a sudden increase in the VIX Index caused by the S&P downgrade of U.S. sovereign debt from AAA to AA+ on August 5, 2011.

VIX futures prices and the VIX Index will converge at contract maturity because VIX futures settle against spot VIX at expiration. For a participant who purchases long-dated VIX futures when the market is in contango (the typical situation), the difference between the spot and futures price will decline over time as the futures price moves toward spot VIX at expiration. If the market is in backwardation, the futures price should rise over time as it moves toward spot VIX. The profit or loss generated as the basis moves toward zero over the life of the futures contract is referred to as roll yield. When the short end of the VIX futures curve is steeper than the long end, the roll yield will be magnified.

| Position | Term Structure | Roll Yield |
|---|---|---|
| Long futures position | Contango | Negative |
| Short futures position | Contango | Positive |
| Long futures position | Backwardation | Positive |
| Short futures position | Backwardation | Negative |

## VIX Options

**VIX options** are cash-settled European-style options. VIX options can only be exercised at contract maturity; therefore, the value of the option is determined by the expectations of VIX at the contract expiry. VIX call options will gain in value if expectations of volatility at maturity of the option increase, and put options will gain in value if expectations of volatility fall.

## Other Volatility Indexes

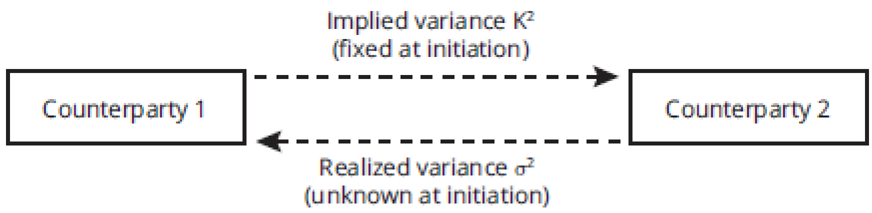
Volatility indexes are also available on other U.S. stock indexes, including the S&P 100, DJIA, Nasdaq, and Russell 2000.

Volatility indexes also exist on European stock market indexes. Using similar methodology to the VIX Index, VSTOXX is an implied volatility-based index based on the EURO STOXX 50 Index. VFTSE is a volatility index based on the FTSE 100, and VDAX-NEW is based on the DAX 30.

## Variance Swaps

**Variance swaps** payoffs are based on variance rather than volatility (standard deviation). Variance is $\sigma^2$. These products are termed swaps as they have two counterparties, one making a fixed payment and the other making a variable payment. The fixed payment is typically based on implied volatility$^2$ (implied variance) over the period and is known at the initiation of the swap; this is referred to as the variance strike. The variable payment is unknown at swap initiation and is only known at swap maturity. It is the actual variance of the underlying asset over the life of the swap and is referred to as realized variance ($\sigma^2$).

The party receiving the variable payment (the purchaser) will gain on the contract when the realized variance is greater than the implied variance and will lose when the realized variance is less than the implied variance. A variance swap can, therefore, be viewed as a pure play on whether realized variance will be higher or lower than expected variance (implied variance) over the tenor of the swap.




There is no exchange of notional principal at the initiation of the swap. A variance swap also has no interim settlement periods. With a variance swap, there is a single payment at the expiration of the swap based on the difference between actual and implied variance over the life of the swap:

settlement $\text{amount}_T$ = (variance notional)(realized variance – variance strike)

The value of the swap is zero at initiation because implied volatility is the best ex ante estimate of realized volatility.

Long (purchaser) describes the counterparty who receives the realized variance (actual) and pays the swap's variance strike (implied volatility).

Realized volatility > strike Buyer (long) of swap makes a profit

Realized volatility < strike Buyer (long) of swap makes a loss

Realized variance is calculated by taking the natural log of the daily price relatives, the closing price on day *t*, divided by the closing price on day *t* – *1*:

$R_i = \ln(P_t / P_{t-1})$

If we have *N* days of traded prices, we can compute *N* – *1* price relatives (R):

$$\text{daily variance} = \left[\frac{\sum_{i=1}^{N-1} R_i^2}{(N-1)}\right]$$

annualized variance = daily variance × 252; 252 = assumed trading days in a year

### PROFESSOR'S NOTE

This appears to be an unusual variance computation, as most computations we have seen deduct the mean from the numerator before squaring (i.e., $\frac{\sum_{i=1}^{N-1}(R_i - \bar{R})^2}{(N-1)}$. In this variance computation, the mean is not deducted. The logic is that we are calculating movement regardless of direction rather than movement around a mean. This has the advantage of making the variances perfectly additive (i.e., one-year variance can be split into two equal six-month periods). This concept will be used later for valuing variance swaps prior to maturity.

Variance swaps can be created for any underlying asset as long as it is traded and there is a record of daily prices.

The notional amount for a variance swap can be expressed as either variance notional ($N_{VAR}$) or vega notional ($N_{vega}$). Variance notional represents the profit or loss per point difference between implied variance ($\text{strike}^2$) and realized variance ($\sigma^2$). Variance notional can therefore be thought of as a multiplier that turns the point difference between $\sigma^2$ and $K^2$ into a monetary amount:

profit/(loss) = $N_{VAR} \times (\sigma^2 - K^2)$

where:
$\sigma$ = realized volatility
K = strike volatility (implied volatility)

PROFESSOR'S NOTE

Both the actual ($\sigma$) and the implied volatility on the swap (K) are quoted in standard deviations but remember this is a variance swap and therefore we must square the volatility.

The market convention is to quote the notional on a swap as vega notional ($N_{vega}$) rather than variance notional ($N_{VAR}$). Recall that vega refers to the change in option premium per a 1% change in volatility, $\frac{\Delta Premium}{\Delta Volatility}$, a natural way to think about the return for volatility.

Given the relationship between $N_{VAR}$ and $N_{vega}$, we can calculate the gains or losses on a variance swap with either of them. Using $N_{VAR}$, this calculation is more intuitive as it is multiplied by the difference between actual and implied variance:

$$\text{variance notional} = \frac{\text{vega notional}}{2 \times \text{strike price (K)}}, \text{ so profit/(loss)} = N_{VAR} \times (\sigma^2 - K^2)$$

$$= N_{vega} \times \left(\frac{\sigma^2 - K^2}{2K}\right)$$

## Convexity

Because the payoffs on a variance swap are based on variance, while the strike price is expressed in terms of volatility, the payoffs for a variance swap are convex with respect to volatility. Compared to the payoffs on a volatility derivative with payoffs that are linear with respect to volatility, (1) when realized volatility is below the strike, the losses on the variance swap are smaller than the losses on the volatility derivative, and (2) when realized volatility is above the strike, the gains on the variance swap are greater than the gains on the volatility derivative. This convexity is similar in nature to the convexity of bond prices with respect to yield. With the variance swap, payoffs are increasing at an increasing rate when volatility rises and decreasing at a decreasing rate when volatility falls.

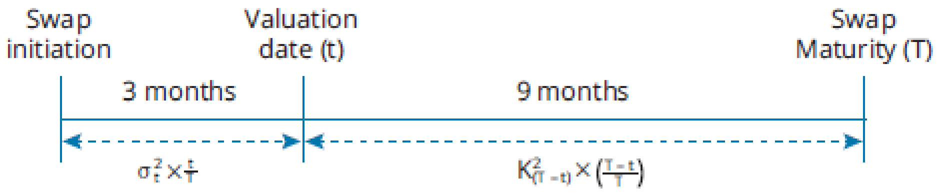
Convexity is an attractive feature to those who use variance swaps to hedge tail risk. When equity values fall sharply and volatility increases dramatically, decreases in portfolio value are offset by profits on a variance swap that increase at an accelerating rate.

## Mark to Market

The value of a variance swap is zero at initiation, but over time, the swap will either gain or lose value as realized and implied volatility diverge. At any point, the expected variance at maturity is simply the time-weighted average of the variance realized over the time since swap inception and the implied variance over the remaining time to maturity.

Consider a one-year swap where three months have elapsed since inception:

*Step 1*: Compute expected variance at maturity (the time-weighted average of realized variance and implied variance over the remainder of the swap's life).




$$\text{expected variance to maturity} = \left(\sigma_t^2 \times \frac{t}{T}\right) + \left(K^2_{(T-t)} \times \frac{T-t}{T}\right)$$

where:

$\sigma_t^2$ = annualized realized volatility from initiation to valuation date squared

$K^2_{(T-t)}$ = annualized implied volatility from valuation date to swap maturity squared

$\frac{t}{T} = \frac{3}{12}$

$\frac{T-t}{T} = \frac{9}{12}$

*Step 2*: Compute expected payoff at swap maturity:

payoff = $N_{VAR}$ × (expected variance to maturity − original strike$^2$)

*Step 3*: Discount expected payoff at maturity back to the valuation date.

EXAMPLE: **Valuing a variance swap during its life**

Luke Amos, an equity fund manager, has purchased a one-year variance swap on the S&P 500 with vega notional of $100,000 and a strike of 20%.

Nine months have passed and the S&P has realized a volatility of 21%. The strike price for a three-month variance swap at this time is quoted at 22%, and the annual interest rate is 2%.

**Compute** the current value of the swap.

**Answer:**

*Step 1*: Compute the expected variance at maturity:

$$\left(21^2 \times \frac{9}{12}\right) + \left(22^2 \times \frac{3}{12}\right) = 330.75 + 121 = 451.75$$

*Step 2:* Compute the expected payoff at maturity:

$$\text{variance notional} = \frac{\text{vega notional}}{2 \times K} = \frac{\$100{,}000}{2 \times 20} = \$2{,}500$$

expected payoff at maturity = ($\sigma^2$ − $K^2$) × variance notional

expected payoff at maturity = (964 − 225) × €5,000 = €3,695,000

*Step 3*: Discount expected payoff from maturity to valuation date (3 months):

$$\text{unannualize the interest rate} = 2\% \times \frac{3}{12} = 0.5\%$$

current value of swap = $\frac{\$129{,}375}{1.005} = \$128{,}731$

This is a gain to the purchaser (long) and a loss to the seller (short).

## MODULE QUIZ 9.4

*To best evaluate your performance, enter your quiz answers online.*

1. Which of the following comments is *least* accurate regarding the VIX Index?
   A. Empirically, the VIX Index and equity returns are negatively correlated.
   B. VIX measures realized volatility over a 30-day period on the S&P 500.
   C. The VIX Index level is the annualized standard deviation of implied volatility on the S&P 500.
2. Which of the following comments is *most* accurate? The payoff on a variance swap can be calculated by multiplying the difference between actual variance and implied variance by:
   A. notional vega.
   B. notional variance.
   C. the expected return to volatility.
3. Quark Dealers sold a one-year FTSE MIB variance swap with a strike of 15 three months ago. Quark set the vega notional at €150,000. As part of their swap agreements, Quark requires the contract to be marked to market and subject to margining every three months.

   At the end of the first three-month period, realized volatility is 28. The strike on a nine-month variance swap is 32, and the annual interest rate is 0.6%.

   **Compute** the mark-to-market value of the swap.

# MODULE 9.5: USES OF DERIVATIVES IN PORTFOLIO MANAGEMENT

Video covering this content is available online.

**LOS 9.e: Demonstrate the use of derivatives to achieve targeted equity and interest rate risk exposures.**

*CFA® Program Curriculum, Volume 2, page 112*

## Using Equity Swaps

EXAMPLE: **Using equity swaps to reduce equity exposure**

Jennifer Seago has a concentrated holding of 80,000 shares in ABC Gmbh. Seago does not want to sell the shares—which she has held for many years—for tax reasons. ABC Gmbh is currently trading at €6.00 and she is concerned that the share price will decline over the next year as the company undergoes a restructuring. One-year Euribor is 0.95% and ABC is expected to pay an annual dividend of €0.05.

Suggest a swap strategy that will address Seago's concerns and constraint. **Evaluate** the results of this strategy for both an increase of 5% and a decrease of 5% in the price of ABC.

Consider the use of a one-year annual-pay total return swap. The reference rate for the interest leg of the swap is Euribor. The notional principal is 80,000 shares × €6.00 = €480,000.

*Scenario 1:*

The stock price falls by 5% and ABC pays a dividend of €0.05:

$$\text{total return on ABC} = \frac{€5.70 + €0.05}{€6.00} - 1 = -4.1667\%$$

$€6.00 \times (1 - 0.05) = €5.70$

Seago receives interest and will pay positive returns on the stock and receive negative stock returns. Seago receives:

$[0.0095 - (-0.041667)] \times €480,000 = €24,560$

*Scenario 2:*

The stock price rises by 5% and ABC pays a dividend of €0.05:

$$\text{total return on ABC} = \frac{€6.30 + 0.05}{€6.00} - 1 = 5.8333\%$$

$€6.00 \times (1 + 0.05) = €6.30$

Seago receives:

$(0.0095 - 0.058333) \times €480,000 = -€23,440$ (i.e., pays €23,440)

# Cash Equitization

EXAMPLE: **Investing surplus cash using index futures**

Yoann Barbet is the manager of an equities fund for which the investment universe is the FTSE 100. Currently, the fund holds £60 million in cash and £300 million in equities with a beta of 1.2 relative to the FTSE 100. The six-month rate earned on the cash will be 0.86% (annualized). Barbet does not want to commit the cash to specific equities over the next six months but is concerned about cash drag. If he wants to avoid cash drag and would like the beta of the portfolio to be 1.2, what strategy should be employed?

Barbet should gain exposure to equities with FTSE 100 futures over the next six months.

Six-month FTSE 100 futures are currently at 7,348.50 with a multiplier of £10. The beta of the FTSE 100 futures is 1. The tick size of the contract is 0.5 index points.

$$\text{number of futures to purchase} = \left(\frac{\beta_T}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$$

$$\text{number of futures to purchase} = \left(\frac{1.2}{1}\right)\left(\frac{£60,000,000}{£73,485}\right)$$

$$= 979.79 \text{ (i.e., 980 contracts)}$$

*Scenario:*

The FTSE 100 gains 6% over the six-month period, six-month £LIBOR is 0.86%, and the futures price at the end of the period is 7,642.

value of equities invested = £300 million × [1 + (0.06 × 1.2)] = £321.6 million

return on equity portfolio = £321.6 million − £300 million = £21.6 million

Receives:

interest on cash holding = £60 million × 0.0086 × 180 / 360 = £258,000

futures profit = (7,642 − 7,348.50) = 293.5 points; 293.5 points × £10 × 980 contracts = £2,876,300

total return = £21,600,000 + £258,000 + £2,876,300 = £24,734,300

$$\text{return \%} = \frac{£24,734,300}{(£300,000,000 + £60,000,000)} = 6.87\%$$

Note that the underperformance of the portfolio relative to the 6% return on the index plus a beta of 1.2 (overall desired portfolio return of 7.2%) results from rounding in the number of contracts, rounding of the futures price to the nearest 0.5 index point, and a basis change on the FTSE forward contract.

Note the change in the FTSE 100 futures = $\dfrac{£7{,}642}{£7{,}348.50} - 1 = 3.99\%;$;

however, the FTSE 100 increased by 6%.

### LOS 9.f: Demonstrate the use of derivatives in asset allocation, rebalancing, and inferring market expectations.

*CFA® Program Curriculum, Volume 2, page 113*

## Asset Allocation Using Derivatives

EXAMPLE: **Changing allocations between asset classes using futures**

Mathieu Chausset is a French fund manager with €800 million assets under management. Currently, Chausset has 80% allocated to equity and 20% allocated to French fixed-income securities. Chausset currently splits his equity portfolio 50-50 between German and French stocks.

Chausset wishes to alter his asset allocation for the next six months. Firstly, he wishes to increase the fixed-income proportion to 40% and reduce the equity proportion to 60%. Secondly, he wishes to reduce the proportion of his equity holdings in German securities to 30% and increase the proportion in French equity to 70%. Chausset intends to achieve his new asset allocation by using index and government bond futures.

French government bonds = OATs

Chausset's German stock portfolio has a beta of 1.2 relative to the DAX 30, and the French stock portfolio has a beta of 0.95 relative to the CAC 40. The French government bonds (OATs) portfolio has a modified duration of 8.5.

| **Futures Contract Details (Equity Index)** | | |
|---|---|---|
| Index name | French CAC 40 | German DAX 30 |
| Futures price | 5,500 | 12,200 |
| Multiplier | €10 | €25 |
| Beta | 1 | 1 |
| Tick size | 0.5 points | 0.5 points |

| **Futures Contract Details (French OATs)** | |
|---|---|
| Futures price | €163.84 |
| Contract size | €100,000 |
| CTD | €127.71 |
| CF | 0.7768 |
| CTD modified duration | 8.89 |

**Determine** how many long and short futures positions Chausset will need to use to implement his desired asset allocation.

**Answer:**

| | Original | New | Change in Exposure |
|---|---|---|---|
| **Equity** | €640 million = 80% | €480 million = 60% | |
| German stocks | €320 million = 50% | €144 million = 30% | Decrease €176 million |
| French stocks | €320 million = 50% | €336 million = 70% | Increase €16 million |
| **Fixed Income** | | | |
| French OATs | €160 million = 20% | €320 million = 40% | Increase €160 million |

*German stocks:* Alter exposure from €320 million to €144 million = decrease of €176 million

number of futures required = $\text{number of futures required} = \left(\frac{\beta_T - \beta_P}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$

where:

$\beta_T$ = target beta = 0 (the target beta is set to zero because we are reducing our exposure to German stock)

$\beta_P$ = portfolio beta = 1.2

$\beta_F$ = futures beta (i.e., beta of the index)

$MV_P$ = reduction in portfolio exposure = €176 million

F = futures price × multiplier = 12,200 × €25 = €305,000

$$\text{number of futures required} = \left(\frac{0 - 1.2}{1}\right)\left(\frac{€176{,}000{,}000}{€305{,}000}\right) = -692.45$$

$$= -692 \text{ futures contracts}$$

Chausset needs to sell 692 DAX futures.

*French stocks:* Alter exposure from €320 million to €336 million = increase of €16 million

$\beta_T$ = target beta = 0.95 (we need to create an additional €16 million exposure with a beta of 0.95)

$\beta_P$ = portfolio beta = 0

$\beta_F$ = futures beta (i.e., beta of the index) = 1

$MV_P$ = increase in portfolio size = €16 million

F = futures price × multiplier = 5,500 × €10 = €55,000

$$\text{number of futures required} = \left(\frac{0.95 - 0}{1}\right)\left(\frac{€16{,}000{,}000}{€55{,}000}\right) = 276.36$$

$$= 276 \text{ futures contracts}$$

Chausset will need to purchase 276 futures on the CAC 40.

*French OATs:* Alter exposure from €160 million to €320 million = increase of €160 million

$$BPVHR = \frac{BPV_{target} - BPV_{portfolio}}{BPV_{CTD}} \times CF$$

$BPV_{target} = MD_{target} \times 0.0001 \times MV_{portfolio} = 8.5 \times 0.0001 \times$ €160 million = €136,000

$BPV_{CTD} = MD_{CTD} \times 0.0001 \times$ (price / 100 × contract size) = 8.89 × 0.0001 × [(€127.72 / 100) × €100,000] = €113.54

$$BPVHR = \frac{€136{,}000 - €0}{€113.54} \times 0.7768 = 930.46 = 930 \text{ futures contracts}$$

Chausset will need to purchase 930 French OATs futures contracts.

| Summary | Futures Position | Number of Contracts |
|---|---|---|
| German stock | Short DAX 30 futures | 692 |
| French stock | Long CAC 40 futures | 276 |
| French bonds | Long OATs futures | 930 |

Assume that over the next six months, the German stock portfolio decreases in value by 4% while the French portfolio increases in value by 2%; at the end of the six-month period, the CAC 40 futures price is 5,616 and the DAX 30 futures price is 11,793.5. What is the impact on Chausset's portfolio after the asset allocation adjustments in the example have been made?

**Answer:**

*German portfolio:*

Original holding falls in value by €320 million × −0.04 = −€12,800,000

DAX futures gain = (11,793.5 − 12,200) × €25 × −692 = €7,032,450

net loss = −€12,800,000 + €7,032,450 = −€5,767,550

If the portfolio had been reduced to €144,000,000 by physically selling stock, the loss would have been €144,000,000 × −0.04 = −€5,760,000.

imperfection in hedge = −€5,767,550 −(−€5,760,000) = −€7,550 (caused by rounding in the hedge ratio and the basis change on futures position)

*French portfolio:*

Original holding increases in value by €320 million × 0.02 = €6,400,000

CAC futures gain = (5,616 − 5,500) × €10 × 276 = €320,160

net gain = €6,400,000 + €320,160 = €6,720,160

If the portfolio had been increased to €336 million by buying stock, the gain would have been €336,000,000 × 2% = €6,720,000.

imperfection in hedge = €6,720,160 − €6,720,000 = €160

Using the data from Chausset's asset allocation example, assume that the French yield curve undergoes a parallel downward shift of 50 bp. What is the impact on Chausset's portfolio after the asset allocation adjustments have been made?

**Answer:**

original holding gain = −8.5 × −0.005 × €160,000,000 = €6,800,000

bond futures gain/(loss) = $BPV_F$ × change in yield × number of futures contracts

$BPV_F = BPV_{CTD}$ / CF = €113.54 / 0.7768 = €146.16

bond futures gain/(loss) = €146.16 × 50 × 930 = €6,796,440

net position = €6,800,000 + €6,796,440 = €13,596,440

If the portfolio had been increased to €320,000,000 by buying physical OATs, the gain would have been −8.5 × −0.005 × €320,000,000 = €13,600,000.

EXAMPLE: **Rebalancing asset allocation using futures**

Josh Birmingham is the fund manager for a portfolio that has a target asset allocation of 70% equity and 30% government bonds. The portfolio increased in value from $200 million to $210 million over the previous month. The following table shows the portfolio's current position and what is needed to maintain the target allocations:

| Equity | Current | Target | Change in Exposure |
|---|---|---|---|
| U.S. large cap | $140 million (66.67%) | $147 million (70%) | +$7 million |
| **Fixed Income** | | | |
| U.S. Treasury bonds | $70 million (33.33%) | $63 million (30%) | –$7 million |
| **Total** | $210 million | $210 million | |
| Equity portfolio beta = 0.8 | | | |
| Fixed-income portfolio modified duration = 9.5 | | | |

Birmingham intends to use the following futures contracts to hedge his position:

| S&P 500 futures | | Classic U.S. Treasury futures | |
|---|---|---|---|
| Futures price | 2,930 | Futures price | $135.00 |
| Multiplier | $250 | Contract size | $100,000 |
| Beta | 1 | CTD | $110.25 |
| Tick size | 0.5 points | CF | 0.8140 |
| | | CTD modified duration | 8.5 |

**Determine** the futures positions Birmingham will need to use to rebalance the asset allocation.

**Answer:**

Equity portfolio:

Aim: increase exposure by $7 million

$$\text{Number of futures required} = \left(\frac{\beta_T - \beta_P}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$$

$$\text{Number of futures required} = \left(\frac{0.8 - 0}{1}\right)\left(\frac{\$7{,}000{,}000}{\$732{,}500}\right) = 7.65$$

$$= 8 \text{ futures contracts}$$

F = 2,930 × $250 = $732,500

Birmingham will need to purchase 8 S&P 500 futures.

Fixed-income portfolio:

Aim: decrease exposure by $7 million

$$\text{BPVHR} = \frac{\text{BPV}_{\text{target}} - \text{BPV}_{\text{portfolio}}}{\text{BPV}_{\text{CTD}}} \times \text{CF}$$

$BPV_{portfolio} = MD_{portfolio} \times 0.0001 \times MV_{portfolio} = 9.5 \times 0.0001 \times \$7$ million = $6,650

$BPV_{CTD} = MD_{CTD} \times 0.0001 \times [\text{price} / 100 \times \text{contract size}] = 8.5 \times 0.0001 \times [(\$110.25 / 100) \times \$100{,}000] = \$93.71$

$$BPVHR = \frac{\$0 - \$6{,}650}{\$93.71} \times 0.8140 = -57.76 = -58 \text{ futures contracts}$$

Birmingham will need to sell 58 Treasury futures contracts.

## Changing Allocations Between Asset Classes Using Swaps

EXAMPLE: **Altering asset allocation using swaps**

Akasuki Weber is a portfolio manager running the Cross Bright Helper fund. The fund has a current value of ¥21,580,000,000. The portfolio is currently invested in Japanese equity and bonds. Within the equity portion, the fund is split into exposures to both growth and value stocks. Within the fixed-income portion, the fund is split into exposures to government and corporate bonds.

Weber wants to alter the allocation between fixed income and equity and alter the allocation to the subfunds. The following table summarizes the changes she would like to make:

| Stock | Current | Target | Change in Exposure |
|---|---|---|---|
| Value stock portfolio | ¥9,063,600,000 (60%) | ¥3,884,400,000 (30%) | −¥5,179,200,000 |
| Growth stock portfolio | ¥6,042,400,000 (40%) | ¥9,063,600,000 (70%) | +¥3,021,200,000 |
| Total equity | ¥15,106,000,000 (70%) | ¥12,948,000,000 (60%) | |
| **Fixed income** | | | |
| Government bonds | ¥3,237,000,000 (50%) | ¥5,179,200,000 (60%) | +¥1,942,200,000 |
| Corporate bonds | ¥3,237,000,000 (50%) | ¥3,452,800,000 (40%) | +¥215,800,000 |
| Total fixed income | ¥6,474,000,000 (30%) | ¥8,632,000,000 (40%) | |
| **Total fund** | ¥21,580,000,000 | ¥21,580,000,000 | |

To avoid transaction costs involved in physical changes to the fund's asset allocation, Weber decides to use equity and fixed-income swaps. She has identified the following indexes, which have the closest characteristics with her existing subportfolios:

- MSCI Japan Value Index
- MSCI Japan Growth Index
- S&P Japanese Government Bond Index
- S&P Japanese Corporate Bond Index

**Answer:**

*Swap 1*: Pay return on MSCI Japan Value Index, receive floating reference rate (− dealers margin bp), based on a notional principal of ¥5,179,200,000

*Swap 2*: Pay reference rate (+ dealers margin bp), receive return on MSCI Japan Growth Index, based on a notional principal of ¥3,021,200,000

*Swap 3*: Pay reference rate (+ dealers margin bp), receive return on S&P Japanese Government Bond Index, based on a notional principal of ¥1,942,200,000

*Swap 4*: Pay reference rate (+ dealers margin bp), receive return on S&P Japanese Corporate Bond Index, based on a notional principal of ¥215,800,000

The equity and fixed-income indexes used in the swaps are unlikely to match the performance of Weber's subportfolios unless her subportfolios are passive trackers of these indexes. In addition, the index funds track total return (i.e., price and cash flow return on the index). Take swap 1 where Weber is paying the return on the MSCI Japan Value Index—Weber's value portfolio will not generate the price-change element of index return unless capital gains are realized by selling securities. Additionally, the dealer's margin on the floating rates will also need to be paid.

## Inferring Market Expectations

Market expectations are current expectations derived from market prices. In the event of a market shock, market expectations can change rapidly.

Typical applications:

| Application | Derivative |
|---|---|
| Inferring expectations of FOMC moves | Fed funds futures |
| Inferring expectations of inflation | CPI swaps |
| Inferring expectations of future volatility | VIX futures and options |

## Using Fed Funds Futures to Infer the Expected Average Federal Funds Rate

Market participants can use Fed funds futures to infer the expected probabilities of upcoming Fed interest rate changes. Some terms and definitions used in the analysis include the following:

- **Federal funds rate.** This is the interest rate that deposit institutions (banks and credit unions) charge other deposit institutions for loans in the overnight interbank markets. The federal funds effective (FFE) rate is the weighted average of interest rates charged on overnight interbank loans.
- **Federal funds target rate.** This is the rate set by governors of the Federal Reserve in Federal Open Market Committee (FOMC) meetings. The FOMC meets eight times a year to set the target rate based on current and forecasted macroeconomic variables. The most important considerations when setting the target rate are inflation rates and GDP growth rates. When market participants refer to the central bank (Fed) changing interest rates, it is typically this target rate they are referring to. The target rate is typically set as a range (e.g., 2.25%–2.50%).

Note that the Fed does not directly control the FFE rate, but it influences the rate through its monetary policy tools with the goal of keeping it within the target range. The monetary policy tools are open-market operations and the interest rate paid on bank reserves held at the Fed. Many central banks function in a similar fashion.

Fed fund futures are traded on the CME. The futures price reflects the market expectation of the FFE rate at the time of contract maturity. The Fed funds futures price will reflect market expectations about future changes in the Fed funds target rate. Fed fund futures can have monthly maturity dates as far out as 36 months.

To determine the probability of a change in the Fed funds target rate, use the following equation:

$$\text{percent probability of rate change} = \frac{\text{effective rate implied by futures} - \text{current Fed funds target rate}}{\text{Fed funds rate assuming a rate change} - \text{current Fed target funds rate}}$$

Note that this can be expressed as

$$\frac{\text{implied Fed funds effective rate} - \text{current target rate}}{\text{expected size of rate change}}$$

**EXAMPLE: Determining the markets expectation of a target rate increase**

Joe Stokes works at a bank where the interest received on loans made is linked to the FFE rate. Stokes has been asked to compute the likelihood that the FOMC will increase the rate by 25 bp at the next FOMC meeting.

Stokes has collected the following market data:

| | |
|---|---|
| Fed funds future price* | 98.1625 |
| Current Fed funds target rate | 1.50%–1.75% |

*Nearest futures contract after the date of the next FOMC meeting

**Calculate** the following:

1. The expected average FFE rate at the futures contract maturity
2. The probability of a 25 bp increase in target rate at the next FOMC meeting

**Answer:**

1. Expected average FFE rate at contract expiration: 100 − 98.1625 = 1.8375%
2. Current target rate midpoint: $\frac{1.5\% + 1.75\%}{2} = 1.625\%$

   Target rate assuming a 25 bp rise: 1.625% + 0.25% = 1.875%

   Percent probability of a rate change = $\frac{1.8375\% - 1.625\%}{1.875\% - 1.625\%}$

   $$= \frac{1.8375\% - 1.625\%}{0.25\%} = 0.85 = 85\%$$

## MODULE QUIZ 9.5

*To best evaluate your performance, enter your quiz answers online.*

1. Elise Schwarz manages a €400 million fund that invests in German and French equities and government bond futures. Currently, her portfolio has a 60% exposure to equity and a 40% exposure to government securities. Schwarz believes that the monetary policy of the ECB will provide a significant stimulus to European equity markets and would like to increase her equity exposure to 70% of the portfolio's value.

   Additionally, the current portfolio is 50% invested in Spanish stocks and 50% in German stocks. Schwarz would like to change the proportions to 60% Spanish stocks and 40% German stocks. She also wishes to change the asset allocation of her fixed-income portfolio—which is currently 50% invested in German Bunds and 50% in Spanish Obligaciones del Estado—to 70% German government debt and 30% Spanish government debt.

   Her current portfolios have the following details:

   | | Beta | | Modified Duration |
   |---|---|---|---|
   | Spanish equity | β = 1.2 | Spanish fixed income | 7.34 |
   | German equity | β = 0.9 | German fixed income | 10.25 |

   Elise intends to use futures to achieve her new asset allocation, to avoid transaction costs involved with liquidating positions, and reinvesting.

   Elise has gathered the following futures information:

| Equity Futures | German | Spanish |
|---|---|---|
| Index | DAX 30 | IBEX 35 |
| Futures price | 12,500 | 9,200 |
| Multiplier | €25 | €10 |
| Futures beta | 1 | 1 |

| Government Bond Futures | German Bund | Spanish Obligaciones del Estado |
|---|---|---|
| Contract size | €100,000 | €100,000 |
| CTD price | €105.44 | €149.94 |
| CTD CF | 0.6095 | 0.9628 |
| CTD modified duration | 9.67 | 8.26 |

**Calculate** and describe the future positions that would achieve Elise's new target asset allocation.

2. Stuart Zackaman has been announced as the new chair of the Federal Reserve. In his inaugural speech, he mentions that it is time that the United States stopped punishing savers to bail out irresponsible lenders.

   Joe Bear works at a bank where the interest paid on deposits is linked to the Fed funds rate. Bear observes that Zackaman's speech caused Fed funds futures prices to fall.

   Joe has collected the following market data:

| | |
|---|---|
| Fed funds future price* | 97.925 |
| Current Fed funds target rate | 1.75%–2.00% |

   *Nearest futures contract after the date of the next FOMC meeting

   What is the probability of a 50 bp increase in target rate at the next FOMC meeting implied from the current Fed funds future price?

   A. 20%.
   B. 40%.
   C. 80%.

# KEY CONCEPTS

## LOS 9.a

- Interest rate swaps can be used to convert floating-rate assets (or liabilities) into fixed-rate assets (or liabilities).
- Interest rate swaps can be used to alter a fixed-income portfolio's duration.
  - Payer swaps (pay fixed) have negative durations.
  - Receiver swaps (receive fixed) have positive durations.
- To compute the notional principal of a swap to achieve a target duration, use the following equation:

$$NP_S = \left(\frac{MD_T - MD_P}{MD_S}\right)(MV_P)$$

where:

$NP_S$ = notional swap principal

$MD_T$ = target modified duration

$MD_P$ = current portfolio modified duration

$MD_S$ = modified duration of swap

$MV_P$ = market value of portfolio

- Forward rate agreements (FRAs) are OTC forward contracts that can be used to hedge short-term future floating lending or borrowing requirements (i.e., lock into a fixed interest rate). FRAs can also be used to speculate on the direction of interest rates.
  - Long FRA = pay fixed and receive floating, from FRA expiry to the end of a notional borrowing or lending period.
  - Short FRA = pay floating and receive fixed, from FRA expiry to the end of a notional borrowing or lending period.
  - The price of an FRA is a forward rate of interest determined from spot rates.
  - Long FRA increases in value when interest rates rise.
  - Short FRA increases in value when interest rates fall.
- Short-term interest rate (STIR) futures are exchange traded and, therefore, benefit from liquidity and no credit risk. Like FRAs, STIR futures can be used to hedge short-term future interest rate risk and speculate on interest rate direction.
  - STIR futures use IMM price convention = 100 − annualized interest rates.
  - Long STIR futures will increase in value when rates fall.
  - Short STIR futures will increase in value when rates rise.
  - The forward rate in the STIR future is the same forward rate in an FRA (assuming the same expiry and borrowing/lending periods).
  - STIRs are typically more liquid than bond futures.
  - Strips of STIRs are often used to hedge bonds with 2–3 years to maturity.
- Government bond futures are used to hedge fixed-income portfolios when the constituent bonds have more than 2–3 years to maturity.
  - Treasury bond futures prices are based on a notional bond (typically with a 6% coupon).
  - Short party to the contract can deliver a range of eligible government bonds.
  - One of the government bonds will be cheapest to deliver (CTD).
  - The CTD bond has the highest repo rate or lowest basis.
  - Futures price is based on the CTD price divided by the CTD conversion factor (CF).
  - Each eligible bond has a CF.
  - Proceeds to short on delivery = (FP at settlement × CF of bond delivered) + $AI_T$.
- Hedging with Treasury futures is determined as follows:

$$BPVHR = \frac{BPV_{target} - BPV_{portfolio}}{BPV_{CTD}} \times CF$$

where:

BPV hedge ratio = BPVHR = number of futures required

BPV of target = $BPV_{target} = MD_{target} \times 0.0001 \times MV_{portfolio}$

$BPV \text{ of portfolio} = BPV_{portfolio} = MD_{portfolio} \times 0.01\% \times MV_{portfolio}$

MD = modified duration

$BPV \text{ of CTD} = BPV_{CTD} = MD_{CTD} \times 0.01\% \times MV_{CTD}$

market value of futures contract = $MV_{CTD}$ = CTD price / 100 × \$100,000

To fully hedge a portfolio against interest rate risk, set $BPV_{target}$ to zero.

## LOS 9.b

- Currency risk is the change in value of assets and liabilities denominated in overseas currencies when converted to the domestic currency and is caused by exchange rate fluctuations.
- Cross-currency swaps = synthetic overseas borrowing.
  - Borrow in cheap currency (often but not exclusively domestic).
  - Use a cross-currency swap to exchange domestic borrowing for overseas currency.
  - Principal exchanged using the spot rate at initiation at the start and end of the swap's life.
  - Counterparties pay the interest on the currency received at initiation.
  - The breakdown of covered interest rate parity means many currencies trade at a negative basis to the dollar.
  - Negative basis means the cost of synthetic \$ borrowing > the cost of direct \$ borrowing (i.e., lenders of the \$ receive a premium).
  - Negative basis means that the \$ lender will pay less than overseas LIBOR on their interest payments (i.e., overseas LIBOR – basis).
  - Negative basis allows U.S. fixed-income managers to lend dollars via a swap, invest the foreign currency in a foreign bond market, and generate a higher return (due to the basis) than if they invested domestically.
- Currency forwards allow a participant to lock in a guaranteed exchange rate for converting a fixed amount of one currency into another at a future delivery date.
- Currency futures are exchange-traded currency forwards:

$$HR = \frac{\text{value of risk exposure}}{\text{futures contract size}}$$

## LOS 9.c

- Equity swaps can be used to create synthetic exposures to equity market return.
- There are three main types of equity swaps:
  - Pay fixed, receive equity return.
  - Pay floating, receive equity return.
  - Pay one equity return, receive another equity return.
- Equity return may be based on:
  - A stock index.
  - A basket of stock.
  - A single stock.

Return may be computed as price return or total return (including dividends).

- The equity payer in an equity swap pays the return if positive and receives the return if negative.
- Equity futures are available for most major stock market indexes.
- Benefits of equity futures include:
  - Low transaction costs.
  - Implementing tactical asset allocation without transactions in the physical securities.
    - Selling futures: reduces equity exposure.
    - Buying futures: increases equity exposure.
  - Diversification of portfolios.
  - Gain exposure to a different equity market.
- To achieve a target beta, use the following:

$$\text{number of futures required} = \left(\frac{\beta_T - \beta_P}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$$

where:

$\beta_T$ = target portfolio beta

$\beta_P$ = current portfolio beta

$\beta_F$ = futures beta (beta of stock index)

$MV_P$ = market value of portfolio

F = futures contract value = futures price × multiplier

  - To reduce equity exposure $\beta_T = 0$ $MV_P$ = market value of exposure to reduce
  - To equitize a cash position $\beta_P = 0$ $MV_P$ = cash value to invest

## LOS 9.d

- VIX = volatility index (CBOE Volatility Index):
  - Measures implied volatility of the S&P 500 over a forward period of 30 days.
  - Implied volatility computed from call and put options on the index.
  - Volatility mean reverts over time.
  - Market participants cannot directly invest in VIX.
- VIX level and equity returns are negatively correlated.
- VIX futures:
  - Term structure of futures allows us to view the market's expectation of volatility for different contract maturities.
  - Typically, the market is in contango when implied 30-day forward volatility is low.
  - VIX futures can be used to offset tail risk in equity portfolios.
- Variance swap payoff = $(\sigma^2 - K^2) \times N_{VAR}$
- Based on realized vs. implied volatility over the swap's life:
  - $N_{vega}$ = profit or loss for a 1% change in volatility
  - $N_{VAR}$ = multiplier that converts $(\sigma^2 - K^2)$ into a payoff

– K = implied volatility over the swap period
– σ = realized volatility over the swap period
– variance notional = $\dfrac{\text{vega notional}}{2 \times \text{strike price (K)}}$

- Variance swaps have convex payoffs with respect to volatility.
- Volatility options and futures have linear payoffs with respect to volatility.
- Convexity makes variance swaps more attractive for hedging tail risk because, as volatility rises and equity returns fall, the payoffs on variance swaps increase at an increasing rate.
- Mark-to-market valuation of a variance swap:

*Step 1*: Compute expected variance at maturity (the time-weighted average of realized variance and implied variance over the remainder of the swap's life):

$$\text{expected variance to maturity} = \left(\sigma_t^2 \times \frac{t}{T}\right) + \left(K_{(T-t)}^2 \times \frac{T-t}{T}\right)$$

*Step 2*: Compute expected payoff at maturity:

$$\text{variance swap payoff} = (\text{expected variance} - \text{K}^2) \times \text{N}_{\text{VAR}}$$

*Step 3*: Discount expected payoff from maturity back to the valuation date.

## LOS 9.e

- Use an equity swap to reduce equity exposure by entering into a pay total return equity swap receive fixed.
- Invest surplus cash by purchasing equity index futures.

## LOS 9.f

- Probability of FOMC rate changes can be inferred from Fed funds futures:

percent probability of rate change

$$= \frac{\text{effective rate implied by futures} - \text{current Fed funds target rate}}{\text{Fed funds rate assuming a rate change} - \text{current Fed target funds rate}}$$

Note that this can be expressed as

$$\frac{\text{implied Fed funds effective rate} - \text{current target rate}}{\text{expected size of rate change}}$$

# ANSWER KEY FOR MODULE QUIZZES

## Module Quiz 9.1

1. **C** The variable leg cash flow on an interest rate swap is determined by the LIBOR rate determined at the previous settlement date. Remember, LIBOR is an add-on yield with payment in arrears. (LOS 9.a)

2. Type of swap:

   Schwarz is receiving variable LIBOR base cash flows on the FRN he holds. To hedge his interest rate risk, Schwarz will want to swap the floating rate he receives on the

FRN for a fixed rate on a swap. Schwarz will use a receiver swap with a notional principal of $4 million, in order to pay floating and receive fixed.

**Swap cash flow at settlement date 1:**

Fixed leg = 4% × 180 / 360 × $4 million = $80,000

Floating leg = 3.5% × 180 / 360 × $4 million = $70,000

Net receipt = $80,000 – $70,000 = $10,000

**Swap cash flow at settlement date 2:**

Fixed leg = 4% × 180 / 360 × $4 million = $80,000

Floating leg = 2.5% × 180 / 360 × $4 million = $50,000

Net receipt = $80,000 – $50,000 = $30,000

**Net return settlement date 1:**

Interest received on FRN = (3.5% + 40 bp) × 180 / 360 × $4 million = $78,000

Net receipt on swap = $10,000

Total cash received = $78,000 + $10,000 = $88,000

$ return = $88,000 / $4,000,000 = 2.2%, annualized = 4.4%

**Net return settlement date 2:**

Interest received on FRN = (2.5% + 40 bp) × 180 / 360 × $4 million = $58,000

Net receipt on swap = $30,000

Total cash received = $58,000 + $30,000 = $88,000

$ return = $88,000 / $4,000,000 = 2.2%, annualized = 4.4%

Schwarz's annualized return is 4.4%, equal to the 4% rate on the swap and the 40 bp cost on the FRN. (LOS 9.a)

3. **B** Cost of 3-month borrowing on bridging loan = 2.5%

   Profit on unwinding hedge = 98 − 97.5 = 50 bp

   Net cost = 2.5% − 50 bp = 2%

   Cost of loan = 0.025 × 90 / 360 × €8 million = €50,000

   Profit on futures = 50 bp × €25 × 8 contracts = €10,000

   Net cost = €50,000 – €10,000 = €40,000

(€40,000 / €8 million) × 360 / 90 = 0.02, or 2%

(LOS 9.a)

4. **A** $BPV_{target}$ = 8 × 0.0001 × \$200 million = \$160,000

   $BPV_{portfolio}$ = 12 × 0.0001 × \$200 million = \$240,000

   $BPV_{CTD}$ = 14.54 × 0.0001 × [(\$126.39 / 100) × \$100,000] = \$183.77

$$BPVHR = \frac{BPV_{target} - BPV_{portfolio}}{BPV_{CTD}} \times CF$$

$$= \frac{\$160{,}000 - \$240{,}000}{\$183.77} \times 0.7689 = -334.72 = -335$$

(LOS 9.a)

## Module Quiz 9.2

1. **B** If the NZD is trading at a positive cross-currency basis to the USD, New Zealand investors can earn superior returns by lending NZD via a currency swap and investing in U.S. government bonds. There is an additional return because the interest rate on lending NZD is higher than the rate suggested by covered interest rate parity (CIRP). Note that when the NZD has positive basis against the USD and the GBP has negative basis to the USD, then the GBP must have negative basis against the NZD. Most currencies trade at a negative cross-currency basis to the USD, due to high demand for USD funds versus a shortage of supply and a failure of CIRP. The positive basis on NZD and AUD (Australian dollar) has led organizations such as the World Bank to issue bonds in NZD and AUD and swap back to USD, reducing borrowing costs compared to borrowing directly in USD. (LOS 9.b)

2. Number of contracts needed to hedge = $\frac{€20{,}000{,}000}{€125{,}000} = 160$ contracts

   Wood is converting from the price currency to the base currency and, therefore, will need to buy futures.

   **Unhedged position:**

   Cost at current exchange rate = €20,000,000 × 0.8929 = £17,858,000

   Unhedged position in 30 days = €20,000,000 × 0.9034 = £18,068,000

   Cost of euro strengthening = £18,068,000 – £17,858,000 = £210,000

   **Hedged position:**

   Cost of euro strengthening = £18,068,000 – £17,858,000 = £210,000

   Profit on hedge = (£0.9054 – £0.8989) × €20,000,000 = £130,000

   Note that when Barney enters the contract, he is agreeing to buy euros at £0.8989, and when he closes out, he is agreeing to sell euros at £0.9054.

Net position = £130,000 − £210,000 = loss £80,000

This loss on the hedge is the result of the change in basis:

| | Spot | Future | Basis |
|---|---|---|---|
| At initiation £/€ | 0.8929 | 0.8989 | 0.006 or 60 pips |
| At close | 0.9034 | 0.9054 | 0.002 or 20 pips |

Change in pips = 60 to 20 = −40

−40 pips ÷ 10,000 × €20,000,000 = −£80,000

(LOS 9.b)

3. **Exchange of principal at initiation of swap:**

£30 million × $1.2/£ = $36 million

ABC Robotics, Inc., borrows $36 million domestically and uses the currency swap to exchange $36 million for £30 million.

**At the first settlement date:**

*Pays:*

£ interest on swap = £30 million × (1.5% − 0.15%) × 180 / 360 = £202,500

$ interest on loan = $36 million × (2.5% + 0.4%) × 180 / 360 = $522,000

*Receives:*

$ interest on swap = $36 million × 2.5% × 180 / 360 = $450,000

*Total net payments:*

£ interest on swap = £202,500

$ difference between the loan and swap = $522,000 − $450,000 = $72,000, which represents the 40 bp on the U.S. loan ($36 million × 0.4% × 180 / 360 = $72,000)

Direct £ borrowing cost = £30 million × (1.5% + 0.5%) × 180 / 360 = £300,000 (cost LIBOR + 50 bp)

Cost of synthetic borrowing = £30 million × (1.5% + 0.4% − 0.15%) × 180 / 360 = £262,500 (cost LIBOR + 25 bp)

Benefit of swap = £300,0000 − £262,500 = £37,500

Benefit of swap = (0.5% − 0.25%) × 180 / 360 = £37,500

**At the second settlement date:**

*Pays:*

£ interest on the swap = £30 million × (1% − 0.15%) × 180 / 360 = £127,500

$ interest on loan = $36 million × (2.25% + 0.4%) × 180 / 360 = $477,000

*Receives:*

$ interest on the swap = $36 million × 2.25% × 180 / 360 = $405,000

*Total net payments:*

£ interest on swap = £127,500

$ difference on loan and swap = $477,000 − $405,000 = $72,000, which represents the 40 bp on the U.S. loan ($36 million × 0.4% × 180 / 360 = $72,000)

Direct £ borrowing cost = £30 million × (1% + 0.5%) × 180 / 360 = £225,000 (cost LIBOR + 50 bp)

Cost of synthetic borrowing = £30 million × (1% + 0.4% − 0.15%) × 180 / 360 = £187,500 (cost LIBOR + 25 bp)

Benefit of swap = £225,000 − £187,500 = £37,500

Benefit of swap = (0.5% − 0.25%) × 180 / 360 = £37,500

**Conclusion:**

By borrowing in dollars and entering a currency swap, ABC Robotics has locked into a cost of £LIBOR + 25 bp for their USD borrowing, reflecting the 40 bp spread above $LIBOR on the loan less the 15 bp received on the swap. (LOS 9.b)

## Module Quiz 9.3

1. **A**

$$\text{Number of futures required} = \left(\frac{\beta_T - \beta_P}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$$

$$\text{Number of futures required} = \left(\frac{1.4 - 0.8}{1}\right)\left(\frac{£20{,}000{,}000}{£74{,}250}\right) = 161.62$$

$$= 162 \text{ futures contracts}$$

Futures contract value = 7,425 × £10 = $74,250

(LOS 9.c)

2. **A** Cash element of fund = ¥4,350,000,000 × 5% = ¥217,500,000

$$\text{Number of futures required} = \left(\frac{\beta_T - \beta_P}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$$

$$\text{Number of futures required} = \left(\frac{1 - 0}{1}\right)\left(\frac{¥217{,}500{,}000}{¥21{,}624{,}000}\right) = 10.06$$

$$= 10 \text{ futures contracts}$$

$\beta_T$ = 1 (the beta of the future equals the beta of the index)

$\beta_P$ = 0 (the beta of a cash position always equals zero)

Futures contract value = 21,624 × ¥1,000 = ¥21,624,000

(LOS 9.c)

## Module Quiz 9.4

1. **B** VIX is a measure of expected volatility of the S&P 500 Index over the forthcoming 30 days. It is an annualized implied volatility calculation using an option-pricing model and the price of call and put options trading in the market. It suggests +/– range for the percentage change in the S&P 500, with a 68% level of confidence.

   Empirically, VIX and equity market performance is negatively correlated (i.e., when volatility spikes upwards, equity returns fall dramatically). The convexity of variance swaps relative to volatility makes their returns attractive when volatility is rising and equity markets are falling. (LOS 9.d)

2. **B** The payoff on a variance swap can be calculated as notional variance × ($\sigma^2$ – $K^2$). Using notional vega, we must additionally divide by 2 times the strike price (implied volatility), K:

   $$\text{payoff} = N_{\text{vega}} \times \left(\frac{\sigma^2 - K^2}{2K}\right)$$

   (LOS 9.d)

3. *Step 1*: Compute the expected variance at maturity as the time-weighted average of realized and implied volatility:

   $$\text{expected variance at maturity} = \left(\sigma_t^2 \times \frac{t}{T}\right) + \left(K_{(T-t)}^2 \times \frac{T-t}{T}\right)$$

   $$\text{expected variance at maturity} = \left(28^2 \times \frac{3}{12}\right) + \left(32^2 \times \frac{9}{12}\right) = 964$$

   *Step 2*: Compute the expected payoff at maturity:

   $$\text{variance notional} = \frac{\text{vega notional}}{2 \times K} = \frac{€150{,}000}{2 \times 15} = €5{,}000$$

   $K^2 = 15^2 = 225$

   expected payoff at maturity = ($\sigma^2$ – $K^2$) × variance notional

   expected payoff at maturity = (964 – 225) × €5,000 = €3,695,000

   *Step 3*: Discount expected payoff from maturity to valuation date (3 months):

   $$\text{unannualize the interest rate} = 0.6\% \times \frac{9}{12} = 0.45\%$$

   $$\text{current value of swap (purchaser)} = \frac{€3{,}695{,}000}{1.0045} = €3{,}678{,}447$$

This is the gain to the purchaser of the variance swap. Quark Dealers is a seller and, therefore, this is a loss. Note that this illustrates the risk of shorting variance. When volatility suddenly spikes upward, the losses increase at an accelerating rate. (LOS 9.d)

## Module Quiz 9.5

1. *Step 1*: Set out current, target, and changes to asset allocations in percentages and monetary value.

| Summary | Original | New | Change in Exposure |
|---|---|---|---|
| **Equity** | **€240 million (60%)** | **€280 million (70%)** | |
| German stocks | €120 million = 50% | €112 million = 40% | Decrease €8 million |
| Spanish stocks | €120 million = 50% | €168 million = 60% | Increase €48 million |
| **Fixed Income** | €160 million (40%) | €120 million (30%) | |
| German Bunds | €80 million = 50% | €84 million = 70% | Increase €4 million |
| Spanish Obligaciones del Estado | €80 million = 50% | €36 million = 30% | Decrease €44 million |

*Step 2*: Compute each futures position.

**German equity:**

$$\text{Number of futures required} = \left(\frac{\beta_T - \beta_P}{\beta_F}\right)\left(\frac{MV_P}{F}\right)$$

$\beta_T$ = target beta = 0 (the target beta is set to zero because we are reducing our exposure to German stock)

$\beta_p$ = portfolio beta = 0.9

$\beta_F$ = futures beta (i.e., beta of the index)

$MV_P$ = reduction in portfolio size = €8 million

F = futures price × multiplier = 12,500 × €25 = €312,500

$$\text{Number of futures required} = \left(\frac{0 - 0.9}{1}\right)\left(\frac{€8{,}000{,}000}{€312{,}500}\right)$$
$$= -23.04 = -23 \text{ futures contracts}$$

**Spanish equity:**

$\beta_T$ = target beta = 1.2 (the target beta is set to the beta of the existing portfolio)

$\beta_P$ = portfolio beta = 0

$\beta_F$ = futures beta (i.e., beta of the index)

$MV_P$ = increase in portfolio size = €48 million

F = futures price × multiplier = 9,200 × €10 = €92,000

$$\text{Number of futures required} = \left(\frac{1.2-0}{1}\right)\left(\frac{€48{,}000{,}000}{€92{,}000}\right)$$
$$= 626.09 = 626 \text{ futures contracts}$$

**German fixed income:**

$$\text{BPVHR} = \frac{\text{BPV}_{\text{target}} - \text{BPV}_{\text{portfolio}}}{\text{BPV}_{\text{CTD}}} \times \text{CF}$$

$\text{BPV}_{\text{target}} = \text{MD}_{\text{portfolio}} \times 0.0001 \times \text{MV}_{\text{portfolio}} = 10.25 \times 0.0001 \times €4{,}000{,}000 = €4{,}100$

$\text{BPV}_{\text{CTD}} = \text{MD}_{\text{CTD}} \times 0.0001 \times [\text{price} / 100 \times \text{contract size}] = 9.67 \times 0.0001 \times [(€105.44 / 100) \times €100{,}000] = €101.96$

$$\text{BPVHR} = \frac{€4{,}100 - €0}{€101.96} \times 0.6095 = 24.51 = 25 \text{ futures contracts}$$

**Spanish fixed income:**

$$\text{BPVHR} = \frac{\text{BPV}_{\text{target}} - \text{BPV}_{\text{portfolio}}}{\text{BPV}_{\text{CTD}}} \times \text{CF}$$

$\text{BPV}_{\text{portfolio}} = \text{MD}_{\text{portfolio}} \times 0.0001 \times \text{MV}_{\text{portfolio}} = 7.34 \times 0.0001 \times €44{,}000{,}000 = €32{,}296$

$\text{BPV}_{\text{CTD}} = \text{MD}_{\text{CTD}} \times 0.0001 \times [\text{price} / 100 \times \text{contract size}] = 8.26 \times 0.0001 \times [(€149.94 / 100) \times €100{,}000] = €123.85$

$$\text{BPVHR} = \frac{€32{,}296}{€123.85} \times 0.9628 = -251.07 = -251 \text{ futures contracts}$$

| Summary of Futures Positions | |
|---|---|
| German DAX 30 futures | Sell 23 futures |
| Spanish IBEX 35 futures | Buy 626 futures |
| German Bund futures | Buy 25 contracts |
| Spanish Obligaciones del Estado futures | Sell 251 |

(LOS 9.f)

2. **B** Expected average effective rate at contract expiration = 100 – 97.925 = 2.075%

$$\text{Current target rate midpoint} = \frac{1.75\% + 2.00\%}{2} = 1.875\%$$

$$\text{Target rate assuming a 50 bp rise} = 1.875\% + 0.50\% = 2.375\%$$

$$\text{Percent probability of a rate change} = \frac{2.075\% - 1.875\%}{2.375\% - 1.875\%} = \frac{2.075\% - 1.875\%}{0.50\%}$$

$$= 0.4 = 40\%$$

(LOS 9.f)

The following is a review of the Derivatives and Currency Management principles designed to address the learning outcome statements set forth by CFA Institute. Cross-Reference to CFA Institute Assigned Reading #10.

# READING 10: CURRENCY MANAGEMENT: AN INTRODUCTION

**Study Session 4**

## EXAM FOCUS

Globalization of financial markets is an important topic in portfolio management and for the CFA exam. This section reviews currency math and then discusses an extensive list of currency management tools and techniques.

## MODULE 10.1: MANAGING CURRENCY EXPOSURE

Video covering this content is available online.

### Introduction

#### PROFESSOR'S NOTE

Good technique always matters but particularly with currency. This material emphasizes (1) thinking of a currency quote as a base currency in the denominator and a pricing currency in the numerator, and (2) being prepared to interpret a currency quote from the perspective of either the base or pricing currency.

**The Price and Base Currencies:** The **base currency** is the denominator of the exchange rate and it is **priced** in terms of the numerator. Unless clearly identified otherwise, the terms "buy" and "sell" refer to the base currency. But remember, there are two currencies involved. For example, sell spot 1,000,000 at CAD/USD 0.9800 is assumed to mean sell for "immediate delivery" 1,000,000 U.S. dollars and buy 980,000 Canadian dollars. (The convention is settlement in two business days but this detail is ignored in most cases; the FX swap is an exception where the two business days are considered).

Buy 500,000 USD/CHF six months forward at 1.07 is assumed to mean buy 500,000 Swiss francs, settling in six months versus sell USD 535,000.

**Bid/Asked Rules:** Currencies are quoted with a **bid/offered** or **bid/asked price**. By convention, the smaller number is written first and the larger number is second. However, both the bid and the asked can be interpreted as the sale of one currency versus the purchase of the other currency. The difference is the dealer's profit margin to buy or sell the currencies. The customer pays the bid/ask spread, paying more and/or receiving less in the transaction. A quote of 0.9790/0.9810 CAD/USD has four interpretations.

Deliver more CAD can be phrased as:

- Buy 1.0000 USD and deliver (sell) 0.9810 CAD.
- Sell 0.9810 CAD and receive (buy) 1.0000 USD.

Receive less CAD can be phrased as:

- Sell 1.0000 USD and receive (buy) 0.9790 CAD.
- Buy 0.9790 CAD and deliver (sell) 1.0000 USD.

**Spot Versus Forward: Spot exchange transactions** are for immediate settlement and a **forward transaction** is a price agreed to on a transaction date for delayed (longer than spot) settlement. The forward quote can be given directly or in forward points (an adjustment from the spot quote).

Forward points are an adjustment to the spot price to determine the forward price. The points are interpreted based on the number of decimal places in which the spot price is quoted. The rule is to move the decimal in the points to the left by the same number of decimal places shown in the right for the spot price. For example:

| Spot Quote | Forward Points | Points with Decimal Adjusted | Forward Price |
|---|---|---|---|
| 1.33 | 1.1 | 1.1 / 100 = 0.011 | 1.33 + 0.011 = 1.341 |
| 2.554 | –9.6 | –9.6 / 1,000 = –0.0096 | 2.554 – 0.0096 = 2.5444 |
| 0.7654 | 13.67 | 13.67 / 10,000 = 0.001367 | 0.7654 + 0.001367 = 0.766767 |

There is a myth that the forward points are always divided by 10,000. That is only true if the spot quote is given to four decimal places. To continue the pattern, if the spot quote shows five decimals on the right, move the forward point decimal five places to the left (i.e., forward points / 100,000).

EXAMPLE: **Spot and forward bid/asked quotes of the Australian dollar/euro**

| Maturity/Settlement | Spot Quote/Forward Points |
|---|---|
| Spot AUD/EUR | 1.2571/ 1.2574 |
| 30 days | –1.0/–0.9 |
| 90 days | +11.7/+12.0 |

1. What is the 30 day forward bid/offered quote?
2. If a manager sells 1,000,000 AUD forward 90 days, **calculate** what the manager will deliver and receive. When will the exchange take place?

**Answer:**

1. The spot quote is given to four decimal places making the forward points for 30 days: –1.0 / 10,000 = –0.00010 and –0.9 / 10,000 = –0.00009, a four decimal place adjustment to match the spot quote. The 30-day forward bid/asked are: 1.2571 – 0.00010 = 1.25700 and 1.2574 – 0.00009 = 1.25731.
2. The exchange will be 90 days from the trade date, at contract expiration. The manager will deliver AUD 1,000,000.

   The 90-day forward quotes are 1.2571 + 0.00117 by 1.2574 + 0.00120, which is 1.25827/1.25860 for the AUD/EUR. The manager is delivering AUD and receiving EUR. The manager must deliver more AUD or receive fewer EUR. In this case, the bid/asked quotes are both for 1 EUR and the manager will deliver AUD.

   The manager must deliver at AUD/EUR 1.25860.The manager will receive EUR: AUD 1,000,000 / (1.25860 AUD/EUR) = EUR 794,533.61.

**Offsetting Transactions and Mark to Market:** While forward contracts do not require market to market cash flow exchanges prior to settlement, it is often desirable or required for regulatory purposes to mark the position to market value. The mark-to-market value is the present value of any gain or loss that would be realized if the contract were closed early with an offsetting contract position.

EXAMPLE: **Offsetting transactions**

Based on the initial quotes given in the previous example, a different manager entered into a trade to sell (deliver) 90 days forward, EUR 10,000,000 at the "all-in" forward quote of AUD/EUR 1.25827. Thirty days have passed and exchange rates are now the following:

| Maturity/Settlement | Spot Quote/Forward Points | LIBOR Rates AUD |
|---|---|---|
| Spot AUD/EUR | 1.3189/1.3191 | |
| 30 days | +1.1/+1.2 | 1.10% |
| 60 days | +10.3/+10.5 | 1.20% |
| 90 days | +15.3/+16.1 | 1.25% |

1. **Identify** the offsetting position the manager would take to close the initial transaction and **calculate** the resulting gain or loss. When will this gain or loss be settled?
2. **Calculate** the mark to market the manager would report on day 30 of the original trade if the trade were not closed out early.

**Answers:**

1. Thirty days have passed and the initial trade to sell EUR 10,000,000 forward has 60 days until expiration. The offsetting transaction is to buy 10,000,000 EUR 60 days forward. The solution is done in steps.

   *Step 1*: Thirty days have passed and the initial trade to sell EUR 10,000,000 forward has 60 days until expiration. The offsetting transaction is to buy 10,000,000 EUR 60 days forward. The solution is done in steps. Identify the forward exchange rate for the offsetting position. The manager must buy EUR 10,000,000 (which requires delivering AUD) 60 days forward at AUD/EUR 1.3191 + 0.00105, which is AUD/EUR 1.32015.

   *Step 2*: In 60 days, the manager will do the following:

   - On the original trade: sell EUR 10,000,000 and buy AUD at AUD/EUR 1.25827. The manager will receive AUD 12,582,700.
   - On the offsetting trade: buy EUR 10,000,000 and sell AUD at AUD/EUR 1.32015. The manager will pay AUD 13,201,500.

   The difference, a loss of AUD 618,800, will be settled and paid 90 days after the initial transaction and 60 days after the offsetting transaction.

   Alternatively, this can be solved directly. The base currency (euro) is sold at 1.25827 AUD and then bought at 1.32015 AUD for a loss of 1.32015 – 1.25827 = 0.06188 AUD per euro. On the trade of 10,000,000 euros, this is a loss of AUD 618,800.
2. The current mark to market is the present value of the gain or loss that would be locked in with an offsetting transaction. That offsetting loss was calculated in Solution 1 as AUD 618,800. The 60-day LIBOR rate on the AUD is 1.20%.

   Mark-to-market loss = AUD 618,800 / {1 + [0.012 (60 / 360)]} = AUD 617,564.87

**An FX Swap:** The FX swap is not a currency swap or even a swap as that term is otherwise used. The FX swap rolls over a maturing forward contract using a spot transaction into a new forward contract. An existing forward is "swapped" for another forward transaction.

EXAMPLE: **An FX swap**

A manager purchased 10,000,000 South African rand (ZAR) three months forward at ZAR/USD 9.4518.

Two days before contract expiration the manager decides to extend the transaction for another 30 days. **Explain** the FX swap used to implement this decision.

> **Answer:**
>
> The manager sells spot ZAR 10,000,000 to offset the maturing contract. Both the initial forward and offsetting spot transaction will settle in two business days. The manager enters a new 30-day forward contract to buy ZAR 10,000,000 versus the USD to rollover the trade.

**Option Basics:** A call option is a right to buy the underlying and gains value as the underlying rises above the strike price; its delta approaches 1.00 (a 100-delta). The call loses value as the underlying falls below the strike price and its delta approaches 0.00 (a 0-delta).

A put is the right to sell the underlying and gains value as the underlying falls below the strike price; its delta approaches –1.00 (this can also be referred to as a 100-delta, the negative sign is assumed and not written). The put loses value as the underlying rises above the strike price and the delta approaches 0.00 (a 0-delta).

For a call and a put with identical parameters (time to expiration, strike price, and price of the underlying), the sum of the absolute deltas is 1.00 or 100-delta.

**Currency Option Basics:** Currency options require two currencies and a call on one currency is a put on the other currency. Unless otherwise specified, the option is from the base currency perspective. For example, a call option to buy 10,000,000 at a strike price of ZAR/GBP 14.56 is the right to buy 10,000,000 British pounds and sell 145,600,000 South African rand. It is also a put option—the right to sell 145,600,000 South African rand and buy 10,000,000 British pounds.

A put option to sell 100,000 at MXN/EUR at 20.1 is the right to sell 100,000 euros and buy 2,010,000 Mexican pesos. It is also a call option to buy 2,010,000 Mexican pesos and sell 100,000 euros.

The important relationships can be summarized as follows:

| As the Price of the Base Currency Increases: | The Call Option to Buy the Base Currency: | The Put Option to Sell the Base Currency: |
|---|---|---|
| From 0 to the strike price | Is out-of-the-money and rising in value. Delta is shifting from 0.0 toward 0.5 (from a 0-delta to a 50-delta). | Is in-the-money and falling in value. Delta is shifting from –1.0 toward –0.5 (from a 100-delta to a 50-delta). |
| To the strike price | Is at-the-money. Delta is approximately 0.5 (a 50-delta). | Is at-the-money. Delta is approximately –0.5 (a 50-delta). |
| From the strike price upward | Is in-the-money and rising in value. Delta is shifting from 0.5 toward 1.0 (from a 50-delta to a 100-delta). | Is out-of-the-money and falling in value. Delta is shifting from –0.5 toward 0.0 (from a 50-delta to a 0-delta). |

## Effects of Currency on Portfolio Risk and Return

**Domestic currency** or **home currency** is the currency of the investor (or the currency in which portfolio results are reported and analyzed).

**Domestic asset** is an asset denominated in the investor's domestic currency.

**Foreign currency** and **foreign asset** are a currency other that the investor's domestic currency and an asset denominated in that foreign currency. These are sometimes called the local currency and local market, respectively.

**Foreign-currency return** ($R_{FC}$) is the return of the foreign asset measured in its local (foreign) currency. It can be called the local market return.

The **percentage change in value of the foreign currency** is denoted as $R_{FX}$. It can be called the local currency return.

**Domestic-currency return** ($R_{DC}$) is the return in domestic currency units considering both the **foreign-currency return** ($R_{FC}$) and the percentage change in value of the foreign currency ($R_{FX}$).

## LOS 10.a: Analyze the effects of currency movements on portfolio risk and return.

*CFA® Program Curriculum, Volume 2, page 147*

An investment in assets priced in a currency other than the investor's domestic currency (a *foreign asset* priced in a *foreign currency*) has two sources of risk and return: (1) the return on the assets in the foreign currency and (2) the return on the foreign currency from any change in its exchange rate with the investor's *domestic currency*. These returns are multiplicative and an investor's returns in domestic currency can be calculated as:

Equation 1: $R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1 = R_{FC} + R_{FX} + (R_{FC})(R_{FX})$

$R_{DC} \approx R_{FC} + R_{FX}$

### PROFESSOR'S NOTE

There are three ways to calculate $R_{DC}$ that you will see and are responsible for. The choice of approach is dictated by the case facts and question.

- $R_{DC} \approx R_{FC} + R_{FX}$: This approach is an approximation of the more accurate compounded calculation. It emphasizes the two sources of return, $R_{FC}$ and $R_{FX}$. It is acceptable when precision is not needed, such as selecting between three quite different multiple choice answers or discussing the theoretical sources of return.
- $R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1 = R_{FC} + R_{FX} + (R_{FC})(R_{FX})$: This approach is precise if the precise $R_{FX}$ is known. I would generally use this approach, unless given clear reasons to do something else.
- However, there are cases where determining $R_{FX}$ is not simple. If the currency is hedged, then a precise currency hedge must short the ending number of foreign currency units; however, that ending number is not knowable for a risky asset. You will see a naïve hedge is normally used and the beginning number of foreign currency units are sold forward. In that case, a simple comparison of $F_0$ and $S_0$ will not be the true $R_{FX}$. In that case, you will see a different set of calculations made. You would directly calculate beginning and ending value of the portfolio in the investor's domestic currency units. Then $R_{DC}$ is (EV – BV) / BV.

EXAMPLE: **Calculating domestic currency returns**

Consider a USD-based investor who invests in a portfolio of stocks that trade in euros. Over a one-year holding period, the value of the portfolio increases by 5% (in euros) and the euro-dollar exchange rate increases from 1.300 USD/EUR to 1.339 USD/EUR.

The EUR has appreciated with respect to the USD, so the investor has positive returns from foreign exchange of:

$R_{FX} = 1.339 / 1.300 - 1 = 0.03 = 3\%.$

The investor's return in domestic currency terms over the one-year holding period is:

$R_{DC} = (1.05 \times 1.03) - 1 = 0.05 + 0.03 + (0.05)(0.03) = 0.0815 = 8.15\%$

$R_{DC} \approx R_{FC} + R_{FX} = 5 + 3 = 8\%$

This example illustrates two important points. First, simply adding $R_{FC}$ and $R_{FX}$ (5% + 3% = 8%) yields an approximation of the domestic currency return. The approximation is closer to the actual return the smaller the values of the two sources of return.

Second, the exchange rate quotes must use the foreign currency (EUR) as the base currency (the denominator) to calculate the change in value of the currency ($R_{FX}$). To see why, consider what happens if the domestic currency (USD) had been the base currency.

| FX Quotes | Foreign Currency as the Base Currency | 1/X for Domestic Currency as the Base Currency |
|---|---|---|
| Beginning value | USD/EUR 1.300 | EUR/USD 0.76923 |
| Ending value | USD/EUR 1.339 | EUR/USD 0.74683 |

0.74683/0.76923 − 1 = −0.02912 = −2.912%, which is depreciation of the USD relative to the EUR. The appreciation of the EUR is not simply the negative of the depreciation in the USD. $R_{FX}$ is 3.000%, not 2.912%.

### PROFESSOR'S NOTE

The message is to be careful when working with currency. Read the question and determine which is the foreign versus domestic currency. Label the numbers to determine if you are looking at domestic/foreign or foreign/domestic. Always use domestic/foreign (taking reciprocals if needed) and then solve as *EV / BV − 1 = RFX*.

## Calculating Portfolio Return for Multiple Investments in Foreign Assets

An investor may invest in multiple markets with different currencies. In that case, the domestic portfolio return is a weighted average of the domestic currency returns for each investment. Formally, we have the following.

Equation 2: $R_{DC} = \sum_{i=1}^{n} w_i \left( R_{DC,i} \right)$

where:

$w_i$ = the proportion (in domestic currency terms) of the portfolio invested in assets traded in currency *i*

$R_{DC,i}$ = the domestic currency return for asset *i*

The following example illustrates this calculation.

EXAMPLE: **Domestic currency returns on an investment in two foreign markets**

A euro-based investor has a 75% position in GBP denominated assets and a 25% position in USD denominated assets. The results for the past year are the following.

$R_{FC}$ for the GBP assets = 12%

$R_{FC}$ for the USD assets = 5%

Beginning EUR/GBP exchange rate: 1.1666

Ending EUR/GBP exchange rate: 1.1437

Beginning USD/EUR exchange rate: 1.332

Ending USD/EUR exchange rate: 1.324

**Calculate** the investor's return over the period in domestic (EUR) currency terms.

**Answer:**

First, calculate the $R_{DC}$ (in EUR) for each investment.

For the investment denominated in GBP, we have:

$$R_{DC} = 1.12 \times (1.1437 / 1.1666) - 1 = (1.1200 \times 0.9804) - 1 = 9.80\%.$$

The foreign currency (GBP) has depreciated approximately 2% relative to the euro. The negative currency return reduces the 12% return of the foreign market.

For the investment denominated in USD, the exchange rates were given with the foreign currency (USD) in the numerator. These can be inverted to make the investor's currency (the euro) the price currency and the foreign currency (USD) the base currency.

$$1 / 1.332 = 0.7508 \text{ EUR/USD}$$

$$1 / 1.324 = 0.7553 \text{ EUR/USD}$$

Allowing the investment denominated in USD $R_{DC}$ (in EUR) to be calculated as:

$$R_{DC} = [1.05 \times (0.7553 / 0.7508)] - 1 = (1.0500 \times 1.0060) - 1 = 5.63\%$$

The foreign currency (USD) has appreciated approximately 0.6% relative to the euro. The positive currency return increases the 5% return of the foreign market.

The investor's total portfolio return is the weighted average of the $R_{DC}$ for each market:

$$(0.75 \times 9.80\%) + (0.25 \times 5.63\%) = 7.35 + 1.41 = 8.76\%$$

# Risk

An investor investing in a foreign denominated asset has two sources of risk: the fluctuation of the foreign currency and the fluctuation in foreign currency price of the foreign asset. Both will affect the standard deviation of $R_{DC}$.

The variance of $R_{DC}$ can be calculated using a variation of the basic formula for variance of a two asset portfolio:

$$\sigma^2(R_{DC}) \approx w^2(R_{FC})\sigma^2(R_{FC}) + w^2(R_{FX})\sigma^2(R_{FX}) + 2w(R_{FC})w(R_{FX})\sigma(R_{FC})\sigma(R_{FX})\rho(R_{FC},R_{FX})$$

where:

$\rho$ = the correlation between $R_{FC}$ and $R_{FX}$

However, this basic two asset variance formula can be simplified when a domestic investor holds a single foreign currency denominated asset. The exposures (weights) to $R_{FC}$ and $R_{FX}$ are each 100% with the weights in the formula expressed as 1.0. The formula becomes:

Equation 3: $\sigma^2(R_{DC}) \approx \sigma^2(R_{FC}) + \sigma^2(R_{FX}) + 2\sigma(R_{FC})\sigma(R_{FX})\rho(R_{FC},R_{FX})$

The standard deviation of $R_{DC}$ is the square root of this variance. Examining the equation indicates risk to our domestic investor:

- Depends on the standard deviation of $R_{FC}$ and $R_{FX}$.

- May be higher for our domestic investor because standard deviation of $R_{FX}$ is an additive term in the equation.
- However, correlation also matters. If the correlation between $R_{FC}$ and $R_{FX}$ is negative, the third component of the calculation becomes negative. The correlation measures the interaction of $R_{FC}$ and $R_{FX}$.
  - If the correlation is positive, then $R_{FC}$ returns are amplified by $R_{FX}$ returns, increasing the volatility of return to our domestic investor.
  - If the correlation is negative, then $R_{FC}$ returns are dampened by $R_{FX}$ returns, decreasing the volatility of return to our domestic investor. (This is discussed further under this reading's topic of minimum variance hedge ratio).

**PROFESSOR'S NOTE**

The variance formula in Equation 3 is only an approximation but appropriate. It is based on the simple addition of *RFC* and *RFX* and ignores the cross product of *(RFC)(RFX)*. The use of an approximate variance formula relates to the number of correlations that would be required for true variance. Consider a portfolio of two foreign assets that has four variables, two foreign assets, and two foreign currencies resulting in six correlation pairs. With three foreign assets, there are six variables resulting in a total of 15 correlation pairs. A precise variance calculation would require accurately estimating all possible correlation pairs. That is considered unrealistic and the exact formula would create a false impression of precision. The approximation method is used for the CFA text. A special case is discussed in the following. Think of this special case as risk depends on end of period exposure to the foreign asset.

**If $R_{FC}$ is a Risk-Free Return:** In this case, its standard deviation and correlation with $R_{FX}$ are zero. When $R_{FX}$ is the only source of risk for the domestic investor in the foreign asset, a direct and precise calculation of the standard deviation of $R_{DC}$ is practical.

Equation 4: $\sigma(R_{DC}) = \sigma(R_{FX})(1 + R_{FC})$

where:
$R_{FC}$ = the return on a foreign currency denominated risk-free asset

**PROFESSOR'S NOTE**

Equation 4 is a special case when the foreign asset ($R_{FC}$) is a risk-free asset and cannot be derived from equation 3.

## Strategic Decisions

### LOS 10.b: Discuss strategic choices in currency management.

*CFA® Program Curriculum, Volume 2, page 152*

**PROFESSOR'S NOTE**

This is a lengthy discussion of factors to consider. The next LOS summarizes the conclusions.

Neither academic nor empirical analysis support firm conclusions on currency risk management. Opinions range from doing nothing to active management.

- Arguments made for not hedging currency risk include:
  - It is best to avoid the time and cost of hedging or trading currencies.

  - In the long-run, unhedged currency effects are a “zero-sum game”; if one currency appreciates, another must depreciate.
  - In the long-run, currencies revert to a theoretical fair value.
- The argument for active management of currency risk is that, in the short run, currency movement can be extreme, and inefficient pricing of currencies can be exploited to add to portfolio return. Many foreign exchange (FX) trades are dictated by international trade transactions or central bank policies. These are not motivated by consideration of fair value and may drive currency prices away from their fair value.

**Currency management strategies** for portfolios with exchange rate risk range from a passive approach of matching benchmark currency exposures to an active strategy that treats currency exposure independently of benchmark exposures and seeks to profit from (rather than hedge the risk of) currency exposures. Different approaches along this spectrum include:

- **Passive hedging** is rule based and typically matches the portfolio’s currency exposure to that of the benchmark used to evaluate the portfolio’s performance. It will require periodic rebalancing to maintain the match. The goal is to eliminate currency risk relative to the benchmark.
- **Discretionary hedging** allows the manager to deviate modestly from passive hedging by a specified percentage. An example is allowing 5% deviations from the hedge ratio that would match a currency’s exposure to the benchmark exposure. The goal is to reduce currency risk while allowing the manager to pursue modest incremental currency returns relative to the benchmark.
- **Active currency management** allows a manager to have greater deviations from benchmark currency exposures. This differs from discretionary hedging in the amount of discretion permitted and the manager is expected to generate positive incremental portfolio return from managing a portfolio’s currency exposure. The goal is to create incremental return (alpha), not to reduce risk.
- A **currency overlay** is a broad term covering the outsourcing of currency management. At the extreme, the overlay manager will treat currency as an asset class and may take positions independent of other portfolio assets. Seeking incremental return, an overlay manager who is bearish on the Swedish krona (SEK) for a portfolio with no exposure to the SEK would short the SEK. The manager is purely seeking currency alpha (incremental return), not risk reduction. Overlay managers can also be given a pure risk reduction mandate or restricted to risk reduction with modest return enhancement.

**The IPS:** The account’s policy on whether to hedge or not to hedge currency risk should be recorded in the client’s investment policy statement (IPS). Sections of the IPS that will be particularly relevant in reaching this strategic decision include investor objectives (including risk tolerance), time horizon, liquidity needs, and the benchmark to be used for analyzing portfolio results. The IPS should also specify:

- The target percentage of currency exposure that is to be hedged.
- Allowable discretion for the manager to vary around this target.
- Frequency of rebalancing the hedge.
- Benchmarks to use for evaluating the results of currency decisions.
- Allowable (or prohibited) hedging tools.

EXAMPLE: **Choosing a hedging approach**

A client with a USD based portfolio has little need for liquidity and is focused on short- term performance results. The client evaluates performance relative to a global equity index, which fully hedges currency exposure back to the USD and rebalances the hedge monthly.

1. **Discuss** how this information would affect the manager's views on hedging currency exposure in the portfolio.
2. **Explain** why rebalancing of currency exposure could be needed even if no changes are made to asset holdings.

**Answers:**

1. The client information leads to two possible strategies. (A) If the manager lacks currency expertise, the manager should also fully hedge currency risk and rebalance monthly, then focus on other areas such as asset selection to add value. (B) If the manager does have views on currency movement, the manager can instead increase exposure to currencies expected to appreciate and decrease exposure to currencies expected to depreciate.

   Given the client's focus on short-term results, the manager must consider the currency exposure of the index and either match it or deliberately deviate. A long-term assumption that "currency does not matter" is not appropriate. The lack of liquidity needs reduces the need for currency hedging as it reduces the likelihood of liquidations of foreign asset positions at depressed values.
2. Suppose both the U.S. client and the index allocate 10% to U.K. equities and sell the GBP forward to fully hedge the currency risk. Then over the course of the month, the U.K. stocks in the benchmark fall in value ($-R_{FC}$) while the U.K. stocks in the portfolio rise in value ($+R_{FC}$). The index will reduce the short GBP position to reflect the decreased GBP asset value. In contrast, the manager needs to increase the GBP short position to reflect increased GBP market value. Rebalancing the hedge must consider not only explicit transactions by the manager but also differentials in $R_{FC}$ between the index and the portfolio.

## Strategic Diversification Issues

- In the longer run, currency volatility has been lower than in the shorter run, reducing the need to hedge currency in portfolios with a long-term perspective.
- Positive correlation between returns of the asset measured in the foreign currency ($R_{FC}$) and returns from the foreign currency ($R_{FX}$) increase volatility of return to the investor ($R_{DC}$) and increase the need for currency hedging. Negative correlation dampens return volatility and decreases the need to hedge.
- Correlation tends to vary by time period, providing diversification in some periods and not in others, suggesting a varying hedge ratio is appropriate.
- Some investors assert that there is higher positive correlation between asset and currency returns in bond portfolios than in equity portfolios. If that is true, then there is more reason to hedge currency risk in bond portfolios than in equity portfolios. In a bond portfolio, the riskiness of the asset and currency are more likely to reinforce each other.
- The hedge ratio (the percentage of currency exposure to hedge) varies by manager preference.

**Strategic Cost Issues:** Hedging is not free and benefits must be weighted versus costs.

- The bid/asked transaction cost on a single currency trade is generally small, but repeated transaction costs add up. Full hedging and frequent rebalancing can be costly.
- Purchasing options to hedge involves an upfront option premium cost. If the option expires out-of-the-money, the premium is lost.

- Forward currency contracts are often shorter term than the hedging period, requiring contracts be rolled over as they mature (an FX swap). The hedge lowers return volatility but the rollover can create cash flow volatility with realized gains and losses on the maturing contracts. Financing cash outflows when interest rates are high can be costly as the interest that would have been earned on the funds is lost.
- Overhead costs can be high. A back office and trading infrastructure are needed for currency hedging. Cash accounts in multiple currencies may have to be maintained to support settlements and margin requirements.
- One hundred percent hedging has an opportunity cost with no possibility of favorable currency movement. Some managers elect to “split the difference” between 0 and 100% hedging and adopt a 50% strategic hedge ratio.
- Hedging every currency movement is costly and managers generally chose partial hedges. They may hedge and rebalance monthly rather than daily or accept some amount of negative currency return rather than zero.

### LOS 10.c: Formulate an appropriate currency management program given financial market conditions and portfolio objectives and constraints.

*CFA® Program Curriculum, Volume 2, page 162*

In conclusion, the factors that shift the strategic decision formulation toward a benchmark neutral or fully hedged strategy are:

- A short time horizon for portfolio objectives.
- High risk aversion.
- A client who is unconcerned with the opportunity costs of missing positive currency returns.
- High short-term income and liquidity needs.
- Significant foreign currency bond exposure.
- Low hedging costs.
- Clients who doubt the benefits of discretionary management.

## MODULE QUIZ 10.1

*To best evaluate your performance, enter your quiz answers online.*

**Use the following information for Questions 1 and 2.**

A Djiboutian (DJF) investor holds an international portfolio with beginning investments of USD 1,253,000 and EUR 2,347,800. Measured in the foreign currencies, these investments appreciate 5% and depreciate 7%, respectively.

Additional information:

| Beginning Spot Exchange Rate | Beginning Forward Exchange Rate | Ending Spot Exchange Rate |
|---|---|---|
| DJF/USD 179.54 | DJF/USD 185.67 | DJF/USD 192.85 |
| EUR/DJF 0.00416 | EUR/DJF 0.00413 | EUR/DJF 0.00421 |

1. The ending value of the USD investment is *closest* to:
   A. USD 1,150,000.
   B. DJF 236,200,000.

C. DJF 253,700,000.

2. The unhedged return to the investor of the U.S. investment is *closest* to:
   A. –3%.
   B. +3%.
   C. +12%.
3. A European investor holds a diversified portfolio. From the euro perspective, the portfolio is weighted 60% and 40% in U.S. and U.K. investments.

| Assets | Returns measured in foreign currency | Returns measured from investor's perspective | Standard deviation of asset's returns measured in foreign currency | Standard deviation of the foreign currency's returns |
|---|---|---|---|---|
| U.S. | 5% | 6% | 4.5% | 3.7% |
| U.K. | 7% | 8% | 3.5% | 4.7% |

   The correlation between the foreign-currency asset's returns and returns on the foreign currency are 0.81 and 0.67, respectively, for the U.S. and English assets. **Compute** the standard deviation for the investor in the U.S. assets. **Show** your work.
4. The strategic decision to hedge currency risk will be *least* affected by the:
   A. manager's market views.
   B. correlation between asset and currency returns.
   C. investor's time horizon, risk aversion, and liquidity needs.
5. Which of the following clients would *most likely* allow a manager to implement discretionary currency hedging?
   A. One with a shorter time horizon and higher liquidity needs.
   B. One with more confidence in the portfolio manager and high income needs.
   C. One very concerned with minimizing regret and higher allocation to equity investments.
6. Jane Simms manages a German portfolio and has a 1,000,000 long position in South Korean won (KRW) through a forward contract that is about to come due. The current spot exchange rate is EUR/KRW 0.00067/0.00068. The forward points for a three-month forward contract are –1.2/–1.1. She expects the KRW to depreciate significantly and has the authority to increase or decrease the contract size by 10%. **Explain** whether she will increase or decrease the size of the forward contract and the forward exchange rate at which she will contract.
7. Jane Archer manages a Swiss-based (CHF) hedge fund. A portion of the fund is allocated 60% and 40%, respectively, to EUR and AUD investments. She has collected the following information.

| Estimates | Euro zone | Australia |
|---|---|---|
| Asset return in foreign currency | 2.0% | 2.5% |
| Change in spot exchange rate versus the CHF | –1.0% | 3.0% |
| Asset risk measured in foreign currency (σ) | 15.0% | 25.0% |
| Currency risk (σ) | 7.0% | 9.0% |
| Correlation of asset and currency return | +0.85 | +0.65 |
| Correlation of returns (CHF/EUR, CHF/AUD) | +0.70 | |

   The following questions are from the portfolio perspective, measured in CHF.

   a. **Calculate** the expected return of the portfolio.

b. **Calculate** the standard deviation of the portfolio.

c. **Calculate** the expected return to the portfolio if Archer takes a leveraged position with a 150% positive weight in Australia and a 150% negative weight in the euro zone.

d. **Calculate** the expected standard deviation of returns to the portfolio if Archer takes a leveraged position with a 150% positive weight in Australia and a 150% negative weight in the euro zone.

# MODULE 10.2: ACTIVE STRATEGIES: FUNDAMENTALS AND TECHNICAL ANALYSIS

Video covering this content is available online.

**LOS 10.d: Compare active currency trading strategies based on economic fundamentals, technical analysis, carry-trade, and volatility trading.**

*CFA® Program Curriculum, Volume 2, page 164*

The strategic decision sets the portfolio's normal currency hedging policy. If discretion is allowed, the manager can make active tactical decisions within defined boundaries, seeking to increase return. In all cases, active management requires that the manager have a view or a prediction of what will happen. Tactical decisions can be based on four broad approaches. Unfortunately, none of the approaches works consistently.

## Economic Fundamentals

This approach assumes that, in the long term, currency value will converge to fair value. For example, a fundamental approach may assume purchasing power parity will determine long-run exchange rates. If the basket of goods and services produced in Country A costs 100 units of Country A's currency and that basket costs 200 units of Country B's currency in Country B, then the currency exchange rate of A to B is 100/200, a 0.50 A/B exchange rate.

Several factors will impact the eventual path of convergence over the short and intermediate terms. Increases in the value of a currency are associated with currencies:

- That are more undervalued relative to their fundamental value.
- That have the greatest rate of increase in their fundamental value.
- With higher real or nominal interest rates.
- With lower inflation relative to other countries.
- Of countries with decreasing risk premiums.

Opposite conditions are believed to be associated with declining currency values.

## Technical Analysis

Technical analysis of currency is based on three principals:

1. Past price data can predict future price movement and because those prices reflect fundamental and other relevant information, there is no need to analyze such information.
2. Fallible human beings react to similar events in similar ways and therefore past price patterns tend to repeat.

3. It is unnecessary to know what the currency should be worth (based on fundamental value); it is only necessary to know where it will trade.

Technical analysis looks at past price and volume trading data. FX technical analysis focuses on price trends as volume data is generally less available. Technical analysis works best in markets with identifiable trends. Typical patterns that technicians seek to exploit are the following.

- An **overbought** (or **oversold**) market has gone up (or down) too far and the price is likely to reverse.
- A **support level** exists where there are substantial bids from customers to buy. A price that falls to that level is then likely to reverse and bounce higher as the purchases are executed.
- A **resistance level** exists where there are substantial offers from customers to sell. A price that rises to that level is then likely to reverse and bounce lower as the sales are executed.

At both support and resistance levels, the price becomes "sticky." However, if the market moves through the sticky resistance levels, it can then accelerate and continue in the same direction.

For example, assume technical traders have observed a support level for the GBP at 1.70 USD/GBP. The traders place limit orders to buy GBP at 1.70 USD/GBP. However, to limit their losses, the traders also enter stop loss orders to sell GBP at various prices between 1.70 and 1.69. If the GBP declines to the support level of 1.70, the buy orders are executed, supporting that price and explain the "sticky price behavior." However, if the GBP then declines lower, the stop loss sell orders are executed, driving the GBP lower as the GBP breaks its support level.

**Moving averages** of price are often used in technical analysis. A common rule is that if a shorter-term moving average crosses a longer-term moving average, it triggers a signal. The 50-day moving average rising above the 200-day moving average is a buy signal, falling below is a sell signal.

# MODULE 10.3: ACTIVE STRATEGIES: CARRY AND VOLATILITY TRADING

Video covering this content is available online.

## The Carry Trade

A **carry trade** refers to borrowing in a lower interest rate currency and investing the proceeds in a higher interest rate currency. Three issues are important to understand the carry trade.

1. **Covered interest rate parity** (CIRP) holds by arbitrage and establishes that the difference between spot ($S_0$) and forward ($F_0$) exchange rates equals the difference in the periodic interest rates of the two currencies.
   - The currency with the higher interest rate will trade at a **forward discount**, $F_0 < S_0$
   - The currency with the lower interest rate will trade at a **forward premium**, $F_0 > S_0$
2. The carry trade is based on a violation of **uncovered interest rate parity** (UCIRP). UCIRP is an international parity relationship asserting that the forward exchange

rate calculated by CIRP is an unbiased estimate of the spot exchange rate that will exist in the future. If this were true:

- The currency with the higher interest rate will decrease in value by the amount of the initial interest rate differential.
- The currency with the lower interest rate will increase in value by the amount of the initial interest rate differential.

If these expectations were true, a carry trade would earn a zero return.

3. Because the carry trade exploits a violation of interest rate parity, it can be referred to as trading the forward rate bias. Historical evidence indicates that:
    - Generally, the higher interest rate currency has depreciated less than predicted by interest rate parity or even appreciated and a carry trade has earned a profit.
    - However, a small percentage of the time, the higher interest rate currency has depreciated substantially more than predicted by interest rate parity and a carry trade has generated large losses.

Generally, the carry trade is implemented by borrowing in the lower interest rate currencies of developed economies (**funding currencies**) and investing in the higher interest rate currencies of emerging economies (**investing currencies**). In periods of financial stress, the currencies of the higher risk emerging economies have depreciated sharply relative to the currencies of developed economies and such carry trades have generated significant losses. Given that periods of financial stress are associated with increasing exchange rate volatility, traders often exit their carry trade positions when exchange rate volatility increases significantly.

EXAMPLE: **A carry trade**

The spot exchange rate is BRL/USD 2.41. The interest rates in the two countries are 6% and 1%, respectively.

1. **Estimate** the one-year forward exchange rate for the Brazilian Real.
2. **State** the steps to initiate the carry trade and the theory on which it is based.
3. What is the profit on the trade if the spot exchange rate is unchanged and the trade is initiated by borrowing 100 currency units? **Show** your work.
4. What is the primary risk in this trade?

**Answers:**

1. The forward exchange rate for the Real should be approximately 5% below the current spot exchange rate to reflect the initial interest rate differential. The precise calculation is:

   BRL/USD 2.41 × $(1.06 / 1.01)^1$ = BRL/USD 2.529
2. 
    - Borrow USD at 1%.
    - Convert USD to BRL at the spot exchange rate of BRL/USD 2.41.
    - Invest the BRL at 6%.

   The carry trade is based on a violation of uncovered interest rate parity. It is profitable if the spot exchange rate of the higher interest rate currency declines less than predicted by the forward exchange rate.
3. It is 5%, reflecting the initial interest rate difference and unchanged spot exchange rate.
    - Borrow USD 100 creating a loan payable of USD 101.
    - Convert USD 100 to BRL 241 (= 100 × 2.41).
    - Invest the BRL 241 at 6% creating an ending value of BRL 255.46.

- Convert the BRL 255.46 at the unchanged spot exchange rate back to USD 106.00 (= 255.46 / 2.41).
- Pay off the USD loan for a profit of USD 5.00 on a USD 100 initial investment.

4. This is an unhedged trade and the profit or loss depends on the ending value of the BRL. If the BRL declines by more than 5%, the trade is unprofitable.

Figure 10.1: Summary of the Carry Trade

| The Carry Trade: | | |
|---|---|---|
| Is implemented by: | Borrowing and then selling in the spot market the lower yield currency. | To buy and invest in the higher yield currency. |
| Is trading the forward rate bias: | Selling in the spot market the currency trading at a forward premium. | And buying in the spot market the currency trading at a forward discount. |

The carry trade is generally profitable under normal market conditions. But it can generate large losses in periods of financial distress and high volatility as investors flee high risk (yield) currencies.

PROFESSOR'S NOTE

You should notice this section does not support using the forward exchange rate as a prediction of how currency value will change, sometimes referred to as uncovered interest rate parity (UCIRP). Under IRP, the currency with the higher short-term interest rate will trade at a forward discount. UCIRP asserts that this calculated forward rate is a prediction of what will happen to the spot exchange rate and the higher rate currency will depreciate. This section has (1) noted that empirical evidence indicates the currency with the higher rate tends to appreciate, not depreciate, and (2) the carry trade is based on the higher rate currency appreciating or depreciating less than suggested by UCIRP. You should conclude that the Level III curriculum does not support using the forward exchange rate as a valid prediction of what will happen. The forward exchange rate can be and is used for hedging, but it just is not a good predictor of how the spot exchange rate will move, unless you want a very short career as a currency manager.

## Volatility Trading

Volatility or "vol" trading allows a manager to profit from predicting changes in currency volatility. Recall from Level I and Level II that **delta** measures the change in value of an option's price for a change in value of the underlying and that **vega** measures change in value of the option for changes in volatility of the underlying. Vega is positive for both puts and calls because an increase in the expected volatility of the price of the underlying increases the value of both puts and calls.

**Delta hedging** entails creation of a **delta-neutral position**, which has a delta of zero. The delta-neutral position will not gain or lose value with small changes in the price of the underlying assets, but it will gain or lose value as the implied volatility reflected in the price of options changes. A manager can profit by correctly predicting changes in volatility.

A manager expecting volatility to increase should enter a **long straddle** by purchasing an at-the-money call and put. The manager is buying volatility. The two options will have equal but opposite deltas making the position delta neutral. If volatility increases, the options will rise in net value and the trade will be profitable.

A manager expecting volatility to decrease should enter a **short straddle** by selling both of these options. If volatility declines, the options will fall in net value. The options can be repurchased at lower prices for a profit.

### PROFESSOR'S NOTE

Delta hedging will come up several times in the CFA curriculum. An important caveat is that the deltas will change and the positions must be continually rebalanced to maintain a delta-neutral position.

A **strangle** will provide similar but more moderate payoffs to a straddle. Out of-the-money calls and puts with the same absolute delta are purchased. The out-of-the-money options require larger movement in the currency value to create intrinsic value but will cost less. Both the initial cost and the likely profit are lower than for the straddle.

### MODULE QUIZ 10.2, 10.3

*To best evaluate your performance, enter your quiz answers online.*

1. A currency overlay manager will *most likely* implement a carry trade when the yield of investing currencies is:
   A. lower and volatility is falling.
   B. higher and currency volatility is rising.
   C. higher and currency volatility is stable.
2. Which of the following statements about volatility and interest rates is *most likely* true?
   A. Falling currency volatility leads traders to exit a carry trade.
   B. Rising currency volatility will increase the cost of a collar more than the cost of a protective put.
   C. A delta neutral hedging strategy is more likely to tilt to a net long position in the euro when the euro zone is experiencing rising real interest rates.

## MODULE 10.4: IMPLEMENTATION AND FORWARDS

Video covering this content is available online.

**LOS 10.e: Describe how changes in factors underlying active trading strategies affect tactical trading decisions.**

*CFA® Program Curriculum, Volume 2, page 170*

Active trading strategies are, by definition, risky. An active manager forms market expectations and implements shorter term tactical strategies seeking to add value. If the manager is wrong or does not cover the transaction costs, return is reduced. Manager expectations that trigger tactical trading decisions include the following.

| Expectation: | | Action: |
|---|---|---|
| Relative currency: | Appreciation | Reduce the hedge (short position) on OR increase the long position in the currency |
| | Depreciation | Increase the hedge on or decrease the long position in the currency |
| Volatility: | Rising | Long straddle (or strangle) |
| | Falling | Short straddle (or strangle) |
| Market conditions: | Stable | A carry trade |
| | Crisis | Discontinue the carry trade |

Subtle variations on these actions include the following.

- A carry trade may involve a bundle of funding and investment currencies and positions need not be equally weighted. For example, if the manager expects a particular currency to show greater relative increase in value, the trade would be structured with increased long (or decrease short) positions in that currency.
- Delta neutral positions can be "tilted" to net positive or negative based on the manager's view. A manager expecting a currency to appreciate (depreciate) could shift to a net positive (negative) delta.

## Currency Management Tools

### PROFESSOR'S NOTE

We now examine a variety of hedging techniques and tools plus special considerations that may arise in some situations. The CFA text includes the warning "rote memorization" is not advised. Instead think of basic "building blocks" that allow an infinite number of combinations; focus on the basic concepts and terminology.

Some useful tips to sort through the material include the following. Some of these may be repeated from other sections.

1. What is the currency exposure that needs to be hedged? A typical situation is a portfolio exposed to fluctuation in value of a foreign currency.
2. It is easier to work with FX quotes when the foreign currency is the base currency. If quotes are given as B/P, take the reciprocal to make it P/B.
3. Assume any statements or directions refer to the base currency unless otherwise indicated in the case. But be explicit in your answers and state the currency you are referring to.
4. Decide whether the case requires buying or selling the base currency.
   - Buying forwards (and futures) or buying call options on the base currency increases exposure to the base currency.
   - Selling forwards (and futures) or buying put options on the base currency decreases exposure to the base currency.
   - Remember that:
     - A call on the base currency is a put on the pricing currency.
     - A put on the base currency is a call on the pricing currency.
5. Hedging is not free.

- Hedges using forwards have no or minimal initial cost but high opportunity cost because the potential upside of the hedged currency is eliminated.
- Purchasing options has high initial cost but retains the upside of the hedged currency (the protective put strategy).
- Lowering the cost of the hedge will require some combination of less downside protection or upside potential. Cost can be lowered through some combination of:
  - Writing options to generate premium inflow.
  - Adjusting the option strike prices.
  - Adjusting the size (notional amount) of the options.
  - Adding exotic features to the options.

6. Discretionary hedging allows the manager to deviate from a policy neutral hedge position. Allowing the manager discretion can lower hedging costs and enhance return but also increases the risk of underperformance.
7. The IPS (or question specifics) should define the strategic, policy neutral hedge position. Generally this is a 100% hedge to match the currency exposure of the portfolio's benchmark.

## LOS 10.f: Describe how forward contracts and FX (foreign exchange) swaps are used to adjust hedge ratios.

*CFA® Program Curriculum, Volume 2, page 175*

Typically, **forward contracts** are preferred for currency hedging because:

- They can be customized, while futures contracts are standardized.
- They are available for almost any currency pair, while futures trade in size for only a limited number of currencies.
- Futures contracts require margin which adds operational complexity and can require periodic cash flows.
- Trading volume of FX forwards and swaps dwarfs that of FX futures, providing better liquidity.

A hedge can be a **static hedge**, which is established and held until expiration, or a **dynamic hedge**, which is periodically rebalanced.

Consider a EUR-based manager who must hedge an initial CHF 10,000,000 of asset exposure. One month later, the asset has appreciated to CHF 11,000,000. Assume the manager can initially sell a one- or three-month contract.

1. Initially sell 10,000,000 CHF in the forward market with a one-month forward contract. At contract expiration, roll over the hedge. At rollover, the change in initial contract price will produce a realized gain or loss and cash flow settlement consequences. At the rollover, the size of the new contract can be adjusted to match the new value of the position to be hedged. Over the initial month, the hedge is static but can be dynamic at the rollover.

   If desired, the rollover can be done using an FX swap so that cash flows occur on the expiration date of the initial contract. For an FX swap, the manager would, two days prior to initial contract expiration, buy CHF 10 million in the spot market to cover the short position in the forward and sell forward CHF 11 million to roll over the hedge. This is termed a "mismatched" FX swap because the "near" spot leg and "far" forward leg are not of equal size.

Both the initial short forward contract and the spot market purchase of CHF are for CHF 10,000,000 and settle in two business days. Any difference between the EUR/CHF rate of the initial forward contract and the current spot price will produce a (positive or negative) cash flow in EUR. For example, if the CHF declined by EUR 0.01, the initial hedge (short forward) will produce a cash gain of EUR 100,000 ( = EUR 0.01 × 10,000,000).

2. Initially sell 10,000,000 CHF in the forward market with a three-month forward contract. One month later, the manager is underhedged with a CHF 10,000,000 short position versus an asset now worth CHF 11,000,000.
   a. With a static hedge, the manager would do nothing even though CHF exposure has increased.
   b. With a dynamic hedge, the manager would increase the hedge to cover the additional exposure by selling an additional CHF 1 million forward for two months to create a total short position of CHF 11 million. Because no contracts are being closed on the rebalancing date, all realized gain and losses and cash flows are deferred until the end of the three-month period. A dynamic hedging strategy will specify periodicity of rebalancing the hedge.

The choice of hedging approach should consider:

- Shorter term contracts or dynamic hedges with more frequent rebalancing tend to increase transaction costs but improve the hedge results.
- Higher risk aversion suggests more frequent rebalancing.
- Lower risk aversion and strong manager views suggest allowing the manager greater discretion around the strategic hedging policy.

# Roll Yield

Hedging also exposes the portfolio to **roll yield** or **roll return**. Roll yield is a return from the movement of the forward price over time toward the spot price of an asset. It can be thought of as the profit or loss on a forward or futures contract if the spot price is unchanged at contract expiration. Determining whether the roll yield produces a profit or a loss will depend on two factors: (1) whether the currency is trading at a forward premium or discount and (2) whether is it purchased or sold. Roll yield for a contract held to expiration is determined by initial forward minus spot price divided by initial spot price.

For example, consider an investor who sells CHF 1 million six-month forward for USD 1.05 when the spot rate is 1.04. The forward price is at a premium so the roll yield on a short position will be positive. Think of it as the investor sells at a high price and the price rolls down for a gain. The investor can deliver CHF 1 million for 1.05 USD when its initial cost in the market (at spot) is 1.04 USD, for a gain of USD 10,000. The unannualized roll yield is 0.01/1.04 = 0.96%.

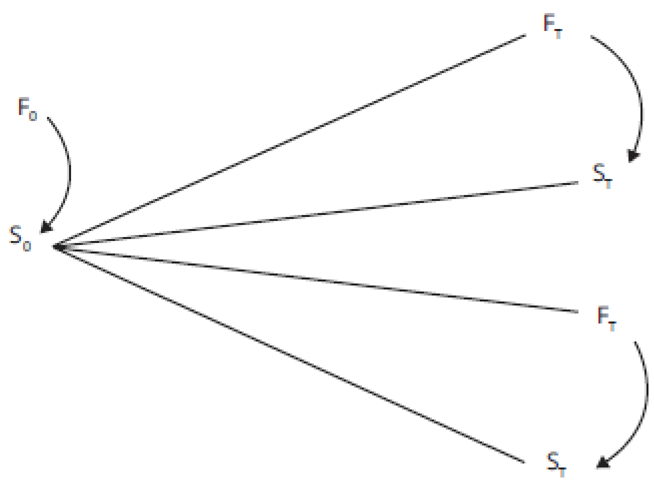
Roll yield will affect the cost/benefit analysis of whether to hedge the currency risk. It is a cost of hedging. Positive roll yield will shift the analysis toward hedging and negative roll yield will shift the analysis away from hedging. The relationships of forward premium or discount, initial difference in interest rates, positive or negative roll yield, and impact on hedging cost are summarized in Figure 10.2.

Figure 10.2: Forward Premiums or Discounts and Currency Hedging Costs

| Current position of foreign asset in currency B | The hedge requires: | $F_{P/B} > S_{P/B}$, $i_B < i_P$ The forward price curve is upward-sloping. | $F_{P/B} < S_{P/B}$, $i_B > i_P$ The forward price curve is downward-sloping |
|---|---|---|---|
| Short the foreign asset | A long forward position in currency B, the hedge earns: | Negative roll yield, which increases hedging cost and discourages hedging. | Positive roll yield, which decreases hedging cost and encourages hedging. |
| Long the foreign asset | A short forward position in currency B the hedge earns: | Positive roll yield, which decreases hedging cost and encourages hedging. | Negative roll yield, which increases hedging cost and discourages hedging. |

## PROFESSOR'S NOTE

Suppose the initial forward price of the base currency is above its initial spot price. If the base currency is sold forward, $F_T$ and $S_T$ will converge at contract expiration and provide positive roll yield for the short position. The positive roll for the short position does not depend on whether the spot price increases or decreases. This is depicted in the following figure. It shows that the forward and spot price will converge at contract expiration regardless of whether the spot price increases or decreases. Suppose a manager sells the base currency forward when the initial forward price is above the spot price, $F_0 > S_0$ . Convergence dictates that at contract expiration, $F_T = S_T$ and the roll return will be positive.




Note that the positive roll for the base currency short position is a negative roll for the long position. This discussion of roll and a contract on the base currency is equally true for contracts on any other assets such as stocks, bonds, and commodities.

Also note that the roll yield is not the total return from selling or buying the forward. The underlying spot price can increase or decrease. The forward price will converge to that unknown spot price at expiration of the forward. The total of the return to the forward position will be the change in price of the forward. That change in price of the forward has two components: 1) the unknown-in-advance change in the spot price, and 2) the known-in-advance roll yield.

EXAMPLE: **Roll yield and interest rates**

A USD-based investor has exposure to the South African rand (ZAR). The USD interest rate is 2.8% and the ZAR interest rate is 3.6%. **Determine** the roll yield for the investor if he hedges his ZAR exposure with a six-month forward.

**Answer:**

To hedge the long ZAR exposure, the investor sells the ZAR forward (buy the USD). IRP determines the premium or discount earned (roll yield) on the transaction. From IRP, the periodic risk-free rate of the currency purchased (USD) will be gained and the currency sold (ZAR) will be lost. Over a six-month period, this is approximately + 2.8% / 2 − 3.6% / 2 = −0.4%. The ZAR will trade at approximately a 0.4% forward discount.

A precise calculation of the discount requires first calculating the initial forward price using IRP:

$$F_{P/B} = S_{P/B}\left(\frac{1+i_P}{1+i_B}\right)$$

Then compare that forward price to the initial spot price to calculate the percentage roll yield (i.e., the forward premium or discount):

$$(F - S) / S$$

However by "assuming" an initial spot exchange rate between the two currencies of parity, a 1/1 exchange rate, this can be reduced to a single calculation:

% forward premium / discount = % roll yield

$$= (1.00)(1.028 / 1.036)^{0.5} - 1 = -0.387\%$$

Note that to analyze the ZAR, the ZAR is in the denominator of all terms.

## PROFESSOR'S NOTE

The CFA text mentions but does not further apply a "similarity" between roll yield and trading the forward rate bias. Both depend on the initial interest rate differential between two currencies. In the previous example, the ZAR traded at a forward discount because it had an initially higher periodic interest rate.

- The forward rate bias trade (the carry trade) would buy the ZAR in the spot market to invest in and earn the higher interest rate.
- An investor who needs exposure to the ZAR would buy the ZAR in the forward market at a discount and earn positive roll yield.

The "similarity" is buying the higher yielding currency.

### EXAMPLE: **Hedging and roll yield**

A portfolio's reporting currency is the Korean won (KRW) and the portfolio holds investments denominated in EUR, USD, and CHF. Current exchange rate information is provided below along with the manager's expectation for the spot rate in six months.

| | Spot FX Rate | Six-Month Forward FX Rate | Manager's Forecast |
|---|---|---|---|
| KRW/EUR | 1,483.99 | 1,499.23 | 1,450.87 |
| KRW/USD | 1,108.78 | 1,112.56 | 1,146.63 |
| KRW/CHF | 1,265.22 | 1,257.89 | 1,212.55 |

1. Which foreign currencies trade at a forward premium or discount?
2. Which foreign currency hedges would earn a positive roll yield?
3. Which foreign currencies would an active currency manager hedge?
4. **Comment** on how the roll yield affects the decision to hedge the EUR or USD.
5. **Calculate** the implied unannualized roll yield of a currency hedged for the portfolio's long exposure to CHF.

**Answers:**

1. The EUR and USD trade at a forward premium; forward price is above spot price.
2. The hedge will require a forward sale of the currency and sale at a forward premium will earn positive roll yield. Those are the EUR and USD.
3. An active manager will selectively hedge those currencies where the hedge is expected to improve return. The manager will compare expected unhedged with hedged returns. The manager is

initially long each foreign currency so increases in the currency's value are a gain.

| | Unhedged | Hedged |
|---|---|---|
| EUR | (1,450.87 / 1,483.99) –1 = –2.23% | (1,499.23 / 1,483.99) –1 = 1.03% |
| USD | (1,146.63 / 1,108.78) – 1 = 3.41% | (1,112.56 / 1,108.78) – 1 = 0.34% |
| CHF | (1,212.55 / 1,265.22) – 1 = –4.16% | (1,257.89 / 1,265.22) – 1 = –0.58% |

Comparing unhedged expected returns with hedged returns, the manager will hedge the EUR and CHF.

4. Selling forward the USD and EUR will result in positive roll yield which will reduce hedging costs. However, roll yield is only one factor to consider. The positive roll yield for selling the USD forward is not as attractive as the expected appreciation of leaving the USD unhedged.
5. The implied roll yield is the forward premium or discount. It is also the hedged currency return:

   $(F_0 - S_0) / S_0 = (F_0 / S_0) - 1 = (1{,}257.89 / 1{,}265.22) - 1 = -0.58\%$

This example demonstrates two issues involved with forward currency hedging. In essence, they are the same issue viewed from two different perspectives:

1. Positive (negative) roll yield will reduce (increase) hedging cost compared to the initial spot price.
2. Hedging locks in the forward price as an end of period exchange rate.

# MODULE 10.5: IMPLEMENTATION AND OPTIONS

Video covering this content is available online.

**LOS 10.g: Describe trading strategies used to reduce hedging costs and modify the risk–return characteristics of a foreign-currency portfolio.**

*CFA® Program Curriculum, Volume 2, page 185*

The initial forward premium or discount is one cost factor to consider in analyzing the cost/benefit of a currency hedge. To reduce hedging cost, the manager can increase the size of trades that earn positive roll yield and reduce the size of trades that earn negative roll yield.

Forward hedging also incurs **opportunity cost**. Locking in a forward price to hedge currency risk will eliminate downside currency risk but also will eliminate any upside opportunity for gain from changes in exchange rates. Discretionary or option-based hedging strategies are designed to reduce opportunity cost.

Perfect hedging is expensive. If the manager wishes to insure against downside risk and retain upside potential, costs rise further. Reducing those hedging costs involves some form of less downside protection or less upside opportunity, moving the portfolio away from a 100% hedge ratio and/or toward more active decision making. The following discussion of strategies applies to a manager who wishes to hedge long exposure to the CHF (the base currency) and quotations are EUR/CHF.

1. **Over- or under-hedge with forward contracts** based on the manager's view. If the manager expects the CHF to appreciate, she can reduce the hedge ratio, hedging less than the full exposure to CHF risk. If the CHF is expected to depreciate, she can

increase the hedge ratio, hedging more than the full exposure to CHF risk. If successful, this strategy creates "positive convexity"; gains will be increased and losses reduced. This is a relatively low cost strategy.

The rest of this discussion proceeds from roughly highest to lowest initial option cost.

2. **Buy at-the-money (ATM) put options** (also called **protective puts** or **portfolio insurance**). This strategy provides asymmetric protection, eliminating all downside risk and retaining all upside potential. But an at-the-money option is relatively expensive and has only time value (no intrinsic value). This strategy has the highest initial cost but no opportunity cost.
3. **Buy out-of-the-money (OTM) put options.** An ATM put would have a delta of approximately −0.50, called a 50-delta put because the sign of the delta is ignored with this terminology. Out-of-the-money puts have deltas that are smaller in magnitude than 0.50, so a 35-delta put is out of the money and a 25-delta put is further out of the money. Puts are less expensive the further they are out of the money, but also offer less downside protection. The manager will have downside CHF exposure down to the strike price of the puts. Compared to buying ATM protective puts, this strategy reduces the initial cost of the hedge but does not eliminate all downside risk.
4. **Collar**. The manager could buy the 35-delta puts on the CHF and sell 35-delta calls on the CHF. The OTM put provides some downside protection while costing less than an ATM put. The sale of the OTM call removes some upside potential (increasing opportunity cost) but generates premium income to further reduce initial cost. This strategy further reduces initial cost but also limits upside potential compared to buying out-of-the money put options only.

   A counterparty who buys the OTM call and sells the OTM put has taken on a risk reversal. The risk reversal profits if the underlying rises above the OTM call strike price and loses if the underlying falls below the OTM put strike price. The seller of the call and buyer of the put (used in the collar) can be described as short the risk reversal.
5. **Put spread**. Buy OTM puts on the CHF and sell puts that are further out of the money, (e.g., buy a 35-delta put and sell a 25-delta put). There is downside protection, which begins at the strike price of the purchased puts, but if the CHF falls below the lower strike price of the put sold, that downside protection is lost. This strategy reduces the initial cost and also reduces downside protection compared to buying out-of-the money put options only.
6. **Seagull spread**. This is a put spread combined with selling a call (e.g., buy a 35-delta put, sell a 25-delta put, and sell a 35-delta call). Compared to the put spread, only this hedge has less initial cost and the same down side protection, but limits upside potential.

Further alternatives include varying the degree of upside potential and downside protection. The manager can vary the notional amounts of the options. For example, a 1 × 2 put spread would buy 100 40-delta puts and sell 200 30-delta puts. The sale of additional puts increases premium income, reducing the initial cost of the hedge, but doubles the downside risk if the currency value falls below the strike price on the 30-delta puts.

All of these strategies are considered "plain vanilla" in that they are combinations of standard options. **Exotic options** introduce features not found in standard options.

1. A **knock-in option** is a plain vanilla option that only comes into existence if the underlying first reaches some prespecified level.
2. A **knock-out option** is a standard option that ceases to exist if the underlying reaches some prespecified level.
3. **Binary** or **digital options** pay a fixed amount that does not vary with the difference in price between the strike and underlying price.

PROFESSOR'S NOTE

Clearly there are any number of combinations and odd names for hedging strategies that use combinations of options positions. The important thing is to recognize how the above strategies affect the tradeoff between the cost of a hedge, its downside protection, and its upside potential.

The issues involved with selecting a hedge are summarized in the following steps.

1. Determine the base currency in the P/B quote. In a USD/CHF quote, the CHF is the base and if the quoted price increases (decreases), the CHF appreciates (depreciates).
2. Determine whether the base currency will be bought or sold. If bought and the quoted price increases (decreases), there is a gain (loss). If sold and the quoted price increases (decreases), there is a loss (gain).
3. If buying the base currency is required to hedge the existing risk, buying forwards or calls can be used. Buying OTM calls or writing options will reduce the hedge cost but also reduce downside protection or upside potential.
4. If selling the base currency is required to hedge the existing risk, forwards are sold or puts are purchased. Buying OTM puts or writing options will reduce the hedge cost but also reduce downside protection or upside potential.
5. The higher the client's risk tolerance and the stronger the manager's views, the less likely a simple 100% hedge will be used.
6. Various combinations of options, strike prices, and position sizes can reduce initial hedging costs, even to zero, but only by reducing downside protection or upside potential.

## Hedging Multiple Currencies

International portfolios will typically have exposure to more than one foreign currency. Generally, hedging each exposure individually is unnecessary, expensive, and time consuming. Consider a European investor who is underweight the AUD and overweight the NZD. The mechanical solution is a long position in AUD and a short position in NZD to reach neutral weights in both. Because the Australian and New Zealand economies are very similar, their currencies exhibit strong positive correlation. The two currencies are natural hedges for each other. If the initial over- and underweights were equal, there may be no need for any additional hedging.

# MODULE 10.6: MORE ADVANCED IMPLEMENTATION ISSUES

Video covering this content is available online.

**LOS 10.h: Describe the use of cross-hedges, macro-hedges, and minimum-variance-hedge ratios in portfolios exposed to multiple foreign currencies.**

*CFA® Program Curriculum, Volume 2, page 192*

A **cross hedge** (sometimes called a **proxy hedge**) refers to hedging with an instrument that is not perfectly correlated with the exposure being hedged. Hedging the risk of a diversified U.S. equity portfolio with S&P futures contracts is a cross hedge when the portfolio is not identical to the S&P index portfolio. Cross hedges are generally not necessary in currency hedging because forward contracts for virtually all currency pairs are available but cross hedges may improve the efficiency of hedging.

Cross hedges also introduce additional risk to hedging. When the correlation of returns between the hedging instrument and the position being hedged is imperfect, the residual risk increases. The AUD and the NZD have a high positive correlation with each other so hedging an underweighting in the AUD with an overweighting in the NZD has little, but not zero, cross hedge risk.

The historical correlation is not a guarantee of the future. The future correlation may be different from historical correlation. If the correlation between two currencies moves toward zero, the (cross) hedge will not perform as expected. Portfolio performance could benefit or suffer from a change in correlation. The residual risk of the hedge is increased.

A **macro hedge** is a type of cross hedge that addresses portfolio-wide risk factors rather than the risk of individual portfolio assets. A bond portfolio might have interest rate risk, credit risk, and volatility risk exposures that the manager could hedge with bond futures (to hedge interest rate risk by modifying duration), credit derivatives (to hedge credit risk), and with volatility trading (to alter volatility risk).

One type of currency macro hedge uses a derivatives contract based on a fixed basket of currencies to modify currency exposure at a macro (portfolio) level. The currency basket in the contract may not precisely match the currency exposures of the portfolio, but it can be less costly than hedging each currency exposure individually. The manager must make a choice between accepting higher residual currency risk versus lower cost.

The **minimum-variance hedge ratio** (MVHR) is a mathematical approach to determining the hedge ratio. When applied to currency hedging, it is a regression of the past changes in value of the portfolio ($R_{DC}$) to the past changes in value of the hedging instrument to minimize the value of the tracking error between these two variables. The hedge ratio is the beta (slope coefficient) of that regression. Because this hedge ratio is based on historical returns, if the correlation between the returns on the portfolio and the returns on the hedging instrument change, the hedge will not perform as well as expected.

The practical implications of this are as follows:

1. Our forward hedging examples up to now have been "direct" hedges. For example, a USD portfolio that is long CHF 1,000,000 sells CHF 1,000,000 forward to hedge the risk, a simple one-for-one hedge ratio of the notional exposure. In technical terms, the portfolio is long CHF, the hedging vehicle is a forward contract on the CHF, and the CHF and its forward have a virtually 1.00 correlation; therefore, no MVHR analysis is needed, sell CHF 1,000,000 forward.
2. Cross hedges or macro hedges are considered "indirect" hedges, the correlation between the currency exposure in the portfolio and a currency contract may not be 1.00 and the minimum-variance hedge ratio may not be one-for-one.
3. The MVHR can be used to jointly optimize over changes in value of $R_{FX}$ and $R_{FC}$ to minimize the volatility of $R_{DC}$.

To illustrate this use of the MVHR, consider the case of a foreign country where the economy is heavily dependent on imported energy. Appreciation of the currency ($+R_{FX}$) would make imports less expensive, which is likely to decrease production costs, increasing profits and asset values ($+R_{FC}$). **Strong positive correlation between $R_{FX}$ and $R_{FC}$ increases the volatility of $R_{DC}$. A hedge ratio greater than 1.0 would reduce the volatility of $R_{DC}$.**

Consider the case of a foreign country where the economy is heavily dependent on exports. Appreciation of the currency ($+R_{FX}$) would make its exports more expensive, likely reducing sales, profits, and asset values ($-R_{FC}$). **Strong negative correlation between $R_{FX}$ and $R_{FC}$ naturally decreases the volatility of $R_{DC}$. A hedge ratio less than 1.0 would reduce the volatility of $R_{DC}$.**

EXAMPLE: **Determining and applying the MVHR**

A U.S.-based portfolio is long EUR 2,000,000 of exposure. The portfolio manager decides to jointly hedge the risk of the asset returns measured in EUR and the risk of the currency return to minimize the volatility of the portfolio's returns measured in USD. The manager first adjusts all currency quotes to measure the value of the foreign currency by expressing the currency quotes as USD/EUR. He then calculates weekly percentage changes in value of the EUR (the $R_{FX}$) and unhedged percentage changes in value of the portfolio position measured in the portfolio's domestic currency (the $R_{DC}$). He performs a least squares regression analysis and determines based on the historical data that:

$R_{DC} = 0.12 + 1.25(\%\Delta S_{USD/EUR}) + \varepsilon$

With a correlation between $R_{FX}$ and $R_{FC}$ of 0.75

1. **Calculate** the size of and **state** the currency hedge to minimize expected volatility of the $R_{DC}$.
2. **Comment** on how effective the hedge is likely to be.

**Answers:**

1. EUR 2,000,000 × 1.25 = EUR 2,500,000; the manager will short EUR 2,500,000 to hedge a long EUR 2,000,000 exposure in the portfolio.
2. This is a cross hedge and is based on past correlation. The correlation can change and the hedge may perform better or worse than expected. In addition, a correlation of 0.75 is not perfect and there is random variation even in the past data.

# Managing Emerging Market Currency

**LOS 10.i: Discuss challenges for managing emerging market currency exposures.**

*CFA® Program Curriculum, Volume 2, page 203*

The majority of investable asset value and FX transactions are in the six largest developed market currencies. Transactions in other currencies pose additional challenges because of: (1) higher transaction costs, "high markups" and (2) the increased probability of extreme events. Examples of these problems include the following.

- Low trading volume leads dealers to charge larger bid/asked spreads. The problem is compounded as the spreads tend to increase even further during periods of financial crisis.
- Liquidity can be lower and transaction costs higher to exit trades than to enter trades. Consider the carry trade that leads investors to gradually accumulate long

positions in higher yield emerging market currencies. During periods of economic crises, the majority of those investors may attempt to exit a carry trade at the same time, driving the value of the emerging market currency down below its fundamental value and disrupting normal trading activity.

- Transactions between two emerging market currencies can be even more costly. Few dealers have the expertise to directly make a market between the currencies of smaller markets. A dealer may quote a transaction between the Malaysian ringgit (MYR) and Hungarian forint (HUF) but would, in fact, execute component transactions in EUR/MYR and EUR/HUF with other dealers who have the expertise to trade only one of the two currencies.
- Emerging market currencies return distributions are non-normal with higher probabilities of extreme events and negative skew of returns. Many trading strategies and risk measures assume a normal distribution and are, therefore, flawed.
- The higher yield of emerging market currencies will lead to large forward discounts. This produces negative roll yield for investors who need to sell such currencies forward.
- Contagion is common. During periods of financial crisis the correlations of emerging markets with each other and with their currencies tend to converge toward +1.0. Both emerging markets and their currencies have declined as a group. At the very time diversification is most needed, it tends to disappear.
- There is *tail risk*; the governments of emerging markets tend to actively intervene in the markets for their currencies, producing long periods of artificial price stability followed by sharp price movements when market forces overwhelm the government's capacity to intervene. The "tail risk" refers to these negative events occurring more frequently than would be assumed in the normal distribution.

**Non-deliverable forwards** (NDFs): Emerging market governments frequently restrict movement of their currency into or out of the country to settle normal derivative transactions. Such countries have included Brazil (BRL), China (CNY), and Russia (RUB). NDFs are an alternative to deliverable forwards and require a cash settlement of gains or losses in a developed market currency at settlement rather than a currency exchange.

A benefit of NDFs is lower credit risk because delivery of the notional amounts of both currencies is not required. Only the gains to one party are paid at settlement.

An additional point to consider with NDFs is that they exist because the emerging market government is restricting currency markets. Changes in government policy can lead to sharp movements in currency values (i.e., there is tail risk).

EXAMPLE: **Calculating cash settlement values for an NDF**

A trader buys EUR 1,000,000 six months forward at RUB/EUR 39. Six months later, the spot exchange rate is RUB/EUR 40. **Calculate** the cash flows that will occur at settlement.

**Answer:**

The trader has agreed to "sell" RUB 39,000,000 for EUR 1,000,000. At settlement, the market value of EUR 1,000,000 is RUB 40,000,000 so the investor has a gain of RUB 1,000,000.

However, NDF settlements are made in the developed market currency at the ending spot exchange rate so we must convert the gain of RUB 1,000,000 to EUR at RUB/EUR 40.The EUR value of RUB 1,000,000 at settlement is 1,000,000 / 40 = 25,000 euros and the trader will receive this payment from the counterparty. There is only a net exchange of gain.

## MODULE QUIZ 10.4, 10.5, 10.6

*To best evaluate your performance, enter your quiz answers online.*

1. Peter Perkins has a U.S.-based portfolio and decides to hedge his exposure to the Swiss franc (CHF) with a protective put strategy. However, he also decides he is willing to reduce the downside protection to lower the initial cost. Which of the following strategies will accomplish his objective?
   A. Buy 50-delta calls and puts on the CHF.
   B. Buy a 40-delta put and sell a 20-delta put on the CHF.
   C. Buy a 40-delta put and sell a 35-delta call on the CHF.
2. Jane Archer manages a Swiss-based (CHF) hedge fund. GBP 1,000,000 is currently invested in a diversified portfolio of U.K. stocks. Archer regresses the monthly returns of a diversified U.K. stock index (returns measured in CHF) versus the monthly change in value of the CHF/GBP. The regression coefficients are intercept = 0.11 and slope coefficient = 1.25. **Determine** the quantity of GBP Archer will short to implement a hedge of direct currency risk and a minimum-variance hedge.

| Direct currency hedge | Minimum-variance hedge |
|---|---|
| A. GBP 1,000,000 | GBP 1,000,000 |
| B. GBP 1,000,000 | GBP 1,250,000 |
| C. GBP 1,250,000 | GBP 1,250,000 |

3. A trader enters a short three-month non-deliverable forward on 2,000,000 CNY at CNY/USD 6.1155. At the end of the period, the spot exchange rate is USD/CNY 0.1612. The trader's gain or loss is *closest* to:
   A. USD 4,600 loss.
   B. USD 4,700 loss.
   C. USD 4,650 gain.

# KEY CONCEPTS

## LOS 10.a

An investment in assets priced in a currency other than the investor's domestic currency (a *foreign asset* priced in a *foreign currency*) has two sources of risk and return: (1) the return on the assets in the foreign currency and (2) the return on the foreign currency from any change in its exchange rate with the investor's *domestic currency*. These returns are multiplicative and an investor's returns in domestic currency can be calculated as:

Equation 1: $R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1 = R_{FC} + R_{FX} + (R_{FC})(R_{FX})$

$R_{DC} \approx R_{FC} + R_{FX}$

Equation 2: $R_{DC} = \sum_{i=1}^{n} w_i (R_{DC,i})$

Equation 3: $\sigma^2(R_{DC}) \approx \sigma^2(R_{FC}) + \sigma^2(R_{FX}) + 2\sigma(R_{FC})\sigma(R_{FX})\rho(R_{FC},R_{FX})$

Equation 4: $\sigma(R_{DC}) = \sigma(R_{FX})(1 + R_{FC})$

where for Equation 4:
$R_{FC}$ = the return on a foreign currency denominated risk-free asset

## LOS 10.b

**Passive hedging** is rule-based and typically matches the portfolio's currency exposure to the portfolio's benchmark in order to eliminate currency risk relative to the benchmark.

**Discretionary hedging** allows the manager to deviate modestly from passive hedging. The primary goal is currency risk reduction while seeking some modest value added return.

**Active currency management** allows wider discretion to selectively hedge or not hedge and to deviate substantially from the benchmark. The goal is value added, not risk reduction. At the extreme, an active manager can treat currency as an asset class and take positions independent of the portfolio assets. For example, a manager who is bearish on the Swedish krona (SEK) can short the SEK even if no SEK assets are owned.

**Currency overlay management** is a broad term referring to the use of a separate currency manager. The asset manager first takes positions in the markets considered most attractive, without regard to the resulting currency exposures. The overlay manager then adjusts the currency exposures. The overlay manager's mandate can be passive, discretionary, or active.

Arguments made for not hedging currency risk include the following:

- Avoid the time and cost of hedging or trading currencies.
- Currency effects are a "zero-sum game"; if one currency appreciates, another must depreciate.
- In the long run, currencies revert to a theoretical fair value.

Arguments for active currency management include the following:

- In the short run, currency movement can be extreme.
- Inefficient pricing of currencies can be exploited to add to portfolio return. Inefficient pricing of currency can arise as many foreign exchange (FX) trades are dictated by international trade transactions or central bank policies.

## LOS 10.c

Factors that favor a benchmark neutral or fully hedged currency strategy are:

- A short time horizon for portfolio objectives.
- High risk aversion.
- High short-term income and liquidity needs.
- Significant foreign currency bond exposure.
- Low hedging costs.
- Clients who doubt the benefits of discretionary management.
- A client who is unconcerned with the opportunity costs of missing positive currency returns.

## LOS 10.d

1. Economic fundamentals assumes that purchasing power parity (PPP) determines exchange rates in the very long run. In the shorter run, currency appreciation is associated with:
    - Currencies that are undervalued relative to fundamental value (based on PPP).
    - Currencies with a faster rate of increase in fundamental value.
    - Countries with lower inflation.

- Countries with higher real or nominal interest rates.
- Countries with a decreasing country risk premium.

2. Technical analysis:
   - Overbought (or oversold) currencies reverse.
   - A currency that declines to its support level will reverse upward unless it pierces the support level, in which case, it can decline substantially.
   - A currency that increases to its resistance level will reverse downward unless it pierces the resistance level, in which case, it can increase substantially.
   - If a shorter term moving average crosses a longer term moving average, the price will continue moving in the direction of the shorter term moving average.
3. The carry trade exploits the forward rate bias (i.e., forward exchange rates are not a valid predictor of currency market movement).
   - Borrow the lower interest rate currency (often a developed market).
   - Convert it to the higher rate currency (often an emerging market) at the spot exchange rate.
   - Invest and earn the higher interest rate.

   This is a risky, not a hedged, trade. If the higher interest rate currency appreciates or depreciates less than "implied" by the forward rate, the trade will be profitable. In times of severe economic stress, the carry trade can be very unprofitable as the higher interest rate (and riskier) currency collapses.
4. Volatility trading profits from changes in volatility.
   - If volatility is expected to increase, enter a straddle (purchase a call and put with the same strike price, typically using at-the-money options). A strangle (buy an out-of-the-money call and put) can also be used. The strangle will cost less but will have less upside if volatility increases.
   - If volatility is expected to decline, enter a reverse straddle or strangle (i.e., sell the options).

## LOS 10.e

| Expectation: | | Action: |
|---|---|---|
| Relative currency: | Appreciation | Reduce the hedge (short position) on OR increase the long position in the currency |
| | Depreciation | Increase the hedge on or decrease the long position in the currency |
| Volatility: | Rising | Long straddle (or strangle) |
| | Falling | Short straddle (or strangle) |
| Market conditions: | Stable | A carry trade |
| | Crisis | Discontinue the carry trade |

## LOS 10.f

Typically, forward contracts are preferred for currency hedging because:

- They can be customized, while futures contracts are standardized.

- They are available for almost any currency pair, while futures trade in size for only a limited number of currencies.
- Futures contracts require margin which adds operational complexity and can require periodic cash flows.
- Trading volume of FX forwards and swaps dwarfs that of FX futures, providing better liquidity.

A hedge can be a **static hedge**, which is established and held until expiration, or a **dynamic hedge**, which is periodically rebalanced.

The choice of hedging approach should consider:

- Shorter term contracts or dynamic hedges with more frequent rebalancing tend to increase transaction costs but improve the hedge results.
- Higher risk aversion suggests more frequent rebalancing.
- Lower risk aversion and strong manager views suggest allowing the manager greater discretion around the strategic hedging policy.

Hedging also exposes the portfolio to **roll yield** or **roll return**. Roll yield is a return from the movement of the forward price over time toward the spot price of an asset. It can be thought of as the profit or loss on a forward or futures contract if the spot price is unchanged at contract expiration.

**Forward Premiums or Discounts and Currency Hedging Costs**

| Current position of foreign asset in currency B | The hedge requires: | $F_{P/B} > S_{P/B}$, $i_B < i_P$<br>The forward price curve is upward-sloping. | $F_{P/B} < S_{P/B}$, $i_B > i_P$<br>The forward price curve is downward-sloping |
|---|---|---|---|
| Short the foreign asset | A long forward position in currency B, the hedge earns: | Negative roll yield, which increases hedging cost and discourages hedging. | Positive roll yield, which decreases hedging cost and encourages hedging. |
| Long the foreign asset | A short forward position in currency B the hedge earns: | Positive roll yield, which decreases hedging cost and encourages hedging. | Negative roll yield, which increases hedging cost and discourages hedging. |

## LOS 10.g

The cost of hedging a currency exposure:

- **Positive roll** will reduce and **negative roll** will increase hedging costs.
- Hedging with forward (or futures) has no explicit option premium cost, but it has **implicit cost**; it removes upside as well as downside.
- Active managers can selectively **over- or under-hedge**. Buy more or sell less of the currency expected to appreciate.
- An **at-the-money (ATM) put** (a **protective put** or **portfolio insurance**) is the most expensive (upfront premium cost) form of option hedging (e.g., buy a 50 delta put).

Option hedging costs can be reduced by decreasing upside potential or increasing downside risk. To hedge an existing currency exposure:

- **Buy an out-of-the-money (OTM) put.**
- **Use a collar; buy an OTM put and sell an OTM call.**
- **Use a put spread; buy an OTM put and sell a further OTM put.**

- **Use a seagull spread; buy an OTM put, sell a further OTM put and sell an OTM call.**
- **Use exotic options** that require additional conditions before they can be exercised or which can expire early.

## LOS 10.h

A **cross hedge** (sometimes called a proxy hedge) uses a hedging vehicle that is different from, and not perfectly correlated with, the exposure being hedged.

A **macro hedge** is a type of cross hedge that addresses portfolio-wide risk factors rather than the risk of individual portfolio assets. One type of currency macro hedge uses a derivatives contract based on a fixed basket of currencies to modify currency exposure at a macro (portfolio) level.

The **minimum-variance hedge ratio** (MVHR) is a mathematical approach to determining the hedge ratio. Regress past changes in value of the portfolio ($R_{DC}$) to the past changes in value of the hedging instrument (the foreign currency) to find the hedge ratio that would have minimized standard deviation of $R_{DC}$. The hedge ratio is the beta (slope coefficient) of that regression.

- Positive correlation between $R_{FX}$ and $R_{FC}$; MVHR > 1.
- Negative correlation between $R_{FX}$ and $R_{FC}$; MVHR < 1.

## LOS 10.i

A transaction in a lesser developed country's currency poses challenges because of: (1) higher transaction costs, and (2) the increased probability of extreme events. Examples of these problems include the following:

- Low trading volume leads dealers to charge larger bid/asked spreads.
- Liquidity can be lower and transaction costs higher to exit trades than to enter trades.
- Transactions between two emerging market currencies can be even more costly.
- Emerging market currencies return distributions are non-normal with higher probabilities of extreme events and negative skew of returns.
- The higher yield of emerging market currencies will lead to large forward discounts. This produces negative roll yield for investors who need to sell such currencies forward.
- Contagion is common during periods of financial crisis; the correlations of emerging markets with each other and their currencies tend to converge toward +1.0. At the very time diversification is needed most, it tends to disappear.
- *Tail risk* exists where the governments of emerging markets actively intervene in the markets for their currencies producing long periods of artificial price stability followed by sharp price movements when market forces overwhelm the government's capacity to intervene. These negative events occur more frequently than would be assumed with a normal distribution.

**Non-deliverable forwards (NDFs)** are forward contracts in which the exchange of the notional a3mounts of the currencies are not required. NDFs are an alternative to deliverable forwards and allow for the gains or losses of an emerging market's restricted currency to be settled in a developed market currency, which lowers credit risk. Only the gains to one party are paid at settlement.

## ANSWER KEY FOR MODULE QUIZZES

### Module Quiz 10.1

1. **C** The ending value in USD is: USD 1,253,000 × 1.05 = USD 1,315,650.The ending value in DJF is: USD 1,315,650 × DJF/USD 192.85 = DJF 253,723,103. (LOS 10.a)
2. **C** $(1 + R_{FC})(1 + R_{FX}) - 1$

   (1.05)(192.85 / 179.54) − 1 = 12.78%

   (LOS 10.a)

3. It depends on the standard deviation of the asset returns measured in the foreign currency, the standard deviation of the currency, and the correlation between these two sources of return.

   Variance = $(1.0^2)(4.5^2) + (1.0^2)(3.7^2) + 2(1.0)(1.0)(0.81)(4.5)(3.7) = 60.913$

   Standard deviation = 7.8%

   (LOS 10.a)

4. **A** The manager's market views affect tactical decisions to vary away from the strategic decision. The portfolio and market circumstances determine the strategic decision. (LOS 10.b)
5. **C** Any of the following will shift the portfolio toward active currency management allowing greater manager discretion:
   - A long time horizon for portfolio objectives.
   - Low risk aversion.
   - Concern with regret at missing opportunities to add value through discretionary currency management.
   - Low short-term income and liquidity needs.
   - Little foreign currency bond exposure.
   - High hedging costs.
   - Clients who believe in the benefits of discretionary management.

   (LOS 10.b)

6. The case states that Simms must hold a long position in the KRW and her long futures position is coming due. She must roll it over with another long position. She does have the authority to increase or decrease the long hedge position by 10%. Because she believes the KRW will depreciate, she should reduce the hedge size 10% and will buy only 900,000 KRW rather than the existing 1,000,000 when she rolls over the hedge. The quotes are given in EUR/KRW so she must transact at the higher price of 0.00068 reflecting she is paying more EUR per KRW. The spot quote

is given in five decimal places so the forward points decimal must be moved five places to the left for a forward price of 0.00068 – (1.1 / 100,000) = 0.00068 – 0.000011 = 0.000669 EUR/KRW. (LOS 10.a)

7. a. The expected returns measured in the investor's domestic currency (CHF) are:

   EUR asset: (1.02)(0.99) – 1 = +0.98%
   AUD asset: (1.025)(1.03) – 1 = +5.58%
   The weighted average return is: 0.6(0.98%) + 0.4(5.58%) = 2.82%

   b. The standard deviations of asset returns measured in the investor's domestic currency are:

   EUR asset: $[(15.0^2) + (7.0^2) + 2(15.0)(7.0)(0.85)]^{1/2} = 21.27\%$
   AUD asset: $[(25.0^2) + (9.0^2) + 2(25.0)(9.0)(0.65)]^{1/2} = 31.60\%$
   The standard deviation of portfolio returns is:
   $[0.6^2(21.27^2) + 0.4^2(31.60^2) + 2(0.6)(0.4)(0.70)(21.27)(31.60)]^{1/2} = 23.42\%$

   c. The expected returns measured in the investor's domestic currency (CHF) are:

   EUR asset: (1.02)(0.99) – 1 = +0.98%
   AUD asset: (1.025)(1.03) – 1 = +5.58%
   The weighted average return is: –1.5(0.98%) + 1.5(5.58%) = 6.90%

   d. The standard deviations of asset returns measured in the investor's domestic currency are:

   EUR asset: $[(15.0^2) + (7.0^2) + 2(15.0)(7.0)(0.85)]^{1/2} = 21.27\%$
   AUD asset: $[(25.0^2) + (9.0^2) + 2(25.0)(9.0)(0.65)]^{1/2} = 31.60\%$
   The standard deviation of portfolio returns is:
   $[(-1.5)^2(21.27^2) + (1.5)^2(31.60^2) + 2(-1.5)(1.5)(0.70)(21.27)(31.60)]^{1/2} = 33.87\%$
   (LOS 10.a)

## Module Quiz 10.2, 10.3

1. **C** A carry trade should be more profitable in periods of economic stability (low, stable currency volatility) with lower interest rates in the borrowing currencies and higher interest rates in the investing currencies. (Module 10.3, LOS 10.d)

2. **C** Rising real interest rates in the euro zone would attract capital and be associated with a rising currency value, leading a manager to tilt to a long position in the euro. The other two answers are incorrect. Low volatility is favorable to a carry trade. Rising volatility increases the price of both calls and puts. It is likely to have a greater impact on the cost of the protective put, which requires purchase of a put. In contrast, the collar cost is increased to purchase the put but offset by an increased receipt from selling the call. (Module 10.3, LOS 10.d)

## Module Quiz 10.4, 10.5, 10.6

1. **B** This question requires you select the strategy that meets the objectives set by Perkins. He has three objectives and only one answer choice meets all three. He

wants a protective put on the CHF; all three strategies buy a put on the CHF. He wants to lower the initial cost; one strategy buys a call, which will raise the cost, but it must be rejected. He is willing to reduce his downside protection in order to lower the initial cost; the only one strategy to do this is the buy a 40-delta put and sell a 20-delta put on the CHF. Note the strategy that sells an OTM call also lowers the initial cost but does so by limiting upside; this is not what Perkins specified. (Module 10.5, LOS 10.g)

2. **B** A direct currency hedge is a simple 1.0 hedge ratio; Archer will sell 1,000,000 GBP forward. A MVHR considers the correlation between returns of the foreign asset measured in the portfolio's domestic currency and change in value of the foreign currency. The hedge ratio is the beta (slope coefficient) of the regression. Archer will sell 1,250,000 GBP forward. (Module 10.6, LOS 10.h)

3. **C** An NDF settles in the developed market currency; however, the information is presented in a mixture of CNY/USD and USD/CNY which requires additional steps:

   Determine the size of the trade in USD at the forward exchange rate:

   CNY 2,000,000 / (CNY/USD 6.1155) = USD 327,037.85

   Determine the G/L on the USD position in CNY. The two exchange rates need to be in CNY/USD.

   Ending spot exchange rate USD/CNY 0.1612 is CNY/USD 6.20347.

   G/L = (CNY/USD 6.20347 − 6.1155) × 327,037.85 = CNY 28,769.52

   Determine the G/L in USD based on ending spot exchange rate is:

   G/L = CNY 28,769.52 × USD/CNY 0.1612 = USD 4,637.65

   The CNY was shorted at CNY/USD 6.1155 and declined in value to CNY/USD 6.20347 producing a gain on the trade of USD 4,637.65.

   (Module 10.6, LOS 10.i)

# TOPIC QUIZ: BEHAVIORAL FINANCE

*You have now finished the Derivatives and Currency Management topic section. On your Schweser online dashboard, you can find a Topic Quiz that will provide immediate feedback on how effective your study of this material has been. The test is best taken timed; allow three minutes per question. Topic Quizzes are more exam-like than typical QBank questions or module quiz questions. A score less than 70% suggests that additional review of the topic is needed.*

# FORMULAS

Put-call parity:

call premium (paid initially) – put premium (received initially) = initial stock price paid – PV(X) received

In symbols, $c_0 - p_0 = S_0 - PV(X)$, which can be rearranged to $S_0 + p_0 = c_0 + PV(X)$.

Notional principal of the interest rate swap:

$$NP_s = \left(\frac{MD_T - MD_P}{MD_s}\right)(MV_P)$$

where:

$NP_S$ = notional swap principal

$MD_T$ = target modified duration

$MD_P$ = current portfolio modified duration

$MD_S$ = modified duration of swap

$MV_P$ = market value of portfolio

Identifying the CTD bond at delivery:

profit/(loss) on delivery = [(settlement price × CF) + $AI_T$] – (CTD clean price + $AI_T$)

To fully hedge (immunize) a portfolio's value against interest rate changes:

$\Delta P = HR \times \Delta$ futures price

where:

$\Delta P$ = change in portfolio's value

HR = hedge ratio = number of futures contracts

$$\Delta P = HR \times \frac{\Delta CTD}{CF} = \frac{\Delta P}{\Delta CTD} \times CF$$

Duration-based hedge ratio (BPVHR):

To achieve a target duration, the formula can be amended to:

$$\text{BPVHR} = \frac{-\text{BPV}_{\text{portfolio}}}{\text{BPV}_{\text{CTD}}} \times \text{CF}$$

BPVHR = number of short futures

$$\text{BPV}_{\text{portfolio}} = \text{MD}_{\text{portfolio}} \times 0.01\% \times \text{MV}_{\text{portfolio}}$$

MD = modified duration

$$\text{BPV}_{\text{CTD}} = \text{MD}_{\text{CTD}} \times 0.01\% \times \text{MV}_{\text{CTD}}$$

$$\text{MV}_{\text{CTD}} = \text{CTD price} / 100 \times \$100{,}000$$

$$\text{BPVHR} = \frac{\text{BPV}_{\text{target}} - \text{BPV}_{\text{portfolio}}}{\text{BPV}_{\text{CTD}}} \times \text{CF}$$

$$\text{BPV}_{\text{target}} = \text{MD}_{\text{target}} \times 0.0001 \times \text{MV}_{\text{portfolio}}$$

Number of futures contracts needed

$$= \frac{\text{monetary value of position to be hedged}}{\text{futures price} \times \text{multiplier}}$$

The hedge ratio for futures can be calculated as:

$$\text{HR} = \frac{\text{amount of currency to be exchanged}}{\text{futures contract size}}$$

$$\text{Number of futures required} = \left(\frac{\beta_T - \beta_P}{\beta_F}\right)\left(\frac{\text{MV}_P}{F}\right)$$

where:

$\beta_T$ = target portfolio beta

$\beta_P$ = current portfolio beta

$\beta_F$ = futures beta (beta of stock index)

$\text{MV}_P$ = market value of portfolio

$F$ = futures contract value = futures price × multiplier

Variance over the life of the swap:

$$\text{settlement amount}_T = (\text{variance notional})(\text{realized variance} - \text{variance strike})$$

Realized variance:

$$R_i = \ln(P_t / P_{t-1})$$

$$\text{daily variance} = \left[\frac{\sum_{i=1}^{N-1} R_i^2}{(N-1)}\right]$$

annualized variance = daily variance × 252; 252 = assumed trading days in a year

Variance notional:

$$\text{variance notional} = \frac{\text{vega notional}}{2 \times \text{strike price (K)}}, \text{ so profit/(loss)} = N_{VAR} \times (\sigma^2 - K^2)$$

$$= N_{vega} \times \left(\frac{\sigma^2 - K^2}{2K}\right)$$

$$\text{expected variance to maturity} = \left(\sigma_t^2 \times \frac{t}{T}\right) + \left(K_{(T-t)}^2 \times \frac{T-t}{T}\right)$$

where:

$\sigma_t^2$ = annualized realized volatility from initiation to valuation date squared

$K_{(T-t)}^2$ = annualized implied volatility from valuation date to swap maturity squared

Probability of a change in the Fed funds target rate:

percent probability of rate change

$$= \frac{\text{effective rate implied by futures} - \text{current Fed funds target rate}}{\text{Fed funds rate assuming a rate change} - \text{current Fed target funds rate}}$$

Note that this can be expressed as

$$\frac{\text{implied Fed funds effective rate} - \text{current target rate}}{\text{expected size of rate change}}$$

Foreign Asset Return and Risk:

$$R_{DC} = (1 + R_{FC})(1 + R_{FX}) - 1 = R_{FC} + R_{FX} + (R_{FC})(R_{FX})$$

$$R_{DC} \approx R_{FC} + R_{FX}$$

$$R_{DC} = \sum_{i=1}^{n} w_i (R_{DC,i})$$

$$\sigma^2(R_{DC}) \approx \sigma^2(R_{FC}) + \sigma^2(R_{FX}) + 2\sigma(R_{FC})\sigma(R_{FX})\rho(R_{FC},R_{FX})$$

$$\sigma(R_{DC}) = \sigma(R_{FX})(1 + R_{FC})$$

where:

$R_{FC}$ = the return on a foreign currency denominated risk-free asset

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